Abstract

Monetary transmission mechanism in Japan is investigated in two kinds of time intervals [1977, 1989] and [1977, 1998] associated with the burst of the bubble economy in the end of 1989. The VEC model is constructed for nonstationary $I(1)$ variables ($gdp$, money supply, bank loans, price) combined with stationary interest rate $r(t)$. The principal line of attack is to use impulse responses in the growth rate model and accumulate them to obtain impulse responses of level variables. This accumulation gives us convergence property of level variables to non-zero asymptotic states. We can calculate contributions to the asymptotic $gdp$ from asymptotic money supply, bank loans and price in cointegrated and/or non-cointegrated systems. We show that the money channel has a stronger influence to $gdp$ in [1977, 1989] compared with credit one, while in [1977, 1998] containing the period “after the bubble” the importance of credit channel increases dramatically.

KeyWords monetary transmission, impulse response, unit root
JEL codes E44, E52, E58

1 Introduction

There exist two competing views of the transmission mechanism of monetary policy. The first view is a traditional textbook description in which changes in
money supply affect the economy through changes in interest rates. The other view stresses the importance of the bank lending to affect the economy. The former is called the money view while the latter is called the credit view or the bank lending view.

Bernanke [1] showed, in his pioneering work, that shocks in the bank loans have strong effects on aggregate demand by using a method of the structural VAR model. Bernanke and Blinder [2] indicated that the structural model is very vulnerable to the identifying assumption. They concluded that bank loans are an important component of the monetary transmission mechanism from the fact that unemployment and bank loans move together after changes in the federal funds rate.

Gertler and Gilchrist [3] got the result to support the credit view. They disaggregated bank loans and compared the behavior of small and large firms. They showed that large firms issued commercial paper during the time of tight monetary policy, while small firms and consumers that had no access to the CD market, reduced the bank loans.

Romer and Romer [4] used the model to get the evidence on the relative importance of the money channel and credit channel. They focused on the period of the tight monetary policy to avoid the confusion between the effect of money and lending on the economy and the reverse effect from the economy. They concluded that the traditional money view is much more important than the credit view.

Ramey [5] tested the transmission mechanism of monetary policy by using a cointegration analysis in order to develop the Romer and Romer’s approach, where Ramey questioned the isolation of the sample employed by Romer and Romer not to trace out the general equilibrium. She estimated impulse responses of industrial production to the policy shock and found that shutting down the bank loans channel has no noticeable impact on the response of industrial production to policy innovation, while shutting down the money channel essentially eliminates the impact of policy on industrial production. Thus, her conclusion was that the money channel is much more important than the credit channel in the direct transmission of policy shocks.

Miyagawa and Morita [6] applied Ramey’s method to the Japanese economy and got the evidence for the importance of money channel. However the technique used by Ramey is difficult to identify the causation between money or lending and output.

The traditional monetary policy by Bank of Japan starts with the call rate control through the strong influence on the call market. We can understand the BOJ’s policy stance by watching the call rate. So our paper will concentrate on shock to
the call rate intermediate target. For a more detailed explanation of the BOJ’ traditional monetary policy, see Suzuki, Kuroda and Shirakawa (1988) [7]. Furthermore we have to add that the BOJ came to pay more attention to the control of reserves since 2001.

Nakagawa [8] researched this problem in Japanese economy. He showed the importance of credit channel rather than money channel by Granger causality test and impulse responses through Toda and Yamamoto’s method [11]. He pointed out the necessity to distinguish the difference between (i) the path from money to gdp through bank loans and (ii) the path from money to gdp not through bank loans. In the VAR model, by introducing weak exogeneity condition and shutting down feedback terms to money and loans from the other variables, he compared wave forms of such responses each other and concluded that the reaction \([\text{money} \rightarrow \text{gdp}]\) is due to \([\text{money} \rightarrow \text{bank loans} \rightarrow \text{gdp}]\).

Miyao [9] proposed a benchmark research of a recursive structural VAR model with variables \((\text{call rate}, \text{real gdp}, \text{money supply}, \text{stock price})\) in monthly data of (1975, 1998). After recognizing unit root of every variable and detecting no cointegration among variables, the growth rate model was constructed and accumulated impulse responses were obtained in level variables. He investigated impulse responses subjected to every kind of shocks and pointed out that \(\text{real gdp}\) receives long-run effect by call rate shock. He interpreted this phenomenon by Tobbin’s effect. However, in his system model, impulse shock of call rate was inputted to the first difference of call rate and hence call rate itself is subject to a permanent step input. Therefore, it seems to be natural that \(\text{real gdp}\) has a long-run effect. Nevertheless, mathematically speaking, impulse responses of the process with unit root are obtained by accumulating those of growth rate system and therefore have to converge to non-zero value. That is, \(\text{real gdp}\) with unit root exhibits a long-run effect subjected to every kind of impulse shocks.

