Money demand in SOE under a fixed exchange rate regime: the case of Azerbaijan

by

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Abstract

This study examines the stability of the money demand function in Azerbaijan and its determinants. Using quarterly data from 2001 to 2023, various tests and models are employed to explore the relationship between money demand and other variables. The findings suggest that an open economy model, supplemented with country-specific factors, offers a more effective framework for understanding money demand in a fixed exchange rate economy as Azerbaijan. Despite some issues with model stability and inconclusive effects of certain variables, the coefficient stability tests reveal a consistent money demand function. However, caution should be exercised when utilizing these models for policy-making due to their limitations.

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Introduction

This paper aims to analyze the stability of the money demand and factors affecting that in Azerbaijan. In order to clearly understand the money demand issue it is important to define the functions of money, because demand for money intrinsically emanates from the three functions of money, namely, store of value, a unit of account and medium of exchange. The money demand infers an indispensable and vital function of a monetary policy in any economy of country since it implies a pivotal component of the transmission mechanism of that policy.

There are three remarkably approaches to the money demand issue proposed by classical, Keynesian and post-Keynesian scholars. Even though the views of classical economists are innate in the quantity theory of money presented by (Fisher, 2006), where he mentioned the dependency of demand for money on transactions which related to the level of national income and connectiveness of demand for money with the extant volume of trade in an economy, they did not pointedly express a money demand theory.

Having repudiated the ideas endorsed by the classical economists, (Keynes, 1936) introduced a theory of money demand that accentuate the significance of interest rates and proposed three motives attributed for the holding of money: the transactions motive, the precautionary motive, and the speculative one. Moreover, he proclaimed that demand for money is a positive function of income when it appears from the transaction and precautionary motives, while money demand function negatively depends alone on interest rate in case of speculative motive. Additionally, Keynes did not explain why the speculative demand for money is independent of income, however, his work provided the basis to assume that demand and interest rate have a negative relationship.

In his innovative theoretical approach (Baumol, 1952) considered the interest elasticity of transactions demand for money emphasizing that variations in income beget less than commensurate variations in transactions demand for money. A risk aversion (risk-avoiding) theory of liquidity preference based on portfolio selection which developed by (Tobin, 1958) abolished two significant flaws of the Keynesian theory of money demand. These two defects are Keynes's liquidity preference function dependency on the inelasticity of expectations of future interest rates and individuals' intention to hold only one asset, either money or bonds. Therefore Tobin's theory depends on the assumption that expected value of capital gain or loss of interest-bearing assets that one holds is always zero. Additionally, this theory touch upon the diversification issue, it argues that portfolio of individual consists of neither money or bonds, but jointly of the pair of cash and "consols", i.e money and bonds. Individuals are eager to possess a particular amount of real money balances, and real money demand (measured in real money balances) was a function of real income and the opportunity cost of holding real balances (expected rate of inflation and expected return on money, bonds, equity) and that function assumes a stationary long-run equilibrium (Friedman, 1956).

An effective monetary policy means a strong relationship between macroeconomic variables, namely, aggregate output, income, interest rate, price level, etc. The existence of a stable money demand function in the economy of any country is an important prerequisite for an effective monetary policy which in turn brings stable economic growth and development; that's why policymakers are concerned with this issue (Friedman, 1995; Omotor, 2007). A large number of theoretical and empirical researches are devoted to the problems of the demand for money. Contemporary researches indicate the existence of a stable function demand for money in developed countries (Lee et al., 2007). However, the question of the existence of such function in countries with economies in transition, i.e in developing and emerging countries is remarkably controversial.

The occurrence of a stable money demand function in a country with transition economy such as Azerbaijan firstly indicates that there is a shift towards the formation of market mechanisms, secondly, the existence of a stable money demand function makes it possible to use the monetary aggregate as an intermediate goal of monetary policy.

Having regained its independency after the collapse of Soviet Union in 1991, Azerbaijan faced the challenge of transforming from a centrally planned economy to a market one. National Bank of Azerbaijan was established in 1992. Due to lamentable and derogatory economic reforms, political instability, surging state debt and other economic factors, nascent economy of Azerbaijan experienced a recession from 1991 to 1995. This recession could be described as a hyperinflation, severe lessening production and income level, soaring money supply which was created by the National Bank's action to finance a budget deficit, and a paralysis of financial and banking systems. After the ratification of the Contract of the Century which covered major oil fields at the end of 1994, Azerbaijani economy began to brisk and experienced gradually growth. To avert appreciation of exchange rate and to curb inflation expectations, Central Bank of the Republic of Azerbaijan (CBAR) implemented a fixed exchange rate regime in 2004 (Rahimov et al., 2016). As a result of inauguration of the Baku-Tbilisi-Ceyhan (BTC) oil pipeline in 2005, the oil boom period of Azerbaijan had started (Aliyev and Dehning, 2016). Therefore, this period was marked by monetary expansion, extreme domestic absorption and expansionary fiscal policy. Between 2005 and 2008, Azerbaijan experienced significant growth in its banking system alongside a rapidly expanding economy and increasing demand for banking services. This progress took place amidst a backdrop of unstable international financial markets and limited availability of funds. Although inflation started to rise in 2007 and continued into 2008, it remained stable in the following six years despite the global financial crisis. However, since 2009, inflation has shown a relatively steady pattern. During the 2005-2008 period, the country also witnessed substantial inflows of petro-dollars and a significant rise in government spending, driven by revenue generated from oil resources. A deficit in the balance of payments arose due to a decrease in income from the export of oil products and natural gas.Consequently, the "manat", Azerbaijan's currency, faced significant pressure on foreign exchange markets, leading to its devaluation twice in 2015 (on February 21, 2015, and December 21, 2015). The decline in Brent oil prices starting in the second half of 2014 had a profound impact on Azerbaijan's macroeconomic indicators. The country experienced rising inflation due to the effect of oil prices on the national currency, decreased reserves of the Central Bank, increased imports resulting from the devaluation of the manat, diminished consumer confidence, and higher import prices. The continuous devaluation processes in 2015-2016 had a particularly adverse effect on the financial market, especially the banking sector, which subsequently witnessed the bankruptcy of several banks. This situation significantly undermined public trust in the banking sector. It is important to interpret the current state of Azerbaijan's financial market within the context of the global pandemic, as it caused substantial disruptions in financial markets worldwide. The depreciation of the national currency continued in the following period, leading to significant volatility in foreign exchange markets. However, inflation gained momentum in 2015 in response to expectations of further devaluations and the Central Bank's decision to adopt a floating exchange rate regime in response to declining oil prices. In January 2017, the Central Bank announced a complete transition to a floating rate regime and later declared the process concluded in October. From February to April 2017, the manat appreciated against the US dollar due to various factors, including oil price increases, a contraction in foreign exchange markets, and reduced imports. Over the subsequent 12 months (April 2017 to April 2018), the exchange rate exhibited a stable trend, with 1 US dollar equaling 1.7 manat. As (Imanov et al., 2017) points out the financial system of Azerbaijan has not been stable after oil price slump.

Literature Review

A strand of empirical literature exists where the authors try to find the determinants of money demand function and assess its stability. Money demand models hold significant significance for policymakers. These models establish a structure that allows for the explanation of monetary changes through the influence of various macro variables, including economic activity, prices, and interest rates. However, despite extensive research, there is no unanimous agreement on the reliability of money demand functions in general. Evaluations of the stability of these functions have varied over time and across different countries (Kahn and Benolkin, 2007; Calza et al., 2003). During the onset of the financial crisis, there were indications of instability in traditional models of money demand. However, studies incorporating household wealth in money demand functions demonstrated that money demand stability remained favorable, thus capturing the evolution of real money balances (Beyer, 2009). Similarly, approaches explaining international portfolio allocations across borders supported the notion of money demand stability for euro area $M3$ (De Santis et al., 2013). Furthermore, panel cointegration approaches provided evidence in favor of a stable long-term money demand function for $M3$, suggesting that the instability observed in conventional functions could be attributed to an omitted variable (Nautz and Rondorf, 2011). It should be noted that the transmission mechanism's wide range of distortions following the financial crisis, as well as the adoption of non-standard measures, may have impacted this relationship. However, a recent study (Dreger and Wolters, 2015) discovered that the extraordinary measures implemented by the European Central Bank did not introduce instability in the broad money demand relationships in the euro area. According to (Miller, 1991) in the US, it was suggested that monetary policy could be effectively implemented by utilizing the $M2$ monetary aggregate. Similarly, (Hoffman and Rasche, 1989) as well as (McNown and Wallace, 1992) supported the stability of $M2$ in the US. On the other hand, (Melnick, 1990) concluded that currency devaluation leads to instability in the money demand function in the UK and Argentina, respectively. (Bahmani-Oskooee and Shabsigh, 1996) emphasized the significance of the exchange rate in ensuring the stability of the money demand function in Japan. For Korea, (Bahmani-Oskooee and Rhee, 1994) identified a long-term equilibrium relationship between $M2$ and its associated factors. In the case of China, (Hafer and Kutan, 1994) stated that $M2$ can be utilized to establish a stable money demand function. Mixed findings have been discovered regarding stability concerns in both advanced and emerging economies, with specific focus on India. The emergence of financial development or financial liberalization is the underlying reason for the instability observed in the money demand function. It is crucial to acknowledge that the financial structure plays a vital role in the overall progress of an economy. Therefore, incorporating financial development into policy formulation is a fundamental requirement for the effective implementation of monetary policy. Previous studies have overlooked the significance of financial innovation as a crucial determinant for a stable money demand function. Notably, the works of (Arrau and De Gregorio, 1993; Arrau et al., 1995), (Siklos, 1993), and (Dekle and Pradhan, 1997) have drawn researchers' attention to the importance of financial innovation. Additionally, (Gurley and Shaw, 1955) highlighted the financial aspects of economic development, prompting researchers to reconsider the stability of money demand from a new perspective. To summarize, achieving a stable money demand function necessitates the presence of financial development. (Bahmani-Oskooee* and Rehman, 2005) conducted an estimation of money demand for seven Asian countries, including India, Indonesia, Malaysia, Pakistan, Philippines, Singapore, and Thailand. They used quarterly data from 1973 to 2000 and employed the ARDL approach, as well as CUSUM and CUSUMSQ tests. The results revealed that although real $M1$ or $M2$ monetary aggregates in some Asian countries exhibited cointegration with their determinants, the estimated parameters were found to be unstable. In a similar vein, (Arize, 1994) reexamined the money-demand function in three small open economies in Asia, namely Korea, Pakistan, and Singapore. Alongside employing the error correction modeling technique, the study explored the influence of variables such as expected exchange rate changes, foreign interest rates, and foreign exchange risks on money demand. The classical linear regression model assumptions were thoroughly tested. The empirical findings, covering the period from 1973:1 to 1990:1, indicated that the error-correction specification performed well. Additionally, the results suggested that foreign monetary developments, to some extent, had a significant effect on money-demand behavior in these small developing economies, in addition to the traditional variables. (Akinlo, 2006) focused on Nigeria and examined the cointegrating property and stability of money demand using quarterly data from 1970 to 2002. The study applied the ARDL approach in conjunction with CUSUM and CUSUMSQ tests. The results demonstrated that $M2$ exhibited cointegration with income, interest rate, and exchange rate, and a somewhat stable relationship was observed, particularly in the CUSUM test. (Sharifi-Renani, 2007) estimated the demand for money in Iran utilizing the ARDL approach for cointegration analysis. The empirical results suggested the presence of a unique cointegrated and stable long-run relationship among narrow money, income, inflation, and exchange rate. The income elasticity and exchange rate coefficient were found to be positive, while the inflation elasticity was negative. After incorporating the CUSUM and CUSUMSQ tests, the results indicated that the $M1$ money demand function remained stable between 1985 and 2006. (Rao and Kumar, 2009)conducted an estimation of the demand for real narrow money ($M1$) in Bangladesh from 1973 to 2003. They utilized the Gregory and Hansen framework and considered endogenous structural breaks in the cointegration equation. The results revealed a cointegrating relationship between real narrow money, real income, and nominal interest rate. Among the four possible structural breaks, the one with an intercept shift in 1989 yielded meaningful cointegrating coefficients.

