UDK: 336.7(520)
DOI: 10.2478/jcbtp-2023-0011

Journal of Central Banking Theory and Practice, 2023, 1, pp. 249-261
Received: 16 January 2020; accepted: 18 July 2022

Serdar Ongan [*], **Ismet Gocer** [**]

[*] University of South Florida, Department of Economics, Tampa, USA

E-mail (corresponding author): serdarongan@usf.edu

[**] University of Szeged, Department of Statistics, Szeged, Hungary

E-mail: gocer.ismet@szte.hu

Money Supply Determination Process for Japan

Abstract: This study re-investigates the money supply determination process for Japan. The methodology of this study, which differs from previous studies, is constructed on the assumption of potential nonlinear (asymmetric) relations between money supply and monetary base via money multiplier. To this aim, the nonlinear autoregressive distributed lag (ARDL) model by Shin, Yu and Greenwood-Nimmo, (2014) is applied. This model allows us to examine the endogeneity and exogeneity of the money supply determination process via the linkage of the money multiplier under expansionary and contractionary monetary policies of the Bank of Japan (BOJ) separately in a nonlinear manner. The main findings of the study indicate that the money supply determination process is endogenous with an unstable money multiplier for Japan for M1. However, this endogeneity in the BOJ's contractionary monetary policy is more than its expansionary policy. This can be interpreted that the BOJ's expansionary monetary policy has more of a determining role on money supply determination than its contractionary monetary policy. Additionally, the same findings indicate that the BOJ has more power to determine M1 than M2. This result can be interpreted that when the measure of money broadens the BOJ's controllability on money supply decreases. In contrast, in our Canadian study (Ongan and Gocer, 2019) with the same nonlinear ARDL model, we concluded that the Canadian central bank (BOC) was able to determine money supply exogenously for M1, unlike the Japanese central bank (BOJ), and the money multiplier was stable for Canada.

Keywords: The money multiplier model, money supply determination, Exogeneity, Endogeneity, Japan.

JEL Classification: E50, E51, E52, E58.

1. Introduction

The Japanese economy has been suffering from prolonged deflation for the last two decades. To overcome this problem, the Bank of Japan's (BOJ) monetary policy framework consists of two components. The first is the "yield curve control" which adopts very low, zero and negative short-term and long-term interest rates. The second is the "inflation-overshooting commitment" which expands monetary base until the consumer price index (CPI) exceeds 2% and stays above the targeted rate in a stable manner (BOJ, 2019). Therefore, the controllability of the monetary base and thereby the controllability of money supply are of big importance to the BOJ's monetary policy implementation. If the money multiplier is stable, the BOJ may easily control the monetary base and money supply. This means that the BOJ determines the money supply exogenously. On the other hand, an unstable money multiplier may cause difficulties for the BOJ to control the monetary base and money supply, meaning an endogenous money supply determination process for the bank.

The long-standing discussion about the exogeneity and endogeneity of money supply was mainly between Monetarists and Post-Keynesians. The Monetarists (Brunner, 1961; Friedman and Schwartz, 1963; Brunner and Meltzer, 1964) claim that money supply is determined exogenously by the central banks. However, the Post-Keynesians (Kaldor, 1982; Moore, 1988; Palley, 1994; Wray, 1995) claim that the central banks determine money supply endogenously since a country's monetary base cannot be controllable with an unstable money multiplier. According to them, economic actors' different portfolio choices as well as some other factors in financial markets make the money multiplier changeable and unstable. The same discussions are also observed on the current empirical studies that do not give a clear picture of the validity of exogeneity and endogeneity of money supply for different countries.

