A New Keynesian Phillips Curve for Japan

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Abstract

This study examines Japan's inflation between 1973 and 2005 using empirical estimates of the new Keynesian Phillips curve. Although a few other studies look at Japan's inflation in this context, none presents results for the baseline model with robustness tests. The results yield three important conclusions. First, the baseline new Keynesian Phillips curve predicts that a 1 percent change in real marginal cost accounts for as much as a 0.424 percent change in inflation. This new curve also tends to match the path of Japan's actual inflation more closely than the Phillips curve in recent years. In addition, it predicts that Japanese firms change prices every two to four quarters. This rate of price adjustment implies they engage in flexible price setting. Second, in a nested specification, forward-looking price-setting behavior dominates backward-looking behavior. Third, structural breaks in the parameters occurred during the land and asset price bubble of the late 1980s and near the time of the Asian financial crisis in 1997. Subsample estimates of the new Keynesian Phillips curve show that Japan's price rigidity tended to increase after the break points. This tendency is consistent with the notion that Japanese firms found it difficult to further reduce real marginal cost as Japan's economic slowdown became more entrenched.

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1 Introduction

As Japan's low-inflation/deflation episode enters its second decade, it seems reasonable to expect that the backward-looking Phillips curve would underestimate inflation, given the country's disinflationary environment. However, it is less obvious that a forward-looking model such as the new Keynesian Phillips curve would provide meaningful improvement for at least two reasons. First, empirical evidence on these models is still evolving. Second, Japan's inflation experience is unique because of the prolonged deflationary period. Thus, wholesale comparisons empirical results from other countries to describe Japan's experience are necessarily limited. This paper presents evidence that the forward looking new Keynesian Phillips curve provides a good approximation of Japan's inflation and that, in recent years, the new curve tends to match Japan's actual inflation more closely than the Phillips curve does. In addition it shows that the aggregate rate of price adjustment decreased as Japan's deflationary episode took hold.

Gali and Gertler (1999), Gali, Gertler, and Lopez-Salido (2001), Sbordone (2002), Eichenbaum and Fisher (2003), Neiss and Nelson (2005), and Batini et al. (2005), apply the new Keynesian Phillips curve to inflation in the United States, the United Kingdom and other industrialized nations. However, relatively few works consider Japan's inflation in this context. Two examples of Japan studies are Coenen and Wieland (2002) and Leith and Malley (2002). Coenen and Wieland (2002) report they are unable to obtain statistically significant and economically meaningful estimates of the baseline new Keynesian Phillips curve. In looking at G7 nations, Leith and Malley (2002) develop an open-economy model to include terms of trade effects in the determination of output price inflation, and they find a smaller magnitude for the parameter on real marginal cost and a greater degree of price rigidity.

This paper follows the empirical strategies of Gali and Gertler (1999) and Sbordone (2002). It investigates robustness of the model by using alternative measures, a nested specification, and parameter stability tests based on Andrews (1993) and Rossi (2004). There are four main findings. First, the fit of the baseline new Keynesian Phillips curve changes very little when inflation is measured as quarterly growth in the CPI or the GDP deflator for the period 1972:Q1-2005:Q2. In addition, the statistical importance of real marginal cost is higher when it is measured by the unit labor cost than it is when measured by the output gap. Specifically, a one percent change in the unit labor cost per hour accounts for a 0.424 percent change in inflation and a 0.16 percent change when unit labor cost is not adjusted by the number of work hours. These findings also suggest that on average Japanese firms change prices every two to four quarters, which implies a fairly low degree of nominal rigidity. Second, nested specifications show that, for the most part, lagged inflation is not statistically significant. This finding implies that Japan's inflation is not persistent in the context of the new Keynesian Phillips curve. Third, parameter stability tests suggest that significant structural change occurred during the land and asset price bubble of the late 1980s and near the time of the Asian financial crisis in 1997. Finally, subsample estimates of the new Keynesian Phillips curve show that Japan's price rigidity tends to increase after the break points. This pattern is consistent with the intuition that Japanese firms became less likely to change prices as the country's economic slowdown became more entrenched.

The new Keynesian Phillips curve is derived from a dynamic stochastic general equilibrium framework with Calvo (1983) sticky prices. In Calvo's (1983) model, nominal rigidity arises from the individual actions of monopolistically competitive firms setting prices independently over time. Yun (1996), Goodfriend and King (1997), McCallum and Nelson (1997), Rotemberg and Woodford (1998), and Clarida, Gali, and Gertler (1999) develop the application of Calvo's (1983) staggered price-setting scheme to the dynamic stochastic general equilibrium framework.

