The Time-Varying Effects of Monetary Aggregates on Inflation and Unemployment

An Application of the Bayesian Vector Autoregression with Time-Varying Parameters and Stochastic Volatility

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Abstract
This study applies a Bayesian vector autoregression model with time-varying parameters and stochastic volatility to analyze the time-varying effects of monetary aggregates on inflation and unemployment. The impulse response functions of inflation and unemployment rates are computed at different points of time from the 1980s and 2010s. The impulse responses indicate that the effects of monetary aggregates have diminished since the 2000s, which makes it more difficult for monetary expansion to help stimulate the Japanese economy.

Keywords
Monetary Policy, Inflation, Unemployment, Bayesian VAR

1 Introduction
The role of monetary aggregates in monetary policy has diminished since the 1980s. Monetary policy has been instead framed in terms of short-term interest rates. This change in the policy formulation is largely explained by empirical findings that the relationships between monetary aggregates and macroeconomic variables, such as inflation and unemployment, are unstable. Estrella and Mishkin (1997), for example, conclude that monetary aggregates considerably fall short of possible roles in monetary policy as information variables, indicators of policy actions and instruments in a policy rule.

In recent years, however, there is a resurgence of interests in monetary aggregates in a low inflation environment. Since the mid-1990s, Japan has experienced very low inflation and deflation, and short-term interest rates have reached zero bounds. This has made it difficult for the Bank of Japan (BOJ) to stimulate aggregate demand by further lowering short-term interest rates. Bernanke (2000), however, suggested that the BOJ still had options to stimulate aggregate demand through expanding money. Japanese policymakers have then sought ways of monetary expansion, and the BOJ have implemented unconventional monetary policy measures, such as Quantitative Easing (QE) and Quantitative and Qualitative Easing (QQE). In these unconventional policy measures, the BOJ has targeted monetary base, but expected monetary aggregates, such as M1 and M2, to help bolster aggregate demand through real balance effect and portfolio rebalancing.

It is, however, to be empirically investigated whether monetary aggregates have had quantitatively non-negligible effects on macroeconomic aggregates in Japan. This paper addresses this question by applying a Bayesian vector autoregression (BVAR) model with time-varying parameters (TVP) and stochastic volatility (SV) of Primiceri (2005) to Japanese data for the last five decades. The
BVAR-TVP-SV model generates impulse responses at different points of time with time-varying parameters in the model. This methodology allows us to characterize the time-varying effects of monetary aggregates on inflation and unemployment, and address whether the diminishing role of monetary aggregates is transitory or not.

The rest of the paper is organized as follows. The next section describes the model used in this study. Section 3 presents the data, the Bayesian Markov Chain Monte Carlo (MCMC) methodology to simulate the parametric values of the model, and the empirical results, particularly, the impulse responses of inflation and unemployment to monetary aggregates. The last section concludes.

2. The Model

Following Primiceri (2005), this study considers a vector of three variables \( y_t = [1, y_{1t}, y_{2t}, y_{3t}] \), where \( y_{1t} \) is the unemployment rate, \( y_{2t} \) is the rate of inflation, and \( y_{3t} \) is monetary aggregate at time \( t \) (1 is for intercepts). Let \( \epsilon_t \) a \( 4 \times 1 \) vector of error terms. Then, the VAR model has the form

\[
\begin{align*}
y_t &= B_t y_{t-1} + \epsilon_t \\
\epsilon_t &\sim N(0, \Omega_t)
\end{align*}
\]

where \( B_t \) is a \( 4 \times 4 \) vector of time-varying parameters at time \( t \), and the vector of error terms \( \epsilon_t \) is assumed to follow the multivariate normal distribution with the time-varying variance-covariance matrix of \( \Omega_t \).

The model can be rewritten as

\[
y_t = B y_{t-1} + A_t^{-1} \Sigma_t \epsilon_t
\]

where \( A_t \) is a lower triangular matrix, \( \Omega_t \) is a diagonal matrix, and \( \epsilon_t \) is a vector of independent and identically distributed random errors with a variance of one. The matrices \( \Omega_t, A_t \) and \( \Sigma_t \) are related by

\[
A_t \Omega_t A_t^{-1} = \Sigma_t \Sigma_t^{-1}
\]

which is the triangular reduction of \( \Omega_t \).

The dynamic structure of the time-varying parameters and variance-covariance matrices are imposed on the model as

\[
\begin{align*}
\beta_{ij,t} &= \beta_{ij,t-1} + v_{ij,t} \\
a_{ij,t} &= a_{ij,t-1} + \zeta_{ij,t} \\
\ln \sigma_{ij,t} &= \ln \sigma_{ij,t-1} + \eta_{ij,t}
\end{align*}
\]

where \( \beta_{ij,t}, a_{ij,t} \) and \( \sigma_{ij,t} \) are the elements of \( B_t, A_t \) and \( \Sigma_t \) at time \( t \), and \( v_{ij,t}, \zeta_{ij,t} \) and \( \eta_{ij,t} \) are independent and identically distributed random errors with variances of one. The parameters in the model all follow random walk processes.

