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Arabian Economy**

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By

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The joint research project between Saudi Arabian Monetary Authority and King Abdullah
Petroleum Studies and Research Center

Saudi Arabian Monetary Authority

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Demand for Broad Money in the Saudi Arabian Economy

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Abstract

For policymakers, it is important to understand how money demand behaves in order to design the suitable monetary and fiscal policies. Observing the current literature on money demand indicates that there is an inadequate number of studies estimating the demand for money in Saudi Arabia. This in turn has encouraged us to fill out the gap in the literature by employing the most recent data, up to 2016, as well as relying on advanced econometric procedures to opt the most appropriate form of money demand function. To this end, we attempt to examine long-run relationship between money demand and its determinants as well as short-run dynamics among them in the Saudi economy. We employ the Johansen cointegration test with small sample bias correction in order to properly address the existence of long-run relationship between demand for money and its fundamentals. We find that there is a long-run relationship among broad money, income, price and interest rate. We also reveal out that both income and price homogeneity hypotheses hold for the Saudi money demand function. It is further found that growth rate of money demand is associated with error correction term as well as growth rates of income and price in the short run. Finally, we apply different structural break tests to our final ECM as it is important to know whether a given money demand relationship is stable over time. The tests' results indicate that the estimated money demand relationship is stable over time. We conclude our research with some remarks and policy recommendations.

Keywords: Money Demand; Stability; Cointegration; GtSMS; Small Sample Bias Correction

JEL Classification: C12, C13, C22, C52, E41, E52, E12

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1. Introduction

In macroeconomic analysis, the demand for money is one of the important topics being investigated widely since it enables policymakers to construct the proper monetary policy. Thereby, a correctly specified and estimated money demand function is important for monetary authorities to take proper actions when they design their policies. The execution of such policies, undoubtedly, would have pleasant consequences affecting the economy in positive ways.

Notwithstanding the great deal of attention on money demand research focusing on advanced and less advanced economies, the share of empirical studies paying attention to money demand in Saudi Arabia remains insufficient. Hence, analyzing the demand for money in Saudi Arabia is crucial not only due to the shortage of empirical studies concentrating on Saudi money demand function but also due to its importance in designing macroeconomic policies in Saudi Arabia as explained above. Importantly, some may argue that the comprehension of the demand for money in Saudi Arabia is not useful due to the fact that the Saudi riyal has been pegged to the US dollar since 1986. However, for Saudi Arabian Monetary Authority (SAMA), analyzing the behavior of money demand is still important since SAMA has alternative policy instruments in place (i.e. macro-prudential measures and minimum reserve policy) to ensure financial and monetary stability.³ Correspondingly, changes in the demand for money are very essential in planning fiscal policy. To put it in a different way, fiscal policy has crucial role in alleviating costs of any disturbances to real economic activity causing instability of money demand. In their most recent study, Alsamara et al. (2017) discussed that for oil exporting countries, such as Saudi Arabia, oil price shocks may have adverse impacts on real economic activity passing to real money balance negatively. In such circumstances, therefore, the role of fiscal policy becomes very essential to minimize the undesirable outcome of such shocks.

For the reasons above, the objective of this paper is to model the demand for money in Saudi economy to provide some insights about the behavior of money demand to policymakers.

³ Al-Jasser and Banafe (2005) provided further discussion on monetary policy instruments in Saudi Arabia.

We believe that our research contributes to the existing literature by a number of ways. First, we applied the General to Specific Modeling Strategy (GtSMS) in our empirical analysis. To our best knowledge, this is the first time that the GtSMS is applied for the Saudi money demand analysis, and the advantage of the GtSMS is that it provides a parsimonious set of explanatory variables to explain a process at hand. Second, unlike earlier studies, we tested that whether or not theoretical assumptions, such as price homogeneity and income homogeneity hypotheses hold for the Saudi Arabian economy. Our research provides the propositions between money demand and income, price that monetary authorities should take into consideration in their decision-making process. Third, again, unlike many earlier studies, we checked stability of the money demand relationship using a number of tests for parameter stability as well as relationship stability. As documented in the literature, testing stability of money demand is very important for the monetary policy makers in understanding of whether they can target a given monetary aggregate. Fourth, we addressed the econometric issues that have been missing in previous studies. In particular, we accounted for small sample bias, which provides robust estimation results, qualitatively and quantitatively⁴. Fifth, as mentioned above, there are limited studies for the Saudi money demand, and from this viewpoint, our research enriches this literature. Finally, we believe that our research will inspire future money demand studies for Saudi Arabia as well as other similar economies.

The rest of the paper proceeds as follows: section 2 overviews the pertinent literature on money demand with special emphasis on Saudi Arabia, while section 3 presents theoretical framework for money demand function. In section 4, we describe the employed dataset and its sources. The adopted econometric techniques are explained in section 5, while the empirical results are presented in section 6. The discussion of the empirical results is provided in section 7, and the conclusion is contained in section 8.

⁴ As a qualitative example, if a cointegration test with small sample bias correction indicates no cointegrated relationship, then policymakers should not focus on the long-run aspects of the process at hand in a given period.

2. Literature Review

There exists a large volume of empirical research attempting to analyze the behavior of money demand and its determinants in industrialized economies⁵, emerging markets economies⁶, and less developed economies.⁷ An extraordinary work accomplished by Banafea (2012) surveyed the prevailing theoretical and empirical literature on money demand. Nevertheless, despite the large share of the empirical studies analyzing money demand function across different countries around the world, the number of studies considering Saudi Arabia is still sparse. The prevailing studies paying attention to Saudi Arabia are conducted based on two approaches. The first one follows time series techniques, while the other one applies panel data procedure. These studies are documented in Tables 1.1 and 1.2.

⁵ See some studies on the US (i.e. Haug & Tam 2007; Wang 2011), Canada (i.e. Kia 2006), Japan (i.e. Bahmani-Oskooee 2001), European countries (i.e. Coenen & Vega 2001), and the UK (i.e. Hondroyannis et al. 2001; Nielsen 2007).

⁶ See some studies on China (i.e. Zuo & Park 2011; Jiang 2016), Chile (i.e. Arrau & De Gregorio 1993), India (i.e. Rao & Singh 2006; Singh & Pandey 2012), Russia (i.e. Bahmani-Oskooee & Barry 2000), and Turkey (i.e. Özdemir & Saygili 2013; Tunturk 2017).

⁷ See some studies on African countries (i.e. Bahmani-Oskooee & Gelan 2009), Middle Eastern countries (i.e. Bahmani 2008), and developing countries (i.e. Bahmani-Oskooee & Rahman 2005).

Table 1.1. Summary of Money Demand Studies Conducted on Saudi Arabia

Panel A: Time Series Econometric Approach									Estimated Coefficients [†]		
Study	Frequency	Measure of Money	Explanatory Variables	Unit Root Tests	Cointegration Test	Stability Test	Correction for Small Sample	Testing PIH Hypotheses	Y	I	ECT
Al-Bassam (1990)	1979:1 – 1986:2 Q	M2 [†]	Y, INF., ER, I	NA	NA	Chow	NA	NA	0.32**	-0.04**	NA
Alkaswani and Al-Towaijri (1999)	1977:1-1997:3 Q	M1	Y, INF., ER, I	ADF	JJ	None	NA	NA	1.76**	-0.01**	-0.35**
Bahmani (2008)	1971-2004 A	M2	Y, INF, ER	NA	ARDL	CUSUM	NA	NA	2.11**	NA	-0.38**
Masih and Algahtani (2008)	1986-2004 A	M3	Y, I, FI	ADF,PP	JJ	CUSUMSQ	NA	NA	1.49**	1.53**	-1.20**
Abdulkheir (2013)	1987-2009 A	M2	Y, I, ER, INF	ADF, PP	JJ	None	NA	NA	0.09	30.34**	-0.53**
Banafea (2014)	1980-2012 A	M1	Y, I	PP, ZA	GH	H, A, and AP	NA	NA	1.69*	-0.02*	NA
Basher and Fachin (2014)	1980-2012 A	M2	Y, I	ADF-GLS	EG, JJ, ARDL, DF	NA	NA	NA	1.77**	-0.55**	-0.06
Al Rasasi (2016)	1993:1-2015:4 Q	M3	IP, I, ER	ADF, PP, KPSS, ADF-GLS	JJ	H, A, and AP	NA	NA	2.47**	- 0.15**	-0.01***

Table 1.2. Summary of Money Demand Studies Conducted on Saudi Arabia

Panel B: Panel Data Econometric Approach											
Study	Frequency	Measure of Money	Explanatory Variables	Unit Root Tests	Cointegration Test	Stability Test	Correction for Small Sample	Testing PIH Hypotheses	Y	I	ECT
Harb (2004)	1979-2000	M1	Y, I, ER	IPS	Phillips (1992) Pedroni (2000)	NA	NA	NA	0.86**	0.01	NA
Lee et al. (2008)	1979-2000	M1	Y, I, ER	Does not mention the applied tests	Larsson et al. (2001)	NA	NA	NA	0.07	0.21**	NA
Hamdi et al. (2015)	1980Q1-2011Q4	M2	Y, I, FI, ER	LLP, IPS, F-ADF, PP, and B-test	PH, KC, Pedroni (2000)	NA	NA	NA	0.59* (FMOLS)	-0.08***	NA
									0.72** (DOLS)	-0.07***	NA
									0.78** (CCR)	-0.09***	NA

Notes.