Recently, Morita and Miyagawa [10] proposed a quantitative impulse response approach to monetary transmission mechanism, where variables were \((\text{real gdp}, \text{real money supply}, \text{real bank loans}, \text{interest rate})\). Our idea was to find the asymptotic relationship among long-run effects of accumulated impulse responses. In this paper, we shall improve our system model more rigorously with variables \((\text{real gdp}, \text{nominal money supply}, \text{nominal bank loans}, \text{price}, \text{interest rate})\). We start our system model of growth rates that are derived by the first difference of level variables with unit root. Impulse responses of level variables are accomplished by accumulating impulse responses of differenced variables and exhibit convergence property to non-zero asymptotic states. This kind of accumulation approach is commonly used in research of long-run restriction structural VAR model.
(for example, Blanchard and Kuah [12]). However, their approach was limited to noncointegrated systems and structural models always need identifying assumptions about asymptotic values of level variables. On the contrary, our approach is applicable to cointegrated systems and we can calculate, without asymptotic restrictions, algebraic relationship among asymptotic contributions of money and loans to gdp.

2 Modelling

System model. Let \( r(t), m(t), l(t), y(t) \) and \( p(t) \) be interest rate, nominal money supply, nominal bank loans, real gdp and price (gdp deflator) at time \( t = 1, 2, \ldots \). Assume that each variable of \((m, l, y, p)\) is \( I(1) \) and that \( r \) is \( I(0) \). The case of nonstationary \( r \) can be treated without difficulty and is stated in the end of this section.

From the existence of nonstationary processes, we shall consider the VAR model of \((\Delta m(t), \Delta l(t), \Delta y(t), \Delta p(t))\) driven by \( r(t) \). For simplicity of notations, introducing a new variable \( R(t) \equiv r(1) + r(2) + \cdots + r(t) \) and taking the relation \( \Delta R(t) \equiv r(t) \) in mind, the system model of \( x(t) = (R(t), m(t), l(t), y(t), p(t))' \) is described by the following:

\[
\Delta x(t) = \sum_{i=1}^{p-1} A_i \Delta x(t-i) + \alpha \beta' x(t-1) + a_0 + a_1 t + \cdots + a_q t^q + \epsilon(t),
\]

where the second term on the right hand side of Eq.(1) denotes cointegration formulated by Johansen [16], \( a_0 + a_1 t + \cdots + a_q t^q \) is a deterministic trend, and where \( \epsilon(t) \) is an \( n \)-dimensional white noise sequence.

Impulse responses and their asymptotic behavior. Impulse responses of \( \Delta x(t) \) subjected to the \( r(t) \) shock, that is, the first element of \( \epsilon(t) \) are taken into consideration in Eq.(1). Deleting deterministic trends in Eq.(1), impulse responses can be reduced to those around the zero state. Noting that the impulse shock of \( r(t) \) is inputted only at \( t = 1 \) and that \( \Delta x(t) \) are stationary, it can be seen that the cointegrated term behaves as a feedback control and both of the system state \( \Delta x(t) \) and the cointegrated term \( \beta' x(t-1) \) converge to zero as \( t \to \infty \).

When we identify Eq.(1), it is often the case that a covariance matrix of residuals is not diagonal. An orthogonal transformation by Cholesky decomposition of the covariance matrix is introduced.
The next step is to find impulse responses of \( x(t) \) itself by accumulating \( \triangle x(t) \) from 1 to \( t \).

The convergence property of \( \triangle x(t) \to 0 \) and \( \beta' x(t-1) \to 0 \) gives us the information about the asymptotic behavior of \( x(t) \) as \( t \to \infty \):

\[
x(t) \to \bar{x},
\]
\[
\beta' \bar{x} = 0.
\]

Summing both sides of Eq.(1) with a deterministic trend deleted and with \( \varepsilon(t) \equiv 0 \) (\( t \neq 1 \)) from \( t = 1 \) to \( N \), we have

\[
x(N) - x(0) = A_1 (x(N-1) - x(-1)) + \cdots + A_p (x(N-p-1) - x(-p-1))
\]
\[+ \alpha \sum_{i=1}^{N} \beta' x(t-1) + \varepsilon(1), \]
\[
x(t) \equiv 0 \text{ for } t \leq 1.
\]

Then, the asymptotic state as \( N \to \infty \) can be described with \( x(N) \) replaced by \( \bar{x} \) in Eq.(4):

\[
\bar{x} = \sum_{i=1}^{p} A_i \bar{x} + \alpha \sum_{i=1}^{\infty} \beta' x(i-1) + \varepsilon(1).
\]

Transforming the above equation, we have

\[
\bar{x} = (I - \sum_{i=1}^{p} A_i)^{-1} \alpha \sum_{i=1}^{\infty} \beta' x(i-1) + (I - \sum_{i=1}^{p} A_i)^{-1} \varepsilon(1).
\]