The findings also indicated a well-determined and stable demand for money in Bangladesh from 1988 to 2003, with a slight decline in the demand for narrow money following the financial reforms in the 1980s. (Anwar and Asghar, 2012) analyzed the long-run relationship between demand for money, real income, inflation rate, and exchange rate in Pakistan using the ARDL approach. The study revealed a cointegration between the $M2$ monetary aggregate and its determinants, indicating a stable long-run relationship. The findings suggested that monetary authorities and policymakers in Pakistan should primarily focus on long-run stabilization policies. (Nitin et al., 2016) examined the stability of the demand for money function in India from 1991:1 to 2014:9 using co-integration and the Vector Error Correction Mechanism (VECM) framework. The results indicated the existence of a long-run relationship between the demand for real balances, national output, interest rate, and exchange rate. National income and exchange rate were observed to positively affect the demand for real balances, while the interest rate had a negative effect. (Mahmood and Asif, 2016) estimated money demand function for 5 countries using ARDL and CUSUM tests, the stable money demand error correction term's coefficient varied from -0.32 (UAE) to -0.96 (Bahrain). (Bahmani-Oskooee et al., 2015) used NARDL method and found speed of adjustment of -0.08 for Iran.

Data

Based on the literature and the aim of this work, the pertaining variables are obtained from the Central Bank of Azerbaijan Republic (CBAR afterwards). Readily accessible data series start from 2005, hence, the data monthly series starting from 2001 are manually collected from the promulgated statistical bulletins by CBAR, with exception for the US 3-Month Treasury Bill rates and Brent oil price. The date series are obtained in monthly frequencies, then is converted to quarterly ones. More detailed description of the data series is given in Table 1.

Notation	Variable	Description	Source
$M2$	M2 monetary aggregate	Total of the cash and non-cash in circulation (savings and deposits in foreign currency are not included here), million manats	(CBAR)
GDP	Gross Domestic Product	Measured as aggregate of the added value, created in the sectors of economics, million manats	(CBAR)
IPI	Industrial Production Index	Measures levels of production and capacity in industrial sector	(CBAR)
CPI	Consumer Price Index	Measures levels of the value for consumer goods and services, 2001M1=100	(CBAR)
REF_RATE	Refinancing Rate	Interest rate set by the Central Bank	(CBAR)
LEN_RATE	Lending Rate	Average short term lending rates of loans to physical and legal entities by Commercial Banks	(CBAR)
UST_RATE	US 3-Month Treasury Bill Rate	3-month treasury bill rate in the Secondary Market, discount basis	(FRED, a)
$BRENT$	Brent Oil Price	Brent Oil Spot price	(FRED, b)
$INTBANK\_RATE$	Inter-bank Lending Rate	Average overnight inter-bank lending rates	(CBAR)
$REER$	Real Effective Exchange Rate	Measures the value of a currency against a weighted average of several foreign currencies	(CBAR)
EX_RATE	Exchange Rate	The rate of conversion 1 US dollar to 1 Azerbaijani manat	(CBAR)

Table 1: Data Series Description

From the statistical bulletins it is not obvious whether the time series are seasonally adjusted or not. Therefore, several tests are conducted to spot seasonality in the time series if there are ones. Those tests are implemented in (JDemetra+) Software Package developed by National Bank of Belgium and recommend by European Central Bank. It also supports personalized calendar schedules. The default calendar schedule is adjusted for holiday days in Azerbaijan. The test results are reported in Table 2 and Table 3, respectively for monthly and quarterly time series. Only three test results out of several are reported. P-values lower than pertaining significance levels indicates rejection of hypothesis of the series experiencing non-seasonality. As expected, Consumer Price Index, Gross Domestic Product and $M2$ money supply aggregate are unequivocally shows seasonality in the series. The seasonal adjustment procedure is also conducted in (JDemetra+) via TRAMO/SEATS+ method.

	Tests on autocorrelations at seasonal lags	Non parametric (Friedman) test	Non parametric (Kruskal-Wallis) test
M2	0.0000	0.0000	0.0000
GDP	0.0000	0.0000	0.0000
IPI	1.0000	0.8990	0.9121
CPI	0.0000	0.0000	0.0000
REF_RATE	0.6943	0.7117	0.9940
IR	1.0000	0.3668	0.7466
US_T	0.2116	0.0168	0.2894
BRENT	0.8546	0.3834	0.3564
IRB	0.3113	0.3713	0.3543
EX_RATE	0.0181	0.0565	0.9154
REER	1.0000	0.0113	0.0678

Table 2: Tests for seasonality of monthly series

	Tests on autocorrelations at seasonal lags	Non parametric (Friedman) test	Non parametric (Kruskal-Wallis) test
M2	0.4587	0.0002	0.0198
GDP	0.0000	0.0000	0.0000
IPI	0.8206	0.8711	0.9329
CPI	0.0000	0.0000	0.0000
REF_RATE	0.9758	0.7678	0.9723
IR	1.0000	0.1745	0.6084
US_T	0.2239	0.1870	0.7331
BRENT	1.0000	0.0491	0.1239
IRB	0.5832	0.8711	0.9018
EX_RATE	0.0098	0.0030	0.5551
REER	0.9781	0.0743	0.1214

Table 3: Tests for seasonality of quarterly series

Afterwards, nominal series are transformed into real values taking 2001M1 (January of 2001) date as a base year. The reason for this is that $REER$ series that are available has a base date of 2001M1 and NEER is not available for that wide range of time. Therefore, to be in line with this series, the other nominal variables are also converted into real values using 2001M1 as a base year. Below the monthly graphical representations of the time series. R in the beginning of the series name indicates the real value series.