*, **, & *** denote 1%, 5%, and 10% significance levels respectively.

‡ We report only the estimated coefficients that we are interested in for comparison purposes.

† This study also estimates money demand using various monetary aggregates and reaches similar conclusion.

Q denotes quarterly frequency.

Y, I, ER, IP, FI, and INF are real GDP, nominal interest rate, exchange rate, industrial production, foreign interest rate, and inflation rate, respectively.

JJ, ARDL, GH, EG, and DF denote the cointegration tests of the Johansen and Juselius (1990), Pesaran et al. (2001), Gregory & Hansen (1996), Engle and Granger (1987), and Di Iorio and Fachin (2014). PH, KC, & Pedroni represent the panel cointegration tests of Phillips & Hansen (1990), Kao & Chiang (2000), and Pedroni (2004).

IPS, LLP, F-ADF, F-PP, and B-tests denote the panel data unit root tests developed by Im et al. (2003), Levin et al. (2002), Maddala & Wu (1999), and Breitung (2000) respectively. ADF, PP, ZA, KPSS, & ADF-GLS denote time series unit root tests of Said & Dickey (1984), Phillips & Perron (1988), Zivot & Andrews (1992), Kwiatkowski et al. (1992), & Elliot et al. (1996) respectively.

H, A, and AP refer to the stability tests of Hansen (1992), Andrews (1993), and Andrews and Ploberger (1994).

FMOLS, DOLS, & CCR represent the estimation methods of Fully-Modified OLS, Dynamic OLS, and Canonical cointegrating regression.

Starting with the time series econometric approach, Al-Bassam (1990) estimated the demand for money in Saudi Arabia using quarterly data running from 1976:01 to 1986:4. The variables considered in his study consist of M_0 , M_1 , M_2 , M_2^a ⁸, real non-oil GDP, expected inflation, expected exchange rate of the Saudi riyal to US dollar, and short-term market interest rates for both the Saudi riyal and US dollar. The researcher followed the partial adjustment model to estimate the money demand function for Saudi Arabia. In sum, the estimation of various forms of money demand function suggests the influential role of the considered explanatory variables on the long run demand for money in Saudi Arabia as anticipated by theory. Furthermore, all estimated specifications of money demand under the period of study point out to the low adjustment process of money demand to reach its equilibrium level. Regarding stability, the researcher applied the most popular structural change test of Chow (1960) and found supportive evidence confirming the stability of the money demand function in Saudi Arabia.

Alkaswani and Al-Towaijri (1999) augmented the conventional Keynesian money demand function with real exchange rate to evaluate its behavior in the Saudi economy. In their testing procedures, they relied on quarterly data (real GDP, inflation, real exchange rate, and M1) covering the period of 1977:01-1997:04, and used common cointegration procedures. The conclusion of their analysis reveals that money demand behaves over long run in a positive (negative) and significant way with real exchange rate and income (inflation rate and interest rate). They also documented that 35 percent of money demand variations adjust to its steady-state level each period.

Based on the autoregressive distributed lag (ARDL) model, Bahmani (2008) utilized annual data for M2, real GDP, inflation, and nominal effective exchange rate starting from 1971 to 2004 to assess money demand function for 14 Middle Eastern countries, including Saudi Arabia. The finding of this study suggests that the long-run money demand function is stable in Saudi Arabia, in which real income and inflation have the expected impact by economic theory. Strictly speaking, for the case of Saudi

⁸ M_2^a is defined as M2 plus foreign currency.

Arabia, the parameter estimates indicate that real income and exchange rate tend to have a positive impact on the money demand, while inflationary pressures seem to reduce the money demand during the long run. The estimated error correction term indicates that it is only 38 percent of money demand fluctuations are adjusted to its equilibrium level each year.

Masih and Algahtani (2008) considered the long-run structural modeling (LRSM) technique initiated by Pesaran and Shin (2002) to estimate and assess the stability of the long-run money demand function in Saudi Arabia. To reach this objective, they employed annual data spanning from 1986 to 2004 and including M3, real GDP, 12-month interest rate, and foreign interest rate. The estimated coefficients of money demand (M3) are in line with economic theory; likewise, the estimated error correction coefficient implies that money demand deviation from its equilibrium level tends to speed up to return to its normal level. Stability tests also confirm the stability of money demand (M3) function over long run. As a robustness check, the authors estimated money demand function (M2) and reached almost similar conclusion endorsing the stability of money demand (M2) function; however, the only difference is with the international variables, in which the exchange rate seems to be significant in M2 function while the foreign interest rate is the significant one in case of M3 function.

Abdulkheir (2013) analyzed the behavior of money demand function (M2) in Saudi Arabia, considering its essential determinants (real GDP, interest rate, real exchange rate, and inflation rate) and employing annual observations running from 1987-2009. Standard tests of unit root and cointegration with the estimation of vector error analysis show the stability of money demand function (M2) in the long run. In particular, the author documented that a cointegration relationship between money demand and its explanatory variables exists, in which changes in real GDP and inflation rate lead to the rise in money demand. Against theory expectation, the empirical evidence suggests the positive association between interest rate and money demand. On the other hand, exchange rate depreciation decreases the money demand as parameter estimates reveal. Moreover, the estimated speed of adjustment coefficient

indicates that 53 percent of money demand deviation returns to its equilibrium level each period.

Focusing on stability of money demand function, Banafea (2014) relied on the conventional Keynesian money demand framework and used data (M1 deflated by CPI, real GDP, and US treasury bills) with annual frequency from 1980 to 2012. Banafea differentiated his work from existing studies by applying recent econometric tests for unit roots, cointegration, and structural breaks. The applied structural break tests point out to the presence of instable money demand function in Saudi Arabia although the long-run cointegration relationship exists and aligns with theoretical anticipation.

Conversely, Al Rasasi (2016) reassessed the stability of money demand function in Saudi Arabia using quarterly data (M3 deflated by CPI, Libor, nominal effective exchange rate, and industrial production) from 1993:01-2015:03. In specific, the author applied a series of structural break tests as those implemented by Banafea (2014) and concluded the stability of the long-run money demand function in Saudi Arabia. It is also essential to note that the contradiction between the findings of Banafea (2014) and Al Rasasi (2016) might be related to the different data frequency, money demand specification, measures of opportunity cost and the scale variable.

Alternatively, based on panel data econometric procedures, there is a number of empirical studies relying on estimating money demand function for the Gulf Cooperation Council (GCC) countries⁹, with various panel cointegration tests. For instance, Harb (2004) modeled money demand function for GCC countries, employing annual data from 1979–2000. His dataset consisted of M1, real non-oil GDP, private consumption, domestic interest rate, and nominal exchange rate. The implemented panel cointegration tests in this article are pooled panel and mean group of Phillips (1992) and Pedroni (2000) respectively. Based on the applied techniques, Harb found evidence supportive of the existence of cointegration relation in GCC countries. Likewise, estimates of the long-run relationship indicate that real income and nominal exchange rate have significant impacts on determining money demand; only the group mean approach points to the significant role of nominal interest rate influencing the

⁹ The GCC countries consist of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates.

demand for money. When the private consumption is used as a scale variable, both panel cointegration tests show the essential role of private consumption in capturing the movements in money demand, whereas only the pooled cointegration test shows the ability of nominal exchange rate in explaining the variation of money demand. Results concerning Saudi Arabia, using real non-oil GDP, show the disappearance role of domestic market interest rate in understanding the behavior of money demand in the long run. However, parameter estimates of money demand considering the private consumption as a scale variable confirm the key role of real private consumption, interest rate, and nominal exchange role in explaining the behavior of money demand.

