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Abstract

This paper analyzes the effectiveness of non-traditional monetary policy measures implemented by the Bank of Japan (BOJ) based on the quantity theory of money. The reduced form equation regression results explain that quantity easing policy measures have very limited effects on the economy, especially on inflation under the zero lower bound on interest rates. Therefore, it is worth noting that stimulating the demand-side economy and hence money demand through credit creation is much important rather than the expansion of money stock under the zero percent interest rates policy. In other words, the new phase of monetary easing policy measures by the BOJ will not be effective to overcome the deflationary gap, although around one percent inflation will be observed in the second and third fiscal year, which is expected to be affected by rise in import price through yen depreciation, according to the scenario simulation in this study.

Keywords: non-traditional monetary policy, money multiplier, quantitative easing (QE), quantity theory of money, inflation target policy

JEL Classification Numbers: E43, E52, E58

1. Introduction

The Bank of Japan (BOJ) started the zero-interest-rate policy in April 1999 and announced quantitative easing measures (QE) in March 2001 and thereafter expanded QE by the early 2006. Although the BOJ terminated QE in March 2006 due to the longest boom from 2002, QE measures started again just after the 2008 World Financial Crisis (WFC). Furthermore, the BOJ has strengthened QE policy measures as a non-traditional monetary policy. However, despite of strengthened QE policy measures with an inflation target under the situation of the zero lower bound on interest rates, it seems that QE policy measures have not had enough effects on the economy to improve the Japanese deflation. Furthermore the BOJ has started the stronger QE policy measures since the early 2013 as the "new phase of monetary easing". In this situation, many scholars and politicians have a doubt about the consequences of new QE policy measures and indeed stock prices have been fluctuated due to uncertainty in money and financial markets.

On the other hand, in the case of the US, Fed implemented strong QE policy measures just after the 2008 WFC and many scholars and politicians have expected large positive effects of QE on the economy. Indeed, the US economy is expected to be improved and hence Fed examines how the US will shift to the ordinary monetary policy in order to avoid the bubble again.

Therefore, this paper attempts to analyze the effectiveness of the QE policy measures as a non-traditional financial policy and of the inflation target policy in Japan in comparison with the United States. Concerning the effectiveness of non-traditional monetary policy measures, many studies have discussed it in the long-term economic slump in Japan since the mid-1990s. For instance, Nakamura (2013), Ueda (2012),

Honda and Tachibana (2011), Lam (2011), Ugai (2007), Oda and Ueda (2007) analyzed the effectiveness of QE policy measures on the Japanese economy. In these studies, many studies revealed the limitation of the effectiveness despite of fairly large positive effects on stock prices and could not clarify the robust causation between QE policy measures and inflation and hence nominal GDP in Japan.

As for the structure of this paper following this introduction, section 2 discussed the model to evaluate the effectiveness of QE based on the quantity theory of money. Section3 analyzes the effects of QE measures based on an regression analysis and section 4 conducts a scenario simulation analysis by utilizing a macro-econometric model. Finally, section 5 concludes this research as concluding remarks.

2. The Model

The basic theoretical model many scholars implicitly or explicitly assumed in evaluating the effectiveness of non-traditional financial policy on the economy and hence the inflation target policy might be the quantity theory of money as an equation of exchange, as follows.

$$PT = MV$$

Therefore,

$$\dot{P} + \dot{T} = \dot{M} + \dot{V}$$

where P: price level, T: real transaction or real GDP, M: money supply, V: velocity of money.

Based on the conventional quantity theory of money, it is hypothesized that growth rate of T and rate of changes in V are stable and hence inflation rates ($\dot{P}$) depend on changes in money supply, as utilized in the k % rule. However, in the real economy,

velocity of money is not stable or highly fluctuated as a stochastic variable (Bond 1974, Gold and Nelson 1981). Therefore, the model of the quantity theory of money is modified by decomposing money supply (M) in the light-hand-side to monetary base (B) and money multiplier *(m)*, as follows.

$$PT = BmV \qquad (1)$$

Therefore,

$$\dot{P} + \dot{T} = \dot{B} + \dot{m} + \dot{V} \qquad (2)$$

In this equation, monetary base (B) is given as a policy variable and money multiplier (m=M/B) is an endogenous stochastic variable which depends on economic activities and financial and monetary policies. Hence, it is hypothesized that the rate of changes in money multiplier (m) depends on the rate of changes in real GDP ($\dot{T}$), the rate of changes in monetary base ($\dot{B}$) and policy rates (r) [(1)] in the behavioral equation, as follows.