In Bayesian inference, the prior distributions of the parameters must be chosen. The priors for the variances of \( v_{ij,t}, \zeta_{ij,t} \) and \( \eta_{ij,t} \) are assumed to be independent inverse-Wishart distributions. The normal and log-normal priors are placed on the elements of \( B_t, A_t \) and \( \Sigma_t \). The priors for their initial values are assumed to be normal. These prior distributions are chosen for their intuitiveness and convenience.

3. Data and Empirical Results

3.1 Data

The data for the unemployment rate is the monthly series of the harmonized unemployment rate for all persons in OECD Main Economic Indicators. Figure 1 plots the unemployment rate in the sample period from January 1971 to April 2016, which this study covers. The rate of inflation is defined as the percentage change of the consumer price index (CPI) for all items from the same period of the previous year. Figure 2 plots the CPI inflation rate in the sample period. For monetary aggregates, this study uses the percentage change of M1 and M2 from the same month of the previous year. Figures 3 and 4 plot the growth rates of M1 and M2 in the sample period. The data series are all seasonally adjusted, sourced from OECD (2016).
Table 1 presents descriptive statistics for all the data series.

3.2 The MCMC Method

Given the model and the prior distributions described in Section 2, the posterior distribu-

Figure 1: The Monthly Unemployment Rate from January 1971 to April 2016 (Seasonally Adjusted, the Percentage Change from Same Period of the Previous Year)

Source: OECD (2016)

Figure 2: The Monthly Inflation Rate from January 1971 to April 2016 (Seasonally Adjusted, the Percentage Change from the Same Period of the Previous Year)

Source: OECD (2016)
Figure 3: The Growth Rate of M1 from January 1971 to April 2016 (Seasonally Adjusted)

Source: OECD (2016)

Figure 4: The Growth Rate of M1 from January 1971 to April 2016 (Seasonally Adjusted)

Source: OECD (2016)
The initial values of the chain are randomly selected. The parametric values are sampled with 55,000 iterations, and the first 5,000 are discarded as burn-in samples. Thus, the posterior distributions of the parameters are approximated with 50,000 samples. The differing initial values of the chain are experimented, yielding similar results.

### 3.3 Empirical Results

Figure 5 shows the impulse response functions of the inflation rate to shocks of M1 at four different points of time - Januaries of 1980, 1990, 2000 and 2010. The impulse responses are computed with the means of the posterior distributions at each point of time. The standard recursive structure of the variance-covariance matrix of the error terms is assumed. The size of the shocks is assumed to be one standard deviation of the unconditional distribution of the error term, which makes the four impulse responses comparable. The figure shows that M1 have modest effects on the inflation rate in the 1990s while the effects of M1 on the inflation have become negligibly small since 2000.

Figure 6 presents the impulse responses of the unemployment rate to shocks of M1. The figure shows that the effects of M1 on the unemployment rate have diminished over time. The figures also imply that there were Phillips curve relationships between inflation and unemployment, possibly driven by monetary expansion and contraction, in the 1980s and 1990s; the relationships have disappeared since the 2000s.

Figures 7 and 8 present the impulse response functions of the inflation and unemployment rates to shocks of M2. Although the effects of M2 on the inflation rate have diminished since the 2000s, they are still quantitatively non-negligible. The unemployment rate has become insensitive to M2 since 2000s.

### 4. Summary and Conclusions

This paper has applied the Bayesian VAR with time-varying parameters and stochastic volatility to analyze the effects of monetary aggregates on inflation and unemployment. The impulse responses of the inflation and unemployment rates to shocks of M1 and M2 have been computed at four different points of time over the last four decades, finding that the monetary aggregates have had diminishing effects on the macroeconomic variables since the 2000s although M2 still has non-negligible effects on inflation.

Since a classical paper by Poole (1970), debates on the optimal choice of monetary policy instruments have been framed in terms of...
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Figure 5: The Impulse Response of the Inflation Rate to M1

Source: Own Calculation

Figure 6: The Impulse Response of the Unemployment Rate to M1

Source: Own Calculation
Figure 7: The Impulse Responses of the Inflation Rate to M2

Source: Own Calculation

Figure 8: The Impulse Responses of the Unemployment Rate to M2

Source: Own Calculation
the relative stability of the IS and LM curves. In the macroeconomic literature, empirical studies have found that the money demand function is unstable, which makes a short-term interest rate a more favorable policy instrument.

This study has provided alternative evidence against monetary aggregates playing a role in monetary policy. Whether the money demand is unstable or not, the potential role of monetary aggregates has diminished in recent years. Under the condition that short-term (and even long-term) interest rates have reached zero bounds, some might expect monetary expansion to help bolster domestic demand through real balance effects and portfolio rebalancing. In the recent years, the BOJ have implemented unconventional monetary policy measures that target some monetary variables. The findings of this study, however, indicate that the relationships between monetary aggregates and the macroeconomic variables have become too weak to stimulate the aggregate demand and pull the Japanese economy out of very low inflation and deflation.

References
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