THE ROLE OF MONEY AND MONETARY POLICY IN KOREA, 1970–1984 : AN ANALYSIS WITH BAYESIAN VECTOR AUTOREGRESSION MODEL

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1. INTRODUCTION

While the Korean economy has for the past fifteen years recorded economic growth with an annual average of almost 8 percent, on the other side of the story, the economy was suffered from an inflation rate, measured by the wholeasale price index, of 15 percent a year on average, almost twice as high as the real econmic growth rates. There are many researches attempting to analyze and discover the sources of these economic growth-inflationary process over the past 15 years, and it has been generall, acknowledged that the monetary policy has played an important and powerful role throughout these period.[1] In other words, it is admitted that the Korean government and the monetary authority have used monetary policy as a main instrument for economic stabilization : a reconciliation of growth and stability. As a consequence, the money supply, measured by M_2, has expanded by 27 percent a year on average and ranged from a low of 7.7 percent to a high of 39.7 percent a year. In particular, in the years of 1973, 1976, and 1977, when the growh rates of real GNP exceeded 10 percent per year, the corresponding money supply(M_2) was also expanding in excess of 35 percent a year. By observing the comovements in economic growth rates, inflation rates, and the monetary expansion, it was also suggested that the role of monetary factors was passive and accommodative and the monetary expansion has occured endogenously rather than exogenously.[2]

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The purpose of this paper is twofold. First, it analyze whether or not the role of money and policy was really passive and accommodative in the sense of minimizing the disruptive effects of nomonetary and/or supply disturbances on growth and employment. Second, it analyze the effectiveness of monetary policy in two viewpoints. The first question is: Did the monetary policy really contribute to promote steady economic growth over the past 15 years? The second one is: How much were the monetary factors dominating causes of the inflationary process in korea? For these two objectives we will use a multivariate time series model which is know as Vector Autoregression(VAR henceforth) model. Our analytical tool, therefore, is in principle an atheoretical one and is essentially based upon a statistical data analysis.

We begin in section 2 with an introduction to the VAR models and practical applications fo VAR system. In section 3 we will investigate the role of past Korean monetary policy using six-variable VAR model and interpret the empirical results, especially in lights of their effectiveness and policy implications. Summary and conclusions are suggested in final section.

2. VAR APPROACH TO EMPIRICAL MACROECONOMICS
2.1 METHODOLOGY

A VAR system is a multivariate time series model, and was mainly developed for forecasting and data analysis.[3] The basic idea of VAR system emerges from the recognition of the inadequacy of the identification procedure of the traditional keynesian structural macroeconometrics. In a traditional econometric approach, identification of a particular equation was carried out using the so-called zere restrictions, i.e., exclusion/inclusion restriction based upon a particular economic theory. The obvious problem fo this procedure is, according to Sims(1980a) and others, an *ad hoc* and extreme manner in the exclusion/inclusion restrictions. By extreme procedure we mean that a modeler has extreme certainty and complete ignorance about the economy that he tries to analyze.

Considering the complicated nature and the interdependences of the real economy, there may be in principle numerous explanations(hypotheses) for the particular phenomenon, but we never know which one is the best possible one and which one is the least reasonable one. When a modeler, however, uses a exclusion restriction based on a particular economic theory amongst the mumerous candidates for model specification, he treat the excluded variables as if he surely knows that these variables do no role in explaining the dependent variable, i.e., he act as if he is absolutely confident that the best coefficients for these variables excluded from the equation are all zero. What is worse, by letting the data completely determine the coefficients values of the included variables, he treats as if all coefficients values equally likely possible and he is completely ignorant about the way that the included explanatory variables influence the dependent variable. In this case, can we say that the modeler use any theory for model identidication? Is this kind of specification procedure really reasonable? The answers are no. the problem is : a complete certainty and cpmplete ignorance of the standard keynesian procedure in model identification is too rigid to accurately express modeler's true beliefs about the economy and tend to cause useful information in the historical actual data to be ignored.

Unless we have any clear-cut way to distinguish one theory from another we should consider all the possible alternatives as equally likely possible in analyzing the real economy. An obvious solution, therefore, to the above question may be to include all the relevant information(data) in the equation system at the same time. This is an unconstrained VAR (UVAR hereafter) model suggested and analyzed by Sims(1980a, 1980b).

The idea is simly to relate a vector of variables to the vector of past values of those variables, so the name of VAR originates from this set up. With this procedure we can avoid the *ad hoc* manner of the traditional apporoach and at the same time we can consider all the complex structures of the real economy. This UVAR system, however, also confronts another problem : the overfitting phenomena and the consequeses are a very poor forecasting performances of the UVAR models. Litterman(1979, 1980) recognized this problem and incorporated the logic of Bayesian inferences with the UVAR. The resulting model is a constrained VAR system and it is called a Bayesian VAR(BVAR henceforth) model in the literature. The essence of this BVAR lies in the objective and flexible way of incorporation the modeler's prior beliefs with the actual information obtainable from the historical data. With this procedure we can improve our understanding about the workings of the actual economy and this improved understanding may help to improve the forecasting preformances of the model. We will first describe the UVAR system.