$$\dot{m} = f(\ (+)\ \dot{T},\ (-)\ \dot{B}, (+)\ r\ )$$

$$\dot{m} = c_1 + \alpha\ \dot{T} - \beta\ \dot{B} + \gamma\ r \qquad (3)$$

On the other hand, if it is hypothesized that velocity of money is influenced by economic climates and financial and monetary policy measures, changes in velocity of money is endogenized as a stochastic variable, as follows.

$$\dot{V} = f(\ (+)\ \dot{T},\ (-)\ \dot{B}, (-)\ r\ )$$

$$\dot{V} = c_2 + \delta\ \dot{T} - \eta\ \dot{B} - \theta\ r \qquad (4)$$

Then, we get the reduced form equation from the equations (2), (3) and (4), as follows.

$$\dot{P} + \dot{T} = \dot{B} + c_1 + \alpha\ \dot{T} - \beta\ \dot{B} + \gamma\ r + c_2 + \delta\ \dot{T} - \eta\ \dot{B} - \theta\ r$$

$$= (1-\beta-\eta)\dot{B} + (\alpha+\delta)\dot{T} + (\gamma-\theta)r + c_1 + c_2$$

Therein, the reduced form equation in relation to inflation rate eliminating stochastic variables, money supply (M) and velocity of money (V), from the right-hand-side of the quantity theory of money function is defined, as follows.

$$\dot{P} = (1-\beta-\eta)\dot{B} - (1-\alpha-\delta)\dot{T} + (\gamma-\theta)r + c_1 + c_2 \qquad (5)$$

By utilizing equation (5), based on the quantity theory of money, the effects of monetary policy measures on the economy, especially on inflation could be examined. In other words, the effects of monetary base changes on inflation rate depend on the coefficients, α, β, γ, δ, η and θ, with the right-hand-side variables, including monetary base (B), real GDP (T) and interest rates (r), in place of the k% rule.

3. Analysis

Revealing the coefficients in equation (3) and (4) within the modified quantity theory of money function discussed above, the effectiveness of QE policy measures is examined for Japan and the US.

Table 1 demonstrates the TSLS results of money multiplier function based on Equation (3) for Japan and the US. According to the regression results, money multiplier can be explained by real GDP, monetary base, real policy rates and dummy variables, significantly for Japan and the US. The coefficient of real GDP (T) for both Japan and the US is fairly high at 0.554 for Japan and 0.715 for the US in terms of elasticity, which can explain money multiplier is highly influenced by business activities. However, the influence of real GDP to money multiplier for the US is higher than that of

Japan, which may be attributable to the difference of economic structures in relation to deflationary or inflationary situation and maturity of financial economy between Japan and the US. In both countries, monetary base has a negative impact on money multiplier, which explains all of money supply cannot be necessarily utilized in the economy as money demand, especially in the recession periods. As for the effects of rate of interest, both Japan and the US have a similar coefficient at 0.0050 for Japan and 0.0067 for the US.

Table 1: Determinants of money multiplier *(m)* for Japan and the US

(*TSLS*: 2000Q1-2012Q4)

Japan

$$\ln(m) = c_1 + \alpha \ln(T) + \beta \ln(B) + \gamma r + d_{11}D_1 + d_{21}D_2$$

c_1	α	β	γ	d_{11}	d_{21}	R^{2*}	*SE*	*DW*
4.5940	0.5540	−0.8039	0.0050	0.0385	0.0694	0.993	0.010	1.957
(4.12)	(5.33)	(58.3)	(2.14)	(5.38)	(10.4)			

US

$$\ln(m) = c_1 + \alpha \ln(T) + \beta_3 \ln(B)D_3 + \beta_4 \ln(B)D_4 + \gamma r + d_{31}D_3$$

c_1	α	β_3	β_4	γ	d_{31}	R^{2*}	*SE*	*DW*
−3.4221	0.7148	−0.7459	−0.1764	0.0067	3.793	0.998	0.0163	1.213
(3.42)	(2.29)	(23.5)	(4.59)	(5.26)	(8.63)			

Note: D_1 and D_2 indicate the dummy variables for the period of non-traditional QE and QE measures for Japan. D_3 and D_4 explain the dummy variables for traditional and non-traditional QE measures implemented during the period for the US. Values in parenthesis explain t-value. *T*, *B* and *m* mean real GDP, monetary base and money multiplier (M2/B), respectively. *r* refers to real policy rates, call rates for Japan and Federal Fund rates for the US.