Aside from all theoretical discussions, this study aims to empirically re-investigate the money supply determination process for Japan. This re-investigation process corresponds to the methodology of this study which makes it different from the previous empirical studies. Contrary to the previous studies, this methodology is based on the probability of nonlinear (asymmetric) relations between the money supply and the monetary base via the money multiplier. The rationale of applying this methodology is that the asymmetric information problem in financial markets and the rising uncertainties in economies cause economic actors to behave asymmetrically. This means that the relations between the money supply and the monetary base via the money multiplier may be in a nonlinear (asymmetric) characteristic. Increases and decreases (corresponding in this study to the expansionary and contractionary monetary policies respectively) in the monetary base by the BOJ may lead to different size or sign impacts on the money supply in a nonlinear manner. The reason for choosing Japan as the sample country of this study is two-fold. First, BOJ's unconventional monetary policy adopting very low, zero and negative interest rates. These interest rate levels may easily change the Japanese economic actors' portfolio choices, causing an unstable money multiplier. It should be also noted that the term carry trade is usually applied to describe Japanese housewives' portfolio choices. They borrow at low interest rates in Japan and invest in other countries at higher rates. Second, Japanese are defined as one of the highest uncertainty avoidance people by Hofstede (1980) as per the Uncertainty Avoidance Index (UAI). This index ranks countries by each society's tolerance for uncertainty and ambiguity. Considering the results from this index, sensitivities of the Japanese people to the uncertainties in the economy may also affect their financial asset selections and thereby cause an unstable money multiplier. Accordingly, with these two reasons, this study uses Japan as the sample country of this study to re-investigate the money supply determination process.

The second aim of this study is to test-affirm for Japan the new methodology that we used for the first time for Canada and to propose using this methodology in the relevant literature. Therefore, this study, which covers the same period as our previous Canadian study (Ongan and Gocer, 2019), will allow us to compare the effectiveness of the Canadian and Japanese central banks in determining the money supply.

A few empirical studies examined the money supply determination process for Japan. Many of these supports the endogeneity of money supply for this country. For instance, Howells and Hussein (1998) applied cointegration and causality tests for the G7 countries and found endogenous money supply for all countries, including Japan. Badarudin, Ariff Khalid (2013) used the Vector Error Correction (VEC) and Trivariate vector autoregression (VAR) models for the G7 countries and found endogenous money supply for Japan. Nayan, Kadir, Abdullah & Ahmad (2013) used the system Generalized Method of Moments (GMM) for 177 countries, including Japan, and found endogenous money supply for all countries. However, Chai and Hahn (2018) used the Toda-Yamamoto Granger non-causality and the bootstrap tests for seven Asia-Pacific countries and found exogenous money supply only for Japan.

This study is organized as follows: Section 2 describes the empirical model and methodology, Section 3 provides empirical results and Section 4 reviews the concluding remarks.

2. Empirical Model and Methodology

2.1. Empirical Model

In the re-investigation of the money supply process for Japan, the most used money multiplier model by Brunner (1961) and Brunner and Meltzer (1964) is applied.

$$M = mm * MB \quad (1)$$

where M is the money supply, mm is the money multiplier and MB is the monetary base. If we rebuild the model in the Eqn.1 for both narrow money ($M1$) and broad money ($M2$), we obtain the following models for $M1$ and $M2$:

$$M1 = mm1 * MB \quad (2)$$

$$M2 = mm2 * MB \quad (3)$$

Money multipliers ($mm1$, $mm2$) proportionally link monetary bases to money supplies ($M1$, $M2$). If we rewrite Eqns. 2 and 3 in the logarithmic regression form, we obtain the following models:

$$\mathrm{LogM1_t} = \alpha_0 + \alpha_1 \mathrm{Logmm1_t} + \alpha_2 \mathrm{LogMB_t} + e_t \quad (4)$$

$$\mathrm{LogM2_t} = \beta_0 + \beta_1 \mathrm{Logmm2_t} + \beta_2 \mathrm{LogMB_t} + e_t \quad (5)$$

where α_1 and β_1 are logarithms of $mm1$ and $mm2$. The conditions of an exogenous money supply determination processes are stationary (stable) $mm1$ and $mm2$ and stationary monetary base (MB), $M1$, $M2$ or cointegrated MB with $M1$, $M2$ if they are not stationary at the same order of integration (Khan, 2010; Thenuwara and Morgan, 2017; Bhatti and Khawaja, 2018). All this means is that α_1 and β_1 must be zero (logarithms of stable $mm1$ and $mm2$ which equal to 1 in the forms of $\frac{M1}{MB} = 1$, $\frac{M2}{MB} = 1$) and α_2 and β_2 must be 1, implying one-to-one proportion relations between $M1$, $M2$ and MB. The monthly data of $M1$, $M2$ and MB were obtained from the Bank of Japan (BOJ). The coverages of $M1$, $M2$ and MB are provided in Appendix 1.

