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Factors Influencing the Money Stock in Saudi Arabia: An Empirical Investigation

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Abstract. This paper uses both cointegration analysis and forecasting analysis in an attempt to examine the main factors influencing the money supply process in Saudi Arabia over the 1984.07-1995.06 period. The empirical findings seem to suggest that the money multiplier in Saudi Arabia is the mirror image of the currency ratio. A common trend seems to be driving their long run behavior. For most of the time, movements in the currency ratio are to a larger extent equally associated with changes of both demand deposits and currency. Lately, money growth has been largely ascribed to monetary base growth.

The forecasting exercise reveals that the basic model yields relatively higher forecasts for the multiplier.It also indicates that a reserve ratio shock would induce a larger negative effect on the money multiplier and then on to the money stock than a currency ratio shock. This finding may suggest that factors outside SAMA's control that are likely to influence the currency ratio do not greatly limit its ability to manage the money supply process. Thus, the monetarist contention that central banks are able to control the money stock is not that controversial in the Saudi monetary context.

Introduction

The identification of factors that influence the money stock continues to stimulate research. Examples of more recent contributions are Black and Dowd [1], Gauger and Black [2], Garfinkel and Thornton [3], Beenstock [4], Moore [5] and Rasche and Johannes [6] for developed countries, and M'Kaddem [7], Zejli [8] for Morocco, Diabi [9] for Algeria, Maryan and Shamia [10] for Jordan, Assweedy [11] for Qatar, Hossain [12] for Bangladesh, Arab [13] and Deyab and Hashim [14] for Saudi Arabia and earlier on Coats et. al [15] for developing countries in general.

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The role of money in stabilization policy is also widely recognized. Changes in money stock can be used as an indicator of monetary policy actions in the economy. However, the crucial issue centers on whether or not the monetary authorities can determine the growth of money stock with sufficient accuracy, if it is deemed desirable to do so. Therefore, factors that influence the monetary authorities' ability to determine the money stock warrant investigation.

An extensive debate around the issue of money endogeneity has emerged. Monetarists and non-monetarists have been arguing on the ability of monetary authorities to exercise an effective control on the money supply process. Monetarists contend that central banks are able to control the money stock. In contrast, non-monetarists believe that control of the money process can only be partial. In other words, besides the behavior of the central bank, other financial and real factors influence money supply growth.

This paper attempts to provide further insight on the main factors involved in the determination on the money stock in Saudi Arabia, over the 1984.07 1995.06 period. More specifically, it concentrates on movements in money supply which can be decomposed into the part that is directly attributable to SAMA's policy actions, through changes in the monetary base, and the part that is due to changes in technology, tastes and preferences of depository institutions and the public through the money multiplier. In theory, the money multiplier does not depend directly on the policy actions of the monetary authority.[1] Empirically, the degree to which the money multiplier is influenced by policy actions depends on the strength of the relationship between policy actions and demand deposits. In Saudi Arabia, most of the variability of the observed currency ratio is due to variations in demand deposits.

The methodology followed draws from the recent developments in time series analysis, in particular integration, cointegration testing, and ARIMA modeling. A subsidiary objective of the study is to carry a forecasting analysis based on the model which provides a good empirical account of the behavior of both the money multiplier and the monetary base. From a policy standpoint, this exercise may be of interest to those involved in the design of monetary policy. For example, if the money multiplier were independent of policy actions, the monetary base would be the best indicator of the effects of policy actions on the money stock. Inversely, if the money multiplier were not independent of policy actions, the monetary base might not be the best indicator of the effects of policy actions on the money stock, and hence, a full account of the money multiplier could result in improved money stock control. In other words, the target level of M1 can be achieved by forecasting the multiplier, then supplying the amount of high powered money to meet the desired M1 target. If however, the monetary base and the money multiplier were not independent of policy actions, an account of both of them could help improve the money stock control.

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[1]This is true only if the demand for currency and checkable deposits are determined by identical factors and if, conditional on these factors, these demands are strictly proportional.

The paper is organized as follows: Section 2 briefly discusses both the theoretical issues associated with the money supply process, and the institutional setting of the Saudi monetary policy. Section 3 provides a short description of the methodology applied. Section 4 offers a preliminary analysis of the key factors influencing the money supply process, reports the integration and cointegration results and discusses their policy implications. Section 5 estimates the alternative forecasting models and genrates forecasts for the selected monetary variables. Finally, section 6 summarizes the findings and concludes the paper.

The Theoretical and Institutional Setting

Overview of the recent literature

The Money multiplier was first developed by Brunner [16] and Brunner and Meltzer [17] which later on became the standard pattern in macroeconomics text books. At that time, it was assumed that money multiplier was constant and has little affect on money supply. However, later on a number of studies on the money multiplier have emerged.

Johannes and Rasche [6] who developed a component approach to forecasting money multiplier, found that time series models of individual money multiplier were more accurate than those produced by other regression methods. Beenstock [4] used the United Kingdom data from 1950 to 1984 to determine the money multiplier. His simulation results suggest that the dramatic growth in the money multiplier in the UK since 1970 largely reflects monetary reforms, such as the deregulation of banks and the increased competition between banks. His study indicated that a comprehensive theory of money supply must have joint determination of money multiplier, the monetary base, and interest rates.

Garfinkel and Thornton [3] studied the link between M1 and the monetary base in the 1980s for the United States. They ended up with the conclusion that the money multiplier has become less variable. In other study (1991), they also showed that the money multiplier is not independent of monetary policy actions as is commonly assumed. They showed that changes in monetary policy results in changes in the ratio of currency to checkable deposit and, consequently, changes in the money multiplier.

Gauger and Black [2] stated that in the U.S., from 1981 to 1988, the money multiplier was the main source of variation in the money supply. This of course, implies that actions of the public, rather than policy makers were mainly responsible for the volatility of the money supply. They also found that monetary multipliers are more volatile than the monetary base, regardless of the definition of money. They also argue that this reflects the movements of voliatile individual components. Foster [18]; Papademos and Modigliani [19]; and Moore [5] all investigated the money multiplier and the behavior of money supply. They all showed that the currency ratio is counter-cyclical implying a pro cyclical money multiplier.

Hossain [12] investigated the behavior of the money multiplier in Bangladesh from 1972 to 1993. He concluded that because of the unpredictability of movement of the money multiplier, any control by the monetary authority over the monetary base does not guarantee a control over the money supply. He suggests further that in order to conduct an effective monetary policy, it is important to stabilize the value of the money multiplier.