This paper comprises six sections: Section 1 is the introduction, Section 2 discusses the model and estimation strategy, Section 3 describes the data, Section 4 presents the empirical results, Section 5 reports results on robustness tests, and Section 6 concludes.

2 The Model

The new Keynesian Phillips curve is derived from the first order conditions of the dynamic optimization decisions of monopolistically competitive firms and households with Sidrauski (1967) preferences as a log linearization around a zero steady- state inflation rate.[1] Yun (1996) is possibly the first to embody Calvo's (1983) rigidity explicitly in this context. Under Calvo's (1983) pricing, monopolistically competitive firms individually and independently set their respective prices in any period. This innovation greatly simplifies the aggregation of price setting behavior. Equation (1) is the baseline new Keynesian Phillips curve:

$$\pi_t = \beta E_t(\pi_{t+1}) + \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}\psi_t \tag{1}$$

where π is the inflation rate, ψ is a measure of real marginal cost, and E_t is the expectations operator in time t. The parameters β and α are, respectively, the subjective discount rate and the probability that a firm will leave its price unchanged, i.e., the degree of nominal rigidity. Thus, $\alpha \in (0, 1]$ and for large values, prices are increasingly rigid. When the slope parameter is denoted $\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}$, and κ is the elasticity of inflation with respect to real marginal cost when the model is estimated in log form.

[1] Woodford (2003) and Walsh (2003) provide thorough discussions of this model, with applications to monetary theory and policy.

2.1 Empirical Strategy

The empirical approach of this study follows Gali and Gertler (1999), who use the Generalized Method of Moments (GMM). Hansen (1982) and Hansen and Singleton (1982) prove that GMM is a consistent estimator for dynamic models with rational expectations. This result allows for measurement error, a well-known issue in aggregate data, to be addressed by a set of instruments, $\mathbf{z}_t$, which are correlated with the aggregate variables but not with the error term. In the literature on new Keynesian Phillips curves, however, a number of studies e.g., Fuhrer, Moore, and Schuh (1995), Gali and Gertler (1999), Eichenbaum and Fisher (2003), Fuhrer and Rudebusch (2004), point out that the GMM estimator is sensitive to how the nonlinearity is expressed in the moment condition as well as to the size of the instrument set in small samples. This paper shows results for the moment condition:

$$E_t\{(\alpha\pi_t - (1-\alpha)(1-\alpha\beta)\widehat{\psi}_t - \alpha\beta\pi_{t+1})\mathbf{z}_{it}\} = 0 \tag{2}$$

Compared with the baseline model shown in equation (1), the nonlinearity in the moment condition is expressed as a product rather than a ratio. Equation (2) is the specification is estimated by Eichenbaum and Fisher (2003) and is one of the specifications estimated by Gali and Gertler (1999). For the estimations, real marginal cost is measured in terms of its deviation from the steady state, denoted $\widehat{\psi}_t$.[2] The assumption of rational expectations allows for the substitution of next period's actual inflation, π_{t+1}, for $E_t(\pi_{t+1})$.

Sbordone (2002) shows that for the whole economy, real marginal cost, ψ_t, can be measured as the wage share of GDP, $\psi = \frac{WN}{PY}$, where $W, N,$ and PY are wages, employment and GDP.[3]

[2]Following Gali and Gertler (1999), we assume the steady state to be the sample average for the wage-based measures.

[3]To see this, assume the average firm faces constant returns to scale and identical Cobb-Douglas production function. In real variables, the Lagrangean for firm j's cost minimization problem can be expressed: $L =$

2.2 Allowance for Inflation Persistence

One of the criticisms of the new Keynesian Phillips curve is the absence of inflation persistence in the model. Gali and Gertler (1999) develop a hybrid model that adds lagged inflation to the dynamic optimization problem by allowing for some firms to set prices using a backward-looking rule. The resulting model is

$$\pi_t = \tilde{\kappa}\widehat{\psi}_t + \eta_f E_t \pi_{t+1} + \eta_b \pi_{t-1} \tag{3}$$

where $\tilde{\kappa} \equiv (1-\omega)(1-\alpha)(1-\alpha\beta)\phi^{-1}$, $\eta_f \equiv \alpha\beta\phi^{-1}$, $\eta_b \equiv \omega\phi^{-1}$ and $\phi = \alpha + \omega[1-\alpha(1-\beta)]$. The estimated parameters in equation (3) are the degree of rigidity, α; subjective discount rate, β; and ω, the share of firms that use a backward-looking rule of thumb. From these, the coefficients on last period's inflation, η_b, and next period's inflation, η_f, are computed. The moment condition for equation (3) also expresses the nonlinearity as a product rather than a ratio:

$$E_t\{(\alpha + \omega(1-\alpha(1-\beta))\pi_t - (1-\omega)(1-\alpha)(1-\beta\alpha)\widehat{\psi}_t - \alpha\beta\pi_{t+1})\mathbf{z}_{it}\} = 0 \tag{4}$$