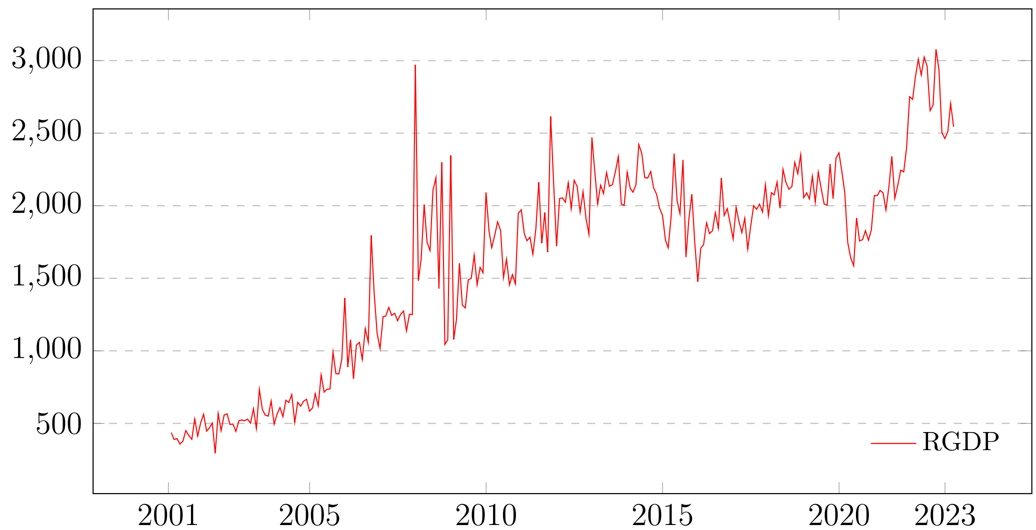

Figure 1: Real GDP, in mln. AZN

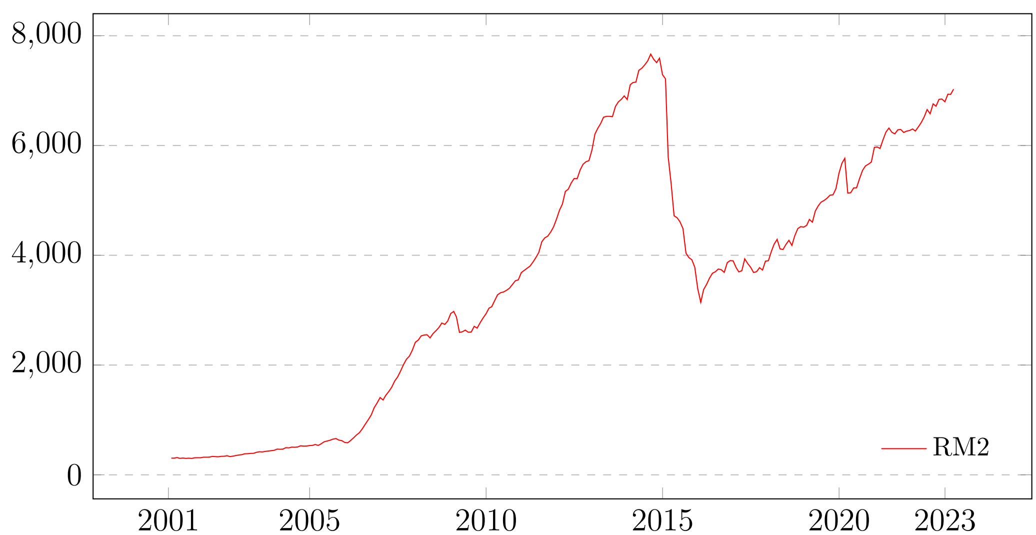

Figure 2: Real $M2$, in mln. AZN

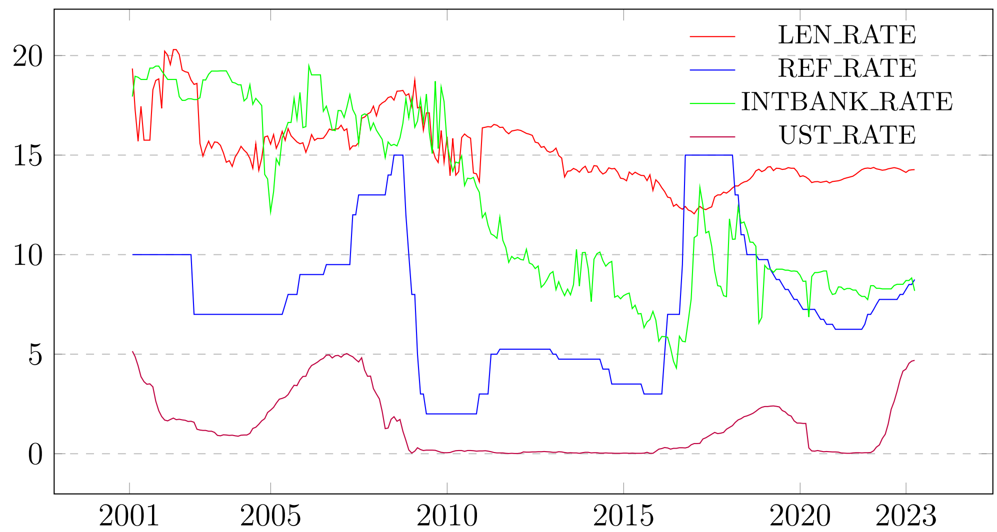

Figure 3: Interest Rate

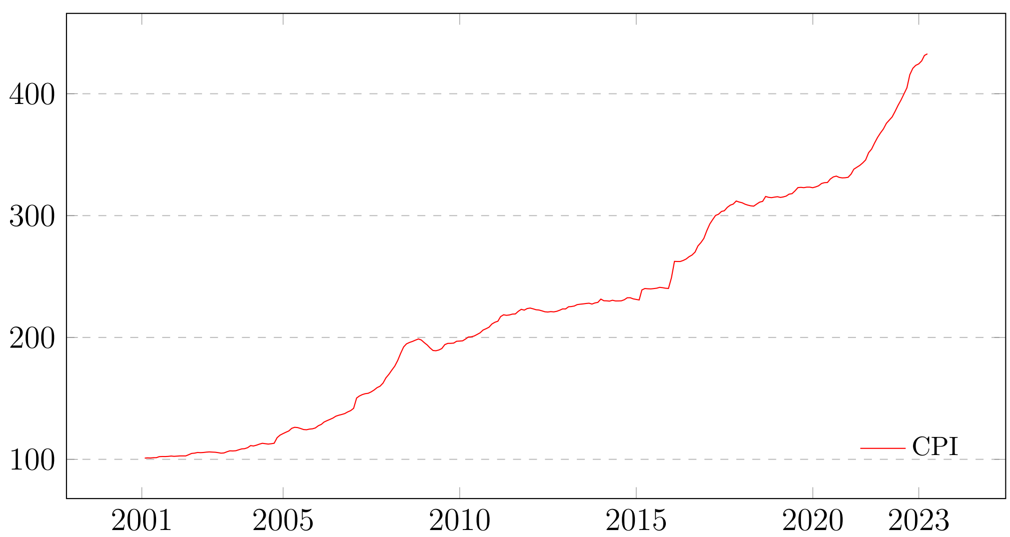

Figure 4: Consumer Price Index

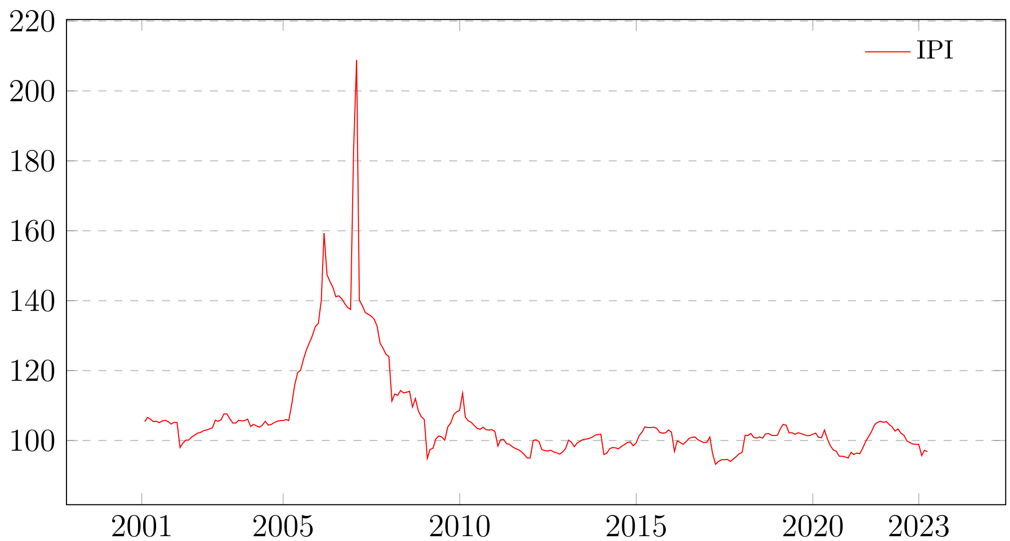

Figure 5: Industrial Production Index

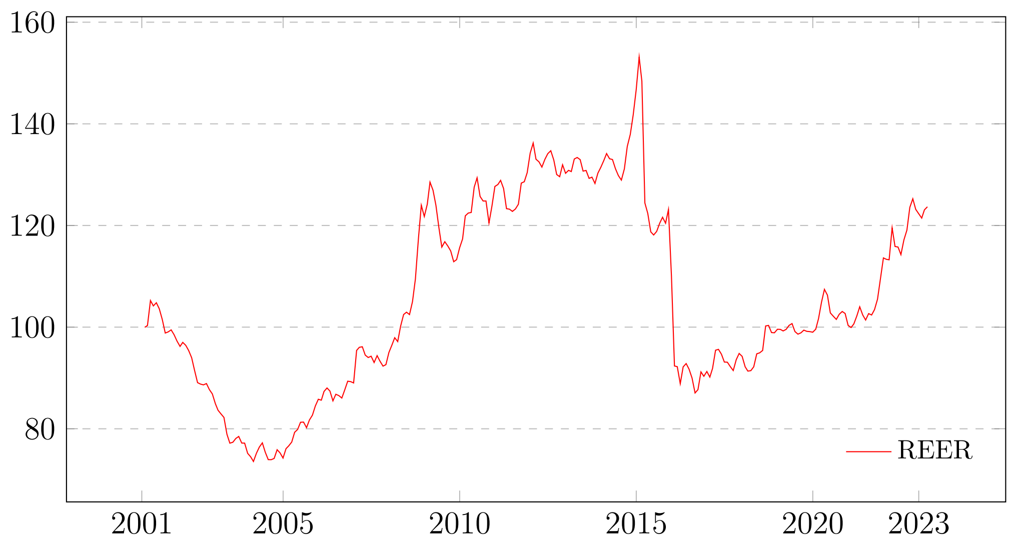

Figure 6: Real Effective Exchange Rate

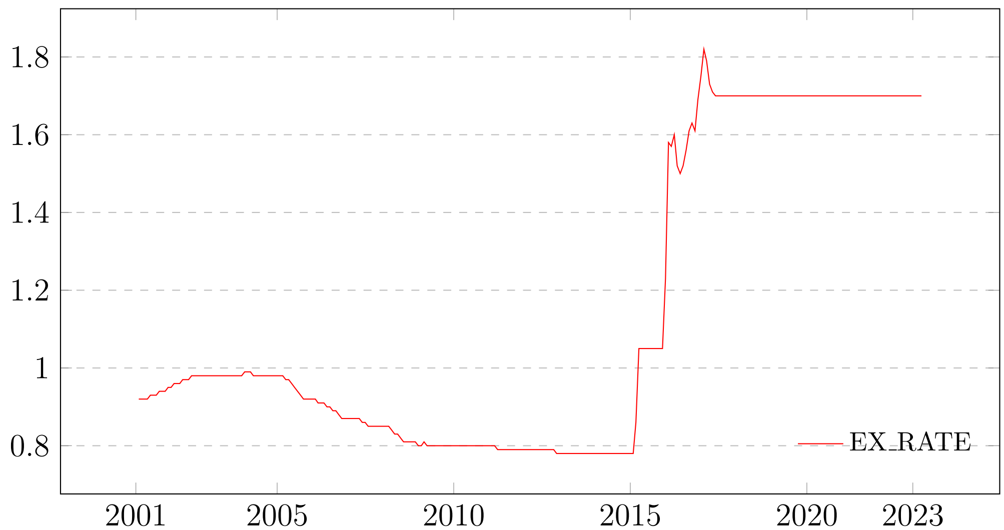

Figure 7: Exchange Rate, USD/AZN

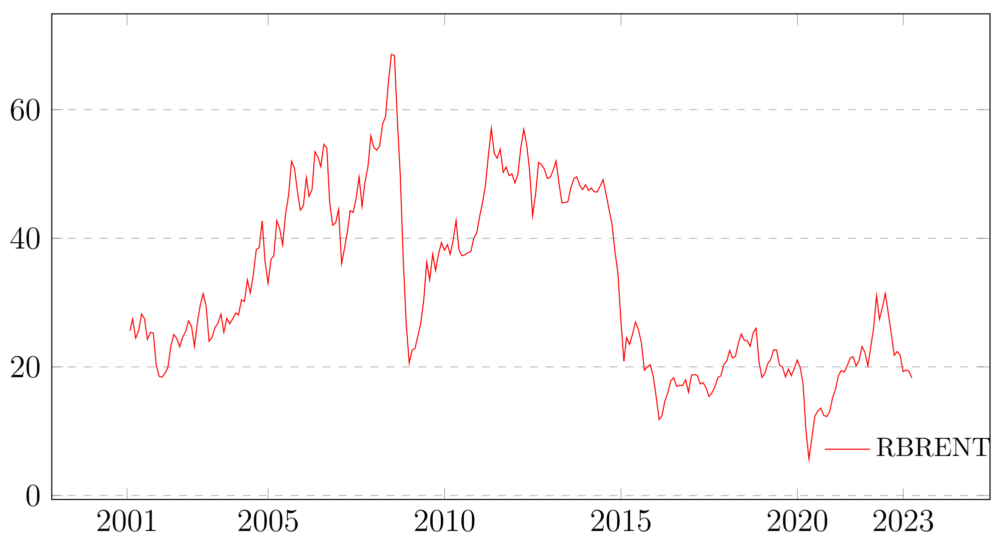

Figure 8: Real Brent Oil Price, in AZN

$M2$ monetary aggregate is chosen as the dependent variable because it yielded the most coherent theoretical framework and statistically significant estimates and test results. One reason for this choice is that narrow money, as $M1$, is no longer considered a meaningful indicator of money since 1980, according to Teles and Zhou (2005). They argue that narrow money fails to accommodate new financial instruments and developments that change over time. Another reason is that broad money tends to establish more consistent relationships with income and other factors related to monetary dynamics compared to narrow money. Several studies support the preference for broad money, including Gavin and Dewald (1989), Hafer and Jansen (1991), Hallman et al. (1989), and Laidler (1993).

At the end, GDP, $M2$, CPI, $BRENT$ series are converted to real values. As one could observe from the graphs above, there are some structural breaks in the given series. Therefore, additionally unit root with the structural breaks tests are done. Also, the exchange rate series (EX_RATE) (Figure 7) will not be used in the further empirical analysis, due to the fact that this series does not possesses quite variation structure and it is integrated of order 2, $I(2)$. Because of the fixed exchange regime, it is almost stable over the period and sharply shifts once, it resembles a regime switching pattern, hence, this variable could be covered up with a structural break or dummy variable. Instead, $REER$ is being used in the further empirical analysis. It is I(1) and does not possesses sudden structural shifts. The same logic apples to REF_RATE (Figure 3). It is a policy variable set by CBAR that changes not so much over a time period, and shifts sharply in times of uncertainty that could be caught just by dummy variables.

Due to not competitive banking sector in Azerbaijan LEN_RATE shows not that much information as $INTBANK\_RATE$ does (Figure 3). Initially, it is assumed that $INTBANK\_RATE$ possesses more information, then it is also verified that $INTBANK\_RATE$ has more predictive power of $M2$ than LEN_RATE.

Note that there is no publicly available data series on prices of Azerbaijani oil (Azeri

Light) from 2001. So, Brent oil price is used as a proxy. Because Brent and Azeri Light has almost similar characteristics and it is assumed that they follow similar pattern of price dynamic in the market. More specifically, Azeri Light has API gravity of 34.9 whereas Brent has that of 37.9, respectively they includes 0.55% and 0.45% of Sulfur[1].

Afterwards, the notation of variables are denoted in lower case meaning the logarithm of the initial variables with the exception for ref_rate, len_rate, ust_rate, $intbank\_rate$. "$r\_$" in the notation means adjustment for inflation, i.e real-valued series. (Mayr and Ulbricht, 2015) shows that in VAR models logs of levels does not change the results and implications, hence, transforming levels to logarithm is mostly harmless, moreover (Lütkepohl and Xu, 2012) mentions that log transformation stabilize variation of the underlying series that's beneficial for empirical analysis.