A number of studies have focused on the demand side of the Saudi money market by trying to identify the main factors influencing the Saudi money demand (e.g., Darrat [20]). Others (e.g., Arab, [13] or Deyab and Hisham, [14]) have examined the issue of the money supply process in Saudi Arabia.

Arab [13] in his study of the money supply in Saudi Arabia showed that while the currency held by the public rose from 1964 to 1978, its proportion to M1 has declined. He also showed that, due to commodity trading and real estate speculation, the ratio of time-saving deposits to M2 rose to 19.7 percent in 1978. His study found that the required reserve ratio ranged between 10 to 17.5 percent out of the demand deposit.

On the other hand, Deyab and Hashim [14] studied the components of money supply in Saudi Arabia. They concluded that, as result of some independent variables that would affect the relationship between demand deposits and currencies, the money multiplier will be influenced and, therefore, the amount of money supply.

It is however worth observing that the studies on Saudi Arabia suffer certain limitations. Overall, they relied primarily on annual data and remained generally more descriptive. Shorter span data, such as monthly data, and the methodology which draws from the recent developments in time series analysis, in particular integration, cointegration testing, and ARIMA modeling can improve singnificantly the analysis of the money supply process in Saudi Arabia.

The institutional setting

The Saudi financial system has evolved from one composed almost entirely of money changers into a modern system with advanced financial networks. It consists of four major parts: The Saudi Arabian Monetary Agency (SAMA) which is in charge of the conduct of monetary policy and the management of the government's foreign assets; the commercial banks which serve primarily the business community; the specialized credit institutions which are established for the purpose of fostering economic development; and finally the money changers[2].

SAMA was first established in 1952 to strengthen the domestic currency, to supervise the existing banks, and to act as an advisor to the government on financial and monetary matters. SAMA is the equivalent of what is generally called central bank. SAMA serves

[2]The importance of money changers has significantly declined with time.

most of the functions traditionally associated with a central bank. Unlike most western central banks, SAMA is very much integrated to the government. Net government spending accounts for by far the largest part of additions to money supply. Actually, money creation has been regarded as the means by which the Saudi government finances its expenditures, particularly those that require payment in Saudi Arabian riyals (S.R). Since government revenues depend exclusively on oil export earnings, taxes and bonds, as supplementary sources revenue, are not of great use.

The execution of monetary policy is entrusted to SAMA. Although SAMA does not have the same range of tools which are available to most central banks, it does exert considerable influence over the supply of riyals. SAMA resorts to one of the three major conventional monetary policy tools, namely the reserve requirement ratio. Given the monetary base, SAMA can only influence the amount of money that commercial banks can create. Its control over commercial banks began in mid-1966 when the first banking control law was enacted. Now SAMA requires about 15% of the bank's deposit liabilities as a reserve. This requirement can be varied by SAMA within a 10-17% range without government approval. SAMA also exercise monetary control by varying the liquidity assets ratio introduced in 1966.

Saudi Arabia's monetary policy has two goals: the maintenance of an acceptable domestic inflation and the stability of the riyal in international markets. The creation of money in Saudi Arabia proceeds along the following lines. The government maintains accounts with SAMA. It continually receives revenues in foreign currencies, mostly U.S. dollars. Periodically, the government makes payments. SAMA converts the U.S. dollars into Saudi riyals, holding the dollars as backing against the new riyals[3]. The conversion of riyals into foreign currencies to pay for imports reverses this process, thus offsetting partially the money creating effect of government spending. With the emergence of new domestic and foreign challenges such the burden of the fiscal deficit, the unstable oil market, and the need for further financial liberalization, SAMA will have to assume its responsability by continuing to play a positive role in the economy and to enhance monetary stabilty.

The Empirical Evidence

Preliminary analysis

Data

The basic raw data used in this study consists of nine time series covering 134 monthly observations, obtained from various SAMA reports for the period 1984.07 through 1995.06. These series are defined in appendix A. Other variables derived from the original series, are also used (e.g. money multipliers).

[3]Currently, the S.R. is among the 16 currencies that define the IMF Special Drawing Right unit (SDR).

There are several measures of money supply. The most important one is, M1, usually known as the narrow definition of money supply, which includes the public's holding of currency, demand deposits, and traveler's checks. M2, on the hands, is the broad definition of money supply. It includes M1 plus savings deposits and certificates. M3, however, is the sum of M2 plus quasi-Money. Based on these conventional definitions of money supply, three measures of the multiplier (MU1,MU2 and MU3) are derived, by dividing the respective money supply by the monetary base.

Some diagnostics

Table 1 presents a wide range of descriptive statistics for the set of selected monetary variables over the full sample period. Based on the estimated Box Pierce Statistics (Q(33)), all the series are white noise. Given both the skewness and excess kurtosis coefficients, the series do not depart from normality except for reserves which follows a rather leptokurtic distribution. On the other hand, M3 is more volatuile than M1 and M2. This can be partly attributed to the highly volatile TDP.

As regards the money multiplier components (i.e., the currency ratio (CR), the free reserve ratio (FR) the statutory reserves ratio (SC) and the other reserves ratio (OR)). The currency ratio has an average value of 0.66. This means that currency in circulation (C) is on average slightly more that half the size of demand deposits (DD). The reserve requirement exhibits a higher variance than the currency ratio.

Table 1. Summary statistics

	Mean	Std/Dev	Coef/Var	t	Min	Max	Skewness	Kurtosis	χ^2	Q(33)
CR	0.66	0.122	18.5	0.91	0.47	0.92	0.185	1.71	20.2	1233
FR	0.15	0.236	16.0	2.05	0.12	0.19	0.443	1.68	68.1	2001
SR	0.19	0.322	17.0	2.78	0.14	0.24	0.199	1.61	29.8	941
M1	105	19.9	18.9	61.05	79.4	142.3	0.422	1.62	88.1	1233
M2	148	23.6	16.0	2.05	117.6	192.4	0.443	1.68	68.1	2001
M3	189	32.2	17.0	2.78	143.4	243.1	0.199	1.61	29.8	941
DD	64.5	15.6	25.7	45.1	44.4	95.02	0.443	1.63	102.7	698
TDP	148	28.8	19.4	59.7	110	196.2	0.200	1.58	38.3	526
HPM	53.4	4.6	8.61	134.5	44.2	61.8	-0.311	1.81	32.7	2058
RES	12.7	1.9	15.3	75.6	10.0	19.4	1.47	4.90	48.9	1954
MU1	1.96	0.28	14.0	0.02	1.51	2.46	0.156	1.75	20.8	1673
MU2	2.77	0.32	11.5	0.03	2.20	3.29	0.043	1.72	23.0	1281
MU3	3.53	0.44	12.5	0.04	2.80	4.24	-0.037	1.52	28.6	1418

Facts on factors influencing the money stock

Figure 1 depicts the plot of the behavior of the money multiplier for narrow and broad aggregates over the period 1984.07-1995.06.