Concerning the velocity of money function, both Japan and the US demonstrate fairly good results, as shown in Table 2. In both countries' cases, the effects of real GDP are fairly large, in which the coefficient is 0.830 for Japan and 1.16 for the US. Furthermore,

the coefficient of monetary base has a negative sign for both Japan and the US, which explains all of increased money supply cannot necessarily circulated in the economy, especially in the recession period as well as money multiplier case..

Table 2: Determinants of velocity of money (V) for Japan and the US

(*TSLS*: 2000Q1-2012Q4)

Japan

$$\ln(V) = c_2 + \delta \ln(T) + \eta \ln(B) + \theta r + d_{12}D_1 + d_{22}D_2$$

c_2	δ	η	θ	d_{12}	d_{22}	R^{2*}	*SE*	*DW*
−8.731	0.8303	−0.1934	−0.0069	−0.0752	−0.0554	0.981	0.014	1.428
(3.97)	(4.86)	(9.82)	(2.74)	(12.3)	(3.43)			

US

$$\ln(V) = c_2 + \delta \ln(T) + \eta_2 \ln(B)D_3 + \eta_3 \ln(B)D_4 + \theta r + d_{32}D_3$$

c_2	δ	η_3	η_4	θ	d_{32}	R^{2*}	*SE*	*DW*
−5.551	1.1660	−0.2276	−0.7238	−0.0034	−3.260	0.958	0.016	1.245
(5.74)	(7.69)	(7.40)	(9.72)	(2.64)	(7.65)			

Note: please see the note of Table 1.

Based on the regression results, the combined coefficients in the reduced form equation (5) can be generated for Japan and the US during the period after the 2008 World Financial Crisis considering dummy variables, as follows.

(Japan)

$$\dot{P} = (0.00270)\dot{B} - (-0.39230)\dot{T} + (-0.00183)r - 4.1642 \quad (6)$$

$$\Delta \dot{P} = 0.0027 \ \Delta \dot{B}$$

In the case of Japan, based on the relation between inflation and rate of changes in monetary base as shown above, a one percent point increase in monetary base directly

causes a 0.0027 percent point rise in inflation, which may be a very limited effect while real interest rates (policy rate) and real GDP are given. In other words, if monetary base is becoming doubled (a one-hundred percent increase), inflation is to accelerate by 0.27 percent. However, in the actual economy, inflation is affected through changes in various factors in the economy. In other words, the following implicit economic relation between inflation and real GDP growth rates can be discussed.

$$\Delta \dot{P} = 0.3923 \ \Delta \dot{T}$$

In addition, the direct relation between inflation and real interest rates is very limited at minus 0.00183 in the reduced form equation with coefficients, in which a one percent point fall in real interest rates causes a 0.00183 percent point rise in inflation in the case of Japan, as follows.

$$\Delta \dot{P} = -0.00183 \ \Delta r$$

On the other hand, in the case of the US, the relation in which a one percent point increase in monetary base causes a 0.0264 percent point rise in inflation, which is fairly sensitive, under the zero lower bound on interest rates after the 2008 WFC. In addition, the relation between inflation and real economic growth is very sensitive at 0.8808 in the case of the US. Furthermore, the direct effects of real interest rate changes on inflation are also very limited at 0.0036, but positive in the reduced form equation with coefficients (Equation 7).

(The US)

$$\dot{P} = (0.0264)\dot{B} - (-0.8808)\dot{T} + (0.0036)r - 8.411 \qquad (7)$$

$$\Delta \dot{P} = 0.0264 \Delta \dot{B}$$

$$\Delta \dot{P} = 0.8808 \Delta \dot{T}$$

$$\Delta \dot{P} = 0.0036 \Delta r$$

In both Japan and the US, although the direct relation of monetary base and real policy rate to inflation can be observed, the indirect relation between real GDP growth and inflation is also important and relatively large. Particularly, the coefficient of the US is fairly large at 0.8808 in comparison with that of Japan at 0.3923, which might be able to explain the difference of economic structures between Japan and the US. In addition, the different coefficient and its sign between inflation and real policy rate at minus 0.0018 for Japan and at 0.0036 for the US might be also attributable to the different maturity of money and financial economy between Japan and the US.