3 Data Description

The data used in this study were obtained from reports issued by the Japan Economic and Social Research Institute (ESRI), and the Japan Statistical Research and Training Institute's *Monthly Statistical Bulletin of Japan* as well as series posted online at the Bank of Japan website.

Inflation, π_t, is measured in terms of the GDP deflator and the CPI. In both cases, π_t is the

$\min N_{jt}(\frac{W_{jt}}{P_t})N_{jt} + \psi_{jt}(c_{jt} - A_t N_{jt})$ yields the first order condition $\psi_{jt} = \frac{W_{jt}}{P_t}$, when the technology parameter, A_t is normalized, $E_t(A) = 1$. For the whole economy, then marginal cost, $\psi_t = (W_t N_t)/(P_t Y_t)$.

quarterly log difference in the respective price level. Three measures are used for real marginal cost. The first two are based on Japan wages. The unit labor cost is the wage share of GDP, composed of the product of average wages per person and total employment divided by GDP. The hourly wage share is just the wage share of GDP divided by the average number of work hours in a quarter.[4] Gordon (1982) argues that the hourly wage share is a more appropriate measure of the unit labor cost given the tendency of firms to adjust both wages and hours to control costs over time. In addition to using the wage share of GDP for real marginal cost, ψ_t, we also provid estimates using the output gap, which is the log deviation in real GDP from a Hodrick-Prescott (HP) filter.[5]

Figure 1 shows GDP deflator inflation with the measures of real marginal cost. The top panel shows inflation with the unit labor cost (ULC) and hourly unit labor cost (ULCH). The bottom panel shows inflation with the HP-filtered real output gap. Negative values for $\widehat{\psi}_t$ occur when the corresponding measure is less than the steady state.

4 Empirical Results

This section presents results for the new Keynesian Phillips curve. We estimated the model is estimated over the period 1973:Q1-2005:Q2 using the Generalized Method of Moments (GMM). The instrument set, $\mathbf{z}$, comprises a vector of ones and two lags each of GDP and CPI inflation, wage inflation, the output gap, and the spread between Japan's Call Rate and CPI inflation, for a total of 13 orthogonality conditions.

Table 1 shows the GMM estimates for Japan's new Keynesian Phillips curve over the period 1973:Q1-2005:Q2. The first estimates presented are based on the wage share of GDP for real

[4] Wages are measured as the quarterly cash earnings for individuals in firms with more than 30 employees and include the large bonus payments that are the custom in most Japanese firms. Hours are quarterly averages for firms of the same size.

[5] The smoothing parameter $\lambda = 1600$.

Table 1: New Keynesian Phillips Curve for Japan, 1973-2005

$$\pi_t = \beta\pi_{t+1} + \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}\widehat{\psi}_t$$

	α	β	κ	$\frac{1}{1-\alpha}$	J_T
Wage Share $\widehat{\psi}_t$					
GDP Deflator π_t	0.665^{**}	1.02^{**}	0.163	2.989	9.484
	(0.035)	(0.036)			[0.577]
CPI π_t	0.719^{**}	1.03^{**}	0.102	3.553	8.754
	(0.043)	(0.027)			[0.645]
Hourly Wage Share $\widehat{\psi}_t$					
GDP Deflator π_t	0.519^{**}	1.044^{**}	0.424	2.081	8.350
	(0.035)	(0.036)			[0.682]
CPI π_t	0.641^{**}	1.023^{**}	0.193	2.784	5.706
	(0.035)	(0.028)			[0.892]
Real Output Gap $\widehat{\psi}_t$					
GDP Deflator π_t	0.740^{**}	1.061^{**}	0.076	3.849	8.059
	(0.043)	(0.030)			[0.708]
CPI π_t	0.766^{**}	1.035^{**}	0.064	4.269	5.281
	(0.040)	(0.022)			[0.912]