Below (from Table 4 to 9) the results of several unit root tests are reported. Table 4 shows the results of the classic unit root tests (augmented Dickey–Fuller test, Phillips–Perron test, Kwiatkowski-Phillips-Schmidt-Shin test). The inclusion of the deterministic regressors is based on the statistical significance factor of those. As one could observe, the null hypothesis of no stationarity (presence of unit root) is not rejected across the almost all variables. This means that those variables are integrated of order 1, i.e $I(1)$. Beginning from Table 5 the results for unit root tests with one or two structural breaks are obtained via (tspdlib) package. The results vary from test to test, but generally inclusion of two dummy variables for structural breaks makes the time series stationary. Based on that, dummy variables for structural breaks are being used in empirical analysis. The frequent structural breaks from the test results are $2006Q4$ and $2014Q4$. This is in line with actual structural change in the economy of Azerbaijan. First break is related to the oil boom in the country that lead to flows of capital, increase in income, increase in spending etc. The

[1]https://www.mckinseyenergyinsights.com/resources/refinery-reference-desk/crude-grades/

second one is related to sudden oil price drop in 2014 that caused harsh turmoil in the economy and this followed by the devaluation of the currency (manat).

	ADF				PP				KPSS		
Variable	Test value	C	t	None	Test value	C	t	None	Test value	C	t
m2	-1.792	×			-1.103	×			0.269***	×	×
gdp	-1.61	×			-1.655	×			0.262***	×	×
ipi	-0.287			×	-0.254			×	0.095	×	×
cpi	-1.991	×	×		5.54			×	0.17**	×	×
ref_rate	-3.38***	×			-1.121			×	0.105	×	
len_rate	-1.945	×			-2.208	×			0.085	×	×
ust_rate	-2.273	×			-2.093	×	×		0.136*	×	×
brent	-2.35	×			-2.2	×			0.235***	×	×
intbank_rate	-2.349	×	×		-2.358	×	×		0.179**	×	×
reer	0.383			×	0.291			×	0.173**	×	×
r_brent	-0.403			×	-0.401			×	0.216***	×	×
r_gdp	-2.043	×			-2.213	×			0.271***	×	×
r_m2	-1.98	×			-1.81	×			0.27***	×	×

Table 4: Stationarity tests

	DF-min-t break selection						Max-abs-t break selection					
Variable	Test value	C	t	C-break	t-break	Date	Test value	C	t	C-break	t-break	Date
m2	-5.11**	×	×	×		2006Q1	-5.11**	×	×	×		2006Q1
gdp	-4.636	×	×	×	×	2007Q3	-4.636	×	×	×	×	2007Q3
ipi	-5.947**	×	×	×	×	2007Q1	-5.947**	×	×	×	×	2007Q1
cpi	-3.742	×	×	×		2006Q4	-3.742	×	×	×		2006Q4
ref_rate	-5.07**	×	×	×		2008Q3	-5.07**	×	×	×		2008Q3
len_rate	-4.826**	×	×			2011Q2	-2.642	×	×	×	×	2004Q1
ust_rate	-3.902	×	×		×	2014Q3	-2.796	×	×	×	×	2019Q2
brent	-4.6	×	×	×		2014Q3	-4.6*	×	×	×		2014Q3
intbank_rate	-4.58**	×		×		2009Q4	-4.58**	×		×		2009Q4
reer	-5.04**	×	×	×		2015Q1	-5.04**	×	×	×		2015Q1
r_brent	-4.739*	×	×	×		2014Q3	-4.739*	×	×	×		2014Q3
r_gdp	-5*	×	×	×	×	2007Q3	-5*	×	×	×	×	2007Q3
r_m2	-4.81**	×		×		2006Q1	-4.285	×	×	×	×	2014Q4

Table 5: Stationarity tests allowing for one structural break (Perron, 1989; Vogelsang and Perron, 1998)

Variable	ADF: Break in level		Break in level and trend	
	Test value	Date	Test value	Date
m2	-3.213	2005Q3	-4.433	2005Q4
gdp	-2.632	2006Q4	-4.605	2006Q4
ipi	-4.628*	2005Q1	-5.49**	2008Q3
cpi	-1.305	2014Q3	-4.052	2005Q4
ref_rate	-4.128	2008Q2	-5.133**	2008Q2
len_rate	-4.826**	2013Q1	-5.047*	2014Q4
ust_rate	-3.800	2008Q2	-5.471**	2009Q2
brent	-3.370	2003Q3	-4.521	2014Q2
intbank_rate	-4.543	2010Q2	-5.063*	2010Q3
reer	-3.009	2007Q1	-3.961	2014Q2
r_brent	-3.957	2014Q2	-4.537	2014Q2
r_gdp	-3.941	2006Q1	-4.874*	2006Q4
r_m2	-3.829	2005Q4	-4.082	2014Q3

Table 6: Stationarity tests allowing for one structural break (Zivot and Andrews, 2002)

Variable	ADF: Break in level		Break in level and trend	
	Test value	Date	Test value	Date
m2	-9.584***	2005Q4 2014Q3	-8.608***	2005Q4 2014Q3
gdp	-4.832**	2004Q4 2007Q2	-6.08***	2007Q2 2019Q3
ipi	-7.286***	2004Q4 2006Q4	-7.525***	2004Q4 2006Q4
cpi	-4.675**	2006Q3 2011Q3	-4.655*	2007Q2 2015Q3
ref_rate	-6.306***	2008Q2 2018Q4	-7.529***	2008Q2 2015Q3
len_rate	-5.315***	2007Q1 2018Q1	-5.937***	2007Q1 2015Q2
ust_rate	-4.361**	2004Q1 2008Q2	-5.743***	2007Q2 2019Q3
brent	-5.457***	2004Q1 2014Q2	-6.032***	2008Q2 2014Q2
intbank_rate	-6.484***	2010Q2 2016Q2	-7.12***	2010Q2 2016Q2
reer	-5.918***	2007Q3 2014Q4	-5.051**	2007Q3 2014Q4
r_brent	-5.453***	2003Q4 2014Q2	-6.15***	2008Q2 2014Q2
r_gdp	-5.277***	2004Q4 2007Q2	-5.869***	2007Q2 2019Q3
r_m2	-9.641***	2005Q4 2014Q3	-9.262***	2005Q4 2014Q3

Table 7: Stationarity tests allowing for two structural break (Narayan and Popp, 2010)

Variable	KPSS: Break in level		Break in level and trend	
	Test value	Date	Test value	Date
m2	0.673***	2006Q3	0.391***	2014Q4
gdp	0.444**	2006Q2	0.175***	2007Q3
ipi	0.604***	2008Q4	0.155***	2007Q4
cpi	0.266**	2006Q4	0.258***	2006Q4
ref_rate	0.287**	2016Q2	0.195***	2016Q2
len_rate	0.268**	2013Q1	0.196***	2015Q3
ust_rate	0.153	2008Q3	0.159***	2008Q1
brent	0.365***	2014Q4	0.222***	2014Q3
intbank_rate	0.301**	2010Q3	0.107***	2010Q4
reer	0.4***	2015Q4	0.406***	2015Q4
r_brent	0.272**	2014Q4	0.212***	2014Q4
r_gdp	0.480**	2005Q3	0.164***	2007Q3
r_m2	0.697***	2006Q3	0.382***	2015Q1

Table 8: Stationarity tests allowing for one structural break (Kurozumi, 2002)

Variable	LM: Break in level		Break in level and trend	
	Test value	Date	Test value	Date
m2	-2.217	2014Q4 2015Q2	-4.602**	2006Q1 2014Q4
gdp	-2.002	2007Q3 2008Q2	-5.288***	2007Q3 2008Q2
ipi	-3.646***	2008Q4 2013Q4	-6.299***	2006Q2 2011Q3
cpi	-3.153**	2008Q1 2009Q4	-4.840***	2006Q3 2011Q3
ref_rate	-4.145***	2015Q4 2018Q2	-5.430***	2008Q2 2017Q1
len_rate	-4.410***	2010Q3 2013Q1	-6.355***	2007Q1 2016Q2
ust_rate	-4.762***	2007Q4 2008Q3	-5.307***	2008Q4 2020Q1
brent	-2.940*	2014Q4 2015Q4	-5.17***	2006Q3 2014Q3
intbank_rate	-3.649***	2009Q4 2017Q4	-5.926***	2010Q2 2016Q4
reer	-2.659	2008Q3 2016Q2	-4.683**	2007Q4 2015Q3
r_brent	-3.358**	2014Q4 2015Q4	-4.7**	2004Q3 2014Q4
r_gdp	-2.429	2005Q3 2006Q2	-5.074***	2006Q1 2014Q4
r_m2	-2.372	2005Q3 2015Q1	-4.69**	2005Q4 2014Q4

Table 9: Stationarity tests allowing for two structural break (Lee and Strazicich, 2003)

Theory and Methodology

4.1 Theoretical Background

There are three main approaches proposed by classical, Keynesian, and post-Keynesian scholars to address the issue of money demand. Classical economists, represented by (Fisher, 2006), focused on the quantity theory of money, which suggests that the demand for money depends on transactions related to national income and the volume of trade in an economy. However, they did not explicitly present a money demand theory.

(Keynes, 1936) rejected the ideas of classical economists and introduced a theory of money demand that emphasized the importance of interest rates. He proposed three motives for holding money: the transactions motive, the precautionary motive, and the speculative motive. According to Keynes, the demand for money is positively related to income for the transaction and precautionary motives. However, for the speculative motive, the demand for money is negatively related to interest rates. Although Keynes did not explain why the speculative demand for money is independent of income, his work laid the foundation for assuming a negative relationship between demand and interest rates.

(Baumol, 1952) presented an innovative theoretical approach that considered the interest elasticity of transactions demand for money. He argued that variations in income lead to less than proportional changes in transactions demand for money. (Tobin, 1958) further developed the theory of liquidity preference based on portfolio selection, addressing two flaws in Keynes's theory. Tobin's theory accounted for the inelasticity of expectations of future interest rates and individuals' preference for holding a combination of money and bonds. It assumed that the expected capital gain or loss from holding interest-bearing assets is always zero.

(Friedman, 1956) introduced the concept of real money demand, which emphasized the relationship between real income, the opportunity cost of holding real money balances (expected rate of inflation and expected return on money, bonds, equity), and the desire of individuals to possess a certain amount of real money balances. A stable money demand function is crucial for effective monetary policy, as it allows policymakers to maintain stable economic growth and development.

While stable money demand functions have been observed in developed countries, the existence of such functions in developing and emerging countries remains a contentious issue. Various theoretical and empirical research studies have focused on the demand for money, and recent research indicates the presence of a stable demand function in developed countries. However, the widely used theory in empirical studies is still the Keynesian approach, which suggests that money demand is driven by the transactions, precautionary, and speculative motives. The first two motives show a positive relationship with income, while the speculative motive has a negative relationship with interest rates on alternative assets.

According to the economic theory, the demand for real money balances is influenced positively by the level of overall economic activity, represented by real output. Conversely, it is negatively affected by the opportunity cost of holding a portion of wealth in the form of money, typically represented by the nominal interest rate.

Among the theoretical advancements in money demand within the post-Keynesian framework (Baumol, 1952; Friedman, 1956; Tobin, 1958, 1956), the cash-in-advance models, incorporating expected inflation as the opportunity cost and monetary substitution, are suitable for specifying money demand in emerging and developing economies. Particularly in developing economies with limited financial sector development (restricted substitution between currency and other financial assets, regulated interest rates, etc.), the expected inflation rate is commonly employed as the primary variable to represent the opportunity cost of holding money.

According to (Keynes, 1936), (Baumol, 1952), (Tobin, 1956, 1958) and (Friedman, 1956, 1959) the general form of money demand function in closed economy is:

$$M = f(Y, P, \mathbf{X}) \tag{1}$$

where M is nominal stock of money, P is price level, Y is real income or wealth and $\mathbf{X}$ is a vector of variables denoting opportunity costs in holding nominal balances and additionally some other variables (deterministic regressors etc.). It is assumed that $f(\cdot)$ is unit homogeneous in prices, increasing in income, and decreasing in opportunity cost variables.