The plot shows that, irrespective of the choice of the monetary aggregates, the same

pattern emerges. After exhibiting a smooth downtrend until the beginning of 1988, the money multiplier rose sharply and remained stable; and by the middle of 1990, it began decreasing until near the beginning of 1991 where it started trending up until the middle of 1993, and it remained relatively stable thereafter.

Figure 2 depicts the currency ratio and the money multiplier (MU1) over the 1984.07-1995.06 period. Note that the multiplier is essentially the mirror image of the currency ratio; the latter seems to account for much of the multiplier month to month variability and for the significant shifts in its longer run trends. Indeed, as it will be shown later in the cointegration analysis, the money multiplier and the currency ratio seem to exhibit a common trend driving their long run behavior.

In sum, variations in the multiplier appear to be determined primarily by variations in the ccccurrency ratio, which, in turn appear to be determined predominantly by changes in DD. The question that remains is what determine the stock of demand deposits? Given the currency ratio, demand deposits are determined solely by the amount of reserves

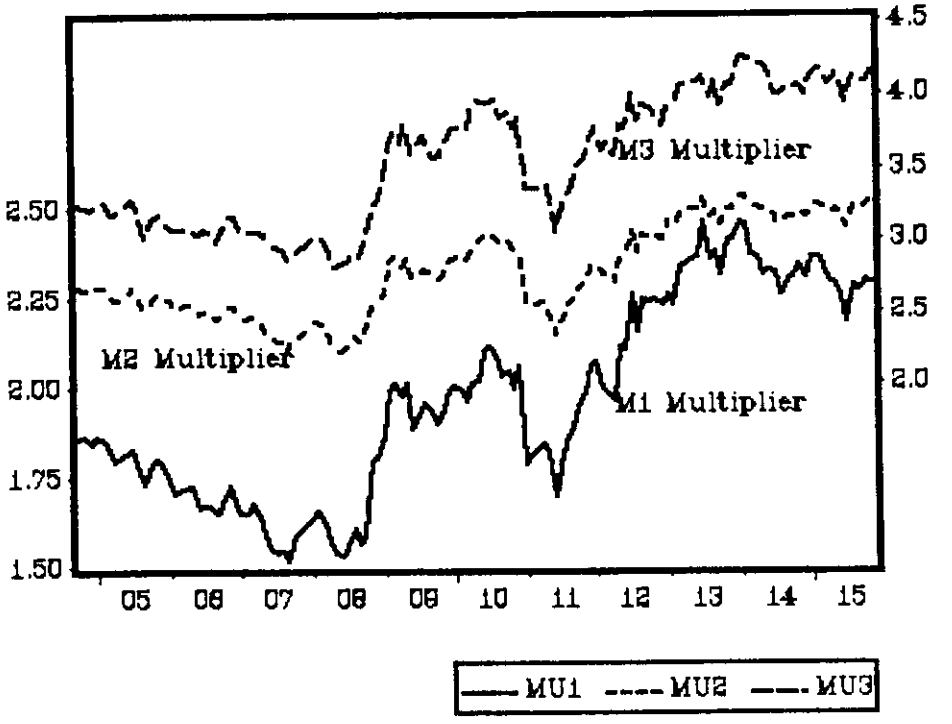

Fig. 1. M1, M2 and M3 Multipliers.

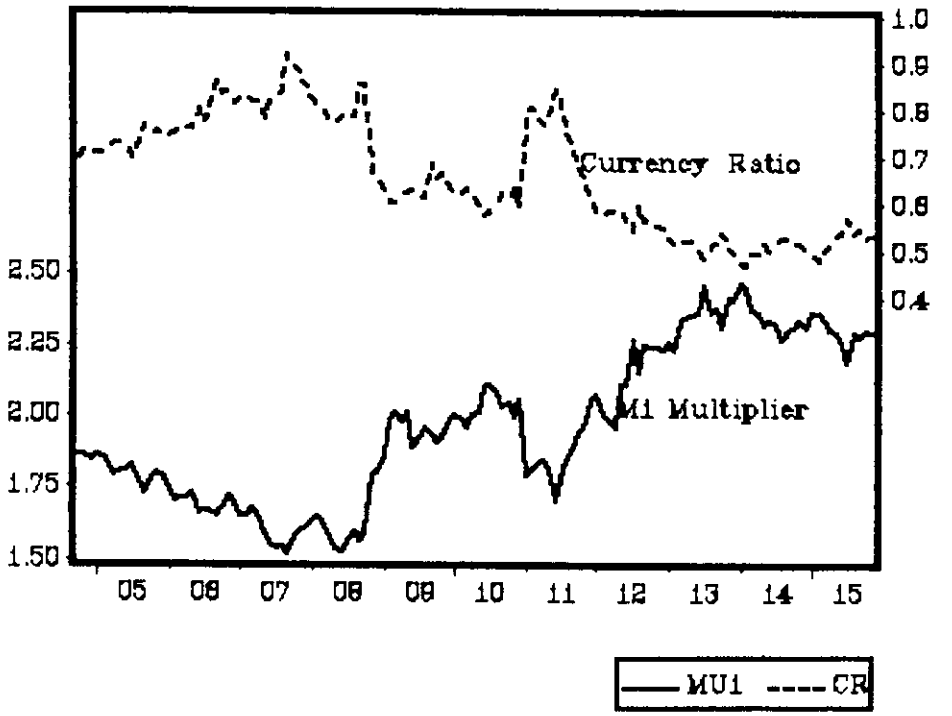

Fig. 2. M1 Mulriplier and the currency ratio.

supplied by SAMA. This strong link arises because reserves (RES) are assumed to be held only to support demand deposits.

Figure 3 shows the plot of the currency ratio (CR), the currency (C), and the demand deposits (DD). Overall, the behavior of these series is rather mixed. Until the beginning of 1991, movements in the currency ratio are to a larger extent equally associated with changes of both demand deposits and currency. In the subsequent period, they are rather more closely associated with changes in demand deposits than with changes in currency.

