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Abstract

This paper evaluates the applicability of the hybrid variant of the New Keynesian Phillips curve (NKPC) for Japan since 1980s through GMM estimation. The result of the empirical study leads us to conclude that the pure forward-looking hypothesis is rejected. With regard to the estimated structural parameters, the coefficient on the degree of backwardness in price setting is larger for the period after the collapse of the bubble economy than before. The coefficient on the degree of price rigidity is also larger after the bubble crash leading to the longer average duration of price adjustment. The estimated values of the discount factor are very close to the theoretically postulated level.

1. Introduction

To study the evolution of aggregate price is one of the prominent topics in empirical macroeconomics, and a clear understanding of the inflationary process is necessary in effective planning of a monetary policy for price stabilization. The so-called New Keynesian Phillips curve (NKPC), which is well established by microeconomic foundations with the New Keynesian DSGE (Dynamic Stochastic General Equilibrium) framework, is recently the most canonical apparatus to investigate this kind of issue. In other words, the shift in recent emphasis from the traditional Phillips curve to the New Keynesian Phillips curve is due to the inability of the former to grasp the developments of today's inflationary processes in several countries. Actually, it is often reported that some countries with high levels of economic activities are accompanied by relatively low levels of inflation that cannot be explained by the traditional framework.

The New Keynesian Phillips curve describes the link between inflation and economic activities based on the firms' price-setting behaviours, marginal costs, and various economic activities. Concretely, it incorporates two significant factors: (1) The forward-looking character of inflation which depends on the firm's price-setting manner with their expectations of demands and costs in the future, (2) The linkages between inflation, real economic activity, and marginal cost.

Concomitantly, literature on the New Keynesian Phillips curve continues to increase. For instance, Woodfood (1996), Goodfriend and King (1997), and Clarida, Galí, and Gertler (1999) study the aggregate inflation through short-run nominal rigidity. Coenen, Levin, and Chilistoffel (2007) investigate the interaction between real and nominal rigidities. Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2005) describe the importance of the lagged inflation term in their model considering the gradual response of inflation to the monetary policy shocks. Sbordone (2002), Galí and Gertler (1999), and Galí, Gertler, and López-Salido (2001) insist that real marginal cost is the key element to analyze inflation dynamics in the U. S. and the Euro area by their NKPC. From the aspect of model's specification, Zhang and Clovis (2010) conclude that further lags of inflation are necessary in the hybrid-type NKPC to rule out serial correlation. Christiano, Eichenbaum, and Evans (2005) incorporate the dynamic inflation indexation as a modification to the Calvo-type sticky and staggered price setting, while Yun (1996) applies the indexation to the inflation in steady-state. Furthermore, Smets and Wouters (2003) and Giannoni and Woodford (2005) utilize the partial dynamic inflation indexation. On the other hand, some of the recent studies deal with the flattening of the NKPC. For instance, Kuester, Müller, and Stölting (2009) insist that the NKPC looks flatter than it actually is by considering the estimated pass-through of marginal costs.

This paper proceeds to investigates whether the hybrid version of NKPC, which incorporates both backward- and forward-looking elements, provides a good description of the evolution of inflation in Japan since 1980s. Empirical study is conducted by GMM (Generalized Method of Moments) estimation for the periods before and after the collapse of Japan's bubble economy happened in the early 1990s.

The reminder of this paper is organized as follows. Section 2 explains the basic formulation of the New Keynesian Phillips curve. Section 3 examines the result of GMM estimations, and Section 4 presents the concluding remarks.

2. The Structure of New Keynesian Phillips Curve

2.1 The Basic Formulation of New Keynesian Phillips Curve

We are able to derive NKPC by proceeding as follows.[1] The business sector is assumed to be a continuum of monopolistic competitor indexed by $i\epsilon[0,1]$, and produces a differentiated good $Y_t(i)$ with a nominal price $P_t(i)$. Firm i faces an isoelastic demand curve given by $Y_t(i) = \left(\frac{p_t(i)}{P_t}\right)^{-\varepsilon} Y_t$. The production function for firm i is given by a special type of Cobb-Douglas technology: $Y_t(i) = A_t\overline{K}_t(i)^{\alpha}N_t(i)^{1-\alpha}$, where A_t is a technological factor, $\overline{K}_t(i)$ is the fixed firm specific capital stock, and $N_t(i)$ is the employment.

