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The Endogenous or Exogenous Nature of Money Supply: Case of Iran

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This paper investigates the endogenous money supply hypothesis in Iran. To this end, we attempt to find causality directions between bank credits and money aggregates. Utilizing Diks and Panchenko's (2006) nonparametric Granger causality test for the time series data over the period 2006:04-2018:12 confirms the existence of a significant causality running from bank credits to money aggregates. These results indicate that the money supply in Iran is demand-determined, which is in line with Post-Keynesians' money supply endogenous theory. In this case, following the interest rate targeting rather than the monetary aggregate targeting approach is recommend, and therefore, applying open market operation is necessary.

Keywords: Endogenous Money Supply, Post Keynesian Hypothesis, Nonparametric Econometrics, Granger Causality Test
JEL Classification: C14, C32, E52, E58.

1 Introduction

One of the most critical debates between monetary economists is the nature of the money supply. Determining whether the supply of money is exogenous or endogenous would help central banks set appropriate targets and choose the most effective instruments for designing monetary policies.

In general, economic schools of thought can be divided into two groups of orthodox and heterodox. The first group includes New Classical, New Keynesian and New Consensus economists who believe that money supply is exogenous and under the control of central banks. However, "this was changed with the advent of the New Consensus and the adoption within its macroeconomic model of a central bank reaction function, based on modifications of the target interest rate as is the case with the well-known Taylor rule" (Rahimi, Chu & Lavoie, 2017, P. 883).

In contrast, the second group, containing Post Keynesian economists, argues that money supply is demand-determined and thus endogenous. Based on their endogenous money theory, the supply of money is determined by the

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demand for bank credits, which depends on economic activities. In the Post Keynesian school of economic thought, there are two main branches with different approaches on money supply endogeneity, namely horizontalism and structuralism.

The horizontalist approach is mainly in the spirit of Kaldor (1970) and Weintraub (1978). Some of the most famous exponents of this approach are Moore (1988), Lavoie (1992), and Smithin (1994). Moore (1988) argues that production is a time consuming process. Therefore, firms sometimes need additional funds to finance their working capital. Banks as sellers of credits, adequately accommodate firms' needs at a given interest rate determined by adding a mark-up over the central bank's short-term interest rate. During these operations, banks rely on the role of the central bank as the lender of last resort. As being the lender of last resort, which prevents banks insolvency, the central bank fully accommodates banks' demand for reserves at an exogenous price. This price is the short term interest rate, which is set by the central bank exogenously. Therefore, although central banks cannot control the supply of money, they can set the price of available reserves (Fontana, 2003). In short, horizontalists believe that in response to the demand for bank credit, the central bank has an infinitely elastic reaction function. Hence, according to the horizontalists' view, the supply function of money is horizontal.

In contrast, structuralists by adding liquidity preference to accommodationists maintain that liquidity preferences of households, firms, banks, and the central bank have essential roles in the description of money supply endogeneity. They believe that by supplying loans, the composition and size of banks' portfolios would change, and therefore they do not adequately accommodate the demand for bank credit (Fonatana, 2003). Moreover, they believe that in addition to being the lender of last resort in the money and banking system, acting under some constraints prevents the central bank to completely accommodate the demand for reserves. Thus, the money supply function is not entirely horizontal and has a positive slop (Pollin, 1991). Some of the famous proponents of the structuralist approach are Wray (1990), Pollin (1991), Palley (1996), Sawyer (1996), and Arestis (1997).

To investigate whether the nature of the money supply is exogenous or endogenous, many empirical researchers have applied linear Granger causality tests to investigate the causal relationship between bank credits and money aggregates. The reason, as previously explained, is that neoclassical economists believe that money supply is exogenously determined, and thus, causality runs from money supply to bank credits. In contrast, all Post Keynesians believe that in the creation of money, causality runs from loans to deposits and then to reserves. In this case, while horizontalists believe that causality is mostly moving in one-way (Lavoie, 1984), structuralists maintain that there is a feedback effect, and thus causality is bidirectional.