Another interesting question which warrants inquiry, is which of the money multiplier and the monetary base, contributes most to money supply changes? In this respect, four episodes can be distinguished. During the first episode (i.e., 1984.07-1987.06), the monetary base showed an upward trend, while the money multiplier showed a downward trend. This naturally, resulted in an average positive growth rate in M1. The subsequent episode (i.e., 1987.07-1991.09), witnessed a trend reversal, whereby the multiplier effect was large enough to offset the decline in the monetary base growth, and hence, keep

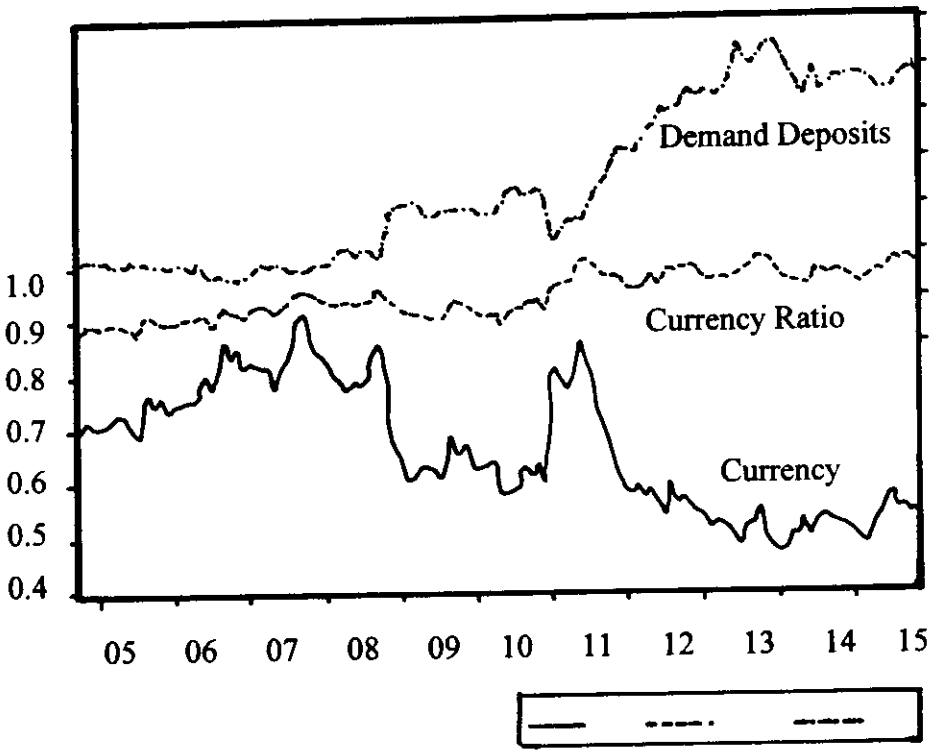

Fig. 3. Currency ratio, currency and demand deposits.

money supply growth relatively sustained. Over the third episode (i.e., 1990.09-1993.04), the multiplier growth contributed largely to money supply growth. While the monetary base growth was erratic, the money multiplier growth reflected in contrast, an upward trend. Finally, over the last episode (i.e.,1993.05-1995.06), the multiplier effect was rather negative and thus, the money supply growth was largely ascribed to the monetary base.

With month to month changes, M1 growth rate fluctuated from as high as 8.6 percent to -5.7 percent. The monetary base growth, on the other hand, reached a maximum of 9.1 percent and a minimum of -7.6 percent. The multiplier growth rate reached a maximum of 11 percent and a minimum of -151 percent. Quite obviously, if the money multiplier were perfectly constant, say at 1.51, then every 1 Saudi riyal increase in the monetary base would, ceteris paribus, result in 1.51 Saudi riyal increase in the money supply (M1). But, if the money multiplier were subject to large unpredictable variations, SAMA would have difficulty in determining the money stock controlling the monetary base. Since the money multiplier is not constant, SAMA must predict the value of the multiplier for the impending month in order to know how much to increase the monetary base to achieve the desired level of money stock.

Integration and cointegration testing methodology

Nelson and Plosser [21] and Stock and watson [22] demonstrated that most macroeconomic time series could be described as following a random walk. Engle and Granger [23] argued that non-stationary time series may be cointegrated. Therefore, it becomes necessary to test for stationarity of time series before estimating any relationship. Specifically, it is necessary to check if the series involved are indeed non-stationary and whether or not they are cointegrated. To test for non-stationarity, we use the unit root test suggested by Dickey and Fuller [24]. This test relies on rejecting a null hypothesis of unit root in favor of the alternative hypothesis of stationarity. The following regression is formed and estimated for each series:

$$\Delta X_t = \alpha_o + \beta X_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta X_{t-1} + e_1 \tag{1}$$

where Δ represents first difference. The null hypothesis is $\beta=0$ with significance levels provided by Fuller [25]. The lag length of the dependent variable, k, is chosen to induce white noise errors. Equation (1) represents the augmented Dickey-Fuller (ADF hereafter) test. The alternative test for unit roots in presence of serially correlated errors is the Phillips-Perron test [26] (PP thereafter). This test is viewed as robust in that it allows for a wide variety of heterogeneously distributed and weakly dependent innovations. It also involves a correction of the t-statistic from the unit root model using a non-parametric procedure.[4]

The integration test is carried out using the following equations:

$$X_t = \beta X_{t-1} + e_t \tag{2}$$

$$X_t = \mu + \beta' X_{t-1} + e_t' \tag{3}$$

$$X_t = \mu' + \delta(t - T/2) + \beta'' X_{t-1} + e_t'' \tag{4}$$

where μ is the drift term, δ tests for the presence of a trend and e_t (e'_t,e''_t) are the random error terms with the usual assumptions. The estimated statistics are $Z(t\beta)$, $Z(t\beta')$, and $Z(t\beta'')$, which are respectively, the standard t-tests used for testing whether $\beta=1$ ($\beta'=1$ and $\beta''=1$); $Z(\phi_1)$ tests the null hypothesis that $(\mu, \beta') = (0, 1)$ in equation 2; $Z(\phi_2)$ tests the null hypothesis that $\mu'=0$ in equation 3; and $Z(\phi_3)$ tests the null hypothesis that $(\mu', \delta, \beta'')= (0, 0, 1)$ in equation 4.