Households are assumed to be paid the nominal wage W_t, and each firm faces the same nominal cost of production. The Dixit-Stiglitz-type aggregate price P_t and output Y_t are represented by:

$$P_t(i) = \left[\int_0^1 P_t^{1-\varepsilon}(i)di\right]^{\frac{1}{1-\varepsilon}}, \qquad (1)$$

$$Y_t(i) = \left[\int_0^1 Y_t^{\frac{\varepsilon-1}{\varepsilon}}(i)di\right]^{\frac{\varepsilon}{\varepsilon-1}}, \qquad (2)$$

where ε is the constant price elasticity of demand. In this model, because investment and foreign trade are abstracted, output $Y_t(i)$ equals consumption $C_t(i)$.

Without any price frictions, firms would set price level $P_t^*(i)$ which maximizes real profit at any given time. The optimization framework gives the markup equation: $P_t^* = \mu + mc_t$, where $\mu = \log(\frac{\varepsilon}{\varepsilon-1})$ represents the fixed markup and mc is the log nominal marginal cost. In this framework, firms set nominal prices in the Calvo (1983)-type staggered fashion facing constraints on the frequency of price adjustment. With this specification, the probability that a firm resets the price in any period t is $1-\theta$, denoting θ as a measure of the degree of price rigidity. Since this probability is time-independent, the mean lag (or duration) of price adjustment becomes $\frac{1}{1-\theta}$. Therefore, a measure $1-\theta$ of producers reset their prices, while a fraction θ remains unchanged. By applying the property of law of large numbers and log linearization of the price index around the steady state of zero inflation, we have the following expression for the evolution of log price P_t as a convex combination of the log of lagged price level P_{t-1} and the log of newly optimized price P_t^*:

$$P_t = (1 - \theta)P_t^* + \theta P_{t-1}. \qquad (3)$$

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[1] See Goodfriend and King (1997), Galí, Gertler, and López-Salido (2001), or Scheufele (2010) for an explicit derivation.

All firms that reset price in period t choose the same value of P_t^* since there are no firm-specific state variables. In addition, with the given technology, factor prices, and the constraint on price adjustment, and the reset probability $1 - \theta$, a firm which resets its price in period t tries to maximize the expected discounted profits. Considering these elements, the Calvo-type optimized reset price can be described as[2]

$$P_t^* = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \left[mc_{t,t+k}^n \right], \qquad (4)$$

where β is a subjective discount factor and $mc_{t,t+k}^n$ means the logarithm of nominal marginal cost at time $t+k$ of a firm which last change its price at time t. This specification implies that firms which reset prices in period t will take into consideration the each expected future stream of nominal marginal cost expressed in percent deviation from the steady state value with the chance that newly reset price might be subject to the adjustment constraints in the future. Thus, prices are expected to remain unchanged for an extended period, and firms place more weight on expected marginal costs when they set current prices as θ increases.

   The next problem is to find a plausible expression of marginal cost in equation (4) as an observable measure. If we assume a simple Cobb-Douglas production function, we have

$$Y_t = A_t K_t^{\alpha} N_t^{1-\alpha}, \qquad (5)$$

where Y_t is production, A_t refers to technology, K_t denotes capital, and N_t is labor. A Cost minimization with this technology implies that the real marginal cost equals the real wage divided by the marginal product of labor. Therefore, the real MC at time $t+k$ for a firm which optimally sets price at time t is given by:

$$MC_{t,t+k} = \frac{(W_{t+k}/P_{t+k})}{(1-\alpha)(Y_{t,t+k}/N_{t,t+k})} \qquad (6)$$