4. Scenario Simulation

As discussed above, the effects of monetary base changes on inflation mainly depends on real GDP growth in the reduced form equation based on the quantity theory of money. According to the reduced form equation with coefficients (Equation 6) for Japan, a one percent point increase in real GDP growth causes a 0.3923 percent point rise in inflation in terms of GDP deflator. Therefore, in order to attain a one percent point rise in GDP deflator, real GDP growth should be accelerated by 2.55 percent points. Therefore, this section examines the effectiveness of non-traditional monetary easing policy measures as the “new phase of monetary easing” and possibilities to attain 2 percent inflation in

CPI (one percent in GDP deflator) targeted during a couple of year by the BOJ by utilizing a multi-equation structural model system.

The macro-econometric model of Japan utilized in the scenario simulation is a conventional Keynesian type macro-econometric annual model.(2) The model consists of nine blocks, including (1) the real expenditure block, (2) the nominal expenditure block, (3) the price and wage rates block, (4) the production block, (5) the population and labor force block, (6) the income distribution block, (7) the money and finance block, (8) the government finance block, and (9) the international balance of payment block, with 127 endogenous variables and 45 exogenous variables. Basically, the model is a demand-side model, but the model contains a production function and the productivity derived from the production function affects prices and wage rates and hence demand-side variables. Therefore, the model can be characterized as a demand-supply integrated type model.(3)

As for the assumption for the scenario simulation, two scenarios, including (1) the scenario without any changes in QE measures as SIM1 and (2) the scenario with the "new phase of quantity easing policy measures" by the BOJ achieving 200 trillion yen monetary base in the end of 2013 and 270 trillion yen in the end of 2014 as SIM2, are assumed. Based on these assumptions, the scenario simulations, SIM1 and SIM2, are conducted from the fiscal year 2013 to the fiscal year 2015.

As shown in Table 3, both the scenario simulations, SIM1 and SIM2, are conducted based on the different monetary base as a policy variable in FY2013, FY2014 and FY2015 listed at the top of Table 3. Major economic indicators explain the effects of monetary base changes on the economy.

Based on the increase of monetary base by 51.5 percent in FY2013, 104.5 percent in FY2014 and FY2015, the Japanese economy has a positive effect, but the effect itself is

fairly limited in comparison with the large increase in monetary base as the new phase QE policy measures. As a result of this QE policy implemented in SIM2, it is expected that real GDP will increase by 0.4 percent in FY2013, by 1.3 percent in FY2014 and by 2.2 percent in FY2015 as compared to SIM1.(4) In SIM1, the real economic growth rates will probably be 3.2 percent by high consumption expenditures with last-minute surge in demand just before the rise in consumption tax rate and will be lower at 1.0 percent in FY2014 and minus 0.4 percent in FY2015 with the deflationary effects of consumption tax rate rise to 8 percent in FY2014 and 10 percent in FY2015. In other words, the growth performance will probably slightly improve from 3.2 percent to 3.6 percent in FY2013, from 1.0 percent to 1.9 percent in FY2014 and from minus 0.4 percent to 0.6 percent in FY2015 in SIM2. However, the effects on real GDP are mainly dependent on the changes in real exports and imports of goods and services and real non-housing investment through changes in exchange rate, but not on an increase in consumption expenditures.

As indicated, exchange rate, yen to US$, is expected to depreciate by 3.9 percent in FY2013, by 7.3 percent in FY2014 and by 10.3 percent in FY2015 by QE policy measures, which mainly causes real exports and real non-housing investment increases and real imports decreases and eventually results in real GDP increase. However, as mentioned earlier, the effects on the economy will be limited as compared to the large monetary base increase between SIM1 and SIM2. Therein, money stock in SIM2 will probably increase by 14.9 percent in FY2013, by 30.3 percent inFY2014 and 31.2 percent in FY2015 in comparison with SIM1and therefore money multiplier will be decreasing sharply.(5)