From Quantity Theory of Money (Friedman, 1989) money demand function could be represented as:

$$\frac{M^d}{P} = K(1 + IR)^{\alpha} Y^{\beta} \tag{2}$$

where M^d is money demand measure, P is price or inflation level, K is a constant, IR is interest rate, Y is real income or wealth. The price homogeneity and Taylor rule is assumed.

According to Neo-Keynesian model of short run adjustment to a long run money demand function, in equilibrium money demand equals money supply. So in this analysis $M^d = M^s$ is assumed, i.e money supply proxies money demand. In short run, variables are endogenous and the Central Bank could either adjust interest rates (Taylor rule) or money supply (McCallum rule). If the long-run demand for money is stable, then, following a McCallum rule using $M2$ as monetary target, monetary policy could help to stabilize the economy. Additionally, if demand for money does not show a pattern of unpredictable and sudden changes, then money supply targeting is a reliable way of attaining and curbing a stable inflation rate.

After logarithmic transformations and taking into account that $\log(1 + IR) \approx IR$ one gets:

$$\log(M) \approx \log(K) + \alpha IR + \beta \log(Y) \tag{3}$$

Or assuming price homogeneity, the model specification for empirical analysis is,

$$m = \beta_0 + \beta_1 y + \beta_2 p + \beta_3 ir + \varepsilon \tag{4}$$

where lower-case letter notation denoted logarithmic transformation of related variables and ε is independent Gaussian error variable with zero mean and covariance matrix. This is a form of nominal money demand model specification (Cuthbertson, 1988; Muscatelli et al., 1988; Miller, 1991; Bårdsen, 1992; Orden and Fisher, 1993; Drake and Chrystal, 1994; Hoffman and Tahiri, 1994).

As mentioned above, price homogeneity is assumed, therefore, one could also model real money demand:

$$rm = \beta_0 + \beta_1 y + \beta_2 ir + \varepsilon \tag{5}$$

where $rm = m - p$

Numerous research studies focus on examining the real money balance rather than the nominal money balance. However, only a limited number of studies have thoroughly examined the statistical significance of the price homogeneity hypothesis prior to analyzing the real money balance. So, one could conduct analysis only with nominal values without necessity for price homogeneity holds. But in this work both nominal- and real-valued model specifications are considered.

Equations 4 and 5 are fundamental specifications for money demand based on classical monetary theory. However, these equations are applicable only in closed economies and do not account for the effects of international interconnectedness. Given the increasing interdependence among countries, researchers have developed and evaluated a theoretical framework for money demand in open economies (Sriram, 1999; Walsh, 2017). This framework takes into consideration exchange rates and foreign interest rates as the primary variables, as discussed by (Bjørnland, 2005; Hossain, 2019) and the others. The analysis is influenced by the literature on currency substitution and the opportunity cost of holding money in an open-economy context, which is summarized in (Sriram, 1999) survey. When the local currency depreciates, the expected return from holding it diminishes. As a result, individuals and institutions substitute domestic currency with foreign currency, and vice versa.

Numerous studies have investigated the relationship between exchange rates and money demand in both developed and developing economies, utilizing various measures of exchange rates. Some notable examples include the works of (Arango and Nadiri, 1981; Bahmani-Oskooee and Malixi, 1991; McNown and Wallace, 1992; Arize, 1994; Chowdhury, 1995; Arize and Shwiff, 1998; Ahumada and Garegnani, 2002).

In economies experiencing high and/or persistent inflation, incorporating an appropriate exchange rate variable becomes crucial to capture the impact of monetary substitution in addition to the expected inflation rate within the money demand equation. Moreover, inflation in Azerbaijani economy very much depends on the exchange rate. When the exchange rate is fixed, it serves as an anchor for prices in the economy, that's in turn impacts domestic demand, investment, and consumption patterns, ultimately influencing the overall level of inflation. It is (Mundell, 1963) that introduced the concept that the demand for money could be influenced by the exchange rate, in addition to income and interest rates. Building upon the works of (Arango and Nadiri, 1981), (Fielding, 1994), and (Bahmani-Oskooee and Ng, 2002), the real exchange rate is being utilized as an indicator for anticipated currency depreciation.

Changes in the real exchange rate impact the demand for domestic currency through two effects: an income effect and a substitution effect. Assuming that wealth holders assess their portfolios in terms of domestic currency, a depreciation in the exchange rate would raise the value of their foreign assets when expressed in domestic currency, thereby increasing their overall wealth. To maintain a consistent portion of their wealth invested in domestic assets, individuals will repatriate some of their foreign assets, including domestic currency. Consequently, the demand for domestic currency rises due to exchange rate depreciation. However, exchange rate movements can also trigger currency substitution effects, influenced by investor expectations. If wealth holders anticipate further deterioration in the exchange rate after an initial depreciation, they may respond by increasing the proportion of foreign assets in their portfolios. In this scenario, currency depreciation implies a higher opportunity cost of holding domestic money, leading investors to use currency substitution as a hedge against this risk. Accordingly, exchange rate depreciation would reduce the demand for domestic currency. The actual impact of exchange rate depreciation is an empirical matter since it depends on which effect predominates. This issue requires empirical investigation, considering various factors, as highlighted by (Baye et al., 2011).

The inclusion of the exchange rate variable in the money demand equation serves the purpose of capturing the impact of currency substitution and reflecting the opportunity cost of holding money, especially in fixed exchange rate systems (Ahumada and Garegnani, 2002; Girton and Roper, 1981). But due to the reasons discussed in Section 3 real effective exchange rate is being used instead.

Having added real effective exchange rate to the Equation 5, one gets open economy specification of money demand model:

$$rm = \beta_0 + \beta_1 y + \beta_2 ir + \beta_3 reer + \varepsilon \tag{6}$$

Even a theoretically well-grounded open-economy framework for money demand, as represented by Equation 6, may not fully capture all the important aspects of money demand in a specific context or country. This inadequacy can arise from both theoretical and data-related challenges. According to (Hendry, 2018) macroeconomic theories are inherently imperfect, inaccurate, and subject to change. Similarly, time-series data in macroeconomics are aggregated, imprecise, non-stationary, and seldom align precisely with theoretical constructs. (Hendry, 2018; Hendry and Johansen, 2015; Hoover et al., 2008) summarize four reasons why a given theoretical framework may not provide a better representation of the underlying process:

1. the variable specified in theory may not be precisely measurable in practical terms
2. theories often fail to specify the exact variables to consider in empirical analysis, leading to potential inclusion of irrelevant variables that do not contribute to the Data Generating Process.
3. all theories rely on assumptions that may not hold true for the specific country or time period being studied.
4. theoretical frameworks do not account for structural breaks or shifts

Within the literature on money demand, (Arrau et al., 1995) highlight that conventional money demand specifications have faced substantial criticism due to their inherent misspecifications. These misspecifications lead to unrealistic outcomes, such as implausible parameter estimates, unstable relationships, absence of cointegration, and excessive predictions. Various discussions by (Arrau and De Gregorio, 1993; Siklos, 1993; Tobin, 1965; Bordo and Jonung, 1987, 1990) underscore these concerns. Moreover, for economies with a high degree of dollarization, (Ahumada and Garegnani, 2012; Nielsen, 2008) suggest deflating nominal money by the nominal exchange rate, rather than relying on the price index assumed in standard money demand theories. Consequently, it is important to avoid imposing a theory without considering stylized facts in the economy. Failing to do so may lead to inconsistent estimates and misleading conclusions.

In pursuit of this objective, the aforementioned studies, along with others, propose an approach that combines theory with country-specific factors. It is crucial to consider country-specific factors to capture the primary determinants that shape the demand for money, particularly variables strongly linked to economic activities. Several studies have introduced various factors as country-specific variables when analyzing money demand. For instance, (Klacek et al., 1995) incorporate private consumption for the Czech Republic, (Klos et al., 2001) include a credit variable for Poland, and (Dou, 2018) consider capital mobility for China. In light of this context, the open-economy money demand framework for Azerbaijan economy, as represented by Equation 6, is augmented by incorporating the Brent oil price (*brent*). The oil price serves as a significant country-specific factor that carries substantial implications for the macroeconomic environment and it helps better approximate the data-generating process money demand under a fixed exchange rate. Now, the model specification is:

$$rm = \beta_0 + \beta_1 y + \beta_2 ir + \beta_3 reer + \beta_4 brent + \varepsilon \tag{7}$$

The increasing interconnectedness of economies on a global scale has elevated the significance of international capital flows. Consequently, it becomes crucial to take into account the foreign opportunity cost of money. In an open economy, individuals may prefer to hold their wealth not only in domestic currency but also in foreign currency and assets ((Sichei and Kamau, 2012; Bjørnland, 2005; Walsh, 2017). Hence, in line with this, the model specification now also includes the variable for US Treasury Bill Rate:

$$rm = \beta_0 + \beta_1 y + \beta_2 ir + \beta_3 reer + \beta_4 brent + \beta_5 ust + \varepsilon \tag{8}$$

Numerous studies, including (Arrau et al., 1995), (Siklos, 1993), (Tobin, 1965), (Bordo and Jonung, 1987, 1990), highlight that a key reason for the inherent misalignment in traditional money demand specifications could be the oversight of financial innovations or the effect of financial development. Empirical research across a wide range of studies consistently concludes that financial innovations or financial development could significantly influence the formation of money demand by economic agents, especially in developing economies. Therefore, it is essential to consider these factors in money demand analyses. For instance, (Arrau et al., 1995) and (Lieberman, 1977) emphasize the challenges in identifying a country-specific measure or proxy for financial innovations or financial development, particularly in developing economies. They propose using a time trend as a proxy. In line with the literature on money demand, a time trend is incorporated into Equation 8:

$$rm = \beta_0 + \beta_1 t + \beta_2 y + \beta_3 ir + \beta_4 reer + \beta_5 brent + \beta_6 ust\varepsilon \tag{9}$$

where β_1 could be interpreted as an average rate of financial innovation or development

The previous equations suggest that an increase in real income is expected to positively influence money demand, primarily due to the transaction motive. When individuals have more income available for spending on goods and services, they will likely increase their demand for money. The income elasticity is predicted to be either 1, according to the Cambridge interpretation of the quantity theory of money, or 0.5, in accordance with the Baumol-Tobin hypothesis (Baumol, 1952; Tobin, 1956).

The price level is expected to have a positive effect on the nominal money balance in Equation 4. This is because as the prices of goods and services increase, economic agents will demand more money. The positive impact of the price level is mathematically determined since the left-hand side of Equation 4 represents the nominal money balance.

Whether the interest rate has a negative or positive impact on money demand depends on both the measure of the interest rate and the money. If interest-bearing deposits are not included in the measure of money, a negative relationship should be observed. For example, if the interest rate on time deposits or demand deposits is used as a measure of the interest rate, and cash in circulation is considered as the money balance, a negative relationship is expected. In this case, the interest rate serves as the rate of return on alternative assets (demand or time deposits) compared to cash. An increase in the interest rate would prompt economic agents to allocate money from cash to demand and time deposits.

Conversely, the relationship should be positive if the interest rate of demand and time deposits is considered as the interest rate measure, and a broad money aggregate as $M2$ (which includes cash in circulation, demand, and time deposits) is used as the money balance measure. In this scenario, the interest rate functions as the own rate of $M2$ money aggregate. An increase in the interest rate would result in a rise in demand and time deposits, which are part of $M2$ (Bjørnland, 2005; Blundell-Wignall et al., 1987; Rother, 1998).

The foreign interest rate differential in equation 8 is expected to have a negative impact on the money balance when the domestic interest rate is considered as the own rate of money. As an opportunity cost of holding money, if the foreign interest rate is higher than the domestic interest rate, individuals are incentivized to invest abroad. This leads to a reduction in the demand for local currency.