If the variables involved are non-stationary, their inclusion in the model becomes problematic. This is because the distribution of the estimates cannot be determined. Typically, this problem has been overcome by differencing the data to induce stationarity. Yet by differencing the data, this means only analyzing co-movements associated with

[4]Using Monte Carlo simulation, Schwert (1989, however, showed that the parametric approach (i.e., ADF) is preferred since it yields a more accurate test size.

the transitory components of the variables. In essence, it is the permanent component which represents the important aspect of the relationship. Therefore, it is suggested to test for cointegration between non-stationary variables.

Engle and Granger [23] suggested a two-step procedure in which first, the cointegrating vector is estimated with ordinary least squares, the OLS residuals are, then, tested for stationarity using the above unit root tests. Another test, suggested by Sargan and Bhargava [28], involves the Durbin-Watson statistic from the estimated cointegrating regression (denoted CRDW). If the CRDW is significantly greater than zero, the null hypothesis of no cointegration (i.e., the OLS residuals are I(1)) is rejected, in favor of the alternative hypothesis of cointegration.

Integration and cointegration results

Our empirical investigation commences by an exploration of the time series properties of the variables. We first, discuss the integration results using both the ADF and the PP tests, and then the cointegrating regressions using ADF, PP , and the CRDW.

Integration tests results

In order to establish the order of integration of the variables in our data set, the ADF, and the PP tests are performed. As stated above, these tests check for unit roots, and for the presence of a deterministic trend and a drift term. First, as may be seen from Table 2,

Table 2. Unit roots tests (levels)

	No trend				With trend				
	ADF	$Z(\alpha^*)$	$Z(t^*\alpha)$	$Z(\phi_1)$	ADF	$Z(t\beta^*)$	$Z(t^*\alpha)$	$Z(\phi_2)$	$Z(\phi_3)$
SR	-1.96	-51.9	-5.53	15.3	-2.61	-56.9	-5.87	11.52	17.27
FR*	-3.75	-67.9	-6.9	23.9	-4.66	-90.3	-8.3	23.1	34.63
OR	-3.51	-3.5	-1.24	0.80	-10.7	-10.7	-2.70	2.70	4.01
CR	-1.16	-6.07	-1.81	2.06	-2.20	-25.9	-3.75	4.92	7.04
C	-5.13	-4.94	-1.50	1.21	-15.8	-15.8	-2.99	3.10	4.57
RES	-2.03	-19.2	-3.26	5.33	-2.32	-19.4	-3.31	3.72	5.58
HPM	-2.05	-9.11	-2.34	3.07	-2.64	-16.4	-3.00	3.26	4.56
DD	-0.31	-0.52	-0.36	1.39	-2.25	-9.92	-2.42	2.86	3.06
TDP	0.034	-0.09	-0.08	3.76	-2.72	-14.5	-2.83	4.87	4.13
M1	-0.096	-0.36	-0.28	2.18	-1.97	-10.2	-2.41	3.24	2.99
M2	0.287	0.144	0.121	3.39	-1.96	-10.5	-2.39	4.06	3.13
M3	0.019	-0.07	-0.07	4.83	-2.51	-14.9	-2.85	5.54	4.1
MU1	-0.645	-2.04	-0.88	0.62	-2.53	-11.7	-2.68	2.65	3.75
MU2	-0.839	-3.28	-1.11	0.81	-2.68	-14.1	-2.84	2.97	4.27
MU3	-0.858	-3.03	-1.10	0.88	-2.83	-16.6	-3.04	3.29	4.71
				Critical value at 10%					
	-2.57	-11.2	-2.57	3.78	-3.13	-18.2	-3.13	4.03	5.34

both the ADF and the PP tests fail to reject the null hypothesis of non-stationarity for a large number of variables e.g., HPM, DD, TDP, M1, M2, M3, MU1, MU2, and MU3). The variable free reserves is unquivocably I(0).

As may be observed from Table 3, stationarity of the variables is achieved after first differencing. Thus, we can confidently conclude that with the exception of free reserves, all the investigated variables are I(1) processes. Second, in levels only SR, FR, CR and RES seem to contain a deterministic trend, but in first difference form, all the variables reveal the presence of both a drift and a deterministic trend. Third, it is worth noting that if the ADF test, marginally rejects the null hypothesis of a second unit root, the PP test incontrast, strongly rejects it.

Table 3. Unit rootstTests (first differences)

	No trend				With trend				
	ADF	**$Z(\alpha^*)$**	**$Z(t^*\alpha)$**	**$Z(\phi_1)$**	**ADF**	**$Z(t\beta^*)$**	**$Z(t^*\alpha)$**	**$Z(\phi_2)$**	**$Z(\phi_3)$**
SR	-4.57	-118	-23.5	275	-4.64	-118	-23.5	186	279
OR	-3.36	-120	-11.6	66.9	-3.36	-118	-11.6	45	67.6
CR	-3.10	-118	-15.1	113	-3.08	-118	-14.9	74	111
C	-3.19	-122	-12.3	50.2	-3.2	-122	-12.3	50	75.3
RES	-3.84	-135	-15.5	119	-3.08	-134	-15.5	80	120
HPM	-2.74	-137	-14.2	100	-2.73	-137	-14.2	67	99.9
DD	-2.79	-107	-10.8	58.9	-2.77	-106	-10.9	39	58.8
TDP	-3.88	-115	-10.8	58.5	-3.89	-114	-10.8	39	58
M1	-2.54	-99	-11.7	67.8	-2.51	-98	-11.7	45.3	67.9
M2	-2.67	-88	-10.7	57.0	-2.73	-86.8	-10.8	38.6	57.9
M3	-3.28	-105	-11.3	63.3	-3.29	-104	-11.3	42.1	63.2
MU1	-3.29	-157	-13.2	86.6	-3.28	-156	-13.2	57.8	86.6
MU2	-3.14	-163	-13.7	94.1	-3.19	-161	-13.8	63.1	94.7
MU3	-3.17	-166	-14.1	98.9	-3.16	-166	-14	65.8	98.6
				Critical value at 10%					
	-2.57	-11.2	-2.57	3.78	-3.13	-18.2	-3.13	4.03	5.34

Cointegration tests results

The foregoing unit root tests clearly, suggest that most of the variables are difference stationary (i.e., I(1)). This therefore, warrants the search for a linear combination of the selected non-stationary variables, which is expected to be I(0). The results concerning the nine cointegrating regressions both with and without a deterministic trend are reported in Table 4. The coefficient of determination (R^2) is also reported. Figures in parentheses are test values in presence of a deterministic trend.