2.2. Methodology

For the estimation of potential nonlinear relations in the money supply determination process for Japan via the money multiplier model, the nonlinear autoregressive distributed lag (ARDL) model by Shin et al. (2014) is applied. This model decomposes the series to its positive and negative changes. Accordingly, we decompose the original monetary base series into increases (MB^+) and decreases (MB^-). Hence, this decomposition enables us to examine the separate effects of the changes in MB^+ and MB^- on the money supply. In other words, with this model we can reveal whether the effects of the changes in MB^+ and MB^- on money supply are symmetric or asymmetric. Only the same size and the same sign significant coefficients of these two will signify symmetric effects on money supply. Insignificant MB^+ or MB^- or significant but different sign-size coefficients of these two variables will signify asymmetric effects on the money supply. However, for the formal decision of asymmetry and symmetry, we apply the Wald test. The decomposition of MB^+ and MB^- is structured in the following partial sum process:

$$MB_t^+ = \sum_{j=1}^{t} \Delta MB_j^+ = \sum_{j=1}^{t} \max(\Delta MB_j, 0)$$
$$MB_t^- = \sum_{j=1}^{t} \Delta MB_j^- = \sum_{j=1}^{t} \min(\Delta MB_j, 0) \quad (6)$$

The nonlinear ARDL model is the extended version of the linear ARDL model by Pesaran, Shin and Smith`s (2001) bounds testing. The nonlinear model for $M1$ and $M2$ are separately given in the following error correction (ECM) forms for the short-run and long-run effects of MB^+ and MB^- on $M1$ and $M2$.

$$\Delta LogM1_t = \alpha_0 + \sum_{j=1}^{p} \alpha_{1j} \Delta LogM1_{t-j} + \sum_{j=0}^{q} \alpha_{2j} \Delta Logmm1_{t-j} + \sum_{j=0}^{r} \alpha_{3j} \Delta LogMB_{t-j}^+ + \sum_{j=0}^{s} \alpha_{4j} \Delta LogMB_{t-j}^- + \alpha_5 LogM1_{t-1} + \alpha_6 Logmm1_{t-1} + \alpha_7 LogMB_{t-j}^+ + \alpha_8 LogMB_{t-j}^- + e_t \quad (7)$$

$$\Delta LogM2_t = \beta_0 + \sum_{j=1}^{p} \beta_{1j} \Delta LogM2_{t-j} + \sum_{j=0}^{q} \beta_{2j} \Delta Logmm2_{t-j} + \sum_{j=0}^{r} \beta_{3j} \Delta LogMB_{t-j}^+ + \sum_{j=0}^{s} \beta_{4j} \Delta LogMB_{t-j}^- + \beta_5 LogM2_{t-1} + \beta_6 Logmm2_{t-1} + \beta_7 LogMB_{t-j}^+ + \beta_8 LogMB_{t-j}^- + \varepsilon_t \quad (8)$$

The long-run effects of increases (MB^+) and decreases (MB^-) in monetary base on $M1$ and $M2$ are determined with the sizes-signs and significances of $-\alpha_7/\alpha_5$, $-\alpha_8/\alpha_5$ and $-\beta_7/\beta_5$, $-\beta_8/\beta_5$ respectively in Eqns. 7 and 8. Similarly, the short-run effects of increases (MB^+) and decreases (MB^-) in monetary base on $M1$ and $M2$ are determined with the sizes-signs and significances of $\sum_{j=0}^{r} \alpha_{3j}$, $\sum_{j=0}^{s} \alpha_{4j}$ and $\sum_{j=0}^{r} \beta_{3j}$, $\sum_{j=0}^{s} \beta_{4j}$ respectively in the same equations.

In the next section, we will pursue the following steps. First, we apply the stationary test and, if the series are stationary, we then apply the cointegration test. The final step is to apply the nonlinear ARDL model for the estimated results.