where $Y_{t,t+k}$ represents output, $N_{t,t+k}$ indicates employment, and α is the curvature of the production function for a firm which has set its price in period t at the optimal value P_t^*. From the aspect of the fact that the real MC of individual firm is unobservable, it is helpful to define the average marginal cost depending only on aggregates:

$$MC_t = \frac{(W_t/P_t)}{(1-\alpha)(Y_t/N_t)} = \frac{S_t^n}{1-\alpha}, \qquad (7)$$

where $S_t^n \equiv \frac{W_t N_t}{P_t Y_t}$ is the labor share (or real unit labor costs).[3] Letting lower case letters describe

percentage deviations from each steady-state value, it becomes

$$\widehat{mc}_t = \hat{S}_t. \qquad (8)$$

Making the assumption of Cobb-Douglas technology with isoelastic demand curve following Woodford (1996), Galí, Gertler, and López-Salido (2001), and Sbordone (2002), we have the log-linear connection between $MC_{t,t+k}$ and MC_t:

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[2] The fixed markup (μ) is disappeared because all variables are expressed in deviation from steady state.

[3] Equation (7) is derived as $MC_t = \frac{W_t}{P_t} \frac{1}{\frac{\partial Y_t}{\partial N_t}}$.

$$\widehat{mc}_{t,t+k} = \widehat{mc}_{t+k} - \frac{\varepsilon\alpha}{1-\alpha}(P_t^* - P_{t+k}), \qquad\qquad (9)$$

where $\widehat{mc}_{t,t+k}$ and $\widehat{mc}_{t+k}$ are the deviation in logarithm of $MC_{t,t+k}$ and MC_{t+k} from their steady-state values.[4] Combination of equations (3), (4), and (9) gives the basic formulation of (marginal-cost-based) New Keynesian Phillips curve (NKPC):[5]

$$\pi_t = \beta E_t[\pi_{t+1}] + \lambda\widehat{mc}_t, \qquad\qquad (10)$$

where

$$\lambda \equiv \frac{(1-\theta)(1-\beta\theta)(1-\alpha)}{\theta[1+\alpha(\varepsilon-1)]}. \qquad\qquad (11)$$

The slope coefficient λ is decreasing in θ (the frequency of price adjustment). Thus, a smaller fraction of firms resetting their prices implies inflation will less sensitive to the evolutions of marginal cost. Since it is also decreasing in α (the elasticity of substitution between factor inputs or the curvature of the production function) and ε (the elasticity of demand), the larger α and ε lead the more sensitive marginal cost to the deviation of price from the average level.

2.2 The Hybrid Model of New Keynesian Phillips Curve

The basic New Keynesian Phillips curve expressed in equation (10) postulates relatively low persistence of inflation. It is, however, not always consistent with actually observed inflation dynamics or not data coherent due to price rigidities. An alternative formulation of the NKPC considering this factor proposed by Galí and Gertler (1999) and Galí, Gertler, and López-Salido (2001) incorporates the backward-looking component or lagged dependence of inflation, as well as the forward-looking element.[6] The derivation of this "hybrid model" starts with the modification of the Calvo-type contract by introducing two kinds of firms. A subsample of firms $1 - \omega$ has forward-looking price-setting behavior, while the remaining fraction ω set their prices with a backward-looking rule of thumb. Therefore, the aggregate price level is given by the equation:

$$P_t = \theta P_{t-1} + (1-\theta)\overline{P}_t^*, \qquad\qquad (12)$$

where $\overline{P}_t^*$ represents the index of prices at time t such that

$$\overline{P}_t^* = \omega P_t^b + (1-\omega)P_t^f, \qquad\qquad (13)$$

where P_t^b is the price for backward-looking rule of thumb and P_t^f is the price for forward-looking firms which behave just as basic Calvo-type sectors. Thus, the behavior of forward-looking firms can be described as

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[4] In the case of linear technology or constant returns to labor ($\alpha = 0$), all firms are confronted with the same marginal cost.