4.2 Econometric Approach

All specifications mentioned above represents time series models, and the property of stationarity is crucial for time series variables. If any of the series in the model are non-stationary, the conventional results of classical regression analysis become unreliable. Regression involving non-stationary series could lack meaningful interpretation and is commonly referred to as spurious. In contrast, stationary time series exhibit temporary shocks that diminish over time, as the series revert to their long-term mean values. Additionally, monthly and quarterly time series often exhibit significant seasonal variations, which could complicate their interpretation. To overcome this seasonality tests and adjustment are conducted as described in Chapter 3.

To examine the presence of cointegration among the component variables of the money demand function, the Johansen's cointegration approach has been employed (Johansen, 1991, 1995). This approach establishes the link between integrated processes and steady state equilibrium. However, the Johansen's approach has faced criticism due to its sensitivity to the choice of lag length. Therefore, it is crucial to select the lag length consistently for both the cointegration analysis and the error correction model. To address this issue, alternative criterias such as Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Hannan–Quinn (HQ), Final Prediction Error (FPE), and the others have been utilized to determine the lag length for cointegration and the Vector Error Correction Mechanism (VECM) (Lütkepohl, 2005).

The existence of a long-term relationship is determined when there is a cointegrating equation that represents the linear combination of non-stationary series. The presence of this cointegrating relationship forms the foundation for the vector error correction specification. The specification of the vector autoregression (VAR) of order p is outlined as follows:

$$x_t = A_1 x_{t-1} + A_2 x_{t-2} + \cdots + A_p x_{t-p} + \epsilon \quad (10)$$

where x_t is a k-vector of non-stationary time-series, i.e $I(1)$ endogenous variables and ϵ is a vector for disturbance term or innovations

By rewriting Equation 10 and adding ΦB_t one could represented a vector error correction model (VECM):

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Phi B_t + \epsilon_t \quad (11)$$

where $\Pi = \sum_{i=1}^{p} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$, ϵ_t is a vector of white noise disturbance term and Γ is matrix of short-run coefficients. B_t is a vector for exogenous variables: trends, constants, dummies for structural breaks.

Granger's representation theorem states that if the coefficient matrix Π has reduced rank $r < k$, then there is $k \times r$ matrices α and β having full rank r such that $\Pi = \alpha\beta'$ and $\beta' x_t$ is $I(0)$. r represents the number of cointegrating equations, also it is called cointegrating rank. β is a cointegrating vector. In VECM framework α is considered as an adjustment parameter or loading coefficients. Johansen's approach involves estimating the Π matrix from an unconstrained VAR model and then assessing whether one can reject the restrictions imposed by the reduced rank of Π through testing.

The number of optimal lag length (p) in the VAR for the given set of the time-series variables is decided by major voting of the above-mentioned criteria whereas Schwarz information criteria (SIC) plays role of a tie-breaker. Two statistical tests are used to examine the presence of cointegrating relationships. The testing process follows a sequential approach, starting with $r = 0$ and ending with $r = k - 1$. The trace statistic, which evaluates the null hypothesis of r cointegrating equations versus the alternative of k cointegrating equations, is calculated in the following manner:

$$LR_{tr}(r \mid k) = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i) \tag{12}$$

where λ_i is i-th largest eigenvalue of Π matrix.

Another statistic is a maximum eigenvalue statistic which tests the null hypothesis of r cointegrating equations against the alternative of $r + 1$ cointegrating is calculated in the following manner:

$$LR_{\max}(r \mid r + 1) = -T \log(1 - \lambda_{r+1}) \tag{13}$$

where $r = 0, \cdots, k - 1$

Critical values are from (MacKinnon et al., 1999). For the case with structural break dummies (Johansen et al., 2000) critical values are used. But it should be pointed out that addition of structural breaks to the model contributes towards stationarity of the cointegrating vectors and that may increase the number of cointegrating vectors.

It is worth noting that within the Johansen framework, various tests such as statistical significance, multivariate stationarity, and weak exogeneity are typically conducted using the estimated VEC model (Johansen, 1992a, b). If a particular variable, say x, demonstrates statistical significance in the long-run space, one could reject the null hypothesis that its long-run coefficient, β_x, is zero at conventional significance levels. The multivariate stationarity or trend stationarity of variable x could be assessed by testing the null hypothesis that its long-run coefficient, β_x, is 1 while the long-run coefficients of other explanatory/regressor variables are zero. If it fails to reject the null hypothesis, it indicates that variable x is (trend) stationary. However, if it rejects the null hypothesis, it suggests that X follows a unit root process. Weak exogeneity of variable x implies that the null hypothesis that α_x (related adjustment parameter or loading coefficient) is 0 cannot be rejected. This weak exogeneity indicates that the disequilibrium in the long-run relationship does not feed back onto the equation of variable x. On the other hand, if null hypothesis of α_x being zero is rejected, it indicates that x is not weakly exogenous, suggesting that the disequilibrium in the long-run relationship influences its equation.

For stability check of the estimated money demand relationship the coefficient stability, residuals stability are utilized.

Another way to examine the long-term relationships and dynamic interactions among the variables of interest, the model is estimated using the ARDL cointegration methodology developed by (Pesaran et al., 1995) and further expanded by (Pesaran et al., 2001). The ARDL approach offers several advantages compared to other cointegration techniques like the residual-based Engle and Granger and the cointegrating rank test by Johansen. The advantages of the ARDL method can be summarized as follows. First, unlike other multivariate cointegration techniques such as the maximum likelihood-based Johansen, the ARDL method does not require pre-testing of the variables included in the model for unit root tests (Pesaran et al., 2001). However, in this study, unit root tests are implemented to ensure the absence of I(2) and presence of I(0) and I(1) variables and to identify significant structural breaks. Overall, by utilizing the ARDL cointegration methodology, one could empirically analyze the long-term relationships and dynamic interactions between the variables of interest while benefiting from the advantages offered by this approach. Second, the ARDL procedure is characterized by its relatively unbiased nature, making it a statistically significant approach for determining the cointegration relationship, especially in cases involving small sample sizes. Third, the ARDL approach circumvents the challenges faced by the Johansen cointegration technique, such as the complex decisions involved in selecting the number of exogenous and endogenous variables, handling deterministic components, and determining the order of the vector autoregression (VAR) model and the optimal number of lags. These choices and decisions greatly affect the estimation process (Pesaran et al., 1995). Finally, the ARDL method has the ability to differentiate between dependent and independent variables in the presence of cointegration. Estimating the long-run relationships using ARDL involves a two-step procedure. In the first step, the existence of a long-run relationship among the variables of interest is investigated, typically tested through an F-test. Once a long-run cointegrating relationship is established, the second step entails estimating the long- and short-run elasticities. The Error Correction Mechanism (ECM) is then applied to determine the short-run adjustment towards the long-run equilibrium. Additionally, the ARDL approach does not require all variables to be integrated at the same order. In fact, if some variables in Equation (ARDL first equation) have a different integration order, traditional methods like the Johansen (1988) cointegration procedure could yield misleading results. If all the level regressors in Equation (ARDL first equation) are integrated of order 1, i.e $I(1)$, it would be considered a cointegration relationship according to the definition. However, if the equation includes both $I(0)$ and $I(1)$ regressors, it indicates evidence of a long-run relationship. Therefore, in this case, the bounds testing approach is more appropriate since the ARDL model can accommodate both $I(0)$ and $I(1)$ variables in a long-run relationship rather than a strict cointegration relationship.

By following the works of (Pesaran et al., 2001) and incorporating two endogenously determined structural breaks (B_1 and B_2) through unit root tests allowing for the structural breaks, the model, for example, for specification 6 with structural breaks could be represented in the form of an unrestricted error correction model (UECM) as:

$$\begin{aligned}\Delta rm_t =& \alpha_0 + \sum_{j=1}^{p} b_j \Delta rm_{t-j} + \sum_{j=1}^{p} c_j \Delta y_{t-j} + \sum_{j=1}^{p} d_j \Delta ir_{t-j} + \sum_{j=1}^{p} e_j \Delta reer_{t-j} \\ &+ \delta_1 rm_{t-1} + \delta_2 y_{t-1} + \delta_3 ir_{t-1} + \delta_4 reer_{t-1} + \delta_5 B_1 + \delta_6 B_2 + \varepsilon_t,\end{aligned} \tag{14}$$

where B_1 and B_2 respectively denotes structural breaks in $2006Q4$ and $2014Q4$. α_0 is a drift component, ε_t is disturbance term following Gaussian white noise. δs are long-run coefficients and b, c, d, e are short-run dynamic coefficients of ARDL. Note that p lags on each variables are not necessarily equal.

To examine whether a long-run relationship exists among the variables, estimations are conducted using unrestricted error correction model (UECM) regressions. In this approach, the null hypothesis is tested by considering the UECM for the model, where all lagged variables are constrained. The null hypothesis is that $H_0 : \delta_i = \delta_j = 0$, and alternative hypothesis is $H_0 : \delta_i \neq \delta_j \neq 0$. A test statistic in this case is F-test with an asymptotic non-standard distribution.

Two sets of critical values are presented, with lower bound critical values assuming that the regressors are integrated of order 0, i.e $I(0)$ and upper bound critical values assuming that the regressors are purely integrated of order 1, i.e $I(1)$. If the computed value exceeds the upper critical value, the null hypothesis of no long-run relationship is rejected, regardless of the orders of integration for the time series. Conversely, if the computed value falls below the lower critical value, the null hypothesis is not rejected, indicating that there is no long-run relationship between the independent variable and its determinants. However, when the F-statistic falls between the lower and upper critical values, the result is inconclusive. In such cases, the determination of the order of integration of the regressors is required to draw a conclusive inference. The lag order in the ARDL model is chosen based on the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC).

The error correction version of ARDL model in Equation 14 is:

$$\Delta rm_t = \alpha_0 + \sum_{j=1}^{p} b_j \Delta rm_{t-j} + \sum_{j=1}^{p} c_j \Delta y_{t-j} + \sum_{j=1}^{p} d_j \Delta ir_{t-j} \tag{15}$$

$$+ \sum_{j=1}^{p} e_j \Delta reer_{t-j} + \theta ect_{t-1} + \delta_1 B_1 + \delta_2 B_2 + \varepsilon_t \tag{16}$$

where θ is the speed of adjustment parameter and ect is the residuals that are obtained from the estimated cointegration model of Equation 14

(Akinlo, 2006) highlighted the potential issue of instability in the analysis when the short-run dynamics that characterize deviations from the long-run relationship are not adequately modeled. Therefore, it is crucial to incorporate these short-run dynamics when testing the constancy of long-run parameters. To address this concern, the study utilized the CUSUM and CUSUMSQ tests proposed by (Brown et al., 1975). Specifically, the CUSUM test calculates the cumulative sum based on the initial set of n observations, which is then recursively updated and plotted against predetermined breakpoints. If the plot of CUSUM statistics remains within the critical bounds represented by a pair of straight lines at the 5% significance level, the null hypothesis of coefficient constancy cannot be rejected. However, if either of the lines is crossed, it indicates that the null hypothesis of stable coefficients in the error correction model can be rejected at the 5% level of significance. A similar procedure is followed for the CUSUMSQ test, which utilizes squared recursive residuals (Bhatta, 2013). These tests are commonly employed by researchers investigating the demand for money (Akinlo, 2006; Dritsakis et al., 2011; Bhatta, 2013; Mansaray and Swaray, 2012).

Empirical Analysis

As discussed in Section 3, the variables in the analysis are integrated of order 1, i.e $I(1)$. Therefore, firstly, Johansen method is being utilized. In Table 10 one could observe the results of Johansen Cointegration Test. Even though in the literature Pantula principle is well-known to choose intercept and trend specification in Johansen Cointegration Test, following the speculation in Section 4.2 about the argument of trend being able to capture financial development and innovation, the specification with trend and intercept is chosen throughout the empirical analysis whenever the test allows for cointegration relationship.