3. Empirical Results

To make sure whether the time series variables are stationary, we apply Vogelsang and Perron (1998) Augmented Dickey Fuller (ADF) unit root tests with structural breaks. The results of the unit root tests are reported in Table 1.

Table 1: Vogelsang and Perron ADF Unit Root Test Results

	Level		First Difference	
	Prob.	Structural Break Date	Prob.	Structural Break Date
*LogM*1	0.99	2012:M11	0.00***	2003:M12
*LogM*2	0.99	2012:M11	0.00***	2004:M04
LogMB	0.17	2012:M11	0.00***	2004:M06
$LogMB^{+}$	0.53	2011:M02	0.00***	2004:M09
$LogMB^{-}$	0.06*	2006:M01	-	-

Note: ***, ** and * denote statistical significances at 1%, 5%, and 10% level, respectively. The optimal lags were automatically selected by using the Modified Akaike Information Criterion. The found structural breaks in 2004 and 2012 correspond to the following years of zero interest rate, quantitative-qualitative monetary easing (QQE) and comprehensive monetary easing policies by the BOJ.

The test results in Table 1 indicate that all series except $LogMB^{-}$ are $I(1)$. Hence, for an exogenous money supply determination process, *M*1 - *M*2 must be cointegrated with *MB*. To this aim, we apply bounds testing by Pesaran et al. (2001). The test results of bounds testing are reported in Table 2.

Table 2: Test Results of Bounds Testing

Dependent Variable	k	F stat.	Critical Values					
			I0 Bound			I1 Bound		
			10%	5%	1%	10%	5%	1%
LogM1	2	6.77***	2.63	3.1	4.13	3.35	3.87	5
LogM2	2	4.96**	2.63	3.1	4.13	3.35	3.87	5

Note: k is number of regressors. *** and **; denotes cointegration at the 1% and 5% significance level, respectively.

The test results in Table 2 indicate that the series are cointegrated in the long-run since the calculated *F-statistics* are over the critical values. The estimated coefficients of the nonlinear ARDL model in both the short-run and long-run with diagnostic tests are reported in Table 3.