This study examines the hypothesis of money supply endogeneity in Iran's economy. This paper, by applying a nonparametric Granger causality test, contributes to the literature to find causality directions between bank credits and money aggregates.

The remaining sections of the paper are organized as follows: Section 2 includes a brief review of the previous empirical studies. Section 3 presents the applied empirical methodology and data. A description of empirical analysis and results is reported in section 4. Finally, section 5 concludes the paper by providing conclusions and policy implications.

2 Empirical Literature Review

Within the empirical literature, there is various evidence in favor of the money endogeneity theory. Kaldor (1982) and Moore (1983) were among the earliest economists who attempted to find evidence of money supply endogeneity in the UK and US, respectively. Using US quarterly data from 1965 to 1979, Moore (1983) investigated determinants of difference in total bank borrowing to commercial and industrial corporations. According to his findings, "the money stock varies endogenously, and the single most important determinant appears to be the behavior of money wages. Whenever money wages are rising rapidly, it will prove very difficult for the Federal Reserve to restrict the rate of monetary growth" (Moore, 1983, P. 555).

Moreover, an empirical study by Panagopoulos and Spiliotis (1998) investigated the lending behavior of commercial banks in Greece for the period of 1971-1993. Using cointegration and VECM approaches in the context of a time series analysis, in addition to applying a Granger causality test, showed that credit money was endogenously determined by the response of the banking system to the demand for loans. With the same approach, Howells and Hussein (1998) found evidence of money endogeneity for G7 economies.

Vera (2001) revealed that in Spain, throughout 1987-1998, the money supply was credit-driven and demand-determined. In this study, the Granger causality test results showed that the causality effect ran predominantly from bank lending to money base and money supply and not in the opposite direction.

Applying time series procedures and estimating an ARDL model, Nell (2000) concluded that the money supply was endogenously determined in

South-Africa for 1966-1997. The results of this research revealed consistency with the Post Keynesian hypothesis, i.e., "loans make deposits, and the decision to borrow is made by credit-worthy borrowers, not the banks or the central bank" (Nell, 2000, P. 325). Moreover, Shanmugam, Nair, and Li (2003) found the same evidence in Malaysia throughout the 1985-2000.

Using a standard Granger causality test, Ahmad and Ahmed (2006) investigated money supply endogeneity in Pakistan for 1980-2003. This study demonstrated that in the short-run, the supply of money in Pakistan was endogenous. However, in the long-run (a period exceeding twenty-four months), the base money determined total bank advances.

Tas and Togay (2012) used data from GCC countries[1]. By employing the IV methodology, this study demonstrated that money was significantly endogenous in all GCC countries. Then, using Granger causality tests revealed that money was not endogenous in Bahrain and Kuwait, but endogenous in other GCC countries.

Nayan, Kadir, Abdullah, and Ahmad (2013) employed dynamic panel data analysis and used a panel dataset of 177 countries for 1970-2011 to show that the money supply was endogenous.

Haghighat (2011) applied cointegration and causality tests for the annual time series data (1968 to 2009) of Iran and found consistent evidence with the Post Keynesian hypothesis on money supply endogeneity. Using the same approach applied to monthly data (2006:1 to 2015:5), Cepni and Guney (2017) provided evidence that the money supply in Turkey was endogenous.

All the above-mentioned empirical studies, which intended to test the money supply endogeneity hypothesis, employed linear Granger causality tests. While, as discussed by Baek and Brock (1992), nonlinear causal effects cannot be detected by standard linear Granger causality tests. Therefore, to overcome this shortcoming and find more precise results, this paper applies a nonparametric test proposed by Diks and Panchenko (2006) to examine Granger causality between bank credits and money aggregates.

