The New Keynesian model of monetary policy predicts no role of monetary aggregates; that is, the quantity of money is not a determinant of the equilibrium levels of output, prices, and interest rates. Recently, Favara and Giordani (2009) evaluated the empirical validity of this prediction by estimating the effects of monetary shocks on other macroeconomic variables using a vector autoregression (VAR) analysis. Their empirical results provide evidence against the New Keynesian monetary model. In this paper, we apply their estimation method to the data from South Korea. Differently from theirs, our empirical results indicate that monetary shocks have little predictive power for output, price, and interest rate, as the New Keynesian models predict. This finding suggests that the role of money may be country-specific.

**Key Words:** New Keynesian, Money, VAR.

**JEL Classification:** E12, E52
I. Introduction

The New Keynesian monetary models (e.g., Clarida, Gali, and Gertler (1999) and Woodford (2003)) predict no role of money stock on the equilibrium level of output, prices, and interest rates. In the New Keynesian monetary models, the monetary authority sets the interest rate and supplies any quantity of money demanded by the market at that interest rate. A shift in money demand is perfectly accommodated so that money stock has no effect on the macroeconomic variables. Thus, for the New Keynesian models, it is irrelevant to specify a traditional money demand (LM) equation.

However, empirical studies have provided at best conflicting results. One group of the empirical studies, analyzing data from the United States, United Kingdom, and Germany, has provided evidence that there is no close or reliable relationship between money and non-financial economic activities (see, for example, Friedman and Kuttner (1992), Estrella and Mishkin (1997), Rudebusch and Svensson (2002), and Ireland (2004)). These studies' results are consistent with the prediction of the New Keynesian models. In contrast, the other group of studies provides evidence against the prediction. Examples of these studies are Stock and Watson (1989), Feldstein and Stock (1993), and Nelson (2002). Leeper and Zha (2000) and Leeper and Roush (2003) also find that exclusion of money from the New Keynesian model is empirically not trivial; that is, the estimated effects of money on output and inflation crucially depend on the way money enters the empirical model. More recently, Favara and Giordani (2009) examined the role of money by analyzing U.S. macroeconomic data from 1966:1 to 2001:3 by a VAR approach. They found that monetary shocks significantly affect other economic variables.

The motivation of this paper is to investigate the role of money in the Korean economy. To do so, we apply the methodology of Favara and Giordani (2009) to the macroeconomic data from South Korea. Money may play different roles in the United States and Korea because the economic structures of the two countries are very different.

This paper is organized as follows. Section 2 briefly explains the
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empirical model of Favara and Giordani (2009). Section 3 explains the data we use for this paper. Section 4 reports our estimation results and compares them with the findings of Favara and Giordani (2009). Some concluding remarks follow in Section 5.

II. Model

Favara and Giordani (2009, FG) import their model from Clarida, Gail, and Gertler (1999) and Woodford (2003). The model consists of three key equations: aggregate supply (AS), aggregate demand (AD), and the decision rule (Taylor rule) for interest rate. These three equations are respectively given by

\[ \pi_t = \beta_\pi E_t (\pi_{t+1}) + \beta_x x_t + \varepsilon_t^\pi \]  
\[ x_t = E_t (x_{t+1}) - \sigma_x (i_t - E_t (\pi_{t+1})) + \varepsilon_t^d \]  
\[ i_t = \theta_\pi \pi_t + \theta_x x_t + \varepsilon_t^\rho \]

where \( x_t = y_t - y_t^n \) is output gap, \( y_t \) and \( y_t^n \) are the logarithms of output and potential output, respectively, \( \pi_t \) is the inflation rate between the two time periods, \( t - 1 \) and \( t \), \( i_t \) is the short-term nominal interest rate that the central bank uses as a policy instrument, \( E_t (\cdot) \) is the expectation operator conditional on the information available up to time \( t \), \( \beta_\pi, \beta_x, \sigma_x, \theta_\pi \), and \( \theta_x \) are structural parameters, and \( \varepsilon_t^\pi, \varepsilon_t^d, \) and \( \varepsilon_t^\rho \) are exogenous disturbances interpretable as unobservable determinants of inflation, output gap, and interest rate. The three equations, (1) - (3), determine the time paths of three endogenous variables \( \pi_t, x_t, \) and \( i_t \). The fourth endogenous variable, \( y_t \), is determined by the identity \( x_t = y_t - y_t^n \).