[Proposition] The asymptotic state \( \bar{x} \) is described by

\[
\bar{x} = (I - \sum_{i=1}^{p} A_i)^{-1} \alpha c + (I - \sum_{i=1}^{p} A_i)^{-1} \varepsilon(1),
\]

where

\[
c = -(\beta' (I - \sum_{i=1}^{p} A_i)^{-1} \alpha)^{-1} \beta' (I - \sum_{i=1}^{p} A_i)^{-1} \varepsilon(1).
\]

[Proof of Proposition] In Eq.(7), we set

\[
c \equiv \sum_{i=1}^{\infty} \beta' x(i-1).
\]
Then, from the relation (3), multiplying $\beta'$ on both sides of Eq.(7) from the left and equating the left hand side to be zero, we have the following:

$$0 = \beta'(I - \sum_{i=1}^{p} A_i)^{-1} \alpha c + \beta'(I - \sum_{i=1}^{p} A_i)^{-1} \epsilon(1),$$

which shows the relation (9). (end of the proof).

From Proposition, $\bar{x} = (\bar{R}, \bar{m}, \bar{l}, \bar{y}, \bar{p})'$ can be obtained. Furthermore, in Eq.(6), $\bar{y}$ is rewritten in componentwise by

$$\bar{y} = a_1\bar{R} + a_2\bar{m} + a_3\bar{l} + a_4\bar{y} + a_5\bar{p} + A_6c + A_7\epsilon(1),$$

where the 1st term of the RHS of the above equation implies the contribution of $\bar{R}$ to $\bar{y}$, the 2nd to 5th terms are contributions of $\bar{m}$, $\bar{l}$, $\bar{y}$ and $\bar{p}$ to $\bar{y}$ respectively, the 6th term is that of the cointegrated term to $\bar{y}$ and the last term is that of impulse shock to $\bar{y}$. Thus, $\bar{y}$ can be decomposed into each element and we can compare the contribution of $\bar{m}$ to $\bar{y}$ with that of $\bar{l}$ to $\bar{y}$ from view point of monetary transmission mechanism.

**Nonstationary interest rate.** In Japan, it is often the case that interest rates exhibit stationary or nonstationary property according to time interval under consideration, while in many countries interest rates become nonstationary. Our analysis stated above can be extended to nonstationary interest rates, where, instead of $R(t)$, we have only to define $x(t) = (r(t), m(t), l(t), y(t), p(t))'$ with nonstationary $r(t)$. Then, the VAR or VEC model of $\triangle x(t) = (\triangle r(t), \triangle m(t), \triangle l(t), \triangle y(t), \triangle p(t))'$ can be derived and the impulse shock of $\triangle r(t)$ is introduced. This shock can be interpreted as a step input of $r(t)$, that is, $r(t)$ changes from zero to a constant value at time $t = 1$ and holds that value permanently. Although the property of shock is different from the case of stationary $r(t)$, the asymptotic contribution of every element of $\bar{x}$ to $\bar{y}$ can be obtained in the same procedure.

3 The Empirical Analysis

**Data description.** The data employed here is Japanese data, quarterly observed from 1977:1 through 1998:4. They are obtained from the Nikkei Needs Database and listed as: real gdp, nominal money supply $M_2 + CD$, nominal bank loans, gdp deflator and call rate. All variables except for call rate are seasonally adjusted and
in logarithms. Symbolic notations are given by

\[ y(t) = 100 \cdot \ln(\text{real gdp}), \]
\[ m(t) = 100 \cdot \ln(M_2 + CD), \]
\[ l(t) = 100 \cdot \ln(\text{bank loans}), \]
\[ p(t) = 100 \cdot \ln(\text{nominal gdp}/\text{real gdp}), \]
\[ r(t) = \text{call rate}. \]


**Unit root test.** Augmented Dicky-Fuller test[13] is carried out as a pre-test for judging whether each variable behaves with \([\text{const.}]\) or with \([\text{const. and trend}]\). Based on this test, unit root is investigated by ERS test (Elliott-Rothenberg-Stock [14]), where AIC criterion is adopted for lag order. Furthermore, KPSS test [15] is also carried out for stationarity as the null hypothesis.