[5] Real marginal cost can be expressed as a related variable of the output gap. Following this condition, the output-gap-based New Keynesian Phillips curve can be derived. For the concrete discussions, see Walsh (2010), Galí (2008), and Woodford (2003).

[6] This kind of specification is regarded as a "hybrid-type" NKPC in the sense that it incorporates both forward- and backward-looking components.

$$P_t{}^f = (1 - \beta\theta) \sum_{k=0}^{\infty}(\beta\theta)^k E_t\ [mc_{t+k}]. \qquad\qquad (14)$$

Galí and Gertler (1999) assume that backward-looking firms follow a rule of thumb behavior based on recent aggregate pricing. In this sense, $P_t{}^b$ can be expressed as:

$$P_t{}^b = \overline{P}_{t-1}^* + \pi_{t-1}. \qquad\qquad (15)$$

Since forward-looking firms set prices as the markups over their marginal costs and fix prices probably more than one period, their decisions over prices are based on expected future streams of marginal costs. On the other hand, backward-looking firms fix prices by referring to the equilibrium levels in the previous period.

Totally, combination of equations (10) through (15) derives the reduced-form specification of the (marginal-cost-based) hybrid NKPC:

$$\pi_t = \gamma_f E_t[\pi_{t+1}] + \gamma_b \pi_{t-1} + \lambda \widehat{mc}_t, \qquad\qquad (16)$$

where

$$\lambda \equiv \frac{(1-\omega)(1-\theta)(1-\beta\theta)(1-\alpha)}{\emptyset[1+\alpha(\varepsilon-1)]}, \qquad\qquad (17)$$

$$\gamma_f = \beta\theta\emptyset^{-1}, \qquad\qquad (18)$$

$$\gamma_b = \omega\emptyset^{-1}, \qquad\qquad (19)$$

$$\emptyset = \theta + \omega[1 - \theta(1-\beta)]. \qquad\qquad (20)$$

This hybrid specification can be regarded as a special case of the basic formulation of NKPC described by equations (10) and (11) with no backward-looking element ($\omega = 0$).

3. Empirical Results

The section 3 is for our fundamental challenge with the estimations of the parameters incorporated in the hybrid NKPC discussed in the previous section by utilizing the Japanese quarterly data spanning the period 1980:1 to 2010:4. Our data set is constructed by the following variables.[7]

    Yr: real GDP (quarterly, chain-linked estimates, first preliminary estimates, reference year: 2000, seasonally adjusted, billion yen)

    Df: GDP deflator (quarterly, first preliminary estimates, reference year: 2000, seasonally adjusted)

    Cp: consumer price index (monthly, excluding fresh food, whole Japan, total, reference year: 2005)

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[7] The data on "GDP deflator" and "compensation of employees" are obtained from the Economic and Social Research Institute, Cabinet Office's website (in English) (http://www.esri.cao.go.jp/en/sna/). The "employed person" and "employee" are retrieved from the "Portal Site" of Official Statistics of Japan administered by the Ministry of Internal Affairs and Communications, Statistics Bureau, Director-General for Policy Planning (Statistical Standards) & Statistical Research and Training Institute (in English) (http://www.e-stat.go.jp/SG1/estat/eStatTopPortalE.do).

Cn: compensation of employees (quarterly, chain-linked estimates, first preliminary estimates, reference year: 2000, seasonally adjusted, billion yen)

Ee: employee (monthly, whole Japan, total, seasonally adjusted)

Ep: employed person (monthly, whole Japan, total, seasonally adjusted)

Wp: nominal wage per capita (= Cn / Ee)

Lp : labor productivity (= Yr / Ep)

Uc: unit labor cost (= Wp / Lp)

Ls: labor share (or real unit labor costs) (= Uc / (Df /100))

Lc: trend component of Ls obtained by the Hodrick-Prescott filter[8] setting the penalty parameter = 1600