Table 3: Nonlinear ARDL Model Estimation Results

Dependent Variable: (M1)			Dependent Variable: (M2)		
Variable	Coef.	Prob.	Variable	Coef.	Prob.
Short-Run Coefficients					
$\Delta LogMB^{+}_{t-2}$	-0.27***	0.00	$\Delta LogMB^{+}_{t}$	0.06***	0.00
$LogMB^{+}_{t-3}$	-0.33***	0.00	$\Delta LogMB^{+}_{t-2}$	-	-
$\Delta LogMB^{+}_{t-4}$	-0.25***	0.00	$LogMB^{+}_{t-3}$	-	-
$\Delta LogMB^{+}_{t-5}$	-0.18**	0.03	$\Delta LogMB^{+}_{t-4}$	-0.11***	0.00
$\Delta LogMB^{+}_{t-6}$	-0.24***	0.00	$\Delta LogMB^{+}_{t-5}$	-0.16***	0.00
$\Delta LogMB^{+}_{t-7}$	-0.32***	0.00	$\Delta LogMB^{+}_{t-6}$	-0.16***	0.00
$\Delta LogMB^{+}_{t-10}$	-0.28***	0.00	$\Delta LogMB^{+}_{t-7}$	-0.11***	0.00
$\Delta LogMB^{+}_{t-11}$	-0.33***	0.00	$\Delta LogMB^{+}_{t-8}$	-0.11***	0.00
$\Delta LogMB^{-}_{t-1}$	-0.60***	0.00	$\Delta LogMB^{+}_{t-9}$	-0.10***	0.00
$\Delta LogMB^{-}_{t-5}$	-0.34**	0.01	$\Delta LogMB^{+}_{t-10}$	-	-
$\Delta LogMB^{-}_{t-9}$	-0.38***	0.00	$\Delta LogMB^{+}_{t-11}$	-	-
$\Delta LogMB^{-}_{t-11}$	-0.41***	0.00	$\Delta LogMB^{-}_{t-1}$	-	-
			$\Delta LogMB^{-}_{t-3}$	-0.48***	0.00
			$\Delta LogMB^{-}_{t-5}$	-	-
			$\Delta LogMB^{-}_{t-9}$	0.55**	0.01
			$\Delta LogMB^{-}_{t-11}$	-	-
			$\Delta LogMB^{-}_{t-12}$	0.53***	0.00
ECT_{t-1}	-0.14***	0.00	ECT_{t-1}	-0.16***	0.00
Normalized Long-Run Coefficients					
$LogMB^{+}_{t}$	0.21***	0.00	$LogMB^{+}_{t}$	0.11***	0.00
$LogMB^{-}_{t}$	0.02**	0.01	$LogMB^{-}_{t}$	0.09	0.12
Constant	15.33***	0.00	*Constant*	15.75***	0.00
Short-Run Coefficients					
$\sum_{j=0}^{r} \alpha_{3j} \Delta LogMB_t^{+}$	-2.24***	-11.92#	$\sum_{j=0}^{r} \beta_{3j} \Delta LogMB_t^{+}$	-0.72***	8.47#
$\sum_{j=0}^{s} \alpha_{4j} \Delta LogMB_t^{-}$	-1.74***	-6.43#	$\sum_{j=0}^{s} \beta_{4j} \Delta LogMB_t^{-}$	0.60***	2.57#
Diagnostic Tests					
	Test Stat.	Prob.		Test Stat.	Prob.
R^2	0.99	-	R^2	0.99	-
$Adj.\ R^2$	0.99	-	$Adj.\ R^2$	0.99	-
DW	1.96	-	DW	2.14	-
X^2_{SC}	0.006	0.93	X^2_{SC}	2.86	0.09
X^2_{FF}	2.10	0.15	X^2_{FF}	-	-
X^2_{NOR}	3.20	0.20	X^2_{NOR}	0.98	0.61
X^2_{HET}	19.53	0.07	X^2_{HET}	8.01	0.88
F	3759.9	0.00	F	4276.66	0.00
W_{LR}	4337.48	0.00	W_{LR}	2791.70	0.00
W_{SR}	101.47	0.00	W_{SR}	35.38	0.00
EG_{MAX}	-1.66	0.08	EG_{MAX}	-1.74	0.07

Note: ***, ** and * denote statistical significances at 1%, 5% and 10% levels, respectively. W_{LR} and W_{SR} are long and short-run Wald tests. Critical t-table values are 2.32, 1.64 and 1.28 for 1%, 5% and 10%. # denotes t- statistic. Normalized long-run coefficients are obtained from $\Delta LogMB^{+}_{t} = -\alpha_7/\alpha_5$, $\Delta LogMB^{-}_{t} = -\alpha_8/\alpha_5$ for M1 and $\Delta LogMB^{+}_{t} = -\beta_7/\beta_5$, $\Delta LogMB^{-}_{t} = -\beta_8/\beta_5$ for M2. We reject the null hypothesis of "there is a symmetric relation" since P-values of W_{LR} and W_{SR} for both M1 and M2 are <0.10