<table>
<thead>
<tr>
<th>var.</th>
<th>ERS</th>
<th>lag</th>
<th>KPSS</th>
<th>additional regressors</th>
</tr>
</thead>
<tbody>
<tr>
<td>(r)</td>
<td>-3.957 ***</td>
<td>1</td>
<td>0.077</td>
<td>const.</td>
</tr>
<tr>
<td>(m)</td>
<td>-1.541</td>
<td>1</td>
<td>0.123 *</td>
<td>const. + trend</td>
</tr>
<tr>
<td>(l)</td>
<td>-1.874</td>
<td>3</td>
<td>0.233 ***</td>
<td>const. + trend</td>
</tr>
<tr>
<td>(y)</td>
<td>-0.969</td>
<td>0</td>
<td>0.152 **</td>
<td>const. + trend</td>
</tr>
<tr>
<td>(p)</td>
<td>-1.174</td>
<td>2</td>
<td>0.233 ***</td>
<td>const. + trend</td>
</tr>
</tbody>
</table>

***, ** and * denote significance levels 1%, 5% and 10% respectively. Critical values are t-statistics by Elliott-Rothenberg-Stock(1996) combined with MacKinnon(1996)[17] and LM-statistics by KPSS(1992). The lag order \(n\) is decided by AIC in the interval \(n \leq 5\).

Table 1 shows the result of unit root test for \(r(t), m(t), l(t), y(t)\) and \(p(t)\). For \(r(t)\), the unit root is rejected in ERS test and the stationarity is not rejected in KPSS test. So, we can say that \(r(t)\) is stationary. For the other variables, any unit root is not rejected and the stationarity is rejected. Therefore, we conclude that each of \((m(t), l(t), y(t), p(t))\) is nonstationary. For the first differenced variables \((\Delta m(t), \Delta l(t), \Delta y(t), \Delta p(t))\), it was seen that every one is stationary. The resultant table was omitted here but is available upon the request.
Cointegration property (Johansen test [16]). Since \( r(t) \) is stationary, the cointegration analysis is applied to \((m(t), l(t), y(t), p(t))\) by Johansen test. Two lags are taken for each variable, and constant terms are included in both the cointegrating equation and the test VAR of differenced form. Furthermore, we introduce a second oil crisis dummy denoted by \( \text{dummy}_{80q2} \) which takes a value of unity at 1980:2 and takes zero otherwise. Table 2 shows the result of cointegration test.

<table>
<thead>
<tr>
<th>Test for the number of cointegrating vectors</th>
<th>( m )</th>
<th>( l )</th>
<th>( y )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{Eigenvalues} )</td>
<td>0.4518</td>
<td>0.3187</td>
<td>0.1809</td>
<td>0.0014</td>
</tr>
<tr>
<td>( \text{Hypotheses} )</td>
<td>( r = 0 )</td>
<td>( r \leq 1 )</td>
<td>( r \leq 2 )</td>
<td>( r \leq 3 )</td>
</tr>
<tr>
<td>( \lambda_{\text{max}} )</td>
<td>28.86*</td>
<td>18.42</td>
<td>9.58</td>
<td>0.069</td>
</tr>
<tr>
<td>( \lambda_{\text{trace}} )</td>
<td>56.93**</td>
<td>28.07</td>
<td>9.65</td>
<td>0.069</td>
</tr>
<tr>
<td>( \text{Adjustment Coefficients} \ \alpha )</td>
<td>&amp;</td>
<td>&amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \Delta m )</td>
<td>-0.0295</td>
<td>&amp;</td>
<td>&amp;</td>
<td></td>
</tr>
<tr>
<td>( \Delta l )</td>
<td>0.1029</td>
<td>&amp;</td>
<td>&amp;</td>
<td></td>
</tr>
<tr>
<td>( \Delta y )</td>
<td>0.1555</td>
<td>&amp;</td>
<td>&amp;</td>
<td></td>
</tr>
<tr>
<td>( \Delta p )</td>
<td>-0.0501</td>
<td>&amp;</td>
<td>&amp;</td>
<td></td>
</tr>
<tr>
<td>( \text{Normalized cointegrating coefficients} \ \beta )</td>
<td>1.00</td>
<td>0.0513</td>
<td>-2.329</td>
<td>-0.0512</td>
</tr>
</tbody>
</table>

** (*) denotes rejection of hypothesis at 1% (5%) significance level and lagged difference is decided to be \( n = 2 \).

System model. The model in Eq.(1) is thus estimated.

- \( r(t)(\equiv \Delta R(t)) \) has regressors \( \Delta m(t - i), \Delta l(t - i), \Delta y(t - i), \Delta p(t - i) \), constant and oil crisis dummy.

- \( \Delta m(t), \Delta l(t) \) and \( \Delta p(t) \) have regressors \( r(t - i), \Delta m(t - i), \Delta l(t - i), \Delta y(t - i), \Delta p(t - i), \) cointegration term, constant and oil crisis dummy.

- \( y(t) \) has the same regressors as those of \( \Delta m(t), \Delta l(t) \) and \( \Delta p(t) \) except for the point that \( y(t) \) is not regressed by \( r(t - i) \), because our aim is to see how monetary policy \( r(t) \) transmits to output \( y(t) \) through channels of \( m(t) \) and \( l(t) \) and because the existence of regressors \( r(t - i) \) to \( \Delta y(t) \) explains in itself the effects of \( r \rightarrow m \rightarrow y \) and \( r \rightarrow l \rightarrow y \).