Lg: proxy variable for $\widehat{mc}(= \hat{S}) = \log(Ls) - \log(Lc)$

The monthly data on "consumer price index"[9], "employee", and "employed person" were converted into quarterly series by taking three-months averages. As to the inflation rate constituted by the consumer price index, four-quarter moving average $(\pi_t^{(4)} = \frac{1}{4}(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})$, where $\pi_t = \log(Cp_t) - \log(Cp_{t-1}))$ is adopted. One problem in our estimation is how we have the proxy for the marginal cost in equation (16) (and (8)). We utilize "Lg" indicated above as our $\widehat{mc}$ with consideration of the characteristic of Japanese data regarding the trend component estimated by the Hodrick-Prescott filter could be the proxy for the steady-state value. Another problem that we confront is the correlation due to the causal relationship between the variables. The expected inflation $E_t[\pi_{t+1}]$ is obliged to be replaced by actually observed π_{t+1} under the assumption of rational expectation since it is unobservable. Thus, we set $E_t[\pi_{t+1}] = \pi_{t+1} + u_{t+1}$ (u: expectational error). However, this treatment may cause the correlation between the error term and the explanatory variable. To cope with this problem, GMM (Generalized Method of Moments) is applied to our estimation.

The reduced-form coefficient λ expressed in equation (17) is a function of $\beta, \omega, \theta, \alpha,$ and ε, but we cannot estimate all these structural parameters because of the identification restriction. One plausible strategy to deal with this problem is as follows. Let us define $\varphi \equiv \frac{1-\alpha}{1+\alpha(\varepsilon-1)} \in (0,1)$ as a function of α and ε. Next, suppose the special case of constant φ, in other words, the case of constant returns to scale or constant marginal costs across firms.[10] If we take advantage of this assumption following Galí, Gertler, and López-Salido (2001) and Maturu, Kisinguh, and Maana (2007), we can regard φ as 1. Plugging $\varphi = 1$ into equation (17), we have

$$\bar{\lambda} \equiv (1-\omega)(1-\theta)(1-\beta\theta)\emptyset^{-1}. \qquad (21)$$

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[8] See Hodrick and Prescott (1997) for a concrete discussion.

[9] Seasonally non-adjusted series of consumer price index was converted into a seasonally adjusted series by Eviews (Ver. 6.1) applying X-12-ARIMA. The spec file for X-12-ARIMA was adjusted as close as possible to those applied to the indices of industrial production by the Ministry of Economy, Trade and Industry. See the interpretive article at (http://www.meti.go.jp/english/statistics/tyo/syoudou/pdf/h2snotee.pdf).

[10] In this case, capital is assumed to be mobile freely across firms.

With this specification, we are able to estimate the parameters β, ω, and θ. The corresponding orthogonality condition for our estimation is constructed as:

$$E_t[\{\pi_t - \omega\emptyset^{-1}\pi_{t-1} - \beta\theta\emptyset^{-1}\pi_{t+1} - \emptyset^{-1}(1-\omega)(1-\theta)(1-\beta\theta)\widehat{mc}_t\}Z_t] = 0, \qquad (22)$$

where Z_t denotes the vector of instrumental variables.

Instrumental variables dated *t–1* and earlier are set to construct Z_t by the following two reasons: (i) The public may not utilize all the current information when they form their expectations, (ii) Certain level of measurement errors of $\widehat{mc}$ may exist, but the errors may not be correlated with lagged instruments (as the past information). In addition, small number of lags of the proxy for $\widehat{mc}$ than the ones of inflation rate is chosen to minimize the potential estimation bias following Galí, Gertler, and López-Salido (2001).[11] Specifically, Z_t includes five lags of inflation rate and four lags of the proxy for marginal cost (Lg).