Table 3: The Effects of Monetary Base Increases on the Japanese Economy

	FY2013	FY2014	FY2015
MB: monetary base (trillion yen)			
SIM1	132.0 (14.8)	132.0 (0.0)	132.0 (0.0)
SIM2	200.0 (73.9)	270.0 (35.0)	270.0 (0.0)
% dev.	51.5	104.5	104.5
GDP: real GDP (trillion yen)			
SIM1	536.95 (3.2)	542.29 (1.0)	540.10 (-0.4)
SIM2	539.04 (3.6)	549.46 (1.9)	552.03 (0.5)
% dev.	0.4	1.3	2.2
CP: real private consumption (trillion yen)			
SIM1	316.15 (2.0)	314.46 (-0.5)	307.89 (-2.1)
SIM2	316.28 (2.1)	315.14 (-0.4)	309.21 (-1.9)
% dev.	0.0	0.2	0.4
IP: real non-housing investment (trillion yen)			
SIM1	70.14 (5.5)	71.87 (2.5)	70.53 (-1.9)
SIM2	71.61 (7.7)	77.29 (7.9)	79.47(2.8)
% dev.	2.1	7.5	12.7
EGS: real exports of goods and services (trillion yen)			
SIM1	84.81 (4.5)	87.85 (3.6)	90.74 (3.3)
SIM2	85.15 (4.9)	88.63 (4.1)	91,90 (3.8)
% dev.	0.4	0.9	1.3
MGS: real imports of goods and services (trillion yen)			
SIM1	74.45 (2.3)	74.50 (0.1)	73.32 (-1.6)
SIM2	74.34 (2.2)	74.46 (0.2)	73.08 (-1.9)
%dev.	-0.1	-0.1	-0.3
GDPN: nominal GDP (trillion yen)　475042			
SIM1	484.17 (1.9)	490.84 (1.4)	491.04 (0.0)
SIM2	487.18 (2.6)	499.95 (2.6)	506.71 (1.4)
% dev.	0.6	1.9	3.0
PGDP: deflator of GDP (100 in 2005 year)			
SIM1	90.17 (-1.3)	90.51 (0.4)	90.92 (0.4)
SIM2	90.38 (-1.0)	90.99 (0.7)	91.79 (0.9)
% dev.	0.2	0.5	1.0

CPI : consumer price index (100 in 2005)　97.9=2005			
SIM1	99.39 (0.3)	99.86 (0.5)	100.47 (0.6)
SIM2	99.47 (0.3)	100.13 (0.7)	101.03 (1.0)
% dev.	0.1	0.3	0.6
WN : nominal wage rates (index, 100 in 2005)			
SIM1	97.73 (0.9)	98.70 (1.0)	99.59 (0.9)
SIM2	97.84 (1.0)	99.17 (1.4)	100.67 (1.5)
% dev.	0.1	0.5	1.1
PMGS: deflator of imports of goods and services			
SIM1	124.05 (12.1)	125.49 (1.2)	128.04 (2.0)
SIM2	128.23 (15.9)	133.60 (4.2)	139.83 (4.7)
%dev.	3.4	6.5	9.2
EXR: exchange rate, yen to US$			
SIM1	93.72 (13.5)	92.83 (-1.0)	92.73 (-0.1)
SIM2	97.34 (17.9)	99.62 (2.3)	102.31 (2.7)
% dev.	3.9	7.3	10.3
M2: money stock (trillion yen)			
SIM1	916.76 (6.9)	924.42 (0.8)	920,92 (-0.4)
SIM2	1,053.19 (22.8)	1,204.46 (14.4)	1,208.27 (0.3)
% dev.	14.9	30.3	31.2
INTGB: government bond yield (10 year)			
SIM1	0.8800 (-1.1)	0.9500 (8.0)	0.9900 (4.2)
SIM2	0.7900 (-11.2)	0.7500 (-5.1)	0.7200 (-4.0)
% dev.	-10.2	-36.8	-27.2
TOPIX: stock prices in TOPIX			
SIM1	1,091.67 (19.2)	1,168.58 (7.0)	1,121.94 (-4.0)
SIM2	1,122.77 (22.6)	1,289.48 (14.8)	1,327.38 (2.9)
% dev.	2.8	10.3	18.3

Note: Values in parenthesis refers to rate of changes (%) from the previous year.
"% dev." denotes a % deviation between SIM1 and SIM2 ((SIM2-SIM1) /SIM1) *100).