A VAR model consisting of N variables and maximum lag length of k can be represented by the following matrix stochastic difference equation of the form,

$$B(L)Y(t)=U(t) \quad (1)$$

where Y(t) is an $N\times 1$ vector stochastic process, B(L) is an $N\times N$ marix of polynomials in the lag operator L, and U(t) is an $N\times 1$ vector of white noise processes with means of zero and covariance matrix

$$E[U(t)U(s)']=V \text{ for } t=s, \text{ or } 0 \text{ for } t\neq s, \quad (2)$$

here E dentoes an expectation operator. The conditions in (2) imply that only contemporaneous values of the error terms to be correlated, otherwise the error terms are both serially and mutually uncorrelated. We can represent the equation (1) in a more convenient form as

$$Y(t)=A(L)Y(t)+U(t) \quad (3)$$

where $A(L)=I-B(L)$ is also $N\times N$ matrix of polynomials in L. Each element in A(L) is also an polynomial in L, for example, $A_{jj}(L)=a_{jj}L+a^2_{jj}L^2+\cdots+a_{jj}{}^kL^k$, where a^k_{jj} denotes the kth lag coefficient value of the jth variable in the ith equation. If we rearrange the array of elements in (3) according to the values of k, (3) can equally be represented as follow.

$$Y(t)=A_1Y(t-1)+A_2Y(t-2)+\cdots+A_kY(t-k)+U(t) \quad (4)$$

where A_k is an $N\times N$ matrix of coefficients of the kth lag of each variable, and U(t) satisfies the usual orthogonality condition,

$$E[U(t)Y(t-k)']=0, \text{ for all } k=1, 2,\cdots, k. \quad (5)$$

The equation (3) or (4) is the basic form of a VAR model in which each variable in the model is treated as being endogenous, and each has two components. One is its best linear predictor given past information available consisting of its own lagged values, the lagged values of all other regressors in the system, and the other is its unpredictable innovations. In general, k, the maximum lag of the system will be infinite, but in practice it is grnerally truncated to some number and this type of lag selection is the only one restriction used in UVAR system. The usual procedure is to select a number k that is both small enough to be computationally feasible and large enough to ensure that the equation residuals are approximately white noise.[4,5] There are also no principle on the choice of N variables and can be made with the purpose of the model.[6] For example, in case of developing a forecasting model for a particular variable, the variables that are important for the prediction of variable in question could be included in the UVAR system. The VAR model of (3) or (4) can be estimated using OLS because each equation contain same explanatory variables.

2.2 THE USES OF VAR MODEL

In this section we will briefly discuss the various techniques used in section 3 in analyzing the role of montary policy in Korea. They are block exogeneity test, impulse response function, innovation accountion(or, variance decomposition), and the historical decomposition of actual time series.

2.2.1 BLOCK EXOGENEITY TEST

Using VAR we test the usual concept of Granger causality : in equation (3), a variable i is said to be exogenous with respect to variable j if $A_{ij}(L) = 0$ for j not equal to i and in this case the variable j does not cause variable i in Grangers' sense.[7]

Besides the econometric problem mentioned in footnote 7, there are fundamental problem in using equation (3) in macroeconomic analysis. When we use VAR as a test for a causal relationships between variables, we implicitly interpret the estimated coefficients as if they were a structural coefficient. It is definitely not a legitimate practice. This is so because both the VAR model is a basically an atheoretical one using no *a priori* economic theory and the specific form of the VAR is actually a reduced form so we can not identify the particular underlying structural model which is based on a explicit economic theory. Therefore the interpretations of estimated VAR model's coefficients as a structural and causal one is misleading.[8]

The structural and causal interpretations of the estimated coefficients is not a basic reason for using VAR models. Instead its usefulness and the importances consist in the forecasting and data analysis : a search for stylized facts and empirical regularities behind the actual macro time series. This task can be done using the moving average representation of the VAR system (1).

2.2.2 IMPULSE RESPONSE FUNCTION ANALYSIS

When the polynomial B(L) is invertible the solution of equation (1) and the moving average representation (MAR hereafter) of VAR can be written in the form,

$$Y(t)=D(L)U(t) \tag{6}$$

where $D(L)=B(L)^{-1}$ is $N\times N$ polynomial in L and each element of the coefficient matrix D(L) is of the form, $D_{ij}(L)=\sum_{k=0}^{\infty} d_{ij}^{0}+d_{ij}^{1}L+d_{ij}^{2}L^{2}+\cdots$, and denotes the responses of variable i at step k to an unit shock to variable j. If we also rearrange the array of the elements in D(L) according to the value of k as in equation (4), we can represent the (6) as

$$Y(t)=\sum_{k=0}^{\infty} D_k U(t-k)=D_0U(t)+D_1U(t-1)+D_2U(t-2)+\cdots,\ (D_0=I) \tag{7}$$

where, D_k coefficients matrix represent the responses of each variable at step k. For example, the response of variable i to an unit shock to variable j at k step ahead is just the ijth element of the D_k. We can analyze the interconnections between variables of interest by investigating the patterns of d_{ij}^{k}s, the so-called impulse response functions (IRFs henceforth). There is one difficulty, however, in the interpretations of this IRF because the covariance marix V is not in general diagonal, i.e., these shocks are nonorthogonal innovations. Therefore we cannot observe the effects of a shock to a single variable in isolation because it moves together with other variables. In order to investigate the independent shock to a particular variable, therefore, it is necessary to look at the MAR with orthogonal innovation : a shock that is uncorrelated serially and across variables. This can be possible by adjusting (7) with some factor S(L) matrix which has folowing characteristics.

$$Q(t)=S(L)^{-1}U(t) \quad (8)$$

$$E[Q(t)Q(t)']=S(L)^{-1}U(t)U(t)'S(L)^{-1}=I \quad (9)$$

conditions(8) and (9) mean that we can obtain orthogonal innovation Q(t) with the factor S(L). Here the I is N×N identity matrix. Such a matrix S(L) can be any solution of $S(L)S(L)'=V=E[U(t)U(t)']$. One possible orthogonalization is to choose a lower triangular matrix S(L) such that $S(L)^{-1}U(t)$ has a diagonal covariance matrix as in (9). This is known as the Choleski decomposition method and with this procedure we can rewrite (7) as follow.[9]

$$Y(t)'=H(L)Q(t) \quad (10)$$

where,$H(L)=D(L)S(L)$ and $Q(t)=S(L)^{-1}U(t)$. Because of the propertity $S(L)S(L)'=V$, the diagonal element in S(L) matrix represents the standard deviation in each innovation and therefore every element in H(L) coefficient matrix also denotes the response of each variable to one standard deviation shock to other variable. The responses to an unit shock can be made by the normalization of S(L) to obtain a normalized matrix G(L) which consists of elements with the following characteristics.