3 Empirical Methodology and Data

It is widespread to apply vector autoregressive models to find linear Granger causality effects. These parametric methods, which are based on distributions of the first moments of variables, are not able to find Granger causality effects

[1] GCC (Gulf Cooperation Council) includes Bahrain, Kuwait, Qatar, Saudi Arabia and the United Arab Emirates.

in higher moments. Moreover, the results of linear Granger causality tests depend on model specifications. Therefore, using these methods is accompanied by a risk of model misspecification.[1]

Non-parametric Granger causality tests have been introduced to the literature to address these limitations. One of the most famous nonparametric tests has been proposed by Hiemstra and Jones (1994). However, according to Dicks and Panchenco (2005), this test suffers from over-rejection of the null hypothesis of non-causality. This problem was modified in a nonparametric test statistic introduced by Diks and Panchenko (2006). To detect Granger causality direction effects, this paper employs Diks and Panchenko's (DP) (2006) nonparametric approach. The next subsections provide a definition of Granger causality, followed by a brief explanation of the DP nonparametric Granger causality test.

3.1 Granger Causality Definition

The causality test concept was first proposed by Granger (1969). To gain an intuitive understanding of Granger's causality test, consider a strictly stationary bivariate stochastic time series process $\{X_t , Y_t\}$. It can be stated that $\{X_t\}$ Granger causes $\{Y_t\}$ if the current and previous values of $\{X_t\}$ contain additional information that can change the prediction of $\{Y_t\}$ based on only its historical value.

In a general definition of Granger causality, again consider a strictly stationary bivariate process $\{X_t , Y_t\}$, where $\{X_t\}$ is a Granger cause of $\{Y_t\}$ for $m \geq 1$:

$$(Y_{t+1}, \dots , Y_{t+m})|\left(\varphi_{X,t} , \varphi_{Y,t}\right) \sim (Y_{t+1}, \dots , Y_{t+m})|(\varphi_{Y,t}) \quad (1)$$

where $\varphi_{X,t}$ and $\varphi_{Y,t}$ contain the information of the current and previous values of X_t and Y_t, respectively, and $\sim$ indicates equivalence in distribution.[2]

3.2 Diks and Panchenko's (DP) Nonparametric Granger Causality Test

Consider two stationary time series X_t and Y_t. Moreover, consider $X_t^{l_x} = (X_{t-l_x-1}, \dots , X_t)$ and $Y_t^{l_y} = (Y_{t-l_y-1}, \dots , Y_t)$ for $l_x ,\ l_y \geq 1$.

By applying $m = 1$ to equation (1), the following null hypothesis, indicating that X_t does not Granger cause Y_t, is achieved:

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[1] Diks and Fang (2017)

[2] Diks and Panchenko (2006)

$$H_0 : Y_{t+1} \left| \left(X_t^{l_x};\ Y_t^{l_y} \right) \sim Y_{t+1} \right| Y_t^{l_y} \quad (2)$$

This hypothesis indicates that the distribution of $(l_x + l_y + 1)$ dimensional vector $K_t = (X_t^{l_x}, Y_t^{l_y}, Z_t)$, where $Z_t = Y_{t+1}$, is invariant. To keep it simple and compact, consider $l_x = l_y = 1$ and remove time indexes. Then, under the null hypothesis, we obtain the following relationship between joint and marginal probability density functions:

$$\frac{f_{X,Y,Z}(x,y,z)}{f_Y(y)} = \frac{f_{X,Y}(x,y)}{f_Y(y)} \cdot \frac{f_{Y,Z}(y,z)}{f_Y(y)} \quad (3)$$

According to Diks and Panchenko (2006), the null hypothesis can be re-expressed as:

$$q = E\left[f_{X,Y,Z}(x,y,z) f_Y(y) - f_{X,Y}(x,y) f_{Y,Z}(y,z)\right] = 0 \quad (4)$$