The normalized estimates in Table 3 indicate that both increases (MB^+) and decreases (MB^-) in the monetary base have cointegrated relation with $M1$ in the long run since their coefficients are significant at 1% and 5% levels. However, their estimated coefficient values are far lower than 1, which denotes less than *one-to-one* cointegrated proportional relation. This implies an unstable money multiplier and endogenous money supply determination for the BOJ in the long run. Yet, the coefficient of MB^+ is much higher than the coefficient of MB^-. This can be interpreted that the BOJ's expansionary monetary policy has more of a determining role on the money supply determination than its contractionary monetary policy. In the same way, only the BOJ's expansionary monetary policy (MB^+) has impact on $M2$ since its coefficient is significant. Furthermore, the comparative results indicate that the BOJ's expansionary monetary policy (MB^+) has more of a determining role on $M1$ with 0.21 than $M2$ with 0.11. This result can be interpreted that when the measure of money narrows, the BOJ's controllability on money supply increases. The short-run estimates indicate that both increases (MB^+) and decreases (MB^-) in monetary base have proportional cointegrated relations with $M1$ and $M2$ since their coefficients are significant. However, their coefficients are far higher or lower than 1, signifying an unstable money multiplier and an endogenous money supply determination for the BOJ in the short run. The negative and significant *ECT* coefficients confirm that short-run deviations converge to long-run equilibrium for $M1$ and $M2$. The long-run (W_{LR}) and short-run (W_{SR}) Wald statistics confirm that both increases (MB^+) and decreases (MB^-) in monetary base have asymmetric (nonlinear) impacts on M1 and M2. This is because $(-\alpha_7/\alpha_5) \neq (-\alpha_8/\alpha_5)$ and $\sum_{j=0}^{r} \alpha_{3j} \neq \sum_{j=0}^{s} \alpha_{4j}$ for M1 and $(-\beta_7/\beta_5) \neq (-\beta_8/\beta_5)$ and $\sum_{j=0}^{r} \alpha_{3j} \neq \sum_{j=0}^{s} \beta_{4j}$ for M2.

To introduce the new methodology of this study in the relevant literature and suggest its use, we compared the empirical results of this study with our Canadian study (Ongan and Gocer, 2019), in which we used the same nonlinear ARDL model. In Table 4, we present the empirical findings of the Canadian study for this purpose.

Table 4: Nonlinear ARDL Model Estimation Results for Canada

	Dependent Variable (M1)			Dependent Variable (M2)	
Variable	Coef.	t-st.	Variable	Coef.	t-st.
$LogM1_{t-1}$	-0.022581	-1.13	$LogM2_{t-1}$	-0.007214	-1.94
$LogMB^{+}_{t-1}$	0.021437	0.79	$LogMB^{+}_{t-1}$	0.003457***	2.60
$LogMB^{-}_{t-1}$	-0.099277**	-2.24	$LogMB^{-}_{t-1}$	0.003798	0.16
$\Delta LogM1_{t-4}$	0.13**	2.40	$\Delta LogM2_{t-3}$	0.044664	1.15
$\Delta LogM1_{t-5}$	-0.18***	-2.92	$\Delta LogM2_{t-4}$	-0.046662	-1.23
$\Delta LogM1_{t-9}$	0.15***	2.76	$\Delta LogM2_{t-5}$	0.133 667***	3.52
$\Delta LogM1_{t-10}$	0.09	1.74	$\Delta LogM2_{t-6}$	-0.055557	-1.46
$\Delta LogM1_{t-12}$	-0.20***	-3.41	$\Delta LogMB^{+}_{t}$	0.021279**	2.39
$\Delta LogMB^{+}_{t}$	0.36***	400.95	$\Delta LogMB^{+}_{t-2}$	0.028404**	2.37
$\Delta LogMB^{+}_{t-5}$	0.19**	2.17	$\Delta LogMB^{+}_{t-3}$	-0.013998	-1.19
$\Delta LogMB^{+}_{t-10}$	0.12	1.56	$\Delta LogMB^{+}_{t-7}$	-0.015856	-1.67
$\Delta LogMB^{+}_{t-12}$	0.14	1.68	$\Delta LogMB^{+}_{t-7}$	-0.020910**	-2.12
$\Delta LogMB^{-}_{t-2}$	0.17	1.79	$\Delta LogMB^{+}_{t-12}$	-0.021958**	-2.46
$\Delta LogMB^{-}_{t-7}$	0.16	1.56	$\Delta LogMB^{-}_{t-6}$	0.025333	1.05
$\Delta LogMB^{-}_{t-10}$	0.11	1.22	$\Delta LogMB^{-}_{t-7}$	0.029728	1.25
Constant	0.125454	1.16	*Constant*	0.067100**	2.07
ECT_{t-1}	-0.81***	-278.89	ECT_{t-1}	-0.31***	-8.66
Normalized Long-Run Coefficients					
$LogMB^{+}_{t}$	0.94**	2.52	$LogMB^{+}_{t}$	0.47***	2.80
$LogMB^{-}_{t}$	-4.39	-1.74	$LogMB^{-}_{t}$	0.52	0.91
Short Run-Coefficients					
$\sum_{j=0}^{q} \alpha_{2j}\Delta LogMB_t^{+}$	0.83***	5.78	$\sum_{j=0}^{q} \alpha_{2j}\Delta LogMB_t^{+}$	-0.023	-1.21
$\sum_{j=0}^{r} \alpha_{3j}\Delta LogMB_t^{-}$	0.44***	2.62	$\sum_{j=0}^{r} \alpha_{3j}\Delta LogMB_t^{-}$	0.055	1.53
Diagnostic Tests					
	Test Stat.	Prob.		Test Stat.	Prob.
R^2	0.99	-	R^2	0.25	-
$Adj.\ R^2$	0.99	-	$Adj.\ R^2$	0.20	-
DW	1.53	-	DW	1.69	-
X^2_{SC}	0.00***	1.00	X^2_{SC}	5.30***	0.15
X^2_{FF}	0.10***	0.74	X^2_{FF}	3.85	0.01
X^2_{NOR}	25.42	0.00	X^2_{NOR}	182.59	0.00
X^2_{HET}	23.71**	0.07	X^2_{HET}	13.87***	0.53
F	12751.55***	0.00	F	4.54***	0.00
W_{LR}	-2.48**	-2.48#	W_{LR}	0.047	0.11
W_{SR}	0.39	1.78	W_{SR}	-0.078**	-2.03#
EG_{MAX}	-11.73***	0.00	EG_{MAX}	-5.41***	0.00