$$g_{ij}=0 \text{ for } i<j, \ 1 \text{ for } i=j, \text{ and } s_{ij}/s_{jj} \text{ for } i>j. \quad (11)$$

where, g_{ij} is ijth element in G(L) and s_{ij} is ijth element in S(L). For conveniences we will later in this paper use the form(10) for the analysis of IRF to orthogonal shocks.[10]

2.2.3 INNOVATION ACCOUNTING

The relative importance of each variables in explaining movements of single variable can be detected with the technique known as innovation accounting or the method of variance decomposition. It is to partition the variance of the forecast error into the proportions attributable to innovations in each variables in the VAR system. For the case of orthogonal contemporaneous innovations, it can be done as follows. From (10) the k-step ahead value of Y, Y(t+k) is

$$Y(t+k)=H_0Q(t+k)+H_1Q(t+k-1)+\cdots+H_{k-1}Q(t+1)+H_kQ(t)+$$

$$H_{k+1}Q(t-1)+\cdots, \tag{13}$$

and k-step ahead forecast of Y(t) is

$$E_t[Y(t+k) \mid Y(t),Y(t-1),\cdots]=Y(t+k)-H_0Q(t+k)-H_1Q(t+k-1)-\cdots - H_{k-1}Q(t+1)-H_kQ(t), \tag{14}$$

therefore the variance of the k-step ahead forecast of variable Y(t) is

$$E[Y(t+k)-E[Y(t+k) \mid \cdot\ ]]^2=\sum_{k=0}^{k}\sum_{j=1}^{N}(h^k_{ij})^2 I_{ij}, \tag{15}$$

since all cross products would be zero by assumption. Here h_{ij} is the ijth element of H matrix. From(15) then the percentage of variance in the k-step ahead forecast of variable i due to innovations in variable j is given by

$$(\sum_{k=0}^{k}(h^k_{ij})^2\ I_{ij}/\sum_{k=0}^{k}\sum_{j=1}^{N}(h^k_{ij})^2\ I_{ij})\times 100. \tag{16}$$

[11,12]

2.2.4 HISTORICAL DECOMPOSITION OF TIME SERIES

The MAR of (8) can be partioned into two parts as

$$Y(t)=\sum_{k=0}^{p-1}D_kU(t-k)+\sum_{k=p}^{\infty}D_kU(t-k) \tag{17}$$

If we let T as some base period in the sample, for any p=1,2⋯,such that T+j is less than or equal to the last period in the sample, we can write Y(T+p) as

$$Y(T+p)=\sum_{k=0}^{p-1}D_kU(T+p-k)+\sum_{k=p}^{\infty}D_U(T+p-k), \tag{18}$$

the sum of two components, the first sum represents that part of the historical time series Y(T+p) due to innovation in periods T+1 to T+p, and can be further examined to investigate the role of the innovations of each variable separately. The second is the base projection Y(T+p) based on information only available at time T. With (18) we can determine the relative importances of any one variable in explaining the behavior of actual time series of interest because each component of the first part represents the extent of the difference between the base projection and actual series due to the innovation of this particular variable in the VAR system.[13]

2.3 BAYESIAN APPROACH TO VAR MODEL

The most commonly used macroeconometric models could be viewed as variants of UVAR with particular type of identifying restrictions. While all these models were formulated and developed to overcome the main weakness of UVAR,i.e., overfitting phenomena due to overparameterization of the model relative to the number of available observations, the resulting various models are exposed to the more serious problems mentioned in section 2.1 : a complete certainty or complete ignorance about the economy. In section 2.1 we ascribed this problem to the extreme identifying procedure based on a particular *a priori* and dubious knowledge.

The idea of Bayesian VAR(BVAR) emerges from the effort to reconcile these two types of macromodels. It therefore takes the two merits of these two approaches, i.e., to incorporate all the available useful informations in the model by including as possible as many variables and at the same time to avoid the overfitting problem by the prior identifying restrictions. With this procedure the model also avoid the above mentioned two difficulties inherent them. This task can be done by applying a statistical theory known as the Bayes' theorem to econometric model specification. By applying Bayes' theorem, we can derive a decision rule known as posterior information with the combination of sample information and the modeler's prior information. In economics context, prior information means the modeler's prior economic theory and the sample information refer to the actual historical data and the parameter estimates derived from them. There are, however, fundamental difference between BVAR and traditional structural macromodels in handling the prior information. It usually takes the form of extreme certainty or ignorance and the subjective judgemental process in the latter approach. Instead, in BVAR model, the prior takes the form of probability distribution about the paramenters of interest. With these probabilistic treatment of prior, we can combine modeler's personal beliefs with the actual data by the objective, reproducible and statistical procedure.

In sum, BVAR models use all available informations by allowing a lot of variables in each equation but at the same time reducing the data's influence on them with the restriction in the form of prior probability density function. With this objective procedure of blending data and personal beliefs, BVAR approach avoids both the problems of overfitting and the extreme outcomes in the traditional exclusion restriction practice.