Consider $\hat{f}_K(K_i)$ as the local density estimator of K_i such that:

$$\hat{f}_K(K_i) = (2e)^{-d_k}(n-1)^{-1} \sum_{i,j \neq i} I_{ij}^K$$

where $I_{ij}^K = I(\|K_i - K_j\| \leq e\ )$ is an indicator function, which is one if $\|K_i - K_j\| \leq e$ and zero otherwise, and $\|k\|$ is the supremum norm.[1] Moreover, e is the bandwidth such that $= Cn^{-\beta}\ C > 0,\ \frac{1}{4} < \beta < \frac{1}{3}$. Accordingly, we have the following test statistic:

$$T_n(e) = \frac{n-1}{n(n-2)} \sum_i (\hat{f}_{X,Y,Z}(X_i\ Y_i, Z_i) \hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i) \hat{f}_{Y,Z}(Y_i, Z_i)) \quad (5)$$

According to Diks and Panchenko (2006), the above-mentioned test statistic satisfies the following:

$$\sqrt{n}\ \frac{(T_n(e) - q)}{S_n} \xrightarrow{D} N(0,1) \quad (6)$$

where q and S_n are the estimators of asymptotic expectation and standard error, respectively.

[1] For more details, see Diks and Panchenko (2006).

3.3 Data
This paper aims to investigate the causality relationship between bank credits (BC) with money base (MB), money (M1), and liquidity (M2) as representatives of money aggregates in Iran. We use seasonally adjusted monthly data, and the sample includes 156 observations from April 2006 to December 2018. These data are taken from the central bank of Iran's time-series database.[1]

4 Empirical Analysis and Results

4.1 Unit Root Test
As mentioned in section 3, the DP nonparametric test statistic is designed to test Granger causality between two strictly stationary time series. Therefore, before using this test, we apply a unit root test to determine whether our data are stationary. The results of the augmented Dickey-Fuller (ADF) unit root test[2] are presented in Table 1.

Table 1
Results of Unit Root Test

	ADF		
Variable	Intercept	Intercept and Trend	No intercept and No trend
BC	-3.08**	-2.94	14.84
MB	-1.76	-3.06	6.10
M1	0.36	-3.17***	1.86
M2	-0.76	-2.39	16.57

Note: All variables are converted to the natural logarithmic form. The null hypothesis is that the series has a unit root. ** and *** denote that the null hypothesis is rejected at the 5% and 10% significance levels, respectively. *Source:* Research Findings.

As can be observed, the null hypothesis of the unit root existence cannot be rejected in most cases. The graphs of variables, which are presented in Figure 1, show that in our time series variables, there exists a trend and also a pattern of seasonality. The seasonal treatment is due to the end of the Persian calendar year, which is in March.

[1] https://www.cbi.ir/page/8020.aspx
[2] See Dickey and Fuller (1979)