Note: *** and ** denote statistical significances at 1% and 5% levels, respectively. W_{LR} and W_{SR} are long and short-run Wald tests. Critical t-table values are 2.57 and 1.96 for 1% and 5%. # denotes t- statistic.

The normalized estimates in Table 4 indicated that Canada's central bank (BOC) determines money supply exogenously for *M*1 since MB^+ is close to 1 (one-to-one relation), implying a stable money multiplier. However, this determination is endogenous for *M*1 through MB^- and for *M*2 through MB^+. On the other hand, the Japanese central bank's (BOJ) neither expansionary (MB^+) nor contractionary (MB^-) monetary policy, the money supply is determined exogenously. This result may stem from low-zero and negative interest rates in Japan for a long time. The test results of Japan and Canada studies in Tables 3 and 4 reveal that the proposed methodology provides these central banks with crucial information on how they can determine their money supply processes in their expansionary and contractionary monetary policies separately.

4. Concluding Remarks

In-depth analysis of the money supply determination process is crucially important for the Bank of Japan's monetary policy implementation. Since the bank's unconventional monetary policy with very low-zero and negative interest rates may easily affect and change the structure of asset portfolios of economic actors, the money multiplier in Japan can be very changeable and unstable, making the money supply uncontrollable (endogenous) for the BOJ. In addition to this, the Japanese people's high uncertainty avoidance behavioral characteristics may also be determinative on their changing portfolio preferences. Therefore, all these factors and the asymmetric information problems in financial markets may cause the Japanese economic actors to behave asymmetrically (nonlinearly). Accordingly, this study re-investigates the money supply determination process for Japan from this methodological perspective which assumes that there may be asymmetric (nonlinear) relations between the monetary base and the money supply via the linkage of the money multiplier. To detect this potential nonlinear relation, the nonlinear ARDL model is applied. This model decomposes the series into its positive and negative changes. Accordingly, we decompose the original monetary base series into increases (MB^+) and decreases (MB^-).

This re-investigation methodology may give more exact information to the BOJ about how the money supply responds to its expansionary and contractionary monetary policies separately. The empirical findings of this study reveal that money supply determination process in Japan is endogenous both in the BOJ's expansionary and contractionary monetary policies. However, this endogeneity in the BOJ's contractionary monetary policy is more than its expansionary policy. This can be interpreted that the BOJ's expansionary monetary policy has more of a determining role on money supply determination than its contractionary monetary policy. Furthermore, the BOJ has more power to determine $M1$ than $M2$. This signifies that when the measure of money narrows, the BOJ's controllability on money supply increase.