The ADF test rejects the null hypothesis of no cointegration only for the relation of M1 with the monetary base (HPM). Based on the PP and the CRDW tests, the null is

Table 4. Test for cointegration

CR*	ADF	PP	CRDW	R^2
MU1 VS CR	2.01	-31.2*	0.49*	0.91
	(-1.90)	(-29.3)*	(0.46)*	(0.94)
MU1 VS HPM	-1.31	-6.31	0.10	0.11
	(-2.00)	(-10.5)	(0.15)	(0.84)
MU2 VS CR	-1.93	-30.92*	0.47*	0.91
	(-1.90)	(-29.5)*	(0.44)*	(0.91)
MU2 VS HPM	-1.31	-6.41	0.11	0.04
	(-12.8)	(-13.8)	(0.18)	(0.88)
MU3 VS CR	-2.35	-33*	0.49*	0.91
	(-3.28)	(-33.8)*	(0.54)*	(0.93)
MU3 VS HPM	-1.39	-7.00	0.12	0.07
	(-2.63)	(-18.3)	(0.25)	(0.94)
CR VS DD	-2.51	-20.8*	0.29	0.82
	(-2.07)	(-20.4)	(0.30)	(0.84)
DD VS RES	-0.66	-1.83	0.04	0.06
	(-12.6)	(-13)	(0.18)	(0.87)
M1 VS MU1	-2.33	-14.9	0.21	0.83
	(-2.09)	(-16.9)	(0.27)	(0.94)
M1 VS HPM	-6.02*	-5.25	0.095	0.47
	(-1.93)	(-9.99)	(0.14)	(0.90)
M1 VS RES	-2.04	-1.93	0.031	0.04
	(-1.87)	(-11.2)	(0.17)	(0.90)
		Critical value at 10%		
	-3.04	-17.1	0.39	
	(-3.50)	(-23.4)		

rejected only for the multiplier in relation with the currency ratio. This suggests the existence of a long run relationship between money supply (M1) and the monetary base, and between the money multiplier (MU1, MU2, or MU3) and the currency ratio. Moreover, the computed R-square suggests that 94 percent (47 percent) of the month to month variability in the multiplier (M1) is explained by the currency ratio (monetary base). Since the cointegration results confirms the evidence for co-movement between money supply and the base and between the multiplier and the currency ratio, it would empirically useful to carry further the analysis on the predictibility of the multiplier and the monetary base and hence the money supply.

Forecasting Analysis

The forecasting analysis of the money supply (M1), the money multiplier (MU1) and the monetary base is carried out using three models: the bassic behavioraal equations model, the Holt-Winters no seasonal model and the ARIMA model. Although other broader definitions of money have been refered to, we conduct the analysis with a M1 definition because it is less complicated and yet provides us with a basic understanding of the money supply process.

The basic monetary behavioral equations

i) The multiplier equation

Based on the conventional money multiplier formula, the multiplier behavioral equation can be expressed as:

$$MU_t = b_0 + b_1 SR_t + b_2 OR_t + b_3 FR_t + b_4 CR_t + U_t \qquad (5)$$

where U_t is the error term with the usual assumptions and the parameter estimates are expected to be all negative (i.e., $b_1, b_2, b_3, b_4 < 0$). The Cochrane-Orcutt procedure yields the following regression equation:

$$MU_t = \underset{(54.3)}{3.044} - \underset{(-5.64)}{2.821} SR_t - \underset{(-14.58)}{1.901} OR_t - \underset{(-10.69)}{2.178} FR_t - \underset{(-15.66)}{0.953} CR_t$$

$$R^2=0.993;\ SEE=0.022;\ DW=2.52;\ F=3831;\ AR(1) = 0.918 \qquad (26.22)$$

Overall, the estimated multiplier equation shows a satisfactory statistical fit. The explanatory power is high; there is no serious autocorrelation problem; and all the parameter estimates appear with the expected sign. The regression results seem to suggest that the statutory reserve ratio influences negatively the size of the multiplier. In other words, a one percent increase in the statutory reserve ratio would , ceteris paribus, lead to a 2.82 percent decrease in the size of the money multiplier. While a one percent increase in the currency ratio would, ceteris paribus, lead to a 0.953 percent decrease in the size of the money multiplier. Therefore, the money multiplier is more responsive to changes in the statutory reserve ratio than to changes in the currency ratio which is generally more influenced by factors outside SAMA's control.This observation seems to be at odds with the preceding descriptive analysis of facts which argues that variations in the money multiplier appear to be determined primarily by variations in the currency ratio. How could this be reconciled remains an empirical open question.

One can speculate and say that since three players are involved in the money game-

SAMA, the depositors, and the banks- it is therefore possible that both SAMA, through its setting of the reserve requirement ratio, and the banks, through their decisions about excess reserves, dominate the influence of the factors that shape depositors' behavior and attitudes towards currency and deposit holding. In other words, this finding may reflect the relative ability of the Saudi monetary authorities to influence the money supply process.

ii) The money supply equation

Starting from the definitional identity of the money supply, that is[5]:

$$M1=MU1.HPM \tag{6}$$

If we total differentiate (6) and divide it by M1, we obtain the following expression:

$$dM1/M1=(MU1/M1).d(HPM) + (HPM/M1).dMU1$$

This equation can be written as:

$$GM1 = GHPM + GMU1 \tag{7}$$

where GM1, GHPM and GMU1 stand as growth rates of M1, HPM and MU1 respectively. Finally GM1 can be regressed against both GHPM and GMU1, that is:

$$GM1_t = a_0 + a_1GHPM_t + a_2GMU1_t + E_t \tag{7'}$$

where E_t is the disturbance term with the usual assumptions; a_1 and a_2 are expected to be positive. The estimated money growth equation is as follows.

$$GM1_t = \underset{}{0.0004} + \underset{(4.30)}{1.002_1}GHPM_t + \underset{(229.2)}{0.997}GMU1_t \quad \underset{(211)}{}$$

$$R2=0.997;\ SEE=0.001;\ DW=2.01;\ F=28672$$

The regression results indicate that growth in monetary base and growth in the multiplier exert a slightly equal influence on money growth. In other words, if either HPM or MU1 grow at one percent, M1 will, ceteris paribus, grow by almost the same rate. This one to one relationship can be an evidence for a first degree homogeneity between M1 growth and the HPM growth, or the multiplier.