Lee et al. (2008) relied on the dataset of Harb (2004) to re-estimate the demand for money in GCC countries and to see whether there exists a cointegration relationship or not. In specific, the analysis is conducted based on the likelihood-based cointegration tests in heterogeneous panels developed by Larsoon et al. (2001). The applied panel cointegration tests confirm the existence of a long-run relationship between money demand and its determinants for GCC economies. However, the estimated money demand function for Saudi Arabia indicates that the real non-oil GDP (exchange rate) is negatively (positively) associated with money demand, contradicting economic theory. Nonetheless, the estimated money demand function with real private consumption is in line with theoretical expectations.

Basher and Fachin (2014) applied both time series and panel data cointegration tests to model the long-run money demand in the GCC countries. This paper employs annual observations of M2, non-oil GDP, and the 3-month US treasury bills over the period 1980-2012. In the time series analysis, the authors rely on the cointegration tests of Engle and Granger (1987) alongside the bound test of Pesaran et al. (2001); both tests reject the null hypothesis of no cointegration only in Bahrain and Saudi Arabia. Applying panel cointegration test of Di Iorio and Fachin (2014), on the other hand, provides a strong support for the existence of a long-run relationship for the GCC money demand. Similarly, the estimated coefficient of money demand function for individual countries is in line with theoretical expectation. The adjustment process to long-run equilibrium, as the estimated error correction coefficients signify,

varies from country to another between 2 years to more than 10 years; for the case of Saudi Arabia, it takes money demand more than a decade to return to its steady-state level.

Hamdi et al. (2015) also looked into the long-run determinants of money demand for the GCC countries, utilizing quarterly observations over the time horizon of 1980:01-2011:04. Their dataset includes M2, real non-oil GDP (real GDP for Bahrain and Oman), exchange rate, the UK three-month treasury-bills, and the US Libor rate to estimate the long-run money demand function. In their empirical analysis, they relied on three alternative panel cointegration tests developed by Phillips & Hansen (1990), Kao & Chiang (2000), and Pedroni (2004). The applied tests indicate the presence of a long-run relationship between money demand and its influential factors. Panel estimates show the alignment of GCC money demand coefficients with economic theory. Relative to Saudi Arabia's money demand function, the obtained evidence is supportive to theory's expectation; in a different way, money demand increases (decreases) with rising income and exchange rate (interest rate). Tables 1.1 and 1.2 provide a brief summary of these studies as well as their estimated coefficients.

An intensive and careful review of these empirical studies reveals their shortcomings that can be summarized in the following points. First, it seems that the existing studies tend to suffer from having inconsistent specification form of money demand function. Strictly speaking, some of these studies estimated the money demand function using real money balance based on the assumption that price homogeneity hypothesis holds without testing the hypothesis. In the same manner, the remaining studies modeled money demand using money supply as a function of various elements excluding prices, implying the validity of price homogeneity hypothesis. Furthermore, few studies used inflation rate rather than prices when they modeled money demand. Second, none of the current studies focusing on Saudi Arabia has treated the issue of small sample bias, which might result in misleading interpretation. Third, assessing the stability of money demand relation with its determinants was neglected by some studies. Fourth, several empirical studies ignored the short-run analysis, including error correction analysis, and focused only on modeling money demand during the long run.

Finally, some studies have not employed the Johansen cointegration method, given that they have more than one explanatory variable in their analysis, which can cause ending up with incorrect specifications and parameter estimations and hence misleading recommendations for policy makers.

3. Theoretical Framework

There has been a number of theoretical perspectives¹⁰ about the demand for money; however, the widely used theory in the vast majority of empirical studies is still the Keynesian theory for money demand. Therefore, we follow the literature mainstream by adopting the Keynesian's approach in analyzing the behavior of money demand in Saudi Arabia.

What is more, it is also important to bear in mind that money demand according to Keynesian theory is built on three motives. First, households seek to acquire money to facilitate their daily transactions. Second, households tend to hold money for precautionary purposes or unexpected events, such as health. It is important to stress that the first and second motives are proportional to income, indicating the presence of positive association between money demand and income. The third motive is a speculative one. To put it another way, money can be used as a store of wealth. For instance, households may prefer to hold their money in cash or in other forms of financial assets, such as bonds. But with low interest rates on bonds, households prefer to hold money rather than holding bonds and vice versa. This in turn suggests the negative relation between money demand and interest rate.

With this background in mind, it is clear that in money market equilibrium, the demand for money (M_t^d) is determined by the motives of holding money, as mentioned above, and it is equal to the actual money supply (M_t^s). In consequence, the required condition for money market equilibrium can be written as follows:

$$M_t^d = M_t^s \quad (1)$$

Since money supply is affected by real income (Y), nominal interest rate (i), and prices

¹⁰ Banafea (2012) discusses all theories of money demand.

(P), then we can write the money supply function as follows:

$$M_t^s = f(Y, i, P) \quad (2)$$

This can also be expressed in the natural logarithm and econometric equation form as follows:

$$\ln(M_t^s) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 i_t + \beta_3 \ln(P_t) + e \quad (3)$$

where \ln is the natural logarithm expression and e is the error term.

4. Data

Our dataset covers 1970-2016 and includes the following indicators as shown in Table 2.

Table 2: Dataset and Its Sources

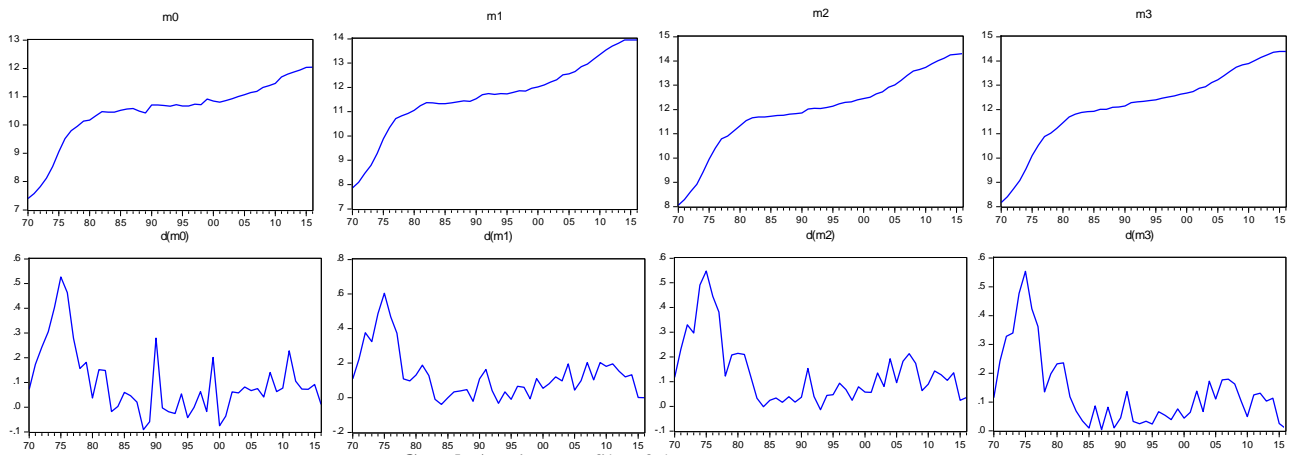
Variable	Notation	Description	Source
M0 monetary aggregate	M0	The currency outside banks.	SAMA
M1 monetary aggregate	M1	The sum of currency in circulation and demand deposits.	SAMA
M2 monetary aggregate	M2	The sum of M1 and time & savings deposits.	SAMA
M3 monetary aggregate	M3	The sum of M2 and other quasi-money deposits, which includes foreign currency deposits.	SAMA
Gross Domestic Product	GDP	The sum of value added produced in all sectors of the KSA economy.	GSTAT
GDP Deflator	PGDP	The percentage ratio of nominal GDP to real GDP.	GSTAT
Interest Rate	RLEND	This is 3-Month Saudi Arabian Interbank Offered Rate (SAIBOR).	Oxford Global Economic Model

All the above-given monetary aggregates are measured in million SAR, while GDP is in real million SAR at 2010 prices. The reference year for the GDP deflator is 2010. Note that RLEND starts in 1987 and hence, we carried out our empirical analysis starting from this year¹¹. Also, note that in the empirical analysis below, we used the natural logarithm of the variables, except for RLEND, denoted in small letters. For example, $m0$ is the natural logarithm of $M0$.