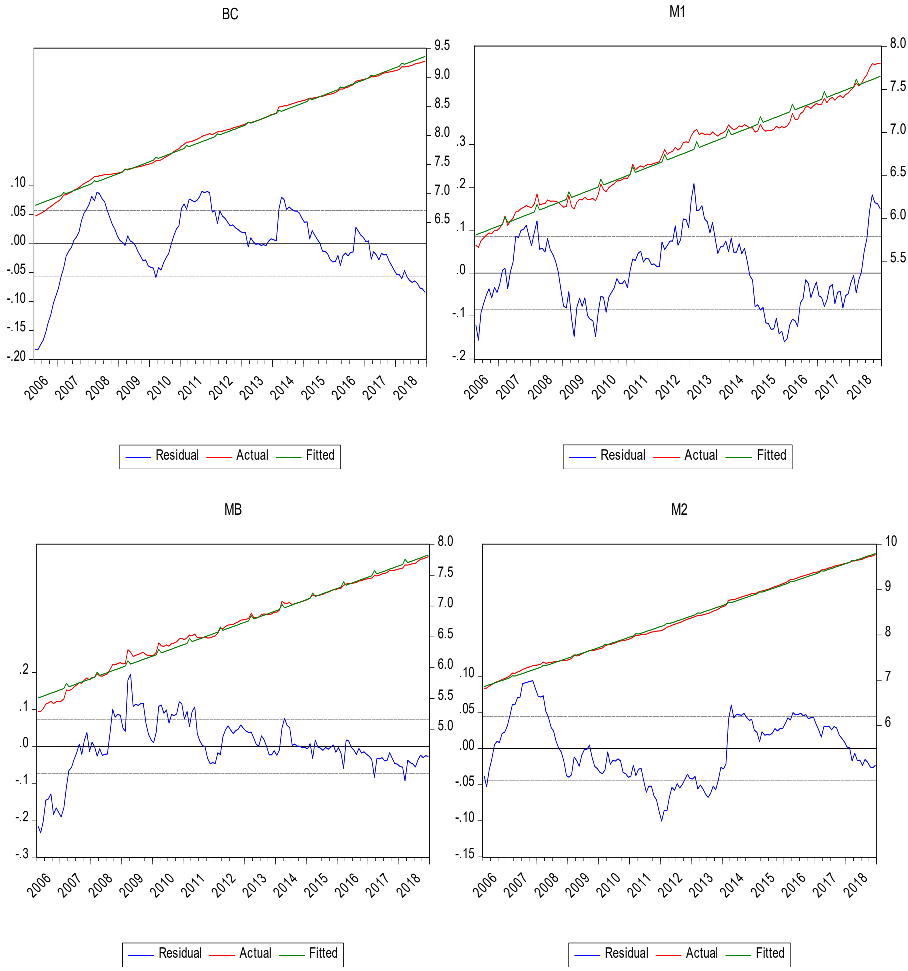

Figure 1. Actual, Fitted and Residual Graphs of the Variables. *Source:* Research Findings.

To remove the trend and seasonality pattern, we regress all the variables on the time trend and use a dummy variable related to March of each year. All the equations also include an intercept. The results of the OLS estimation are presented in Table 2.

Table 2
Regressions Results

	OLS Regression Results		
Dependent Variable	Constant	Trend	Dummy
BC	6.78	0.02	0.03
	(721.33)*	(161.22)*	(1.94)***
MB	5.49	0.02	0.07
	(457.59)*	(114.13)*	(3.15)*
M1	5.79	0.01	0.08
	(413.04)*	(77.65)*	(3.00)*
M2	6.84	0.02	0.02
	(946.45)*	(240.08)*	(1.90)***

Note: The values in parenthesis are t-statistics of the estimated coefficients. * and *** denote the significance levels of 1% and 10%, respectively. *Source:* Research Findings.

As it can be observed, the estimated coefficients are significant in all the equations. After eliminating the intercept, trend, and seasonal effects from our time series variables, the ADF unit root test is applied. The results of this test, which are reported in Table 3, show that all the variables are now stationary.

Table 3
Results of Unit Root Test

	ADF
Dependent Variable	No intercept and No trend
BC	-2.94*
MB	-3.45*
M1	-2.00**
M2	-1.96**

Note: The null hypothesis is that the series has a unit root. * and ** denote that the null hypothesis is rejected at the 1% and 5% significance levels, respectively. *Source:* Research Findings.

4.2 Diks and Panchenko's (DP) Nonparametric Granger Causality Test Results

In applying the DP nonparametric Granger causality test for any two time-series, their lag lengths are assumed to be equal to each other.[1] In other words, for any two X and Y time series, we set $l_x = l_y$. To ensure the robustness of the test results, we conduct the test for the lag length of 1 to 12. The bandwidth

[1] Hiemstra and Kramer (1997)

length of the test is set to $e = 1\sigma$.[1] The variables are standardized before performing the analysis and thus for all the series, $\sigma = 1$.[2]

The results of the DP nonparametric Granger causality test, t-statistic, and the related probability value for each lag length are reported in Tables 4 to 6.

The reported results in Table 4 show that for most lags, the null hypothesis "BC does not cause MB" is rejected at a 5 percent significance level. However, the null hypothesis "MB does not cause BC" cannot be rejected in all lags, even at the 10 percent significance level. Therefore, the results indicate that there is a one-way Granger causality from BC to MB.