The contribution of this study with the compared Canada study to the related literature is to propose analyzing the endogeneity and exogeneity of the money supply determination process via the money multiplier under expansionary and contractionary monetary policies separately in a nonlinear manner. All these findings may provide more and detailed information to the BOJ and BOC while they implement their monetary policies more proactively and predictably.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Badarudin, Z. E., Ariff, M. & Khalid, M. (2013). Post Keynesian money endogeneity evidence in G7 Economies. *Journal of International Money and Finance* 33, 146–162.
2. Bank of Japan (2019). Statistics, http://www.boj.or.jp/en/statistics/index.htm/
3. Bhatti, R.H. & Khawaja, M. J. (2018). The existence of a stable money multiplier in the small open economy of Kazakhstan". *Journal of Economic Studies*, 45(6),1211-1223.
4. Brunner, K. (1961). A Schema for the Supply Theory of Money. *International Economic Review*, 2(1), 79-109.
5. Brunner, K. & Meltzer, A. H. (1964). Some Further Investigations of Demand and Supply of Money. *Journal of Finance*, 19, 240-283.
6. Chai, H-Y. & Hahn, S. B. (2018). Does Monetary Policy Regime Determine the Nature of the Money Supply Evidence from Seven Countries in the Asia-Pacific Region. *East Asian Economic Review*, 22(2), 217-239.
7. Friedman, M. & Schwartz, A. (1963). A Monetary History of United States, 1867-1960, Princeton University Press, Princeton.
8. Hofstede, G. (1980). Culture's Consequences: International differences in work related values. Sage Publications: Beverly Hills, CA.
9. Howells, P.G.A. & Hussein, K. (1998). The endogeneity of money: evidence from the G7. *Scottish Journal of Political Economy*, 45(3), 329–340.
10. Kaldor, N. (1982). Economic prospects of the 1980s. *Economics Notes* 2, 67–86.
11. Khan, M. A. (2010). Testing of Money Multiplier Model for Pakistan: Does Monetary Base Carry any Information? *Economic Analysis Working Paper*s, 9(2), 1-20.
12. Moore, B. J. (1989). The endogeneity of credit money. *Review of Political Economy* 1(1), 64–93.
13. Nayan, S., Kadir N., Abdullah, M. & Ahmad, M. (2013). Post Keynesian Endogeneity of Money Supply: Panel Evidence. *Procedia Economics and Finance*, 7, 48-54.
14. Ongan, S. & Gocer, I. (2019). Revisiting the Stability of Money Multiplier on Determination of Money Supply: Evidence from Canada, *Economics Bulletin*, 39(2), 1621-1628.
15. Palley, T.I. (1994). Competing views of the money supply process: theory and evidence. *Metroeconomica* ,45(1), 67–88.
16. Pesaran, M. H. Shin, Y., & Smith, R. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics* 16(3), 289–326.

17. Shin, Y., Yu, B. & Greenwood-Nimmo, M. (2014). Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Horrace, W.C. and Sickles, R.C., *Festschrift in Honor of Peter Schmidt: Econometric Methods and Applications, eds.*, New York: Springer, 281–314.
18. Thenuwara, W. & Morgan, B. (2017). Monetary targeting in Sri Lanka: how much control does the central bank have over the money supply? *Journal of Economics of Finance*, 41(2), 276–296.
19. Vogelsang, T. J. & Perron, P. (1998). Additional Tests for a Unit Root Allowing for a Break in the Trend Function at an Unknown Time. *International Economic Review*, 39(4), 1073-1100.
20. Wray, L. R. (1995). Keynesian monetary theory: liquidity preference or black box horizontalism? *Journal of Economic Issues*, 29(1), 273–282.

The coverages of *M*1, *M*2 and *MB*

Monetary Base = Banknotes in Circulation + Coins in Circulation + Current Account Balances

*M*1 = currency in circulation + deposit money deposited at depository institutions

*M*2= currency in circulation + deposits deposited at domestically licensed banks, etc. ("domestically licensed banks, etc." indicates the same range of financial institutions stipulated as "M2+CDs depository institutions" in the former statistics). The data sample period is between 2003M4-2019M01.