The estimation periods are divided into two categories – the periods before and after the collapse of Japan's bubble economy in the early 1990s. It is not easy to definitely define the end of bubble economy. However, the peak of the 11th business cycle determined by the Working Group of Indexes of Business Conditions at the Economic and Social Research Institute, Cabinet Office (Government of Japan) is February 1991. Taking into account this definition, the first quarter of 1991 is regarded as the end of the bubble economy and the second quarter of 1991 is set as the start date of the period "after the bubble" in this study for the sake of convenience.

Our model of the hybrid NKPC allows us to estimate the reduced-form and the structural parameters. In particular, the estimation of the latter enables us to examine the impacts of structural parameters on inflation dynamics. The estimation results are summarized in Table 1 and Table 2. The null hypotheses of over-identification for all GMM estimations cannot be rejected by the Hansen's tests. (See each test statistic in notes under each table.)

Table 1 displays the result of estimation for the period before the collapse of the Bubble Economy. Concerning the reduced-form parameters, the estimate for the reduced-form coefficient γ_f on future inflation is significant. Also, γ_b on lagged inflation is significant. The fact that the estimated value of the latter coefficient is larger than that of the former implies the backward-looking behaviour is predominant over inflationary process in the period we concern. This finding seems to reject the pure forward-looking specification. The coefficient λ on the marginal cost (or the slope of NKPC) is significant, and this means the marginal cost is a kind of leading indicator of inflation.

The structural parameter ω, the degree of backwardness in price setting, is significant. This result is consistent with the significance of γ_b on backward-looking component in reduced-form estimation. With respect to θ, which is for the measure of the price stickiness (or for the fraction of firms that keeps price constant), is also significantly estimated. The average duration of a price remaining fixed (in quarters) corresponding to the estimate of θ is 3.724520. It means that the high frequency in price adjustment is not always observed so far as this estimation period is concerned. On the other hand,

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[11] Galí, Gertler, and López-Salido (2001) insist that this bias is generated in small number of samples when there are too many overidentifying restrictions.

Table 1: GMM Estimation of Inflation before the Collapse of the Bubble Economy

reduced-form parameter			
variable	coefficient	standard error	p-value
γ_f	0.433501	0.013659	0.0000
γ_b	0.566344	0.013630	0.0000
λ	0.024628	0.007877	0.0036
structural parameter			
variable	coefficient	standard error	p-value
ω	0.559501	0.043282	0.0000
θ	0.731509	0.026377	0.0000
β	0.999379	7.84E-05	0.0000
duration	3.724520		

Notes (reduced-form parameter): J-statistic = 3.734937, p-value = 0.712495, Included observations = 37 (after adjustments). Convergence achieved after 7 weight matrices, 8 total coefficient iterations. S.E. refers to Newey-West heteroscedasticity and autocorrelation consistent standard error (Kernel: Bartlett, Bandwidth: Fixed (3)).

Notes (structural parameter): J-statistic = 3.732653, p-value = 0.712802, Included observations = 37 (after adjustments). Convergence achieved after 12 weight matrices, 13 total coefficient iterations. S.E. refers to Newey-West heteroscedasticity and autocorrelation consistent standard error (Kernel: Bartlett, Bandwidth: Fixed (3)).

Table 2: GMM Estimation of Inflation after the Collapse of the Bubble Economy

reduced-form parameter			
variable	coefficient	standard error	p-value
γ_f	0.475463	0.006563	0.0000
γ_b	0.524530	0.006562	0.0000
λ	0.012156	0.008122	0.1386
structural parameter			
variable	coefficient	standard error	p-value
ω	0.690140	0.052879	0.0000
θ	0.761407	0.051795	0.0000
β	0.999956	5.37E-05	0.0000
duration	4.191238		

Notes (reduced-form parameter): J-statistic = 7.830030, p-value = 0.250822, Included observations = 78 (after adjustments). Convergence achieved after 14 weight matrices, 15 total coefficient iterations. S.E. refers to Newey-West heteroscedasticity and autocorrelation consistent standard error (Kernel: Bartlett, Bandwidth: Fixed (3)).