Some authors have expressed skepticism about regression models in modeling the money multiplier. Among others, Johannes and Rasche [6] found that time series models of individual money multiplier were more accurate than those produced by other regression

[5]For more details see G. Box and G. Jenkins [29].

methods. In what follows Box-Jemkins models are developed for money supply, the multiplier and the monetary base.

The autoregressive integrated moving average model (ARIMA)

In the section pertaining to integration testing , it has been found that both the money multiplier and the monetary base are I(1) processes. This implies that the trend can be removed from the series after first differencing. The time series properties of these series can be further investigated and a tentative model identified using the so-called Box-Jenkins methodology[6]. The model can be either autoregressive (AR process), or moving average (MA process), or mixed, that is, autoregressive-moving average (ARMA). The identification process is based on the behavior of both the autocorrelation and partial autocorrelation functions.

The general form of an ARIMA model can be written as:

$$(1 - \phi B(p))^{d}X_t = (1 - B(q))U_t$$

where ϕ and B are the parameters of the autoregressive and moving average parts respectively, while p and q are their orders; d is the differencing order. Such a model uses monthly data to estimate the money supply, the monetary base and the money multiplier as a function of their own past lagged values and of the current and past levels of the error term. For model selection the Akaike criterion (ASC) is computed. Detailed results are presented below.

i) The money supply: ARIMA(2,1,2)

The log money supply (LM1) is fitted to follow an ARIMA(2,1,2) process which can be specified as[7]:

$$\underset{(2.65)}{(1- 0.3199B} + \underset{(-7.91)}{0.9144B(2)})\Delta LM1 + \underset{(1.99)}{0.006} = (1 - \underset{(2.43)}{0.378B} + \underset{(-5.48)}{0.849B(2)})Ut$$

$$R^2=0.022;\ \sigma^2=0.00054;\ AIC=-7.45$$

ii) The money multiplier: ARIMA(1,1,1)

The log money multiplier (MU1) is fitted to follow an ARIMA(1,1,1) process which can be specified as:

$$\underset{(-6.25)}{(1 + 0.868B)}\Delta MU1_t = \underset{(-4.17)}{(1 + 0.754B)}U_t$$

$$R^2=0.031;\ \sigma^2=0.003\ AIC=-5.74$$

[6]For a detailed exposition of this methodology refer to W. Vandaele [30].

[7]The numbers in parentheses are t-statistics.

iii) The monetary base: ARIMA(1,1,0)

The monetary base (HPM) is fitted to follow an ARIMA(1,1,0) process which can be specified as

$$(1 + \underset{(-1.958)}{0.167B}) \Delta HPM_t = U_t$$

$$R^2=0.016; \sigma^2=0.0093; \quad AIC=-6.92$$

The Holt-Winters no seasonal model

An alternative model known as the Holt-Winters no Seasonal Model is also used to generate forecasts[8]. This model uses exponential smoothing to estimate an explicit linear trend without seasonal effects. Unlike the other methods, it does not really attempt to model the autocorrelation[9]. It computes recursive estimates of the intercept or permanent component (i.e., γ), and the trend coefficient (i.e., φ). This model is generally formulated as:

$$Y_t = \gamma + \varphi t + \xi_t$$

where Y_t is the dependent variable, t is the time trend, and ξ_t is the error term with the usual assumptions. When applied to money supply, the money multiplier and the monetary base, the parameter estimates are respectively as follows.

i) The money supply

$$\gamma=0.130; \ \varphi=0.030; \ RMSE=0.0256$$

ii) The money multiplier

$$\gamma=0.880; \quad \varphi=0.00; \quad RMSE=0.05597$$

iii) The monetary base

$$\gamma=0.840; \quad \varphi=0.000; \quad RMSE=1651.6$$

Both the money multiplier and the monetary base exhibit some similarities with respect to the parameter estimates. They have a trivial trend coefficient but an equal permanent component. In contrast, money supply appears with a comparatively smaller intercept but a higher trend coefficient.

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[8]For further details on exponential smothing models, the reader may refer to E. Gardner [31].

[9]This technique is computationally simple and when properly chosen it performs well relative to more complicated methods on a wide range of data series.

Forecasting experiments

The foregoing models can be used to generate forecasts for future time periods. Because these models are written in terms of a stationary time series, it is usually converted to the original series before obtaining point or interval forecasts. Out of sample forecasts for the multiplier, the monetary base and themoney supply over the 1995.07-1995.12 period are reported in Tables 5a, 5b, 5c and 5d.

As may be observed from Table 5a , the basic model yields relatively higher forecast values for the multiplier. Unlike the Holt-Winters forecasts which trend up, they exhibit a downtrend. On the other hand, the ARIMA model generates comparatively smaller forecasts. This model seems more suitable for a conservative monetary policy than the others.

Table 5a. Forecasts of the M1 multiplier

	Basic model	ARIMA(1,1,1)	Holt-Winters
1995.07	3.0866	2.18406	2.2933
1995.08	3.0831	2.18336	2.2955
1995.09	3.0799	2.18397	2.2977
1995.10	3.0769	2.18344	2.2999
1995.11	3.0742	2.18390	2.3044
1995.12	3.0717	2.18350	2.3066

Concerning the monetary base, the ARIMA model yields slightly larger forecasts than the Holt-Winters model (see Table 5b). It is however worth observing that both forecasts exhibit an upward trend.

Table 5b. Forecasts of the monetary base

	ARIMA(1,1,1)	Holt-Winters
1995.07	59067.2	58986.9
1995.08	59164.1	59032.9
1995.09	59282.6	59079.0
1995.10	59397.7	59125.1
1995.11	59513.6	59217.3
1995.12	59629.7	59263.4

Table 5c. Forecasts of M1

	Basic model	ARIMA(1,1,1)	Holt-Winters
1995.07	134838	134618.5	134947.4
1995.08	134894.8	134874.5	135104
1995.09	134951.4	134834	135251.3
1995.10	135008.1	135388	135389.4
1995.11	135064.8	136407.2	135518.1
1995.12	135121.5	137036.1	135637.4

As regards M1, the forecasts are rather mixed. Up to 1995.10, the Holt-winters model yields comparatively larger forecasts for money supply (M1). However, in the subsequent months, it is the ARIMA model that produces the largest forecasts, followed by the Holt-Winters model.