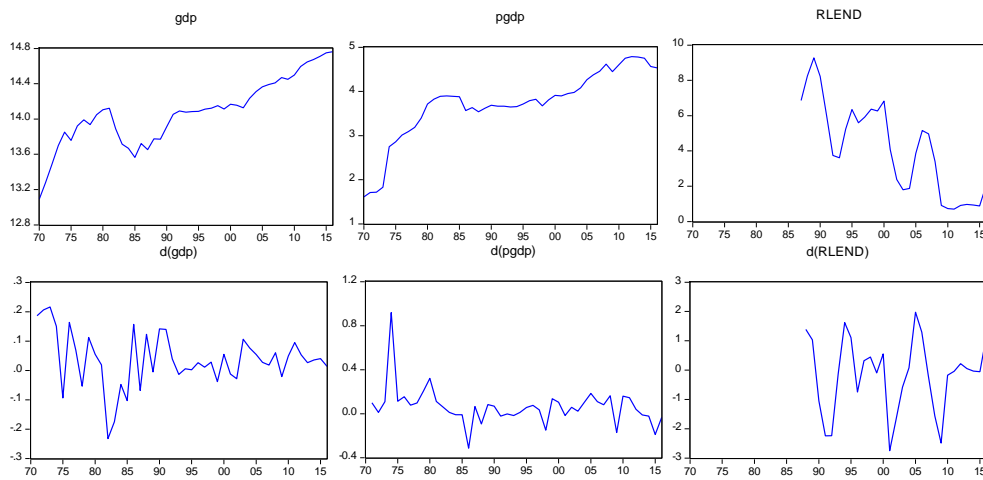
For illustrative purpose, the graphs below portray the logarithmic levels and growth rates of the variables¹².

¹¹ Since government bond rate started in 1994, thereby leaving very small sample for econometric estimations where we use VAR which is very degree of freedom consuming, we did not consider this interest rate measure.

¹² Again, these are level and first difference for RLEND as it is not in logarithmic expression.



Graph A. Time profile of the monetary aggregates.



Graph B. Time profile of the explanatory variables.

Figure 1. The Logarithmic Levels and Growth Rates of the Variables

5. Econometric Methods

We describe the econometric methods used for unit root and cointegration tests as well as estimating long-run and short-run parameters in this section. The section first briefly introduces Unit Root (UR) tests and then describes the Johansen cointegration method. Lastly, it briefs Error Correction Modeling with the General to Specific Modeling strategy.

5.1. Unit Root Test

The cointegration theory articulates that the estimation output is spurious if variables are non-stationary and there is no long-run (cointegrating) relationship among them. This assumes that only stationary cases of variables have to be used in estimations and testing. If, however, there is a long-run (cointegrating) relationship among them, then

the estimation results are not spurious and can be interpreted as a long-run relationship (Engle and Granger, 1987 inter alia). Majority of economic indicators trend over time stochastically. Hence, it is important first to check the stationarity of them by means of UR tests to prevent spurious results. The most widely employed UR tests are the Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) and the Philips-Perron (PP) test (Phillips and Perron, 1988) although there are many UR tests available.

The ADF equation for a given variable y_t can be written as below in the case of an intercept and trend:

$$\Delta y_t = b_0 + b_1 t + b_2 y_{t-1} + \sum_{i=1}^l \gamma_i \Delta y_{t-i} + v_t \quad (4)$$

where b_0 and t are a constant term and a linear time trend, l and Δ denote the number of lags and the first difference operator, and v_t refers to the white noise errors. The ADF sample value is represented by the t -statistic on b_2 . One fails to reject the null hypothesis of UR if this value is smaller than the critical ADF values, in absolute terms, at different significance levels, and it means that y_t has a UR and therefore is not stationary. If this value is greater than the critical ADF values, in absolute terms, at different significance levels, then the null hypothesis can be rejected, and it means that y_t is not non-stationary.

The only difference between the PP test and the ADF test is that in order to remove the serial correlation problem in the residuals, the former uses non-parametric statistical methods, but not lags of the dependent variable. A detailed discussion of the PP test can be found in Phillips and Perron (1988).

5.2. The Johansen Cointegration Method The classic cointegration theory articulates that if variables are non-stationary and their integration order is the same, usually one, then it is meaningful to check whether the variables have a long-run relationship using cointegration tests, such as the EG and the Johansen. Again, the cointegration theory discusses that if there are n number of variables under consideration, then there can be $n-1$ number of cointegrating relationships at maximum.

However, only the Johansen test is enable to discover number of cointegrating relationship among the variables if such relationships is more than one (Engle and Granger, 1986; Johansen, 1988; Enders, 2010). Once the Johansen test suggests only one cointegrating relationship among the variables, then other cointegration tests such as the EG and the ARDLBT can be used or their long- and short-run estimations can be performed as a robustness check.

The full information maximum likelihood of the Vector Error Correction Model (VECM) of Johansen (1988) and Johansen and Juselius (1990) can be expressed as follows:

$$\Delta z_t = \Pi z_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta z_{t-i} + c + e_t \quad (5)$$

where, z_t is a $(n \times 1)$ vector of the n endogenous/modeled variables, c is a $(n \times 1)$ vector of constants, Γ represents a $(n \times (k - 1))$ matrix of short-run coefficients, e_t denotes a $(n \times 1)$ vector of white noise residuals, and Π is a $(n \times n)$ coefficient matrix. If the matrix Π has reduced rank ($0 < r < n$), it can be split into a $(n \times r)$ matrix of loading coefficients α , and a $(n \times r)$ matrix of cointegrating vectors β . The former indicates the importance of the cointegration relationships in the individual equations of the system and of the speed of adjustment to disequilibrium, while the latter represents the long-term equilibrium relationship, so that $\Pi = \alpha\beta'$.

Johansen's reduced rank regression approach of testing for cointegration estimates the matrix Π in an unrestricted form first and then tests whether the restriction implied by the reduced rank of Π can be rejected. In particular, the number of the independent cointegrating vectors depends on the rank of Π , which in turn is determined by the number of its characteristic roots that are different from zero. Max-eigenvalue and Trace test statistics are used to test for nonzero characteristic roots.

Note that significance, stationarity, and weak exogeneity tests are usually conducted in the Johansen framework, using estimated VECM (Johansen, 1992a, b). If a given variable in the long-run space is significant, then the null hypothesis of corresponding β is zero can be rejected. Multivariate stationarity or trend stationarity of a given variable assumes that $(1 \ 0 \ 0)'$ restriction on long-run coefficients cannot be

rejected. If a given variable is weakly exogenous, it implies that the null hypothesis of corresponding α is zero cannot be rejected. The weak exogeneity indicates that deviations from the long-run relationship does not feed back to the variable.

Small Sample Bias Correction in the Johansen Method

Johansen (2002) discussed that in the case of small samples, the Max-eigenvalue or Trace test statistics are biased to reject the null hypothesis of no cointegration. Regarding this issue, Reinsel and Ahn (1992) developed a $\frac{T-kn}{T}$ correction to the Max-eigenvalue or Trace test statistics; where k is the lag length of the underlying Vector Autoregressive (VAR) model in levels and n and T are the number of endogenous variables and observations, respectively.

5.3. Error Correction Model with the General to Specific Modeling Strategy

This sub-section briefly describes that if the variables are cointegrated, then how short-run relationships among variables can be estimated using an ECM¹³.

In the case of single explanatory variable, x , for simplicity, a general or unrestricted ECM of the dependent variable, y , is as follows:

$$\Delta y_t = \varphi_0 + \varphi_y \hat{\varepsilon}_{t-1} + \sum_{i=1}^p \varphi_{1i} \Delta y_{t-i} + \sum_{i=0}^p \varphi_{2i} \Delta x_{t-i} + v_t \quad (6)$$

where p indicates the maximum lag order and v_t is the residuals that are assumed to be white noise. Engle and Granger (1986) showed that if variables are cointegrated, then there should be an ECM representation of them which is represented by Error Correction Term (ECT), $\hat{\varepsilon}_{t-1}$. Furthermore, according to cointegration theory, if there is a stable cointegration relationship between the variables, then the coefficient on ECT, i.e., φ_y must be negative and statistically significant (see Engle and Granger, 1986 among others). This coefficient is known as the Speed of Adjustment (SoA)

¹³ Shortly note that the short-run relationship should be estimated using a VAR or an ARDL of stationary conditions of the variables, where an error correction term is dropped, if the variables are not cointegrated.

coefficient and is usually between -1 and zero. Note that Equation (6) can be estimated using the Ordinary Least Squares (OLS).