In econometrics context, the resulting Bayesian estimator is a mixed estimator develope by Theil. It linearly combines the two GLS type estimators : one for sample information and another for prior information. For convenience we can rewrite the particular equation in system (3) as

$$\underset{T\times 1}{Y} = \underset{T\times N}{X}\ \underset{N\times 1}{A} + \underset{T\times 1}{U}, \qquad U \sim N(0,\ S^2) \tag{19}$$

and this equation is used as a sample information for parameter A(X includes lagged Y's). The corresponding prior information may takes the form

$$\underset{q\times 1}{M} = \underset{q\times N}{R}\ \underset{N\times 1}{A} + \underset{q\times 1}{W}, \qquad W \sim N(0,\ V^2) \tag{20}$$

where ,M represents the best guess of the corresponding elements of RA and the variance matrix V measures the uncertainty with respect to these guesstimates and the deviation from them. Usually M may be a subest of A. If the prior for A takes the form of $A \sim N(a, K^2)$, then M and R can respectively be represented as

$$M = a \times (V/K),\ R = V/K.^{14} \tag{21}$$

The mixed estimator, therefore the posterior mean, which combines the data given by the model in (19) with the prior information in (20), is given as[15]

$$\hat{A} = (X'X + dR'R)^{-1}\ (X'Y + d\ R'M),\ d = S^2/V^2 \tag{22}$$

and the covariance martix of A is $S^2(X'X + d\ R'R).^{-1}$ The specific form of prior used in this paper will be described in datail in next section along with the empirical results using them.

3. EMPIRICAL ANALYSIS

3.1 MODEL

In this section we will apply VAR approach to empirical macroeconomics to analyze and to evaluate the role of money and monetary policy in Korea during past fifteen years with a BVAR system. The sytem includes quarterly observations of the six variables : real GNP at 1980 constant price(Y), wholesale price index at 1980 base (P), money stock measured by M_2(M), fixed investment(F), exports of goods and non-factor services in GNP account at 1980 price(X), and curb-market interest rates in annual rates(R), All variables except interest rates were seasonally adjusted by X-11 procedure. Estimation was done over the period from 1971 : 1 through 1984 : 4 using the logged values of all series. Each equation in this six-variable BVAR system includes 4 lags of each variable, a constant term, and quadratic trend term.[16] The particular form of prior for equation i, i=1,2,⋯,6, used in this model is as follow.[17]

The prior for A in (20) takes the pdf of the form $A \sim N(u, z(i,j,k)^2)$, therefore M and R in (20) also takes the form of

$$M = \begin{cases} (c(i)/z(i,j,k)) \times u, & \text{for first own lag coefficient}(i=j,\ k=1) \\ 0 & \text{otherwise}(i \neq j,\ k \neq 1) \end{cases}$$

$$R = c(i)/z(i,j,k), \text{ where} \qquad (23)$$

$$z(i,j,k) = m/k, \text{ for } i=j \text{ or } m \times w \times c(i)/K \times c(j), \text{ for } i \neq j. \qquad (24)$$

In (23) c(i) is the standard error of the univariate autoregression on equation i. For each equation i, c(i) is used as an estimates of V in (20). u denotes the mean of the first own lag confficient for every equation. In (24), z(i,j,k) represents the standard deviation on the prior distribution for the coefficient on lag k of variable j in equation i, and m means the standard deviation on the first lag of the dependent variable, and k,w, and c(j) are described in the following.

The first step in specifying the prior information is to decide a prior distribution of the model's paramenter. We simply assume that each variable follows a first order Markov process, $Y(t)=u\ Y(t-1)+e(t)$. Here u is the same as in (23) and we take this from the OLS estimates of UVAR system with same explanatory variables as BVAR. Specifically, u takes the values of .3 for GNP, 1.0 for both price and export, .8 for money, .1 for investment, and .03 for interest rates. The standard deviation for u is set equal to. 1, i.e., m= .1 in (24). Then the standard deviations of further corefficients in the lag distribution is set to decrease in a harmonic manner, according to a parameter k in (24), the lag length for lagged variables. Therefore, for example, at k =2 the standard deviation of the coefficient at lag 2 is equal to .1/2. The standard deviations of the lagged variables other than the dependent variable are made tighter than the own variable around a mean of zero at all lags by a factor w in (24) and w is

1.0 or 0.5 The values of w's were determined by examining the F-statistic for causality test results that were described in section 2.2.1. when a variable j Granger cause variable i, it takes a value 1.0 for w otherwise w is .5 to reflect the assumption that this variable j does not significantly account for the variation of given a variable i.

Because the units of each variables are not equal the standard deviation around the coefficient on lags of other than the own variable are not invariant to the scale of each variable. In this paper this scale problem is solved by a scale facator c(i)/c(j), where c(i) and c(j) are the standard errors of the residuals in an unrestriced univariate autoregression for variable i and j respectively. In case of constant and trend term, we completely let the data to determine their values.

In summary, above described prior distribution for equation i can be interpreted in light of equation (20) as follow : R is a diagonal matrix with zeros corresponding to deterministic components(constant and trend terms) and elements c(i)/z(i,j,k) for kth lag of variabe j in equation i. M is a vector of zeros for other than first lag and u×c(i)/m for the first lag of the dependent variable.

All the equations were estimated by single equation OLS using RATS program prepared by Doan and Litterman(1986).

3.2 INTERPRETATIONS OF THE RESULTS

First we will look at the results of block exogeneity test. For comparison for UVAR and BVAR the results are summarized in table 1. The striking feature is that, except for real GNP, all the dependent variables are exogenous with respect to all other explanatory variables. Only price variable Granger cause real GNP at the 6 percent level. We can't observe both the direct and indirect effects of money supply growths on real GNP and price. These results are also confirmed in the UVAR system. However, when we remind the limitations of these causal interpretations on the estimated VAR system, the results in table 1 should not be taken seriously.

We will next examine the various results using the techniques based on a MAR of VAR system in turn. For a first step toward this investigation we should check the contemporaneous correlation matrix of the disturbances in the estimated VAR system. This is shown in table 2.