Moreover, the results in Tables 5 and 6 exhibit that for most lags, there is a significant two-way Granger causality between BC and M1 and also between BC and M2, at least at a 10 percent significance level.

Table 4

Results of DP Granger Causality Test

H0: BC does not cause MB		H0: MB does not cause BC		
t-statistic	P- Value	t-statistic	P- Value	Lx=Ly
0.85	0.20	-0.04	0.51	1
1.07	0.14	0.02	0.49	2
1.35	0.09***	-0.30	0.62	3
1.63	0.05**	-0.41	0.66	4
1.82	0.03**	-0.25	0.60	5
1.76	0.04**	0.14	0.44	6
2.10	0.02**	0.35	0.36	7
1.88	0.03**	0.77	0.22	8
2.06	0.02**	0.68	0.25	9
2.04	0.02**	1.11	0.13	10
1.94	0.03**	1.01	0.16	11
1.78	0.04**	0.88	0.19	12

Note: *, ** and *** denote the significance levels of 1%, 5% and 10%, respectively. *Source:* Research Findings.

[1] For checking the robustness of the results, we chose another bandwidth length of the test $e = 1.5\sigma$, and the causality test results did not change significantly compared to when $e = 1\sigma$.

[2] To conduct the DP nonparametric Granger test, Panchenko's C++ computer codes were used.

Table 5
Results of DP Granger Causality Test

H0: BC does not cause M1		H0: M1 does not cause BC		
t-statistic	P- Value	t-statistic	P- Value	Lx=Ly
1.04	0.15	3.00	0.00*	1
0.98	0.16	2.65	0.00*	2
1.08	0.14	2.03	0.02**	3
1.49	0.07***	1.90	0.03**	4
1.51	0.07***	1.95	0.03**	5
2.05	0.02**	2.14	0.02**	6
1.95	0.03**	1.87	0.03**	7
1.61	0.05**	1.64	0.05**	8
1.60	0.05**	1.92	0.03**	9
2.10	0.02**	2.04	0.02**	10
2.42	0.01*	1.90	0.03**	11
2.36	0.01*	1.83	0.03**	12

Note: *, ** and *** denote the significance levels of 1%, 5% and 10%, respectively. *Source:* Research Findings.

Table 6
Results of DP Granger Causality Test

H0: BC does not cause M2		H0: M2 does not cause BC		
t-statistic	P- Value	t-statistic	P- Value	Lx=Ly
-0.07	0.53	1.82	0.03**	1
1.12	0.13	2.08	0.02**	2
1.82	0.03**	1.77	0.04**	3
2.13	0.02**	1.59	0.06***	4
2.16	0.02**	1.97	0.02**	5
2.13	0.02**	2.05	0.02**	6
2.06	0.02**	2.25	0.01*	7
1.69	0.05**	2.22	0.01*	8
1.77	0.04**	2.03	0.02**	9
1.58	0.06***	1.84	0.03**	10
1.61	0.05**	1.91	0.03**	11
1.44	0.08***	1.78	0.04**	12

Note: *, ** and *** denote the significance levels of 1%, 5% and 10%, respectively. *Source:* Research Findings.

5 Conclusions

This study examined money supply endogeneity in Iran from April 2006 to March 2019. The results of the nonparametric Granger causality test showed that bank credits significantly caused money aggregates. In other words, for the examined period, the money supply in Iran was demand-determined and therefore was endogenous. These findings support the Post-Keynesians' money supply endogenous theory. While finding a unidirectional Granger causality from bank credits to money base is consistent with horizontalists' viewpoints, the existence of bidirectional Granger causality between bank credits and the M1 and M2 variables is in line with structuralists' claims.

When the money supply is endogenous, fluctuations of money aggregates are not under the control of the central bank. In this case, money aggregates targeting is not a practical approach to implement monetary policies. Instead, as mentioned by Moore (1983, P. 555), "central banks can determine the short-term interest rate at which they will be willing to supply liquidity." In other words, following the interest rate targeting approach by monetary authorities and, therefore, applying open market operation is recommended.

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