When the predicted values of both the money multiplier and the monetary base are used as inputs to generate money supply forecasts, the Holt-Winters M1 forecasts are far larger than those obtained by ARIMA (see Table 5d). This finding corroborates the fact that the ARIMA model can prove to be superior if SAMA's target is to induce a slower growth in the money stock.

Table 5d. M1 forecasts based on forecasts of the multiplier and the monetary base

	ARIMA(1,1,1)	Holt-Winters
1995.07	129006.2	135274.5
1995.08	129176.4	135510.1
1995.09	129471.3	135746.5
1995.10	129691.2	135983.6
1995.11	129971.8	136458.8
1995.12	130201.5	136696.8

At last, we run a simulation experiment based on the basic multiplier model. The purpose of this exercise is to explore the money multiplier responses to a hypothetical disturbance. In other words, what would have happened to the money multiplier had the reserve ratio on demand deposits or the currency ratio recorded an increase by one percent, ceteris paribus.

As shown in Table 6, the reserve ratio shock induces a bigger decrease in the money multiplier, and then in the money supply , than the currency ratio shock. This finding confirms the early observation that the reserve ratio impact on the multiplier outweighs that of the currency ratio.

This simulation experiment suggests that the money multiplier is less sensitive to the

Table 6. Effects of hypothetical disturbances on the multiplier (money supply)

	1% increase in reserve ratio	1% increase in currency ratio
1995.09	3.08203 (182710.5)	3.08596 (182943.9)
1995.10	3.07889 (182878.9)	3.08250 (183093.5)
1995.11	3.07601 (183064.2)	3.07932 (183261.7)
1995.12	3.07336 (183263.5)	3.07641 (183445.2)

currency ratio than to the reserve ratio. Therefore, factors affecting the currency ratio which are, to a larger extent, outside SAMA's control, cannot greatly limit the central bank's abilty to regulate money growth. This finding partly supports the monetarist view that central banks can control the money stock. In fact, one can say that if movements of the money multiplier can be predicted with some accuracy, any control by SAMA over the monetary base can facilitate the control of the money supply. It is therefore important to stabilize the value of the money multiplier, if an effective monetary policy is to be conducted.

Summary and Policy Implications

This paper has examined the money supply process in Saudi Arabia over the 1984.07-1995.06 period. The focus is on the main determinants of the money multiplier rather than the determinants of the monetary base. The methodology draws from both the descriptive analysis and the combination of integration and cointegration tests with regression and time series modeling. The main findings can be summed up as follows:

First, the money multiplier in Saudi Arabia seems to be the mirror image of the currency ratio. Moreover, the cointegration analysis reveals the existence of a long run relationship between them , irrespective of the monetary aggregate definition.

Second, for most of the time, movements in the currency ratio are to a larger extent equally associated with changes in both demand deposits and currency, though lately, they have been more closely associated with changes in demand deposits than with changes in currency.

Third, during the late period, the money growth has been largely ascribed to the monetary base growth than to the multiplier growth.

Finally, the forecasting exercise has reached several useful conclusions. First, the basic model yields relatively higher forecasts for the money multiplier than the Holt-Winters or the ARIMA model. The latter model is however more suitable for a conservative monetary policy than the others. Second, the simulation results based on the basic money multiplier model show that a reserve ratio shock would induce a larger negative effect on the money multiplier and then on to the money stock than a currency ratio shock. This finding may suggest that factors outside SAMA's control that are likely to influence the currency ratio do not greatly limit its ability to manage the money supply process. Thus, the monetarist contention that central banks are able to control the money stock is not that controversial in the Saudi monetary context.

Despite the insights that this study may have provided, it suffers certain caveats. Nonetheless, the topic can be extended or enriched in a number of ways. One possible avenue would be to dig further into the issue of the predictability of the money multiplier

and its implications for money stock control and economic activity by using a dynamic error correction model and testing for structural stability.

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Appendix A: Monetary variables definitions (as defined by SAMA)

M1: Narrow definition of money supply which comprises Currency (C) and Demand Deposits (DD) (in million Saudi riyals).

M2: Broad definition of money supply which equals M1 plus Time Deposits (TD) (in million riyals)

M3: Broader definition of money supply which equals M2 plus Quasi-Money. (in million Saudi riyals)

HPM: High Powered Money or Monetary Base (in million Saudi riyals.)

RES: Reserve money (in million Saudi riyals)

SR: Statutory Reserves to Demand Deposits ratio

FR: Free Reserves to Demand Deposits ratio

CR: Currency to Demand Deposits ratio

OR: Other Reserves to Demand Deposits ratio

العوامل المؤثرة في عرض النقود في المملكة العربية السعودية: دراسة تطبيقية

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ملخص البحث. تستخدم هذه الدراسة أسلوبي التكامل المشترك والتنبؤ لتحليل أهم العوامل المحددة لعملية عرض النقود في المملكة العربية السعودية خلال الفترة الواقعة بين 1984.07 و 1995.06. توحي نتائج هذا البحث بأن مضاعف النقود عبارة عن مرآة لنسبة النقد المتداولة. كما تبين أيضا أن التحركات الطويلة المدى لكل من مضاعف النقود ونسبة النقد المتداول يقودها اتجاه مشترك. وفي معظم الفترة فإن تحركات نسبة النقد المتداولة مرتبطة إلى حد كبير بالتغيرات في كل من الودائع تحت الطلب والنقد المتداول. وفي آخر الفترة الزمنية فإن أغلب نمو عرض النقود يُعزى إلى نمو القاعدة النقدية.

تجربة التنبؤ تكشف أن النموذج الأساسي يولد تقديرات مرتفعة نسبيا لمضاعف النقود كما أنها تبين أيضا أن أي صدمة في نسبة الاحتياط قد تؤدي إلى تأثير سلبي على مضاعف النقود، وبالتالي على عرض النقود، أكبر من الصدمة في نسبة النقد المتداول. ويمكن تفسير هذه النتيجة بأن العوامل التي تكون خارج رقابة مؤسسة النقد العربية السعودية والتي يمكن أن تؤثر في نسبة النقد المتداول لا تحد من قدرة مؤسسة النقد على إدارة عملية عرض النقود. أخيراً يمكن أن نخلص إلى القول بأن رأي النقديين من أن البنك المركزي قادر على متابعة عرض النقود ومراقبتها هو أمر غير قابل للجدل في حالة المملكة العربية السعودية.