Table 1 Results for Block Exogeneity Tests

Independent variable	Dependent variable BVAR system						UVAR system					
	Y	M	P	F	X	R	Y	M	P	F	X	R
Y	.000***	.997	.984	.395	.997	.323	.460	.523	.453	.534	.958	.094*
M	.982	.000***	.771	.158	.773	.723	.573	.000***	.899	.269	.787	.021**
P	.025**	.945	.000***	.209	.919	.271	.064*	.403	.000***	.317	.757	.002***
F	.863	.948	.990	.000***	.999	.136	.537	.564	.002***	.972	.276	.037**
X	.492	.951	.981	.938	.000***	.970	.050**	.658	.036**	.759	.000***	.016**
R	.999	.997	.893	.999	.892	.000***	.984	.903	.709	.816	.899	.051**

Notes. Entries represent the significance levels for the F-test on the null hypothesis that all the coefficients are equal to zero for each variable. The variables are as follows: Y-real GNP, P-wholesale price index, M-money stock(M_2), F-fixed investment, X-exports, and R-interest rates. Logged values of these variables were used.
* significant at 10% level.
** significant at 5% level.
*** significant at 1% level.

Assuming that these residuals are all white noise process we can regard these correlations as ones between the inherent stochastic process for six variables. These correlations, therefore, measure the degree of the tightness of their true underlying relationships. Also, as noted in section 2.2.2, by observing these matrix we can check whether or not the model's results are sensitive to the ordering of variables. As we can see in table 2, the highest value in absolute term is .486 between investment and real GNP, and the lowest one is .034 between investment and interest rates. Four cases of them are of special interest: between money and GNP, money and price, prices and GNP, and export and GNP. All they show negtive values contrary to the common view. There may be some possible explanation for these results but they should not be regarded as a conclusive one, because these correlations have little to say about the direction of causation.

We will now closely analyze the interdependences and the empirically possible causation between six variables system using the IRF and other techniques. From these analyses we will later evaluate the role and the effectiveness of money and monetary policy in light of stabilization perspectives. Some results for IRFs are summarized in figures 1 through 3.

Table 2 Contemporaneous Correlation Matrix of Disturbances

Variable	Y	M	P	F	X	
M	−.052					
P	−.211	−.255				
F	.486	.087	.235			
X	−.157	.410	−.163	−.140		
R	.054	−.147	.380	−.034	−.132	
Standard deviations of disturbances	Y	M	P	F	X	R
U	.023	.017	.027	.070	.048	.068
V	.023	.016	.024	.059	.042	.061

Notes. U denotes the standard deviation of the error term in regression for each variable. V is the standard deviation of the orthoganalized disturbances. It is equal to the diagonal elements in S(L), matrix in (8). The ordering is: Y-M-P-F-X-R.

Each figure displays the responses of each of the endogenous variable to one standard deviation initial orthogonal shock to each of the variables in the system. The size of the standard deviation is listed in the last two rows in table 2. Comparison of two kinds of standard deviation indicates that the results are not quite sensitive to the ordering of variables. Because logged values were used for estimation, we can interprete the figures as denoting percentage response of each variables to one standard deviation shock to impulse variable.

Output innovation shows relatively short-lived effects on ecah variable. This innovation cause money stock steadily decreasing and its strongest impact occurs after seven quarter. The negative responses of price variable may be regarded as an indrect effect of monetary contraction following output innovation. This reasoning of course based on the idea that money stock was controlled by the counter-cyclical manner. The negative responses of export until eight quarters reflect both the indirect effect of interest rates increase and decreasing money supply following output innovation. We can see from the figure which is not shown here that the interest rate innovation cause a persistent and negative impact on export. This negative responses of export are reversed at eight quarter.

The negative response of output to price innovaiton is the most interesting and puzzling result(Figure 3). This result is not consistent with the prediction based on expectations augmented phillips curve, i. e., a Lucas