Following FG (2009), we assume that the potential output \( y_t^n \) is exogenously determined. Thus, given the time path of \( x_t \) determined by the three equations and the exogenously given time path of \( y_t^n \), we can also
determine the time path of \( y_t \).

FG (2009) add to the above three equations the following LM equation:

\[
m_t = \gamma_y y_t - \gamma_i i_t + \epsilon_t^{lm}
\]  

(4)

where \( m_t \) is the logarithm of money stock, \( \gamma_y \) and \( \gamma_i \) are positive parameters, and \( \epsilon_t^{lm} \) is a disturbance, which may be correlated with the other exogenous disturbances, \( \epsilon_t^s, \epsilon_t^d, \) and \( \epsilon_t^p \). Given \( y_t, i_t, \) and \( \epsilon_t^{lm} \), the central bank adjusts money stock according to equation (4). In the economy described in equations (1) - (4), the monetary authority determines the target interest rate by equation (3) and accommodates a positive (negative) monetary shock \( \epsilon_t^{lm} \) through passive expansion (contraction) of the money supply by equation (4). Thus, the equilibrium levels of output, inflation, and interest rates should not be affected by the monetary shock \( \epsilon_t^{lm} \).

Following FG (2009), we assume that the vector of the exogenous shocks, \( \epsilon_t = (y_t^n, \epsilon_t^s, \epsilon_t^d, \epsilon_t^p, \epsilon_t^{lm})' \), follows a VAR(1) process:

\[
\epsilon_t = \Lambda \epsilon_{t-1} + \nu_t
\]  

(5)

where \( \epsilon_o \) is exogenously given, \( \Lambda = [\lambda_{ij}]_{5 \times 5} \), and \( \nu_t = (\nu_t^n, \nu_t^s, \nu_t^d, \nu_t^p, \nu_t^{lm})' \) is a vector of orthogonal innovations with a diagonal variance-covariance matrix, \( \Sigma = \text{diag}(\sigma_n^2, \sigma_s^2, \sigma_d^2, \sigma_p^2, \sigma_{lm}^2) \), independently and identically distributed over time. The assumption of passive money supply implies that \( \lambda_{15} = \lambda_{25} = \lambda_{35} = \lambda_{45} = 0 \) because \( \nu_t^{lm} \) does not affect the first four elements of \( \nu_t \). These restrictions allow us to identify the effects of monetary shocks \( \epsilon_t^{lm} \) on the observed economic variables \( Z_t = (y_t^n, y_t, \pi_t, i_t, m_t)' \).

The dynamic path of \( Z_t \) can be obtained as follows. Let \( h_t = (y_t, \pi_t)' \). Then, equations (3) and (4) imply, respectively,
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\[ i_t = \theta'_1 h_t + \theta'_2 e_t \quad (6) \]

\[ m_t = \gamma'_1 h_t + \gamma'_2 e_t \quad (7) \]

where \( \theta_1 = (\theta_x, \theta_\pi)' \), \( \theta_2 = (-\theta_x, 0, 0, 1, 0)' \), \( \gamma_1 = (\gamma_y - \gamma_i \theta_x, -\gamma_i \theta_\pi)' \), and \( \gamma_2 = (\gamma_i \theta_x, 0, 0, -\gamma_i, 1)' \). Equations (1), (2), and (6) imply

\[ E_t (h_t + 1) = A^{-1} B h_t + A^{-1} C e_t \quad (8) \]

where

\[
A = \begin{pmatrix}
0 - \beta_\pi \\
-1 - \sigma_x
\end{pmatrix};
B = \begin{pmatrix}
\beta_x \\
-1 - \sigma_x \theta_x - \sigma_x \theta_\pi
\end{pmatrix}
\]

\[
C = \begin{pmatrix}
-\beta_x \\
(1 - \lambda_{11}) + \sigma_x \theta_x & 1 - \lambda_{12} & 0 & 0 & 0
\end{pmatrix}
\]

because

\[ E_t (x_{t+1}) = E_t (y_{t+1}) - E_t (y^a_{t+1}) = E_t (y_{t+1}) - \lambda_{11} y^a_t - \lambda_{12} e^a_t - \lambda_{13} e^d_t - \lambda_{14} e^p_t \]

by (5) and the assumption of passive money supply \( \lambda_{15} = \lambda_{25} = \lambda_{35} = \lambda_{45} = 0 \).