Concerning the effects on inflation, inflation in terms of CPI is expected to rise in SIM2 by 0.1 percent in FY2013, by 0.3 percent in FY2014 and by 0.6 percent in FY2015 as compared to SIM1, which demonstrates that inflation rate in terms of CPI will

probably be 0.3 percent in FY2013, 0.6 percent in FY2014 and 1.0 percent in FY2015 in SIM2.(6) However, inflation performance in SIM2 may be still lower than the 2 percent target planned by the BOJ, which explains that the new phase of monetary easing will not be able to overcome the Japanese structural deflation.(7) In addition, deflator of GDP (PGDP) in SIM2 will have a similar effect and will probably rise by 0.2 percent in FY2013, by 0.5 percent in FY2014 and by 1.0 percent in FY2015, respectively in comparison with SIM1.(8) Furthermore, the effects on inflation will mainly be attributable to not only the improved demand-side economy but also rise in import price by depreciation of yen. Indeed, import price in terms of import deflator (PMGS) in SIM2 will probably rise by 3.4 percent in FY2013, by 6.5 percent in FY2014 and by 9.2 percent in FY2015 as compared to SIM1.

In summary, the new phase of QE policy measures by the BOJ will have positive effects on the economy, but the goal of the QE planned by the BOJ will not be achieved with a 2 percent inflation target and three percent nominal GDP growth rates despite of a large scale monetary easing. Therein, nominal GDP growth is expected to be 2.6 percent in FY2013 and FY2014 according to the scenario forecasts in this study, therefore, additional policies, including fiscal and wage policies will be needed to strengthen the demand-side economy incorporated with monetary easing policy measures.(6)

5. Concluding Remarks

In Japan, it is expected that non-traditional monetary policy measures have a fairly limited effect on the economy, especially on inflation and hence nominal GDP, which depends on the quantity theory of money. In other words, as long as the interest rates

could be declined to the zero lower bound, traditional monetary policy measures could achieve the role to improve the economy. In turn, it seems the "new phase of QE policy measures by the BOJ may damage credibility of financial markets, although, as many scholars described, QE may successfully have a forward guidance of future lower policy rates and eliminate expected future risks in financial markets.

Therefore, it is noteworthy that policies stimulating the demand-side economy and hence money demand through credit creation is much more important rather than increasing of money supply (stock) by non-traditional QE. This consequence could be revealed by the reduced form of the quantity theory of money and by the scenario simulation by utilizing the macroeconometric model of Japan in this study.

Endnotes

(1) In Japan, call rate is employed for the policy rate in place of official discount rate.

(2) The macro-econometric model of Japan utilized in this study is a revised version for the project of forecasting of the Japanese economy with HEPCO and the other projects. The model is revised employing the latest 2005 year base SNA data base in June, 2013.

(3) For more detailed structure of the model, please see Nakamura (2013).

(4) In the macro-econometric model of Japan, real GDP (demand-side GDP) is determined in an identity, summing up real GDP components, as follows.

$$GDP = CP+CG+IP+IH+IG+JP+JG+EGS-MGS$$

where GDP: real GDP, CP: real private final consumption expenditures, real government consumption, real non-housing investment, IH: real housing investment, JP: real private inventory changes, JG: real government inventory changes, EGS: exports of goods and services, MGS: imports of goods and services.

(5) The macro-econometric model utilizes the following money stock function for scenario forecasting.

$$M2=-204553.1+1.9396\,(MB)+1.4871\,(GDP)-5293.3\,(INTG)+0.64466.9\,(DWFC)$$

' (-3.20) (6.30) (12.51) (-1.27) (4.98)

TSLS (FY1980-2012) $R^2 = 0.990$ SE = 19,290.9 DW = 1.217

where M2: money stock, MB: monetary base, GDP real GDP, INTG: government bond yield, DWFC: dummy for the 2008 World Financial Crisis.

(6) In the macro-econometric model of Japan employed in this study, CPI (consumer price index) is endogenized based on the following behavioral equation.

$$\ln(CPI)=-.14947+0.1844\,\ln(PX)+0.2938\,\ln(WN)+0.5275\,\ln(CPI(-1))$$

(-2.43) (4.15) (5.24) (7.16)

TSLS (1981-2012) $R^2=.993$ SE= .004349 DW= 1.95

where CPI: consumer price index, PX: output price, WN: nominal wage rates.

(7) For the structural deflation of Japan, please see Nakamura (2013).

(8) In the macro-econometric model of Japan, deflator of GDP is endogenized in an identity, as follows.

$$PGDP = GDPN / GDP * 100$$

where PGDP: deflator of GDP, GDPN: nominal GDP, GDP: real GDP

(9) For more detail, please see Nakamura (2013).

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