Figure 1. Responses to GNP Innovation

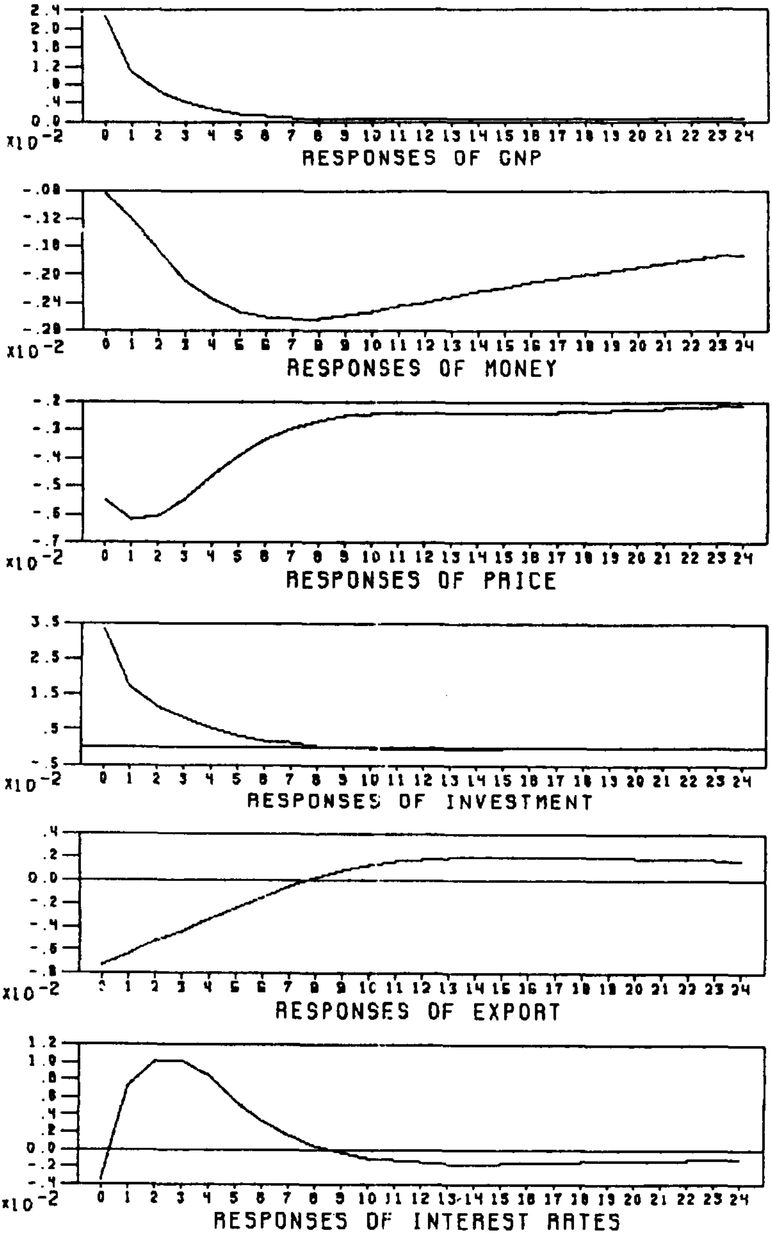


Figure 2. Responses to Money Innovation

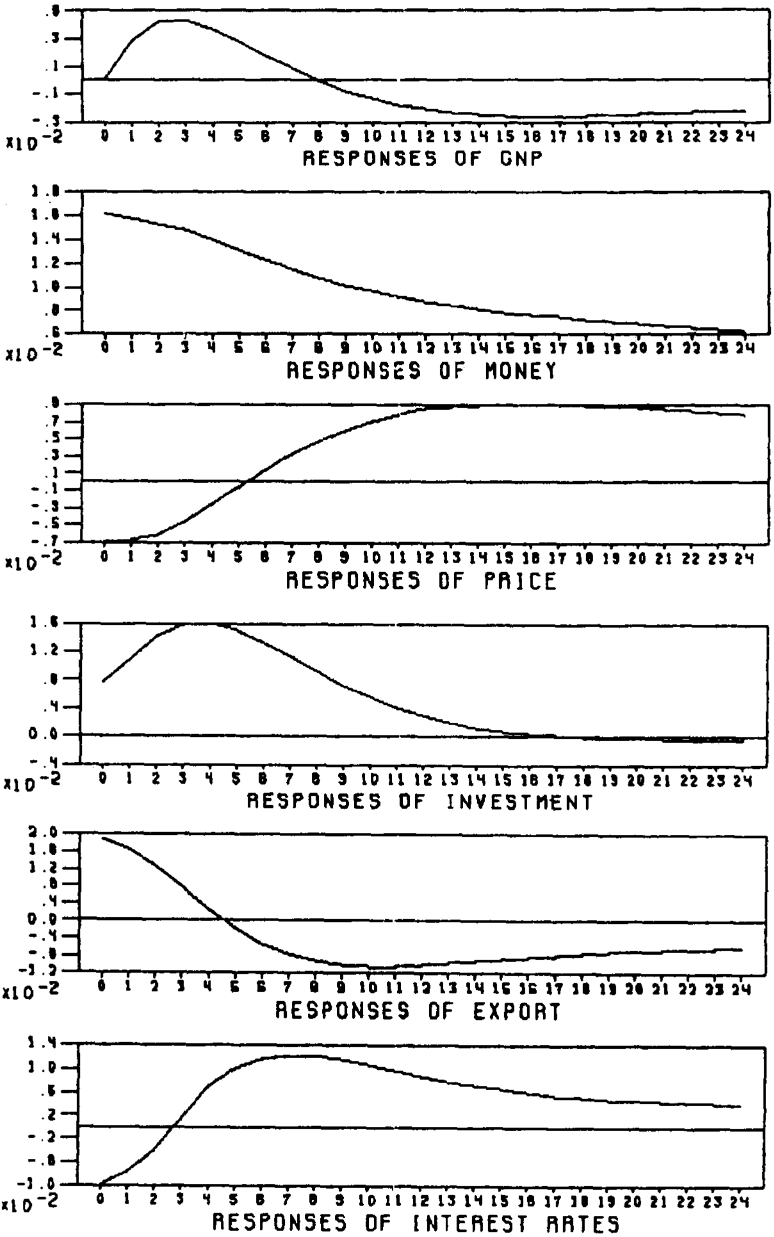
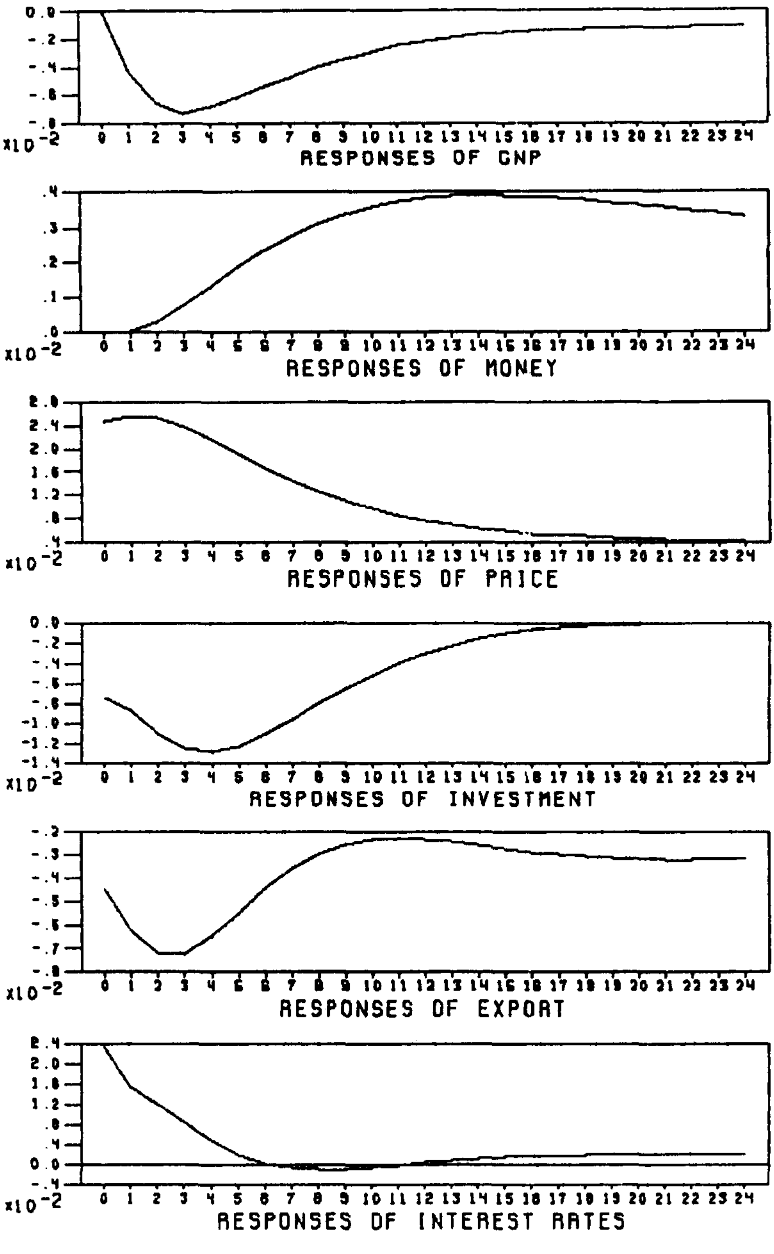