The ordering of variables is set to be \((R, m, l, y, p)\). In general, the ordering influences impulse responses of VAR model with Cholesky decomposition. How-
ever, if we consider the impulse shock of the interest rate \( r \), it is essential to set \( R \) as the front of the ordering, because simple matrix calculation shows us that the
front \( R \) followed by random ordering of the other four variables does not change results of impulse responses at all. (The proof is omitted.)

Although the lagged differences of regressors were basically determined by
\( n = 2 \) in cointegration analysis, we need more delicate adjustments here because
of small sample size of data. At each equation in Eq.(1), the lagged difference
of each regressor is determined by AIC criterion. The resultant lags of regressors
to \( r(t) \) are \((n_{r1}, n_{r2}, n_{r3}, n_{r4}, n_{r5}) = (2, 1, 1, 1, 1)\) in the below equation. Similarly,
\( m(t) \) has the lags of \((1,1,2,1,4)\). \( l(t) \) has the lags of \((4,1,3,1,1)\). \( y(t) \) has the lags of
\((2,3,2,2)\). \( p(t) \) has the lags of \((3,1,4,1,1)\).

\[
\begin{align*}
  r(t) &= \sum_{i=1}^{n_{r1}} a_{1i} r(t-i) + \sum_{i=1}^{n_{r2}} a_{2i} \triangle m(t-i) + \sum_{i=1}^{n_{r3}} a_{3i} \triangle l(t-i) + \sum_{i=1}^{n_{r4}} a_{4i} \triangle y(t-i) \\
  &\quad + \sum_{i=1}^{n_{r5}} a_{5i} \triangle p(t-i) + \mu_r(t) + \epsilon_r(t), \\
  \triangle m(t) &= \sum_{i=1}^{n_{m1}} b_{1i} r(t-i) + \sum_{i=1}^{n_{m2}} b_{2i} \triangle m(t-i) + \sum_{i=1}^{n_{m3}} b_{3i} \triangle l(t-i) + \sum_{i=1}^{n_{m4}} b_{4i} \triangle y(t-i) \\
  &\quad + \sum_{i=1}^{n_{m5}} b_{5i} \triangle p(t-i) + b_6 \triangle z(t-1) + \mu_m(t) + \epsilon_m(t), \\
  \triangle l(t) &= \sum_{i=1}^{n_{l1}} c_{1i} r(t-i) + \sum_{i=1}^{n_{l2}} c_{2i} \triangle m(t-i) + \sum_{i=1}^{n_{l3}} c_{3i} \triangle l(t-i) + \sum_{i=1}^{n_{l4}} c_{4i} \triangle y(t-i) \\
  &\quad + \sum_{i=1}^{n_{l5}} c_{5i} \triangle p(t-i) + c_6 \triangle z(t-1) + \mu_l(t) + \epsilon_l(t), \\
  \triangle y(t) &= \sum_{i=1}^{n_{y1}} d_{2i} \triangle m(t-i) + \sum_{i=1}^{n_{y2}} d_{3i} \triangle l(t-i) + \sum_{i=1}^{n_{y3}} d_{4i} \triangle y(t-i) \\
  &\quad + \sum_{i=1}^{n_{y4}} d_{5i} \triangle p(t-i) + d_6 \triangle z(t-1) + \mu_y(t) + \epsilon_y(t), \\
  \triangle p(t) &= \sum_{i=1}^{n_{p1}} e_{pi} r(t-i) + \sum_{i=1}^{n_{p2}} e_{2i} \triangle m(t-i) + \sum_{i=1}^{n_{p3}} e_{3i} \triangle l(t-i) + \sum_{i=1}^{n_{p4}} e_{4i} \triangle y(t-i) \\
  &\quad + \sum_{i=1}^{n_{p5}} e_{5i} \triangle p(t-i) + e_6 \triangle z(t-1) + \mu_p(t) + \epsilon_p(t),
\end{align*}
\]

where \( \mu_{(\cdot)}(t) \) denotes deterministic terms containing dummy variables. The esti-
mated parameters are available upon the request.