Once the general/unrestricted ECM is specified, we try to get more parsimonious specification of it using General to Specific Modeling strategy (GtSMS). The idea of the GSM strategy with an ECM is to initially estimate the general ECM, Equation (6), with the maximum lag order of the right hand side variables and then exclude statistically insignificant variables, while performing a battery of serial correlation, normality, heteroscedasticity, and misspecification tests, in each time of exclusion. The procedure is repeated until obtaining the most parsimonious specification (see Campos et al., 2005 for a detailed survey on the strategy).

The maximum lag order in the general ECM can be specified using different approaches, such as a time-dependent rule, information criteria (such as Schwarz and Akaike), statistical significance of the maximum lag order, and frequency of the time series used (see Perron, 1989; Newey and West, 1994; Ng and Perron, 1995). For example, Perron (1989) suggested that if the frequency is quarterly and the number of observations is small, then the maximum lag order of four should be chosen. Similarly, if the frequency is annual and the sample size is small (as in the case here), then one or two lags, as a maximum, should be specified.

Note that if x is weakly exogenous to the cointegrating system, then estimating Equation (6), where we have a contemporaneous value of x , by OLS is possible without any loss of useful information (see De Brouwer and Ericsson, 1995, 1998 *inter alia*). If x is not weakly exogenous, then there are different ways to estimate an ECM properly. One approach, but might be with loss of useful information, is to exclude a contemporaneous value of x from ECM and estimate it by OLS. Another approach that does not lead to the loss of any useful information is to estimate a simultaneous system of ECM equations for y and x , where we have the contemporaneous values of both variables. Yet another approach is that we still have the contemporaneous value of x and thereby no loss of useful information, but the final single equation ECM of y should be estimated by Two Stage OLS (TSLS) to address a possible endogeneity issue. One would prefer the last approach since the first approach might cause the loss of useful

information while the second approach has some system-specific complications in estimation and disadvantages (e.g. if there is an issue in one equation, it will contaminate others in the system). Note that it is important first to check whether contemporaneous value of x in the final ECM specification causes an endogeneity issue. For this purpose, endogeneity test, e.g. Durbin-Wu-Hausman test, can be applied. If the test indicates that the contemporaneous value of x is not endogenous, then there is no gain from the TSLS estimation and it is econometrically proved that the OLS is the best estimator.

6. Empirical Analysis

Following the conventional sequence of the procedures for cointegration and error correction analyses, we first perform unit root tests to determine order of integration of the variables and then check whether or not they are cointegrated. If the variables are cointegrated, then we estimate parameters of this cointegrated relationship. As a next step, we estimate error correction representation of this long-run relationship, using general to specific modeling approach. Finally, we perform a number of residuals and stability diagnostics tests to make sure that our final ECM specification has well-behaved residuals and does not suffer from any instability related to coefficients and/or relationship.

6.1. Unit Root Tests Results

We ran the ADF and PP equations in all the three possible combinations of the deterministic variables, i.e. intercept and trend, intercept and no trend as well as no intercept and no trend. Table 3 reports results from those test specifications, in which the deterministic regressors are included or excluded, conditioned upon their statistical significance.

Table 3: The URT Test Results

Variable	The ADF Test					The PP Test			
	Test Value	<i>C</i>	<i>t</i>	<i>None</i>	<i>k</i>	Test Value	<i>C</i>	<i>t</i>	<i>None</i>
<i>m0</i>	-1.39	x	x		0	-1.39	x	x	
<i>m1</i>	-1.42	x	x		0	-1.48	x	x	
<i>m2</i>	-1.98	x	x		0	-1.93	x	x	
<i>m3</i>	-1.82	x	x		0	-1.80	x	x	
<i>gdp</i>	-2.05	x	x		0	-2.11	x	x	
<i>pgdp</i>	-0.68	x			0	-0.69	x		
<i>RLEND</i>	-5.24***	x	x		1	-1.52	x	x	
$\Delta m0$	-6.30***	x	x		0	-7.53***	x	x	
$\Delta m1$	-3.29***	x			0	-3.34**	x		
$\Delta m2$	-3.31**	x			0	-3.24**	x		
$\Delta m3$	-3.18**	x			0	-3.30**	x		
Δgdp	-6.90***	x			0	-6.90***	x		
$\Delta pgdp$	-6.49***	x			0	-6.47***	x		
$\Delta RLEND$	-5.48 ***				1	-2.91***			x

Notes. ADF and PP denote the Augmented Dickey-Fuller and Phillips-Perron tests, respectively. Maximum lag order is set to two, and optimal lag order (*k*) is selected based on the Schwarz criterion in the tests. ***, **, and * indicate rejection of the null hypotheses of unit root at the 1%, 5%, and 10% significance levels, respectively. The critical values for the tests are taken from MacKinnon (1996). Estimation period: 1987-2016. None means that neither intercept nor trend is included in test equation. Note again that final UR test equation can include one of the three: intercept (*C*), intercept and trend (*t*), and none of them (*None*). x indicates that the corresponding option is selected in the final UR test equation.

The PP test sample statistics decisively fail to reject the null hypothesis of unit root for the log levels of the variables, i.e. monetary aggregates, income, price, and interest rate. The ADF test statistics also reach up the same conclusion for the variables, except for *RLEND*. According to the ADF test, *RLEND* is trend-stationary since the sample value of -5.24 is greater than even the critical value at the 1 percent significance level in absolute term. However, graphical illustration of the variable in Graph B in Figure 1 strongly rejects trend stationarity of the variable and instead suggests non-stationarity. Moreover, the PP test also indicates that the variable is a unit root process. Thus, we conclude that *RLEND* is non-stationary, i.e. follows unit root process like other variables above.

The tests statistics profoundly reject the null hypothesis for the first difference of the log levels of all the variables as indicated in the bottom part of Table 3.

Thus, as a summary of the unit root exercise, we conclude that all the variables are non-stationary in their log level but stationary in their first difference. In other words, their integration order is one, i.e. they are I(1) variables.

6.2. Cointegration Tests Results

We should conduct the cointegration test to see whether a long-run relationship exists among the variables as they are all $I(1)$ process. As discussed in the methodological section, in case of more than two variables, only the Johansen method can properly reveal out the number of cointegrated relationships. Therefore, we check the existence of cointegration using the Johansen method as we have four variables in this analysis¹⁴. Following the Johansen method (see Johansen, 1988; Johansen and Juselius, 1990; Juselius, 2006), we first specify a VAR of the four endogenous variables with the lag order of two as a maximum as we have a small number of observations¹⁵. We also include intercept and trend in the VAR as exogenous variables. Then we perform the Lag Exclusion test and Lag Order Selection Criteria to identify optimal lag order. The former test indicates that two lags cannot be reduced to one lag without loss of information. Regarding the latter, all the information criteria, i.e. Likelihood Ratio, Final Prediction Error, Akaike, and Hanna-Quinn, indicate that two lag is optimal while Schwarz prefers one lag. In order to make proper decision and more robust results, we estimate both VARs, i.e. one with two lags and another with one lag, and inspect them. The VAR with two lags has well-behaved residuals in terms of having serial correlation, normal distribution, and homoscedasticity as well as it is also stable over time as documented in panels A through D of Table 4. As for the VAR with one lag, its residuals have first-order autoregressive process which is a serious problem. Therefore, we opt the VAR with two lags for our further tests and estimations.

To conduct the Johansen cointegration test, we transformed the VAR to VECM. The test results are reported in panels E and F of Table 4.

¹⁴ It is worth noting that we used all the monetary aggregates in turn as a measure of money demand along with income, price, and interest rate. However, long-run as well as short-run analyses show that M2 aggregate is a more suitable measure for the Saudi Arabian economy in the given period of time.

¹⁵ Estimation sample covers 1989-2016 as our data start in 1987, and we select lag order of two for the VAR.