Observe that the entries of the last column of matrix \( C \) are all zero. This means that the solution of \( h_t \) from (8) does not depend on \( e_t^m \). Following Klein (2000), we can show that the solution of the dynamic process of (7) is

\[ h_t = \Xi e_t \quad (9) \]

where \( \Xi = [\xi_{ij}]_{2 \times 5} \) is a parameter matrix whose entries are the functions of the structural parameters appearing in equations (1) - (5). Since \( h_t \) does not depend on \( e_t^m \), it should be the case that \( \xi_{15} = \xi_{25} = 0 \).

Equations (5) - (7) and (9) indicate that the dynamic paths of the observed economic variables in \( Z_t \) obtained from (5) - (9) and (9) can be expressed in a single equation:
where

\[ Z_t = \Psi e_t \]  \hspace{1cm} (10) \]

\[ \Psi = [\psi_{ij}]_{5 \times 5} = \begin{pmatrix} \Lambda_1 \\ \Xi \\ \theta_1' \Xi + \theta_2' \\ \gamma_1' \Xi + \gamma_2' \end{pmatrix} \]  \hspace{1cm} (11) \]

It is important to note that \( \psi_{i5} = 0 \) for \( i = 1, 2, 3, 4 \). That is, if the economy can be described by the four equations (1) - (4), the monetary shock \( \epsilon_t^m \) does not influence the economic variables other than money stock \( m_t \).

Finally, equations (10) and (5) together imply that \( Z_t \) follows a VAR(1) process:

\[ Z_t = \Phi Z_{t-1} + u_t, \]  \hspace{1cm} (12) \]

where \( \Phi = [\phi_{ij}]_{5 \times 5} = \Psi \Lambda \Psi^{-1} \), \( u_t = \Psi \nu_t \), and \( \text{Var}(u_t) \equiv \Omega = \Psi \Sigma \Psi' \).

This VAR system has the following properties if the economy is driven by the four equations (1) - (4). First, because of the restrictions, \( \psi_{15} = \psi_{25} = \psi_{35} = \psi_{45} = 0 \), one can identify the idiosyncratic innovation to the LM equation \( \nu_t^m \) by a Cholesky decomposition of \( \Omega \). Second, the restrictions on \( \Psi \) also imply that \( \phi_{15} = \phi_{25} = \phi_{35} = \phi_{45} = 0 \). FG (2009) show that when these restrictions are imposed on \( \Phi \), the impulse response functions of all variables in \( Z_t \) other than \( m_t \) to \( \nu_t^m \) are zero. By these properties, the relevance of the New Keynesian prediction on the role of money can be tested by estimating the impulse response functions from the VAR(1) model (12).
Ⅲ. Data

We use the macroeconomic data available from Statistics Korea. Five time series variables are obtained for the time period from 1987:1 to 2009:4: real GDP, Capacity Utilization in Manufacturing Sector, Consumer Price Index, and M2. They are used to measure the logarithms of output (RGDP), output gap (CAPACITY), price level (CPI), and nominal money stock (M2), respectively. The key interest rate that the Bank of Korea uses for its monetary policy is the call rate, at which the central bank buys and sells short-term government securities. Thus, we use the call rate (IRATE) as an alternative to the federal fund rate used in FG (2009) as monetary policy instrument. Unfortunately, the available time series of IRATE starts from the first quarter of the year 1987, while those of other variables begin in 1966. Thus, our empirical analysis is conducted using data starting from 1987:1.