Figure 3. Responses to Price Innovation



type supply function. The output response shown in figure 3 indicates that a price innovation (unexpected price increase) reduces output persistently, although its effects diminish ultimately and the output approaches the steady state value. One possible explanation for this negative response of output to price innovation is : price shock causes relative price more variable and this increased variability in turn induces an disruptive effect on output. In this six-variable system, however, which includes no variable representing relative price variability, the reasonableness of this logic remains questionable. It may be misleading to attempt to find any possible causal explanation for this result from the various IRFs, because in VAR it is quite difficult to determine which of these variables cause the other. We should concentrate our attention to find the underlying stylized facts and empirical regularities, if any. Responses of interest rates reveals Fisher effect, and the resulting interest rates increase causes investment and output to reduce.

Our pariticular interest lies in the response patterns of money stock. If monetary policy actually followed an accommodative role during past years as suggested by some authors, especially by Park (1983), the money stock should respond positively to price innovation. The results shown in figure 3 exhibit a strong evidence favorable to this suggestion : money stock shows a positive and persistent response to price shock, only after a quarter lag. It responds so as to completely and immediately offest the negative effects of price shocks : a major sources of adverse disturbances in this BVAR system. Whether or not, however, this active and accommodative response of money suppy has achieved a desired end is another thing. We will examine this point below. Price disturbance is also followed by a decrease both in export and investment. These results from the IRFs indicate a strong evidence for an accommodative role for monetary policy in Korea during past fifteen years—a period of rapid economic growth.

Money innovation tend temporarily to increase both the real GNP and export. The peak response of GNP occurs at three quarter and it becomes negative after eight quarters. Also money shock temporary reduce price level. These short run contrary responses of price and output to money innovation seem to be consistent with the quantity theory : while changes in money supply cause only temporany favorable effects on output, these skocks ultimately result in persistent and distruptive price increase. This is just what is appeared in figure 2. After one and a half year the story is completely reversed. Since then, persistent increase in price level is followed by increases in interest rates and sustained drops in both real

GNP and export. Even if we acknowledge the accommodating role of money, the results shown in figure 2 clearly suggest that the favorable effects of this type of monetary policy on output did not last long. Instead the monetary innovation resulted in sustained increase in the price level which in turn exerts perversive effects on the whole economy. In this case, therefore, to accomplish a steady economic growth another accommodating response was required, but the result was an ultimate price increase which called for an another reponse, resulting price increase, and so on. I think that this is the story behind the monetary expansion pròcess in Korea over the 1970-1984 period.

The responses of variables to investment innovation show quite similar patterns as to GNP innovation except for price variable, which shows a strong positive response up to twelve quarter.

The export innovations are followed by strong positive responses in GNP, investment, and money stock. This results seem reasonable when we consider the Korean main development strategy : export-led growth and export-promotive economic policy.

The responses of variables to interest rate shock are all consistent with the standard textbook macrotheory.

The main fact derived from these IRFs can be summarized as follows. First, the suggestion that past Korean monetary policy was accommodative is strongly supported by this analysis. Secondly, while the effect of monetary influence on real GNP is temporary in nature, its effects on price increase are strong and persistent. Thirdly, it seems hard to reconcile the commonly used expectations augmented supply function with the above evidences for Korean economy during past fifteen years.

The results on the variance decomposition are largely similar to those of the IRFs analysis and they are summarized in table 3. The most typical pattern is that all of the variables' own innovations account for almost all of its error variances. This ohenomenon is particulary dominating one for the money variable which account for about 90 percent of its own variation. Money supply, threfore, can safely be regarded as an exogenous variable with respect to other variables in this system. Monetary innovations are the relatively important sources of variations in two variables : price and export. It accounts for 20.9 percent and 26.0 percent of 24-step ahead forecast variance of price and export, respectively. In contrast to these impulses, money innovations only account for small portion (12.1 percent) of GNP variation. In addition, it repuires sixteen quarters to have any effects. It seems that a long time delay and a relatively small effect is a typical pattern of monetary influences on the real economy. These and other results obtainable from Table 3 are also consistent with the exogeneity test results given in Table 1.