Table 4: The VAR Residual Diagnostics and Cointegration Tests Results

Panel A: Serial Correlation LM Test ^a				Panel E: Johansen Cointegration Test Summary					
Lags	LM-Statistic	P-value		Data Trend:	None	None	Linear	Linear	Quadratic
1	18.64	0.29		Test Type:	(a) No C and t	(b) Only C	(c) Only C	(d) C and t	(e) C and t
2	21.84	0.15		Trace:	1	2	1	1	1
3	9.77	0.88		Max-Eig:	1	0	0	1	1
Panel B: Normality Test ^b				Panel F: Johansen Cointegration Test Results for type (d)					
Statistic	χ^2	d.f.	P-value	Null hypothesis:	$r=0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	
Skewness	4.53	4	0.34	λ_{trace}	83.72***	41.06*	16.04	6.62	
Kurtosis	3.18	4	0.53	λ^a_{trace}	59.80*	29.33	11.46	4.73	
Jarque-Bera	7.70	8	0.46	λ_{max}	42.66***	25.02*	9.42	6.62	
				λ^a_{max}	30.47*	17.87	6.73	4.73	
Panel C: Heteroscedasticity Test ^c				Panel D: VAR Stability Test					
White	χ^2	d.f.	P-value	No root lies outside the unit circle.					
Statistic	204.37	180	0.10						

Notes. ^a The null hypothesis in the Serial Correlation LM Test is that there is no serial correlation at lag order h of the residuals; ^b System normality test with the null hypothesis of the residuals are multivariate normal. ^c White Heteroscedasticity Test takes the null hypothesis of no cross terms heteroscedasticity in the residuals. χ^2 is Chi-squared. d.f. means degree of freedom. C and t indicate intercept and trend. r is rank of Π matrix, i.e., number of cointegrated equations. λ_{trace} and λ_{max} are the Trace and Max-Eigenvalue statistics, while λ^a_{trace} and λ^a_{max} are adjusted version of them. *** and * denote rejection of null hypothesis at the 1% and 10% significance levels. Critical values for the cointegration test are taken from MacKinnon et al. (1999); Estimation period: 1989-2016.

Although we reported the test results for all the possible five versions, social and economic processes are usually better represented by versions (c) and (d) in panel E of Table 4. Versions (a) and (e) should not be considered because neither $m2$ has zero autonomous level nor it has quadratic trend. Version (b) indicates either two or no cointegrated relationship, both of them are not relevant as usually there is only one long-run relationship between money and its fundamentals. Moreover, this version implies that the average growth rate of $\Delta m2$ is zero, which is not the case from the variable's time profile in Graph A of Figure 1 and its ADF and PP test specification in Table 3. Thus, we have only versions (c) and (d) to consider. We prefer (d) to (c) because of the following reasons. First, (d) contains trend in the long-run relation of the money demand. One should argue economically that time trend captures innovations and developments in the financial and monetary sectors over time and hence should be allowed in the long-run space. Additionally, time profile of $m2$ as well as the selected ADF and PP unit root test specification for the variable contain time trend. Furthermore, the trend is statistically significant in the long-run equation as reported in panel B of Table 5. Moreover, the Trace and the Max-eigenvalue statistics are consistent each other and indicate one cointegrated relationship. It is also worth noting that apart from our explanation above, we estimate the long-run equation in all the versions for robustness check purposes. Only version (d) produces statistically

significant coefficients with economically meaningful signs and sizes for the explanatory variables as well as speed of adjustment¹⁶.

Thus, we conclude that long-run equation estimated in version (d) produces reasonable and consistent results. Hence we will use this specification for further testing and interpretation purposes.

Both the Trace and Max-Eigenvalue statistics indicate only one cointegrated relationship after adjusting the statistics for small sample bias in version (d) as documented in panel D of Table 4.

The long-run money demand equation corresponding to version (d) is presented in panel A of Table 5.

Table 5: The Significance, Stationarity, Weak Exogeneity and Hypothesis Testing Results

Panel A: Long-run equation: $m2 = \alpha_0 + \alpha_1 gdp + \alpha_2 pgdp + \alpha_3 RLEND + \alpha_4 TREND + e$					
	$m2 = -0.97$	$+ 0.51 gdp$	$+ 1.05 pgdp$	$+ 0.03 RLEND$	$+ 0.04 TREND + e$
		(0.15)	(0.08)	(0.01)	(0.01)
Panel B: Statistics for testing the significance of a given variable in the cointegrating space ^a					
	$m2$	gdp	$pgdp$	$RLEND$	$TREND$
$\chi^2(1)$	15.94***	7.07***	16.73***	5.55**	16.31***
Panel C: Multivariate statistics for testing stationarity ^b					
	$m2$	gdp	$pgdp$	$RLEND$	
$\chi^2(2)$	28.24***	30.12***	31.51***	17.22***	
Panel D: Weak exogeneity test results ^c					
	$m2$	gdp	$pgdp$	$RLEND$	
$\chi^2(1)$	7.37***	3.80*	0.39	3.60*	
Panel E: Price homogeneity hypothesis test results: $\alpha_2 = 1$					
$\chi^2(1) = 0.35$	$m2 = -1.43$	$+ 0.55 gdp$	$+ pgdp$	$+ 0.03 RLEND$	$+ 0.04 TREND + e$
		(0.14)		(0.01)	(0.01)
Panel F: Price and income homogeneity hypotheses test results, $\alpha_1 = 1$ and $\alpha_2 = 1$					
$\chi^2(1) = 5.36^*$	$m2 = -7.47$	$+ gdp$	$+ pgdp$	$+ 0.05 RLEND$	$+ 0.03 TREND + e$
				(0.01)	(0.003)
Panel G: Weak exogeneity test results in the case of price and income homogeneity					
	$m2$	gdp	$pgdp$	$RLEND$	
$\chi^2(1)$	9.07**	10.59**	7.19*	9.42**	
Panel H: Long-run equation in the case of price and income homogeneity and weak exogeneity of price					
$\chi^2(1) = 7.19^*$	$m2 = -7.47$	$+ gdp$	$+ pgdp$	$+ 0.05 RLEND$	$+ 0.03 TREND + e$
				(0.01)	(0.003)

Notes. ^a The null hypothesis is that given variable is statistically insignificant. ^b The null hypothesis is that given variable is (trend) stationary. ^c The null hypothesis is that given variable is weakly exogenous. ***, **, and * denote rejection of the null hypotheses at the 1%, 5%, and 10% significance levels, respectively. Values in parentheses are standard errors. Estimation period: 1989-2016.

¹⁶ Version (a) produces insignificant and negative elasticity for pgdp. Additionally, SoA is also insignificant. Version (b) yields very large and statistically insignificant elasticities for gdp and pgdp. Moreover, SoA is positive and insignificant. Large elasticities for gdp and pgdp and positive and insignificant SoA are also the case of version (c). The estimation results are not reported here to conserve space but can be obtained from the authors upon request.

Panel B shows that all the explanatory variables as well as trend are statistically significant at the higher level while panel C indicates that the variables are not trend-stationary. In other words, they are unit root process. The results here from the multivariate statistics for stationarity confirm those from the ADF and PP, univariate unit root tests, reported in Table 3. This signifies robustness of our conclusion on the integration properties of the variables.

The weak exogeneity tests' results presented in panel D indicate that all the variables are weakly exogenous except for $m2$ at the 5 percent or higher significance level. However, if one goes for the lower significance level, i.e. 10 percent, then gdp and $RLEND$ are not weakly exogenous.

Testing theoretical assumptions.

The money demand theory articulates that money demanded and price can be in one-to-one relationship in the long run. In other words, a 1 percent rise in price level should translate into 1 percent increase in demand for nominal money balance. We tested this assumption, and the results are documented in panel E of Table 5. Chi-square values of 0.35 strongly suggest the null hypothesis of the coefficient on price level being unity cannot be rejected. In the case of price homogeneity hypothesis, the coefficients on $RLEND$ and $TREND$ have the same values that they have in the unrestricted long-run equation, while that for gdp is very similar to each other. Additionally, all of the coefficients keep their sign and statistical significance. It appears that it is very reasonable to assume price homogeneity.

Then we tested another hypothesis coming from the money demand theory, stating that it may be possible that money demanded and income are in one-to-one relationship in the long run. We tested this hypothesis in the case of price homogeneity. The results reported in panel F of the table show that the assumption/restriction can be rejected at the 5 percent level but accepted at the 10 percent significance level. Given that we have a small number of observation points, one should go for 10 percent significance level. We did the same and accepted the restriction as a research decision. Another reason that led us to accept the assumption is that the values of the coefficients

on *RLEND* and *TREND* are still similar to what they were in the un-restricted case. We would prefer this specification of the long-run equation, where we have homogeneity hypothesis for price and income incorporated.