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	1	2	2
Max-Eig	1	1	1	2	2

Table 10: Johansen Test

To begin with, a VAR model with the variables in specification 9 is estimated to choose proper lag length for VECM analysis. For the specification 9 the optimal lag of 1 is chosen. Autocorrelation LM Test (Table 11) rejects the null hypothesis of no serial correlation. The lag of VAR specification is increased up to 4, but the serial correlation persisted, hence, the optimal lag is kept at 1. Also the null hypothesis of no heteroskedasticity is also rejected. However, the VAR is stable as there is no roots out of unit circle. Also, the three roots with modulus magnitude higher than 0.9 hints on three cointegration relationships. To conduct the Johansen cointegration test VAR is transformed to VECM. Under the "Cointegration Equation" panel of Table 11 one could see that coefficients in the cointegration equation are significant with the exception for *reer*. However, testing the significancy of the variables of interest under the VEC system via the putting restrictions on them reveals only trend, *rbrent* and *ust_rate* as the significant ones. Also the stationarity and trend-stationarity of the given variables are rejected, meaning that all variables under the VECM follow unit processes. Weak Exogeneity tests shows that only $REER$ is not weakly exogenous, hence, the disequilibrium of the long-run relationship of rm feeds back onto its equation. As expected rm is not weakly exogenous to its own long-run relationship. Income homogeneity hypothesis is inconclusive, both the conventional hypotheses that income elasticity is equal 1 or to 0.5 cannot be rejected. Estimating the money demand as a single-equation model shows that long-run adjustment speed is around -0.07 meaning that after shock system will take 14 quarters to restore equilibrium state. Even though normality test rejects the null hypothesis of normally distributed, other two tests shows fail to reject the null hypotheses of no serial correlation and no heteroskedasticity. In Figure 9 and 10 CUSUM and CUSUMSQ tests show stability of coefficients in the error correction model. Note that this same specification is estimated also with *ipi* instead of *rgdp*, but the results more or less follow the same direction.

Model:	$rm = rgdp + intbank\_rate + reer + rbrent + ust\_rate + c + t$						
Optimal VAR Lag:	1						
	Lags	LM-Statistic	p-value				
Autocorrelation LM Test:	1	125.8314	0.0000				
	2	64.17086	0.0027				
	3	64.16424	0.0027				
	4	34.28697	0.5502				
Normality Test:	χ^2	df	p-value				
Skewness	63.63405	6	0				
Kurtosis	74.18199	6	0				
Jarque-Bera	137.8160	12	0				
Heteroskedasticity Test:	χ^2	df	p-value				
	360.9362	252	0				
VAR Stability Test:	Root	Modulus					
	0.987968	0.987968					
	0.911637 - 0.101018i	0.917217					
	0.911637 + 0.101018i	0.917217					
	0.883362 - 0.044756i	0.884495					
	0.883362 + 0.044756i	0.884495					
	0.520204	0.520204					
Cointegration Equation	$rm = 1.744+$	$0.738\, rgdp$ (0.196)	$0.015\, intbank\_rate$ (0.006)	$0.118\, reer$ (0.254)	$0.941\, rbrent$ (0.154)	$-0.04\, ust\_rate$ (0.01)	$0.014\, t$ (0.002)
Variable Significancy in Cointegrating Space:	rm	$rgdp$	$intbank\_rate$	$reer$	$rbrent$	ust_rate	t
H_0	$\beta_{rm} = 0$	$\beta_{rgdp} = 0$	$\beta_{intbank\_rate} = 0$	$\beta_{reer} = 0$	$\beta_{rbrent} = 0$	$\beta_{ust\_rate} = 0$	$\beta_t = 0$
$\chi^2(1)$	2.458910	1.097347	0.686396	0.044285	5.427***	4.458**	5.673***
Stationarity test:	rm	$rgdp$	$intbank\_rate$	$reer$	$rbrent$	ust_rate	
H_0	$\beta_{rm} = 1, \beta_{rgdp} = 0, \beta_{intbank\_rate} = 0, \beta_{reer} = 0, \beta_{rbrent} = 0, \beta_{ust\_rate} = 0$	$\beta_{rm} = 0, \beta_{rgdp} = 1, \beta_{intbank\_rate} = 0, \beta_{reer} = 0, \beta_{rbrent} = 0, \beta_{ust\_rate} = 0$	$\beta_{rm} = 0, \beta_{rgdp} = 0, \beta_{intbank\_rate} = 1, \beta_{reer} = 0, \beta_{rbrent} = 0, \beta_{ust\_rate} = 0$	$\beta_{rm} = 0, \beta_{rgdp} = 0, \beta_{intbank\_rate} = 0, \beta_{reer} = 1, \beta_{rbrent} = 0, \beta_{ust\_rate} = 0$	$\beta_{rm} = 0, \beta_{rgdp} = 0, \beta_{intbank\_rate} = 0, \beta_{reer} = 0, \beta_{rbrent} = 1, \beta_{ust\_rate} = 0$	$\beta_{rm} = 0, \beta_{rgdp} = 0, \beta_{intbank\_rate} = 0, \beta_{reer} = 0, \beta_{rbrent} = 0, \beta_{ust\_rate} = 1$	
$\chi^2(5)$	40.189***	39.519***	32.766***	43.698***	35.959***	32.427***	
Weak Exogeneity Test:	rm	$rgdp$	$intbank\_rate$	$reer$	$rbrent$	ust_rate	Joint
H_0	$\alpha_{rm} = 0$	$\alpha_{rgdp} = 0$	$\alpha_{intbank\_rate} = 0$	$\alpha_{reer} = 0$	$\alpha_{rbrent} = 0$	$\alpha_{ust\_rate} = 0$	
$\chi^2(1)$	4.764***	0.311	0.706457	3.865***	2.621	2.056	24.319***
Income homogeneity hypothesis test:							
H_0	$\beta_{rgdp} = 1$	$\beta_{rgdp} = 0.5$					
$\chi^2(1)$	1.044	0.306					
Stability of Cointegration Equation							
ect_{t-1}	-0.072^{***} (0.029)						
Breusch-Godfrey Serial Correlation LM Test:	1.273						
Normality Test (JB):	12.83***						
Heteroskedasticity Test (ARCH):	0.783						

Table 11: VAR and VECM results

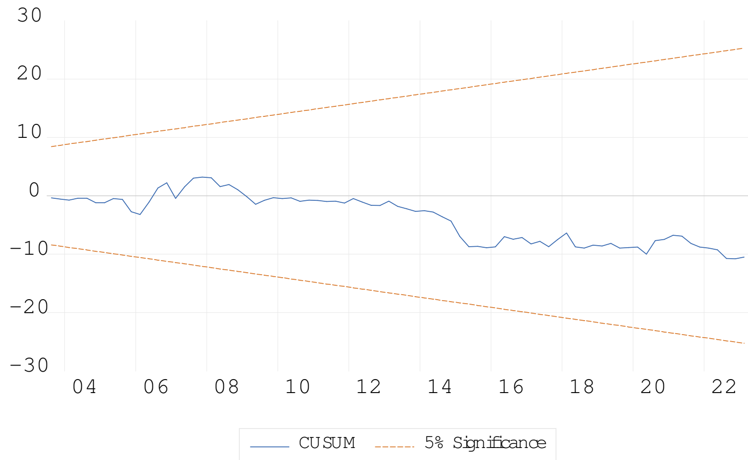

Figure 9: CUSUM Test

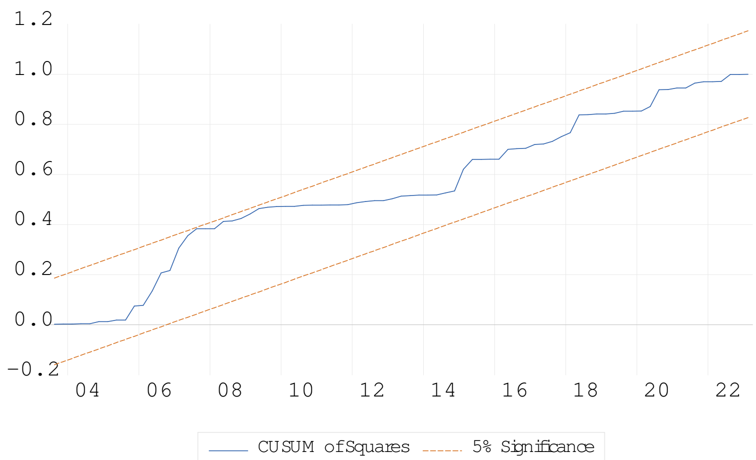

Figure 10: CUSUMSQ Test

Next, to test price homogeneity hypothesis and to explore dynamics with the other specification, the specification 4 is estimated. Table 12 shows the results of Johansen test, as could be seen from table, the null hypothesis of at most 1 cointegration relationship in the favored specification (trend and intercept) is not rejected.

Overall, the implications remain the same as in 11. However, this specification shows

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	2	2	1	1	1
Max-Eig	1	1	1	1	1

Table 12: Johansen Test

quite less serial correlation than the previous one. Moreover, *rgdp* become not weakly exogenous in this model specification. The coefficient on error correction term or long-run adjustment speed is around -0.08 (Table 13) meaning that after shock system will take 12 to 13 quarters to restore equilibrium state. CUSUM Tests shows stable relationship (Figure 11 and 12).

Model:	$m = cpi + rgdp + intbank\_rate + c + t$				
Optimal VAR Lag:	3				
	Lags	LM-Statistic	p-value		
Autocorrelation LM Test:	1	24.87099	0.0724		
	2	25.16489	0.0672		
	3	15.93071	0.4582		
	4	34.54299	0.0046		
Normality Test:	χ^2	df	p-value		
Skewness	22.47866	4	0.0002		
Kurtosis	24.73154	4	0.0001		
Jarque-Bera	47.21020	8	0		
Heteroskedasticity Test:	χ^2	df	p-value		
	219.0504	160	0.0013		
VAR Stability Test:	Root	Modulus			
	0.996091	0.996091			
	0.923745	0.923745			
	0.765048 - 0.033285i	0.765772			
	0.765048 + 0.033285i	0.765772			
	0.617644	0.617644			
	0.257430	0.257430			
	0.057179 - 0.070414i	0.090706			
	0.057179 + 0.070414i	0.090706			
Cointegration Equation	$m = 3.81+$	$-0.167\,cpi$ (0.833)	$2.08\,rgdp$ (0.233)	$-0.002\,intbank\_rate$ (0.009)	$0.007\,t$ (0.005)
Variable Significancy in Cointegrating Space:	m	cpi	$rgdp$	$intbank\_rate$	
H_0	$\beta_m = 0$	$\beta_{cpi} = 0$	$\beta_{rgdp} = 0$	$\beta_{intbank\_rate} = 0$	
$\chi^2(1)$	7.751***	0.019743	9.09***	0.015	
Stationarity test:	m	cpi	$rgdp$	$intbank\_rate$	
H_0	$\beta_m = 1, \beta_{rgdp} = 0,$ $\beta_{intbank\_rate} = 0, \beta_{cpi} = 0$	$\beta_m = 0, \beta_{rgdp} = 0,$ $\beta_{intbank\_rate} = 0, \beta_{cpi} = 1$	$\beta_m = 0, \beta_{rgdp} = 1,$ $\beta_{intbank\_rate} = 0, \beta_{cpi} = 0$	$\beta_m = 0, \beta_{rgdp} = 0,$ $\beta_{intbank\_rate} = 1, \beta_{cpi} = 0$	
$\chi^2(3)$	19.027***	18.234***	18.899***	13.107***	
Weak Exogeneity Test:	m	cpi	$rgdp$	$intbank\_rate$	Joint
H_0	$\alpha_m = 0$	$\alpha_{cpi} = 0$	$\alpha_{rgdp} = 0$	$\alpha_{intbank\_rate} = 0$	
$\chi^2(1)$	4.646**	1.566	4.93***	0.263	11.458***
Price homogeneity hypothesis test:					
H_0	$\beta_{cpi} = 1$				
$\chi^2(1)$	1.109				
Stability of Cointegration Equation					
ect_{t-1}	-0.0873^{***} (0.034)				
Breusch-Godfrey Serial Correlation LM Test:	0.22				
Normality Test (JB):	6.345**				
Heteroskedasticity Test (ARCH):	0.584				