**Impulse responses.** Impulse responses of $R(t) (\equiv \sum r(t))$, $m(t)$, $l(t)$, $y(t)$ and $p(t)$ are shown in Fig.1 to exhibit asymptotic convergence properties. Equation (6) is rewritten componentwise by:

\[
\bar{R} = 0.786\bar{R} - 0.101\bar{m} - 0.740\bar{l} - 0.112\bar{y} \\
-0.387\bar{p} + 0.000 + 0.628,
\]

\[
\bar{m} = -0.144\bar{R} + 0.225\bar{m} + 0.100\bar{l} + 0.140\bar{y} \\
+0.552\bar{p} + 0.001 - 0.010,
\]

\[
\bar{l} = -0.016\bar{R} + 0.004\bar{m} + 0.454\bar{l} + 0.068\bar{y} \\
+0.410\bar{p} - 0.014 - 0.027,
\]

\[
\bar{y} = 0.763\bar{m} + 0.356\bar{l} + 0.172\bar{y} + 0.861\bar{p} \\
-0.023 + 0.164,
\]

\[
\bar{p} = 0.011\bar{R} - 0.048\bar{m} - 0.742\bar{l} + 0.052\bar{y} - 0.004\bar{p} \\
+0.001 + 0.028,
\]

where the last two terms on the RHS are effects by cointegration and Cholesky decomposition for the residual covariance respectively. It should be noted that $\bar{R}$ in Eq.(18) has no cointegration term and that $\bar{y}$ in Eq.(21) does not contain $\bar{R}$ on the RHS.

The asymptotic states ($\bar{R}, \bar{m}, \bar{l}, \bar{y}, \bar{p}$) can be calculated:

\[
\bar{R} = 3.412, \quad \bar{m} = -0.597, \quad \bar{l} = -0.096, \quad \bar{y} = -0.262, \quad \bar{p} = 0.154.
\]

In Eq.(18) combined with the above asymptotic values, $\bar{R}$ is contributed from $\bar{R}$ itself by the value $0.786\bar{R} = 2.683$. Similarly, contributions from $\bar{m}$, $\bar{l}$, $\bar{y}$, $\bar{p}$ and $\varepsilon_r(1)$ are $-0.101\bar{m} = 0.06$, $-0.74\bar{l} = 0.071$, $-0.112\bar{y} = 0.029$, $-0.387\bar{p} = -0.060$ and $0.628 (= \text{standard deviation})$ respectively. Bar graphs of these contributions are depicted in Fig.1 together with impulse responses. In the figure of $\bar{R}$, almost contribution is due to $\bar{R}$ itself and a little is to $\varepsilon_r(1)$ (denoted by chol). $\bar{m}$, $\bar{l}$, $\bar{y}$ and $\bar{p}$ do not contribute to $\bar{R}$.

In the figure of $\bar{m}$, main contributions are by $\bar{R}$ and $\bar{m}$ itself. It should be noted that there is a little contribution from $\bar{y}$ and almost no contribution from $\bar{l}$. 
Figure 1: Impulse Responses and Decomposed Asymptotic Contributions in [1977:1,1989:4]
In the figure of $\bar{I}$, main contributions are due to $\bar{R}$, $\bar{I}$ itself and $\bar{p}$. $\bar{m}$ is negligible. $\bar{y} \rightarrow \bar{I}$ is small but is not negligible.

In the figure of $\bar{y}$, a large amount of contribution is given by $\bar{m}$ and a small portion is occupied by $\bar{I}$ both to downward direction. $\bar{p}$ and $\varepsilon_r(1)$ contribute upward. For transmission mechanism, Nakagawa [8] emphasized the difficulty to distinguish contributions to $y$ from $m$ and $l$. This is because the contribution of $m$ to $y$ contains both (i) $m$ affecting through $l$ and (ii) $m$ working not through $l$.

Fortunately, our approach enables us to obtain concrete values of asymptotic contributions and hence we can compare the contribution of $\bar{m}$ to $\bar{y}$ through credit channel with that not through credit channel. The money and credit contributions to $\bar{y}$ are, from Eq.(21), $0.763\bar{m}$ and $0.356\bar{l}$ with $\bar{m} = -0.597$ and $\bar{l} = -0.096$ respectively. The money contribution $0.763\bar{m}$ should be decomposed. Since bar graphs of $\bar{m}$ and $\bar{l}$ depict only a little contributions $\bar{l} \rightarrow \bar{m}$ and $\bar{m} \rightarrow \bar{l}$, we can estimate that $\bar{m} \rightarrow \bar{l} \rightarrow \bar{y}$ should be less than or equal to $\bar{l} \rightarrow \bar{y}$ ($= 0.356\bar{l}$). Therefore, $\bar{m} \rightarrow \bar{y}$ (not through bank loans) has a lower bound $0.763\bar{m} - 0.356\bar{l}$. The ratio of money channel to credit channel is thus obtained:

$$\frac{(money)}{(credit)} \geq \frac{0.763\bar{m} - 0.356\bar{l}}{0.356\bar{l}} = 12.3 : 1$$  \hspace{1cm} (23)

It can be concluded that the money channel is more effective than the credit one.

In the figure of $p(t)$, the impulse response moves upward. This behavior is somewhat strange in economic sense and is called *price puzzle*. This is because the central bank gets the information about inflation earlier than others and operates the interest rate against the price.