These analyses suuggest that monetary shocks and the resulting price ncreases were the main sources of the adverse disturbances to the past

Table 3 Results for Variance Decompostions

Dependent variable	Horizon (quarters)	Innovation variables Y	M	P	F	X	R
Y	4	71.9(72.6)	5.8(5.1)	17.3	.1	4.8	.1
	16	58.0(58.6)	8.7(8.2)	26.7	.2	6.2	.2
	24	55.3(55.7)	12.1(11.7)	26.3	.2	5.9	.2
M	4	1.3(.5)	97.6(98.4)	.2	.2	.7	.0
	16	3.3(1.9)	89.7(91.2)	5.3	.4	1.1	.0
	24	3.7(2.2)	87.0(88.5)	7.8	.4	1.0	.1
P	4	4.9(5.3)	5.0(4.5)	89.5	.1	.3	.3
	16	4.6(4.6)	13.4(13.4)	81.1	.1	.4	.4
	24	4.7(4.5)	20.9(21.1)	73.5	.1	.5	.3
F	4	22.9(24.0)	12.3(11.2)	8.3	55.5	1.1	.0
	16	19.2(20.3)	18.6(17.5)	13.3	46.3	2.6	.1
	24	19.2(20.3)	18.6(17.5)	13.3	46.3	2.6	.1
X	4	2.4(1.8)	12.9(13.5)	3.2	2.2	79.1	.3
	16	2.4(1.8)	22.7(23.3)	4.2	2.0	68.3	.3
	24	2.6(1.9)	26.0(26.7)	4.9	1.9	64.3	.3
R	4	5.5(5.5)	3.7(3.7)	16.6	4.7	.6	68.9
	16	5.4(5.4)	18.1(18.0)	13.9	4.2	1.8	56.8
	24	5.4(5.4)	19.8(19.8)	13.9	4.0	1.7	55.1

Notes. Entries show the percentage of forecast error variance of dependent variable at four, sixteen, and twenty four quarters ahead, that is accounted for by innovations in the variables in the first row.

Entries in parentheses are for the second ordering which places money on the top, i. e., M-Y-P-F-X-R ordering.

Experiments with various alternative orderings give similar results on the feedback relationships between output, price, and money as the one reported in this table.

Korean economy. These results from variance decomposition analyses are not quite sensitive to the ordering(see Table 3).

The experiences with the technique of historical decomposition are also similar to the above results derived from both IRFs and variance decomposition. The decompositions were done with T in equation(18) set at 1971 : 1, the starting point of the model's estimation period. In explaining the deviation between base projection and the actual time series, the monetary innovation played relatively minor role for GNP. In contrast, price innovation played a major role for the explanation of GNP movement.

4. SUMMARY AND CONCLUSIONS

In this paper we have analyzed two main questions about the role of money and monetary policy in Korea during past fifteen years : the type of montary policy management and the effectiveness of monetary impulses on the growth and inflation. The main results of this study using atheoretical macroeconomic model can be summarized as follows. First, there is a strong evidence for the common view that Korean monetary policy was accommodative. Also the results from variance decompositions indicate the exogeneity of money supply. Secondly, while the effects of the monetary impulses on the economic growth were weak and short-lived, its impact on inflation was steady and persistent. It seems that exogenously and actively accommodated monetary impulses resulted in an adverse effecf on the economy, in the form of price increase, rather than played a stimulating role for real economic growth. These results also imply that it is hard to say that the main sources and causes of rapid economic growth of Korea during past years are monetary expansion. Third, it was difficult to find the empirical backgrounds for popularly used supply function in theoretical macroeconomic literature. These are the main empirical regularities and stylized facts about the Korean economy during past fifteen years.

We conclude this study with the following policy implications. Over the past fifteen years, it is not likely that a high and variable monetary growth played any favorable and persistent role for real economic growth. Rather it had mainly resulted in price increase—a major source of adverse disturbance to the economy. We should now pay more attention to the inflationary aspects of the monetary expansion.

Footnotes

1) We may, among others, list the works of Park(1983), Nam(1979, 1981), and Park and Cole(1984).
2) Park(1983, P.310, P.328).
3) For a good introduction, see Litterman(1979, 1985) and Todd(1984). This section 2 also draws mainly on their works.
4) Gordon and King(1982, PP. 208-209).
5) The lag length k can also be chosen with the usual F-test and other statistical criteria. On this point, see Rossen and Sheehan(1985).
6) We can also use various techniques disscussed next for variables selection.
7) In a strict sence these two concepts of exogeneity and Granger causality are not equal each other, so the condition described in the text does not guarantees the equality of these two concepts. Despite this, I follow here the usual convention of interpreting the F-test results for(4) as a causal ralationships between variables. On the applications of this concept of causality in VAR model, see McGee and Stasiak(1985), Fackler(1985), Sims(1980), Fischer(1981), Friedman(1983), Rossen and Sheehan(1985), and Litterman and Weiss(1985).
8) For a critical assesment of VAR from these points of view, see Cooley and Leroy (1985), and Leamer(1985).
9) Because a change in the ordering of variables in vetor Y(t) also causes a change in both S(L) and H(L) matrix, the changes in the order of decomposition may make difference in the IRF. When the residuals vector U(t), however, are close to be being uncorrelated, the order of factorization makes little difference on the results, since little variance is expained by the other variables. For a rule and the implications of ordering change, see Gordon and King(1982, pp. 212-214), Fischer(1981, pp. 405-407).
10) For applications of this technique, see Friedman(1983), Sims(1980a, 1980b, 1982), Rossen and Sheehan(1985), Fischer(1981), Taylor(1984), Bernanke(1986), and Doan, Litterman and Sims(1984).
11) While the variance itself does not depend upon the ordering, the decomposition does.
12) For applications, see Fischer(1981), Sims(1980a, 1980b), Friedman(1983).
13) Burbidge and Harrison(1985) applied this method to determine the role of money during the Great Depression.
14) This can easily be verified by taking expectation on both sides of(20).
15) Theil((1971, pp. 346-352).
16) The prime criterion used during the model specification search is the overall stability of the model's response to innovations in each variable. In addition to the particular type of prior described next in the text, the selection of lag length k and the inclusion of a somewhat awkward quadratic trend terms are the outcomes of applying this stability criterion. I have known during this search that the model's stability are both relatively sentive to the lag length and, in particular, to the trend term. A model with quadratic term shows a more stable pattern than a one using linear trend.
17) This prior is a variant of Litterman's(1985).

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