Macroeconomic variables are often nonstationary, so, we use the augmented Dickey-Fuller (1981) test to check if each of the five variables (RGDP, CAPACITY, CPI, IRATE, and M2) contains unit root. The test results are reported in Table 1. Only the output gap is found to be stationary. For all other variables, we are unable to reject the null hypothesis of unit root. VAR estimators are consistent even if nonstationary variables are used, but they may not be asymptotically normal. FG (2009) do not provide unit root test results for their data. They simply ignore the possible nonstationarity of the variables in the US data. To compare our results with their results, we first estimate the dynamics of the variables in level by a VAR(1). Then, as a sensitivity analysis, we estimate the same VAR(1) model with differenced data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>RGDP</th>
<th>CAPACITY</th>
<th>CPI</th>
<th>IRATE</th>
<th>M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.747</td>
<td>0.001</td>
<td>0.722</td>
<td>0.884</td>
<td>0.645</td>
</tr>
</tbody>
</table>

Note: All variables, except interest rate, are logged
Ⅳ. Estimation Results and Discussion

Analyzing the US data by a VAR(1), FG (2009) find that the responses to a monetary shock of output (RGDP), output gap (CAPACITY), price (CPI), and the federal fund rate (FFR) are significantly different from zero for several quarters. All of the four variables, RGDP, CAPACITY, CPI and FFR, react to monetary shocks strongly and persistently. Notably, the responses of FFR are positive after a shock. It appears that the US monetary authority increases the fund rate to suppress inflation and over-production.

We fit the VAR(1) model of FG (2009) to the data from South Korea replacing FFR by IRATE. Figure 1 reports the estimated impulse response functions of CAPACITY, IRATE, RGDP, and CPI to a monetary shock. The results are strikingly different from what FG (2009) found from the US data. In all of the cases reported in Figure 1, the 95% confidence intervals of impulse responses contain zero, indicating that none of the four variables, CAPACITY, IRATE, RGDP, and CPI, significantly reacts to unexpected monetary shocks.

<Figure 1> Impulse Responses with 95% Error Bands From Korean Data (1987 ~ 2009)
The VAR(1) estimation results reported in Figure 1 might be the contaminated ones if a structural change had happened in the Korean economy during the sample period. In particular, there are some reasons why the year of 1997 may have been a turning point for the Korean economy. The East Asian financial crisis occurred in 1997 and the IMF bailout programs required the Korean government to undertake large-scale reformatory policies for the financial and money markets. The Bank of Korea was not an exception. The Bank had quite limited authority to implement independent monetary policies until the year of 1997. For example, prior to 1997, the Monetary Policy Committee had been chaired by the Secretary of the Treasury. In contrast, under the Bank of Korea Law revised in December, 1997, the President of the Bank of Korea chairs the committee, although the Treasury Secretary still can assign a member to the committee. The government keeps a rein on monetary policies, but the Bank now has a stronger monetary authority, at least legally, than it used to have until 1997. The Bank’s policy rule also has been changed. From 1979 to 1997, the core of the Korean monetary policies
had been the reserves targeting approach: The Bank set annually a target growth rate of M2 and managed its policy instruments to maintain the target rate. Thus, the Taylor rule (equation (3)) might not be a reasonable description for the Korean economy before 1997. However, the revised Bank of Korea Law explicitly requires that the Bank’s monetary policies should be orchestrated by inflation targeting. These institutional changes might have altered the role of money for the Korean economy.

The 1997 crisis also appears to have had a widespread effect on Korean firms' investment decisions. Since 1997, firms have accumulated a large amount of cash in their vaults, effectively reducing their investments. For example, the data from Statistics Korea show that the average total rate of domestic investment is 36.1% from 1987 to 1997, while it is 29.1% from 1998 to 2009. Since the year of 1997, the drop in domestic investment may have absorbed any positive monetary shock without increasing output production or the inflation rate.