It should be noted that we can see the contribution of $\bar{y}$ in bar graphs of $\bar{m}$ and $\bar{l}$. This phenomena may reflect high and stable growth rate of $gdp$ before the burst of the bubble and cannot be seen after the bubble economy.

### 3.2 \[1977:1,1998:4\] without cointegration

Unit root tests are shown in Table 3. As pre-tests, unit roots of $(\Delta m, \Delta l, \Delta y, \Delta p)$ are detected and every variable is shown to be stationary with a linear trend. Therefore, unit roots of level variables ($m, l, y, p$) should be considered around a quadratic trend. By the table by MacKinnon [17], we can see that units roots of $(m, l, y, p)$ are not rejected. For $r$, ERS test and KPSS test are carried out and the test result may show $r$ to be nonstationary. However, $t$-statistics in ERS and
LM-statistics in KPSS are very near to 10% significance level respectively. Furthermore, using ADF test with dummy variable at 1980:2, we can see that unit root is rejected with 5% significance level. So, in this case, we treat \( r \) as a stationary process. This determination seems to be ad hoc. There is another reason for stationarity of \( r \). When we calculate cointegration tests, every combination of \( r \) with the other variables always exhibits cointegration property, while without \( r \) cointegration properties are not found among the other variables. These results strongly suggest that \( r \) is stationary.

<table>
<thead>
<tr>
<th>var.</th>
<th>ERS</th>
<th>lag</th>
<th>KPSS</th>
<th>additional regressors</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>-2.638</td>
<td>1</td>
<td>0.124+</td>
<td>const. + trend</td>
</tr>
<tr>
<td>ADF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( m )</td>
<td>-2.139</td>
<td>1</td>
<td></td>
<td>quadratic trend</td>
</tr>
<tr>
<td>( l )</td>
<td>-3.182</td>
<td>3</td>
<td></td>
<td>quadratic trend</td>
</tr>
<tr>
<td>( y )</td>
<td>-1.740</td>
<td>3</td>
<td></td>
<td>quadratic trend</td>
</tr>
<tr>
<td>( p )</td>
<td>-2.903</td>
<td>3</td>
<td></td>
<td>quadratic trend</td>
</tr>
</tbody>
</table>

Table 4: Cointegration Test of \((m, l, y, p)\): Quadratic Trend

<table>
<thead>
<tr>
<th>Eigenvalues</th>
<th>( m )</th>
<th>( l )</th>
<th>( y )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r = 0 )</td>
<td>0.2157</td>
<td>0.1853</td>
<td>0.1087</td>
<td>0.0276</td>
</tr>
<tr>
<td>( r \leq 1 )</td>
<td>0.2157</td>
<td>0.1853</td>
<td>0.1087</td>
<td>0.0276</td>
</tr>
<tr>
<td>( r \leq 2 )</td>
<td>0.2157</td>
<td>0.1853</td>
<td>0.1087</td>
<td>0.0276</td>
</tr>
<tr>
<td>( r \leq 3 )</td>
<td>0.2157</td>
<td>0.1853</td>
<td>0.1087</td>
<td>0.0276</td>
</tr>
<tr>
<td>( \lambda_{max} )</td>
<td>20.41</td>
<td>17.21</td>
<td>9.66</td>
<td>2.35</td>
</tr>
<tr>
<td>( \lambda_{trace} )</td>
<td>49.64</td>
<td>29.23</td>
<td>12.02</td>
<td>2.35</td>
</tr>
</tbody>
</table>

The results of cointegration test are exhibited in Table 4 with quadratic trend in level variables. We cannot see cointegration property and we proceed analysis without cointegrations in this time interval.

**System model.** The system model in Eq.(1) is re-estimated similarly as in Eqs.(13) to (17), where cointegration term is deleted and where linear trend terms are added from unit root analysis. The lagged differences are precisely determined at each equation by AIC criterion.

\( r(t) \) has regressors of \( \{r(t-i)\}_{i=1,2}, \{\Delta m(t-i)\}_{i=1,2}, \{\Delta l(t-i)\}_{i=1,2,3}, \{\Delta y(t-i)\}_{i=1,2}, \{\Delta p(t-i)\}_{i=1} \), constant, linear trend and dummy80q2. For simplicity of notation, we describe lagged differences, in this case, as \( i = (2, 2, 3, 2, 1) \).

Each of \( \Delta m(t) \), \( \Delta l(t) \), \( \Delta y(t) \) and \( \Delta p(t) \) has regressors \( r(t-i), \Delta m(t-i), \Delta l(t-i), \Delta y(t-i), \Delta p(t-i) \).
\( \Delta l(t-i), \Delta y(t-i), \Delta p(t-i) \), c, linear trend and dummy80q2, where lagged differences are \( i = (1, 1, 2, 3, 2) \) for \( \Delta m(t) \), \( i = (1, 2, 3, 3, 1) \) for \( \Delta l(t) \), \( i = (\cdot, 1, 2, 3, 3) \) for \( \Delta y(t) \), and \( i = (2, 2, 3, 2, 1) \) for \( \Delta p(t) \). It should be noted that \( \Delta y(t) \) is not regressed by \( r(t-i) \) similarly as in Eq.(16). Description of the system equation is available from the author upon the request.