Notes (structural parameter): J-statistic = 7.829751, p-value = 0.250843, Included observations = 78 (after adjustments). Convergence achieved after 15 weight matrices, 16 total coefficient iterations. S.E. refers to Newey-West heteroscedasticity and autocorrelation consistent standard error (Kernel: Bartlett, Bandwidth: Fixed (3)).

the estimated value of the discount factor β is 0.999379, and it is very close to the theoretically postulated level.[12]

Table 2 indicates the estimated parameters with respect to the period after the collapse of bubble economy. As to the reduced-form parameters γ_f and γ_b, the estimated value of the latter are larger than that of the former. This implies the backward-looking component is relatively dominant than the

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[12] For instance, Christiano, Eichenbaum, and Evans (2005) regard this as $\beta = 1.03^{-0.25}$. This can be interpreted as $\beta = 1.03^{-0.25} \approx 0.99$. Erceg, Henderson, and Levin (2000), Giannoni and Woodford (2003), Steinsson (2003), Walsh (2003), and Christiano, Eichenbaum, and Evans (2005) also assume $\beta = 0.99$.

forward-looking one in shaping inflation dynamics. In this sense, the pure forward-looking specification is rejected again. The coefficient estimated on λ is not significant. This implies that the impact of marginal cost on inflationary process in Japan after the bubble economy is very low or negligible.

The significantly estimated coefficient of the backward-looking price setting measured by the size of ω is 0.690140, which corresponds to the estimates of reduced-form parameters γ_b over 0.5. What is more, the estimated θ is little bit larger than the one for the period before the bubble crash leading to the comparatively longer average duration of price adjustment around 4.2 quarters. This value suggests that price remain unchanged for roughly 13 months. Lastly, the estimate of β, the discount factor, is 0.999956, and this is again close to the usually postulated level.

Comparing the results of estimations for the periods before and after the collapse of the bubble economy, we know that the reduced-form coefficient γ_b (on lagged inflation) as well as γ_f (on future inflation) are significantly estimated in both cases, and this finding seems to deny the pure forward-looking hypothesis in the recent two decades. Moreover, the influence of marginal cost on inflation dynamics after the bubble economy is weaker than that before the collapse of the bubble. From another aspect, the slope of the NKPC might become flatter after the collapse of the bubble economy. With respect to the structural parameters, ω (the degree of backwardness in price setting) is larger in the latter period, and the θ (the measure of the price stickiness) is also larger in the period after the bubble leading to the longer average duration of price adjustment. The estimated values of discount factor β are around 0.99 in both periods.

4. Concluding Remarks

This paper evaluates the applicability of the hybrid variant of the New Keynesian Phillips curve (NKPC) for Japan since 1980s through GMM estimation. By the comparison between the results of estimations for the periods before and after the collapse of bubble economy, it is apparent that the reduced-form coefficient on lagged inflation as well as the one on future inflation **is** significantly estimated in both periods, and this finding virtually rejects the pure forward-looking hypothesis in the recent two decades. In addition, the impact of marginal cost on inflation dynamics for the former period is significant, while the one for the latter period is negligible. From another aspect, the slope of the hybrid NKPC might become flatter after the collapse of the bubble. With regard to the structural parameters, the estimated coefficient on the degree of backwardness in price setting is larger after the bubble crush and the one on the price stickiness is also larger in the latter period leading to the longer average duration of price adjustment. The estimated values of discount factor β are around 0.99 in both periods.

Taken as a whole, it can be concluded that the estimated hybrid New Keynesian Phillips curve provides a good description of the Japanese inflation dynamics since the 1980s. The rejection of the pure forward-looking specification gives us the policy implication that the determination process of monetary policy should contain not only the forward-looking view but also the backward-looking

perspective. Moreover, the estimated larger price stickiness and longer average duration of price adjustment for the period after the collapse of the bubble economy might be the reflection of recent recession. In this sense, the more active monetary and fiscal policies would be required to escape from the prolonged stagnant economy.

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