<Figure 3> Impulse Responses with 95% Error Bands from Korean Data (1987 ~ 1997)
In order to control for the effects of the possible structural change, we estimate the same VAR(1) model but for two separate periods, from 1998 to 2009 and from 1987 to 1997. The estimations results for these two time periods are reported in Figures 2 and 3, respectively. Similarly to Figure 1, Figure 2 shows that the effect of monetary shock is not significant on output gap, price, and interest during the time period after 1997. Monetary shock has somewhat significant short-run effects (1 or 2 quarters) on RGDP, but its longer-run effects (longer than 2 quarters) are insignificant. Figure 3 reveals evidence that before 1997, CPI responds significantly and positively to monetary shocks. It appears from Figure 3 that before 1887, a positive monetary shock could significantly increase the level of CPI even after 16 quarters (4 years). However, the figure also shows that even before 1997, monetary shocks had little effect on RGDP, CAPACITY, and IRATE.

Overall, the results reported in Figures 1 - 3 are quite different from what FG (2009) found from the US data. The Korean data provide evidence that CPI used to significantly respond to unexpected monetary shocks at least until 1997. However, after 1997 CPI became non-responsive to monetary shocks. There is no strong evidence that output (RGDP), output gap, and interest rate have been significantly responsive to monetary shocks. These results indicate that the role of money in the Korean economy is consistent with the prediction of the New Keynesian models.

<Table 2> Estimated Coefficients of Lagged M2 in VAR(1) and Significance Tests

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coefficient (s.e.)</td>
<td>t-statistic (p-value)</td>
<td>coefficient (s.e.)</td>
<td>t-statistic (p-value)</td>
<td>coefficient (s.e.)</td>
<td>t-statistic (p-value)</td>
</tr>
<tr>
<td>GDPGAP</td>
<td>-0.014 (0.041)</td>
<td>-0.345 (0.732)</td>
<td>-0.123 (0.079)</td>
<td>-1.549 (0.129)</td>
<td>0.012 (0.083)</td>
<td>1.475 (0.147)</td>
</tr>
<tr>
<td>IRATE</td>
<td>0.006 (0.016)</td>
<td>0.337 (0.738)</td>
<td>-0.011 (0.053)</td>
<td>0.831 (0.411)</td>
<td>0.009 (0.030)</td>
<td>0.307 (0.760)</td>
</tr>
<tr>
<td>RGDP</td>
<td>0.031 (0.030)</td>
<td>1.07 (0.291)</td>
<td>0.05 (0.068)</td>
<td>0.457 (0.650)</td>
<td>0.131 (0.059)</td>
<td>2.234 (0.030)</td>
</tr>
<tr>
<td>CPI</td>
<td>0.0045 (0.006)</td>
<td>0.705 (0.480)</td>
<td>0.0489 (0.015)</td>
<td>3.202 (0.005)</td>
<td>-0.012 (0.014)</td>
<td>-0.891 (0.378)</td>
</tr>
</tbody>
</table>
An alternative way to test whether money has a predictive power for other economic variables to check the statistical significance of the estimated coefficients of lagged M2 in each of the four equations other than the money equation in the VAR(1) model. Table 2 reports the estimated coefficients in each equation and the t-test results from three different time periods. Observe that the coefficient is statistically significant only in the CPI equation for the time period from 1987 to 1997. This result is consistent with our finding from the analysis of the estimated impulse response functions.

So far, we have discussed the results from the VAR(1) analysis with level data. However, the unit-root tests reported in section 3 indicate that the four variables, IRATE, RGDP and CPI and M2, are nonstationary. In order to check if the nonstationarity of the variables is related to our estimation results, we have reestimated the same VAR(1) replacing RDGP, CPI, and
M2 by differenced RGDP (D_RGDP, real GDP growth), inflation rate (INFLATION, differenced CPI), and differenced M2 (D_M2, money growth), respectively. Although Table 1 indicates that the call rate (IRATE) may be also nonstationary, we do not replace it by differenced IRATE because, in the long-run, interest rates are likely to be mean-reverting.

The estimated impulse response functions obtained using differenced data are reported in Figures 4 - 6. In all of the cases in Figures 4 - 6, none of the estimated impulse responses are statistically significant at a 5% significance level. Differently from the estimation results with level data, there is no strong indication that inflation reacts to unexpected monetary shocks even for the time period from 1987 to 1997. The results in the figures are consistent with the notion that money has no predictive power for other macroeconomic variables in South Korea, strengthening the results obtained from level data.