**Impulse Responses.** Impulse responses of differenced processes are depicted in Figure 2. Accumulation of differenced processes implies level variables responses shown in Figure 3 together with asymptotic contributions. Asymptotic states in Eq.(6) are given by

\[
\begin{align*}
\bar{R} &= 0.896\bar{R} - 0.186\bar{m} + 0.020\bar{l} + 0.006\bar{y} - 0.185\bar{p} + 0.534, \\
\bar{m} &= -0.123\bar{R} + 0.548\bar{m} + 0.302\bar{l} - 0.049\bar{y} + 0.313\bar{p} + 0.042, \\
\bar{l} &= -0.051\bar{R} - 0.063\bar{m} + 1.00\bar{l} - 0.116\bar{y} + 0.217\bar{p} - 0.034, \\
\bar{y} &= 0.215\bar{m} + 0.165\bar{l} + 0.244\bar{y} - 0.14\bar{p} + 0.067, \\
\bar{p} &= 0.085\bar{R} + 0.071\bar{m} - 0.131\bar{l} + 0.07\bar{y} + 0.11\bar{p} + 0.024.
\end{align*}
\]

![Figure 2: Impulse Responses of \( \Delta x(t) \) in [1977:1,1998:4] with \( x(t) = (R(t), m(t), l(t), y(t), p(t)) \)](image-url)
Figure 3: Impulse Responses and Decomposed Asymptotic Contributions in [1977:1,1998:4]
The asymptotic states \((\bar{R}, \bar{m}, \bar{l}, \bar{y}, \bar{p})\) are thus obtained:

\[
\bar{R} = 2.699, \quad \bar{m} = -0.954, \quad \bar{l} = -0.845, \\
\bar{y} = -0.422, \quad \bar{p} = 0.301.
\]

In the bar graph of \(\bar{m}, \bar{l} \rightarrow \bar{m}\) is not negligible, which is quite different from the case in [1977,1989].

In the bar graph of \(\bar{l}, \bar{m}\) does not contribute to \(\bar{l}\) any more, but exhibits an opposite sign by a small amount, while in [1977,1989] we can see a contribution \(\bar{m} \rightarrow \bar{l}\). This may reflect the influence of the credit crunch in 1990s.

In the bar graph of \(\bar{y}\), it can be explicitly seen that \(\bar{l} \rightarrow \bar{y}\) has influence as well as \(\bar{m} \rightarrow \bar{y}\). Taking in mind the fact that in the figures of \(\bar{m}\) and \(\bar{l}\) we have two relations \(\bar{m} \not\rightarrow \bar{l}\) and \(\bar{l} \rightarrow \bar{m}\), the contribution \(\bar{m} \rightarrow \bar{y}\) does not contain the path \(\bar{m} \rightarrow \bar{l} \rightarrow \bar{y}\), while the contribution \(\bar{l} \rightarrow \bar{y}\) contains in itself the path \(\bar{l} \rightarrow \bar{m} \rightarrow \bar{y}\). Thus, the money contribution should be reduced by the amount of \(\bar{l} \rightarrow \bar{m} \rightarrow \bar{y}\), although this amount cannot be measured precisely. We can conclude that the importance of credit channel becomes dramatically large in [1977,1998] containing the period “after the burst of the bubble economy”, compared with that in [1977,1989] ”before the burst of the bubble”.

4 Conclusion

Monetary transmission mechanism in Japan was investigated quantitatively by impulse response approach. Gdp, money supply, bank loans and price are \(I(1)\), while the interest rate is \(I(0)\) or \(I(1)\). The VEC model of growth rates driven by the interest rate was constructed and impulse responses were calculated. Accumulating impulse responses of growth rates, we can obtain impulse responses of level variables with unit root. Taking it into consideration that impulse responses of growth rates converge to zero as \(t\) increases, responses of level variables converge to nonzero asymptotic states. These asymptotic states give us precise information concerning the contribution of money supply and bank loans to gdp. We can exhibit an inequality which decompose the path \(m \rightarrow y\) into \(m \rightarrow l \rightarrow y\) and \(m \rightarrow y\) (not through \(l\)) in the interval [1977,1989]. In this interval, we can see that money channel was more effective than the credit one. In [1977,1998], the importance of the credit channel was shown to be large. Our results suggest that the credit crunch of lending market in 1990’s has a serious effect on the Japanese economy.
References