We tested weak exogeneity of the variables for this specification. It appears that only price is weakly exogenous to the system at the 10 percent significance level as shown in panel G of the table. Finally, we reached the long-run money demand specification, where we have price and income homogeneity and weak exogeneity of the price. The results presented in panel H of Table 5 show that the restrictions are acceptable at the 10 percent, and *RLEND* and *TREND* have statistically significant coefficients with the same magnitudes as they had before. Although it is at the 10 percent significance level, because of the above given explanations, we would accept it as a research decision.

Thus, we will calculate the residuals from the long-run specification given in panel H for our ECM estimation.

6.3. Short-run Analysis

Following the methodological discussion above, we specify our general ECM for $\Delta m2$ with the maximum lag order of one since this lag length is satisfactory to remove serial correlation from the residuals¹⁷. Recall that one lag was also optimal in the VECM estimation above and provided serially uncorrelated residuals. Then we try to get more parsimonious ECM specification by following GSM strategy. Our final ECM specification contains the contemporaneous values of Δgdp and $\Delta pgdp$ along with ECT term and intercept. Recall that the weak exogeneity test results presented in panel G of Table 5 show that Δgdp and $\Delta pgdp$ are not weakly exogenous to the long-run relationship. Therefore, we estimate the final ECM specification with TSLS as well and run the Durbin-Wu-Hausman test to see whether Δgdp and $\Delta pgdp$ are still endogenous. Difference in J-statistic with the null hypothesis of the variables are exogenous, given the sample value of 2.52 with the p-value of 0.28¹⁸. Thus, we conclude that the variables

¹⁷ We also estimated our general ECM with the maximum lag order of two. However, this general ECM yields exactly the same final specification in terms of number of regressors (and also almost exactly the same signs, sizes, significance of the coefficients, etc.) as the general ECM with one lag does. However, in the case of general ECM with two lags, we are forced to start estimation from 1990 while it is 1989 for the general ECM with one lag. Therefore, we preferred the general ECM with one lag as it has one more observation point.

¹⁸ We also ran the test for each variable separately, and the test statistics again failed to reject the null hypothesis of exogeneity.

are exogenous. Hence there is no endogeneity issue, and the OLS is a better estimator than the TSLS.

The final ECM specification of $\Delta m2$ estimated using the OLS is reported in panel A of Table 6.

Table 6: Final ECM Specifications from the Methods

Panel A: The final ECM Specification				
<i>Regressor</i>	ect_{t-1}	c	Δgdp_t	$\Delta pgdp_t$
<i>Coefficient [p-value]</i>	-0.29 [0.00]	0.08 [0.00]	0.36 [0.04]	0.29 [0.01]
Panel B: Residuals Diagnostics Tests Results				
<i>Test</i>	F_{AR}	F_{ARCH}	F_{HETR}	JB_N
<i>Statistic [p-value]</i>	0.40 [0.68]	0.03 [0.85]	0.82 [0.49]	0.90 [0.64]
Panel C: Stability Diagnostics Tests Results				
<i>Test</i>	F_{FF}	F_{CHOW}	F_{QA}	F_{CHOWF}
<i>Statistic [p-value]</i>	0.19 [0.67]	1.49 [0.24]	3.47 [0.53]	0.99 [0.51]
<i>Notes.</i> Dependent variable is $\Delta m2_t$. F_{AR} , F_{ARCH} , and F_{HETR} denote F statistics to test the null hypotheses of no serial correlation, no autoregressive conditioned heteroscedasticity, and no heteroscedasticity in the residuals. JB_N indicates the Jarque-Bera to test the null hypotheses of normal distribution. F_{FF} , F_{CHOW} , F_{QA} , and F_{CHOWF} refer to F statistics to test the null hypotheses of no functional form miss-specification from the Ramsey-RESET test, no structural break from the Chow breakpoint test, no structural break from the Quandt-Andrews unknown breakpoint test, and no structural break from the Chow forecast test, respectively. The breakpoint date is 2004 in the Chow tests. Estimation period is 1989-2016.				

As can be seen, all the explanatory variables have economically expected signs and are statistically significant. Moreover, the SoA coefficients are negative and statistically significant, meaning that the short-run disequilibrium can be corrected to the long-run equilibrium path. Hence the cointegrating relation among the variables is stable over the estimated period.

Note that in terms of the final ECM specification robustness check, we estimated general ECM with Stepwise Regression method. The resulted final specification from the method is identical to what we obtained applying general to specific method manually. This shows that the final ECM specification of $\Delta m2$ is quite robust in terms of survived regressors, their sign, size, and statistical significance.

Panel B documents residuals diagnostics test results. It shows that the residuals of the final ECM specification do not have any problem with serial correlation, ARCH effect, and heteroscedasticity, as well as they are distributed normally.

Stability of the Money Demand Relationship

Finally, we performed different tests to check stability of the final ECM specification of money demand. We first ran residuals and coefficient recursive estimation tests. The results are illustrated in Figure 2.

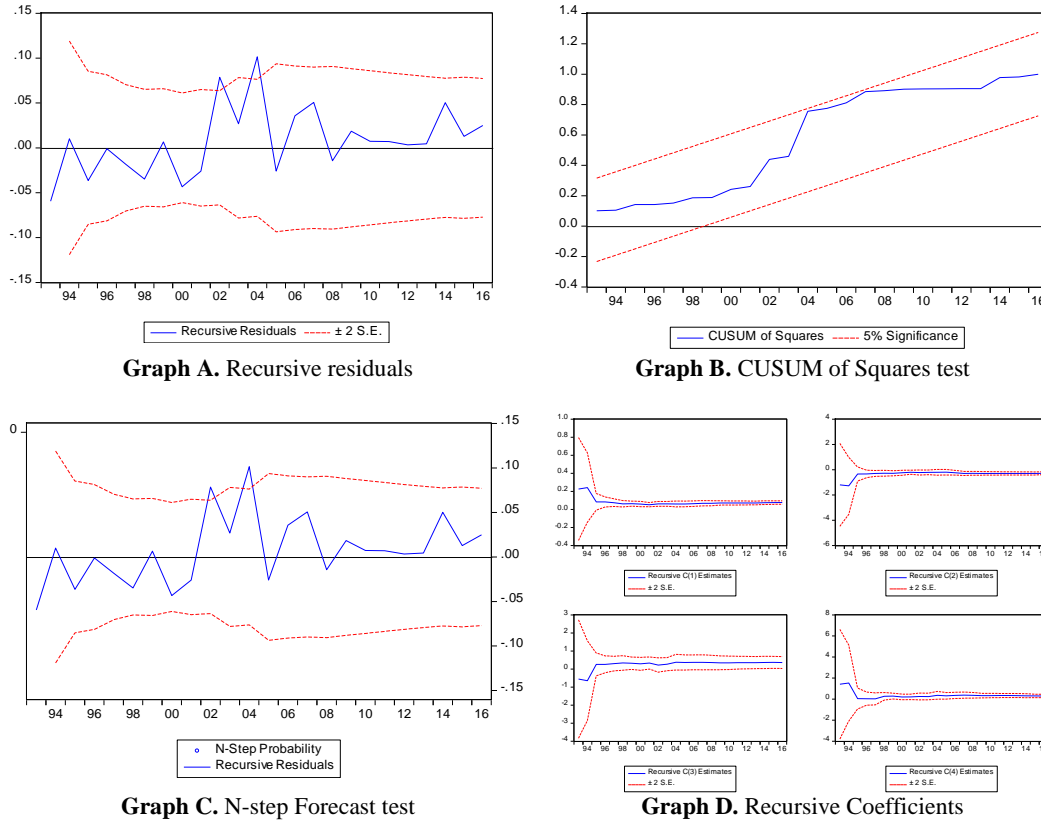


Figure 2: Recursive Estimation Tests Results for the Final ECM.

The first three recursive residuals test results demonstrate that the residuals are quite well-behaved over time, except a spike in 2004. The last graph illustrates that all the estimated four coefficients of the final ECM specification are very stable over time. The coefficients as well as residuals stability are very important in using the model for policy analysis and forecasting purposes. Since the recursive coefficient estimate shows that the coefficients are time invariant and the Ramsey-Reset misspecification test indicates that the final ECM specification does not have any functional form problem, we are only concerned about the spike occurred in 2004 in the residuals. To further address this issue, we ran different breakpoint tests to investigate whether the spike in 2004 causes a structural break. Panel C of Table 6 presents the tests' results.