<Figure 5> Impulse Responses with 95% Error Bands from Korean Data (1987 - 1997)
<Figure 6> Impulse Responses with 95% Error Bands from Korean Data (1998 ~ 2009)

Response to Cholesky One S.D. Innovations with 2 S.E.

<Table 3> Estimated Coefficients of Lagged D_M2 in VAR(1) and Significance Tests
The estimated coefficients of lagged money growth (D_M2) in the VAR(1) equations are shown in Table 3. In all of the cases reported in the table, the coefficients of D_M2 are not significant at a 5% significance level. The coefficient is significant in the INFLATION equation at a 10% significance level for the periods from 1987 to 1997. Interestingly, this is the only case in which the coefficient of lagged M2 is significant at a 5% significance level when the VAR(1) model is estimated with level data. As shown in Figures 4 - 6, Table 3 shows that the Korean data are even more consistent with the prediction of the New Keynesian models (no role of money) when differenced data are used.

V. Concluding Remarks

Using the US data, FG (2009) found evidence against the New Keynesian models of monetary policy. They argue that shocks to monetary aggregates in the United States do contain information on the future paths of output and prices. In this paper, we have analyzed the Korean data by their estimation method and found that the estimated effects of monetary shocks on output, price, and interest rate are much weaker than those that FG (2009) found from the US data. Our results are robust even if the effects of the foreign currency crisis in 1997 and nonstationarity of the variables used are controlled. Our results from the Korean data, together with the results of FG (2009), suggest that the role of money may be country-specific.

However, our findings do not necessarily support the notion that the New Keynesian models can explain the Korean economy well. First, the monetary authority of South Korea (the Bank of Korea) may not have a well-established monetary policy rule yet. It is possible that until 1997, the Bank of Korea had not been active in control of short-term interest rates to achieve its goals: preventing inflation and supporting economic growth. Although the central bank became more responsive after 1997, it may take some time until the Bank could establish its own monetary policy rule suitable for the Korean economy. Many studies have found that the Taylor
rule (equation (3)) fits the US data quite well. However, it is quite possible that the rule may not fit the Korean data well especially if the Korean central bank has a different policy rule. The no-role-of-money doctrine of the New Keynesian models can be better tested if a more accurate policy rule is found. Second, the four equations (equations (1) - (4)) used in our analysis may not adequately describe the structure of the Korean economy. Foreign trade takes a large portion of the Korean GDP. For example, the average ratio of export to GDP during the years from 1987 to 2009 is 35.7% in South Korea, while it is only 8.52% in the US for the years from 1966 to 2001, the time period FG (2009) investigated. The four equations used for our analysis may not be sufficient to capture the effect of foreign trade dependence on dynamics of Korean economy. Once the dependence is adequately modeled and controlled, significant money effects might be found. Whether the New Keynesian doctrine is consistent with the Korean economy can be better tested using a model that adequately incorporates the policy rule of the Bank of Korea and the Korean economy’s dependence on foreign trade.

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References


국문초록

생산, 물가, 이자율에 대한 통화효과의 재조명:
한국경제의 경우

최광신
애리조나주립대학 경제학부 박사과정

안승찬
애리조나주립대학 경제학부 교수

뉴 케인지안 경제모형에 의하면 통화정책은 실물경제변수에 아무런 영향도 주지 않는다. 통화량이 균형 생산량, 물가, 그리고 이자율을 결정하는 인자가 아니기 때문이다. 그러나 최근, Favara and Giordani (2009)는 미국 데이터를 VAR 방법으로 분석하여, 통화충격이 실물 경제에 통계적으로 유 효한 영향을 미치고 있음을 보여 주었다. 본 논문은 그들의 결과가 다른 나라의 경제에도 적용되는지를 확인하기 위하여, 그들의 분석 방법을 한국 데이터에 적용해 보았다. 본 논문의 분석에 의하면, 통화충격은 한국 실물경제에 유효한 영향을 주지 않는 것으로 보인다. 이 결과는 통화정책의 효과가 경제구조에 따라 다를 수 있음을 보여 준다.

주제어: 뉴 케인지안 모형, 통화, VAR 실증분석