Table 13: VAR and VECM Results

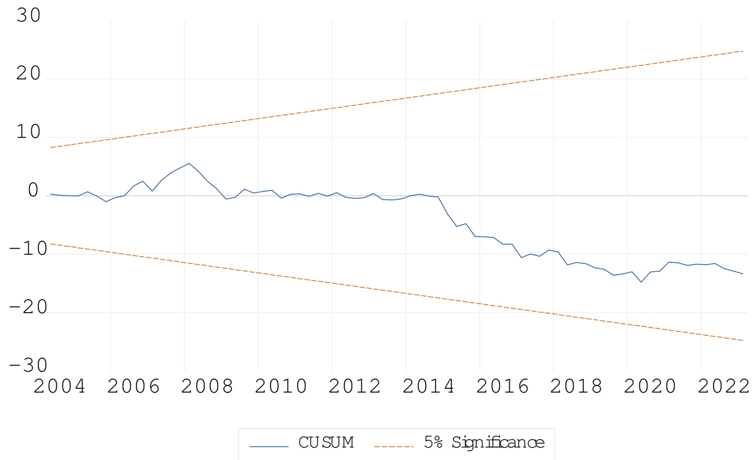

Figure 11: CUSUMSQ Test

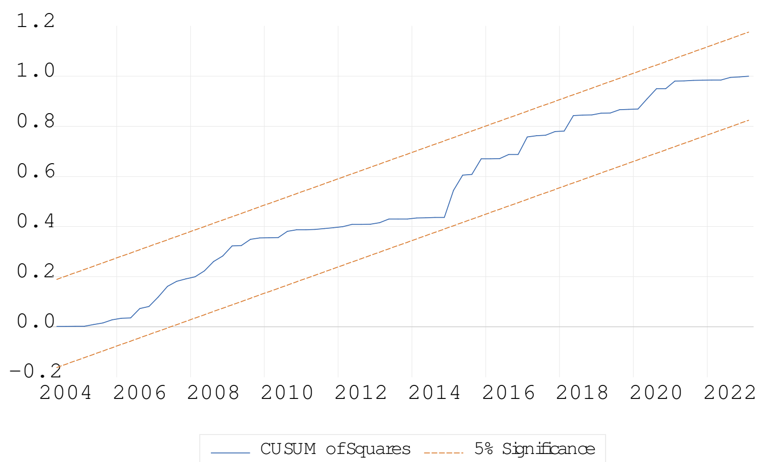

Figure 12: CUSUMSQ Test

For robustness ARDL model is also utilized with specification 9. Lag selection is done based on AIC and SIC, but SIC shows less significant coefficients and reduce the test values across different hypothesis tests, hence, further is based on the lag specification chosen by AIC. The pertaining results are in Table 14. In cointegration equation *intbank_rate* and *ust_rate* variables are not significant. But the model shows no heteroskedasticity, serial correlation in errors, also the errors are normally distributed. The coefficient on error correction term is roughly -0.3 which is in line with results in the literature and thus is much more reliable than the estimated coefficients in VECM. The CUSUM tests shows stability of coefficients (Figure 13 and 14).

Model:	$rm = rgdp + intbank\_rate + reer + rbrent + ust\_rate + c + t$					
Selected Model:	AIC	SIC				
	ARDL(2, 4, 0, 4, 0, 2)	ARDL(2, 3, 0, 2, 1, 1)				
Cointegration Equation	$rm =$	$0.936\, rgdp$ (0.137)	$0.008\, intbank\_rate$ (0.006)	$0.519\, reer$ (0.206)	$0.705\, rbrent$ (0.13)	$-0.0018\, ust\_rate$ (0.009)
F-Bounds Test:	F-statistic					
H_0: No levels relationship	9.846***					
ect_{t-1}	-0.301^{***} (0.037)					
Stability of the Model						
	Lags	LM-Statistic	p-value			
Breusch-Godfrey Serial Correlation LM Test:	up to 2	0.523044	0.5952			
	up to 4	0.756289	0.5577			
Normality Test (JB):	χ^2	p-value				
	1.398	0.497				
Heteroskedasticity Test (ARCH)	F-statistic	p-value				
2 lags	0.368374	0.6930				
4 lags	2.878759	0.0282				

Table 14: ARDL Results

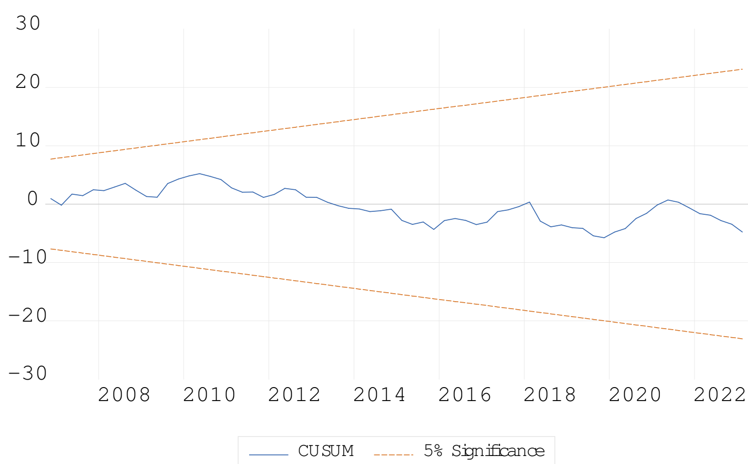

Figure 13: CUSUMSQ Test

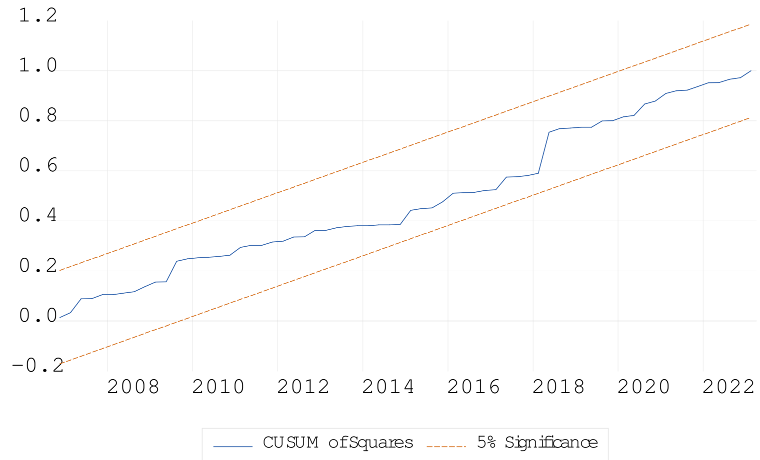

Figure 14: CUSUMSQ Test

Below Table 15 shows the coefficient from cointegration equation of the ARDL-ECM model with two structural breaks discussed in Section 3 and 4.2.The coefficients are less significant than in the previous model, hence, further analysis is not continued.

Model:	$rm = rgdp + intbank\_rate + reer + rbrent + ust\_rate + c + t + B_1 + B_2$					
Selected Model:	AIC	SIC				
	ARDL(4, 4, 3, 4, 3, 2)	ARDL(3, 1, 0, 0, 1, 1)				
Cointegration Equation	$rm =$	$1.941\,rgdp$ (0.499)	$-0.004\,intbank\_rate$ (0.008)	$0.273\,reer$ (0.299)	$-0.29\,rbrent$ (0.33)	$0.028\,ust\_rate$ (0.019)

Table 15: ARDL Results

The conclusion from Table 15 could be that structural breaks do not contribute or strengthen cointegration relationship. Therefore, to shed light on cointegration relationship with structural breaks Maki cointegration test is conducted assuming two unknown structural breaks. In Table 16, $rm = rgdp + intbank\_rate + rbent$ model specification shows strong cointegration with two structural breaks. The ARDL-ECM estimation of this model specification reveals stable cointegration relationship with significant coefficients and the adjustment speed of -0.24, however, the coefficients on interest rate and Brent oil price are negative which is odd (because they are positive in previous specifications and it was assumed that positive interest rate coefficient implies money supply own rate due to reflection of deposit rates), therefore this estimation results are not reported.

Model Specification	Level shift	Level Shift with Trend	Regime Shifts	Trend and Regime shifts
$rm = rgdp + intbank\_rate + rbent + ust\_rate + reer$	-6.091	-5.807	-5.625	-6.184
$rm = rgdp + intbank\_rate + rbent + reer$	-6.143**	-5.86*	-5.595	-6.229
$rm = rgdp + intbank\_rate + rbent$	-6.896***	-6.696***	-6.199	-6.468
$rm = rgdp + intbank\_rate$	-4.430	-6.457***	-4.115	-5.010

Table 16: Maki Cointegration Test

Conclusion

The study is based upon the objective to test the stability of money demand function in Azerbaijan and explore its determinants. To pursue the objectives, quarterly data has been used over the period 2001Q1-2023Q1. Johansen and ARDL Bound Tests are exploited to investigate cointegration or long-term relationship between money demand and the other variables. Also to gauge speed of adjustment VECM and ARDL with ECM are utilized. To the best of the author knowledge, this topic has not been explored in the context of Azerbaijan. Additionally, this work is first time in the literature to use quarterly data series from 2001 in the context of Azerbaijan. As a case study, money demand function for a country with fixed exchange rate regime as Azerbaijan is specified and estimated with testing its stability. The study provides empirical evidence that an open economy model, when supplemented with country-specific factors, is a more effective framework for understanding the money demand function in a fixed exchange rate economy. The empirical findings can be valuable for Azerbaijani monetary policy authorities in gaining a better understanding of the money demand relationship in both the short and long term. This understanding can assist in implementing appropriate monetary policies to maintain macroeconomic stability, particularly with regard to the fixed exchange rate, which has become crucial for diversifying the non-oil sector of the economy. It is the evident that other non-conventional factors also affect money demand. This is important because an inadequate money supply, either excessive or insufficient, can exert pressure on the fixed exchange rate, thereby jeopardizing macroeconomic stability. It is also essential to monitor money demand stability to inform policy decisions. In Azerbaijan, country-specific factors, such as oil prices, play a significant role in shaping money demand, alongside other determinants within an open-economy model. Government spending is the primary means of injecting oil revenues into the economy, and fiscal policy holds a dominant position in the Azerbaijani economy, as is the case in many other oil-exporting nations. Government spending is also an effective measure for stimulating economic growth in fixed exchange rate economies. Therefore, monetary authorities should adjust the money supply in response to changes in oil prices and government spending. Monetary authorities should note that the relationship between real $M2$ (money supply) and real income, interest rate differential, real oil price and real effective exchange rate remains stable over time, even during periods of economic booms or turmoils caused by declines in oil prices. Stable money demand is important for transition to a flexible exchange rate regime and target monetary aggregates or inflation. Albeit several announcement by CBAR about implementing floating exchange rate, it has not been implemented yet, such a policy shift is assumed impractical for Azerbaijan, as the fixed exchange rate regime ensures macroeconomic stability, particularly in terms of inflation reduction. The estimated speed of adjustment is significant across all model specifications but it ranges from -0.07 to -0.3. Although, models have issues with stability (serial correlation, insignificant coefficients, non-normality etc.), the coefficient stability tests shows stable money demand function across the different estimation methods and specifications. Because of that, it is hard to suggest using of those models for policy-making. Also the effects of several variables are inconclusive across the different specifications and methods. It might be due to data artifacts, unlike annual time series, higher frequency time series could have deficiencies.

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