We ran Chow breakpoint test and Chow forecast tests to check whether there is a breakpoint in 2004. Both tests' results failed to reject the null hypothesis of no breakpoint

as panel C documents that estimated sample F-statistics of 1.49 and 0.99 respectively are quite smaller than the critical F-values. As a further robustness, we also ran the Quandt-Andrews unknown breakpoint test and let the test determine endogenously if there is a break. The obtained sample value of the Average Wald F-statistic of 3.47 with the quite high p-value indicate that there is no break in the money demand relationship. The rest five statistics of the Quandt-Andrews test, such as the Average and Maximum Likelihood Ratio F-statistics and Maximum Wald F-statistic, also show that no break occur in the relationship. Thus, we conclude that the spike in 2004 does not cause any structural change either in the estimated parameters or in the relationship between money demand and its drivers.

7. Discussion of the Empirical Results

The Unit Root tests' results show the natural logarithmic expressions of the monetary aggregates, GDP, GDP Deflator, and RLEND are non-stationary in levels and stationary in their first difference. In other words, they are all I(1) processes. The non-stationarity of the variables means that they do not return to their previous mean, and the mean value changes from one time period to another as they are trending over time. There are two main implications, among others, for the non-stationarity of the variables. The future values of the variables form randomly and thus it is difficult to forecast them accurately. If there is a shock affecting the variables, it might have a permanent effect on their time profile. Inversely, stationarity of the variables, in our case the first difference of them, implies that they are mean reverting in the sense that past, present, and future mean values will be very close to each other¹⁹. Hence, it is easier to predict future trajectory of the variables when they are in stationary form. These features should be taken into consideration especially when undertaken research does forecasting exercise.

The Johansen cointegration tests conclude that there is a cointegrated relationship among the M2 monetary aggregate, GDP, GDP Deflator, and RLEND. It means that

¹⁹ Theoretical definition of the stationarity assumes that mean, variance, and covariance values of given variables do not change over time. It is called strict stationarity, which is not the case for the socio-economic variables. Therefore, stationarity in economics is characterized as weak stationarity (Enders, 2010; Gujarati and Porter, 2009).

the variables move together over time. To put it differently, there is a common/shared trend among them. This implies that the relationship between the levels of the variables is not spurious, meaning that the estimated coefficients from the level relationship are valid for analysis and forecasting. In this regard, estimated unrestricted long-run equation of the money demand, reported in panel A of Table 6, indicates that *ceteris paribus*, a 1 percent increase in GDP, PGDP, and RLEND, leads to 0.51 percent, 1.05 percent, and 3 percent (0.03×100) increase in the demand for M2 monetary aggregate in the long-run. The equation also shows that the factors changing over time, which are not included in the equation, caused 4 percent increase in the M2 demand each year over the period 1989-2016. After testing the theoretical predictions, we conclude that M2 can be in one-to-one relationship with PGDP and GDP in the long -run in panel F. It means that a 1 percent increase in price and income is associated with 1 percent increase in demand for broad money.

What follows is the explanation of the impact of the explanatory variables on M2. Note that we have a brief explanation here as our results are consistent with money demand theory as well as being in line with the empirical studies on money demand. Again, as theoretically expected, income has statistically significant and positive impact on the money demand. It can be interpreted as a transaction motive for money works in the Saudi economy, meaning that when economic agents have more income, then they will need more money to spend on goods and services. Our finding is in line with the findings of other money demand studies for the Saudi economy, such as Bahmani (2008) and Banafea (2012). Additionally, the empirical analysis shows that this transaction motive has one-to-one relationship with M2 in the long -run.

The positive effect of price level on money demand can be explained in a way that when price level is higher in the Saudi economy, then goods and services will be more expensive to purchase than they were before. This finding of our research is also in line with the earlier money demand studies on the Saudi Arabia.

We found that demand for M2 monetary aggregate is positively influenced by the 3-month SAIBOR rate. Whether interest rate has negative (or positive) impact on money demand depends on both the interest rate and money demand considered in the

empirical analysis. For example, there should be a negative relationship if one considers demand deposit rate and M0, i.e. cash in circulation, measures of interest rate and money, respectively, simply because an increase in return on demand deposit will induce economic agents to put their cash in demand deposits. However, if one considers demand deposit rate and M1 that is narrow money aggregate, which is sum of cash in circulation and demand deposits, then the relationship should be positive. The reason is that raising the interest rate will increase demand deposits, which is a part of M1. In this regard, we would explain the positive relationship found in our analysis as follows. When loan rate is high, then deposit rate will be high too as these two are closely linked to each other. For instance, if loan rate is high, then commercial banks will increase deposit rate to attract more money from the economic agents and thereby offer more loans. Higher deposit rate will induce economic agents to put more money in their deposit accounts. In order to do so, they will be interested in converting their other assets, such as real state, land area, and jewelry, into money and putting it in their deposit accounts, which will result in an increase in M2 monetary aggregate.

Finally, we found a positive effect of time trend on M2. The time trend can be considered a storage of factors that changes over time, such as institutional and technological developments, innovations, and others in the economy, especially in the money market.

Regarding the short-run relationship, the obtained final ECM specification reported in panel A of Table 6 shows that only ECT, the growth rates of GDP, and PGDP have statistically significant impact on the growth rate of demand for M2. Statistically significant SoA on ECT is theoretically expected as it has a negative sign. Interpretation of it is that any shocks causing the relationship, between the money and its fundamentals, to deviate from the long-run equilibrium path will be corrected back to this equilibrium. The size of SoA indicates that 29 percent of the deviation will be corrected back to the equilibrium level within one year, meaning that the complete correction will take slightly more than three years. All this shows that long-run relationship between M2 and its determinants is stable, and any shocks to this relationship will be temporary in the Saudi economy.

The final ECM further shows that contemporaneous values of income and price are positively related to M2 growth rate. Precisely speaking, a 1 percentage point increase in GDP and PGDP will result in 0.36 and 0.29 percentage points increase in demand for M2 respectively. It is theoretically and empirically expected as we explained for the long-run results above. It is worth noting that short-run effects of the income and price appear smaller than those in the long -run.

Finally, we conduct a battery of different stability tests, as a robustness check, to see whether there is any break in money demand relationship in Saudi Arabia. The general conclusion from these tests, documented in panel C and Figure 2, is that the relationship between M2 and its drivers, such as income, price, and interest rate, is stable over the period considered.

8. Conclusion

For policymakers, it is important to understand how money demand behaves in order to design the suitable monetary and fiscal policies. Consequently, there has been continuous effort from researchers in academia and analysts from government and private entities, aiming to comprehend the influential elements that could explain the variation in money demand. Observing the current literature on money demand indicates that there are an inadequate number of studies estimating the demand for money in Saudi Arabia. This in turn has encouraged us to fill out the gap in the literature by employing the most recent data, up to 2016, as well as relying on advanced econometric procedures to opt the most appropriate form of money demand function.

In specific, in this paper, we attempted to examine long-run relationship between money demand and its determinants as well as short-run dynamics among them in the Saudi economy. We employed the Johansen cointegration test with small sample bias correction in order to properly address the existence of long-run relationship between demand for money and its fundamentals. The result indicates that there is a long-run relationship among broad money, income, price, and interest rate. We also tested the theoretical predictions and revealed out that both income and price homogeneity hypotheses hold for the Saudi money demand function. In the short-run analysis, we

applied the GtSMS to our ECM estimation to properly specify set of explanatory variables and found that growth rate of money demand is associated with error correction term as well as growth rates of income and price. Additionally, it is found that long-run relationship is stable over time as short-run deviations can be adjusted towards the long-run equilibrium level. Finally, we applied different structural break tests to our final ECM as it is important to know whether a given money demand relationship is stable over time. The tests show that the estimated money demand relationship is stable over time.

Lastly, being able to understand how money demand in Saudi Arabia behaves over both short and long runs is essential for policymakers. In particular, maintaining a stable money demand function is a key requirement to forecast the nominal exchange rate based on the monetary model of exchange rate. Likewise, observing money demand fluctuations enables monetary authorities to watch the liquidity level. By doing so, monetary authorities may need to use their available policy instruments to sustain stable liquidity levels.

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