Notes: GMM Estimates using quarterly data over the full sample period 1973:Q1-2005:Q2. π is quarterly inflation, β is the subjective discount rate and α is the degree of nominal rigidity. Prices are increasingly rigid as α approaches 1. κ is the elasticity of inflation with respect to real marginal cost, where $\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}$. $\frac{1}{1-\alpha}$ is the number of quarters between price adjustments. J_T is the test of overidentifying restrictions. Standard errors are shown in parentheses; the p-value for the J-statistic is in brackets. ** and * indicate a significant t-test at the 1 and 5 percent significance levels, respectively. The instrument set is comprised of 2 lags for the following: inflation, unit labor cost, wage growth, output gap and the real interest rate. Inflation is measured as the log of the first difference in the GDP deflator or CPI.

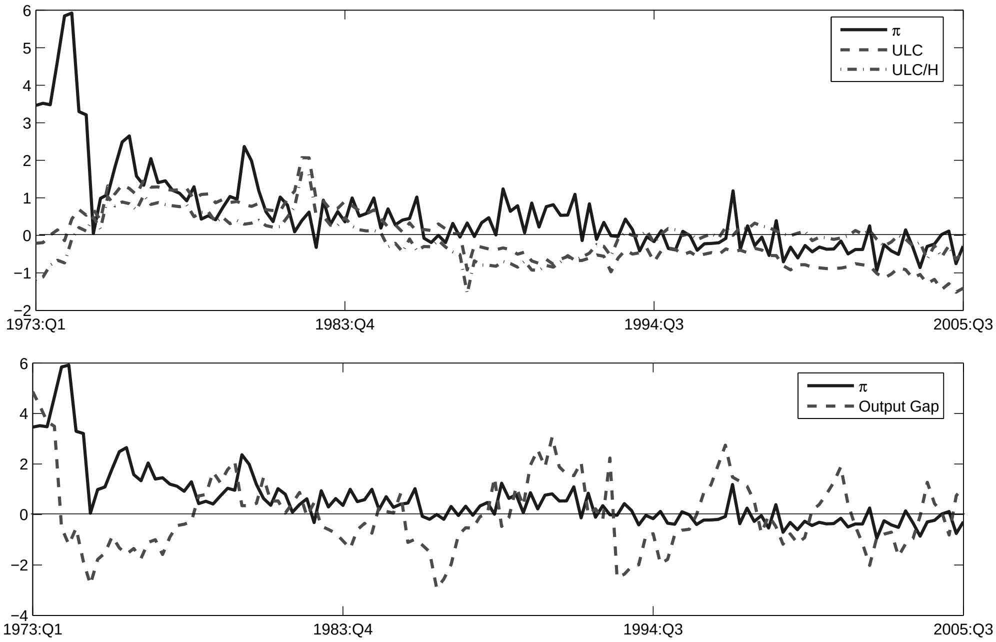

Figure 1: Japan Inflation with Real Marginal Cost Measures, 1973-2005

marginal cost. The second and third estimates, respectively are for the hourly wage share and the output gap. The parameters on inflation and real marginal cost have the correct sign and are statistically significant for all specifications. In addition, the J-test of overidentifying restrictions is not rejected for any of the specifications. The rate of time preference, β, is roughly one. For GDP deflator inflation and wage share of GDP, the slope coefficient, κ, is 0.16, implying that a 1 percent rise in the wage share results in an increase of inflation by 0.16 of a percent. The size of κ increases to 0.424 when $\widehat{\psi}_t$ is the hourly wage share and demonstrates the influence of changes in the length of Japan's work week over the sample. Table 1 also shows that κ is smallest for the real output gap. Overall, the typical wait between price adjustments in Japan is roughly six to twelve, although rigidity tends to increase for CPI-based inflation.

Eichenbaum and Fisher (2003) point out that GMM estimations are also sensitive to the size of the instrument set. We explored this possibility by expanding the instrument set to include three lags of the macroeconomic variables.[6] Although these results are not shown, the parameters, α and β, do not meaningfully change for GDP deflator inflation. However, with CPI inflation, the degree of nominal rigidity, α, is consistently lower, while β, the subjective discount rate, is roughly one. For example, $\alpha = 0.609$ for CPI π_t and the unit labor cost compared with $\alpha = 0.719$ shown in Table 1.

Figure 2 shows the fitted new Keynesian Phillips curve with Japan's actual inflation, using the unit labor cost and GDP deflator inflation. By inspection, it suggests that the new Keynesian Phillips curve tends to lead Japan's actual inflation but matches the turning points fairly well.

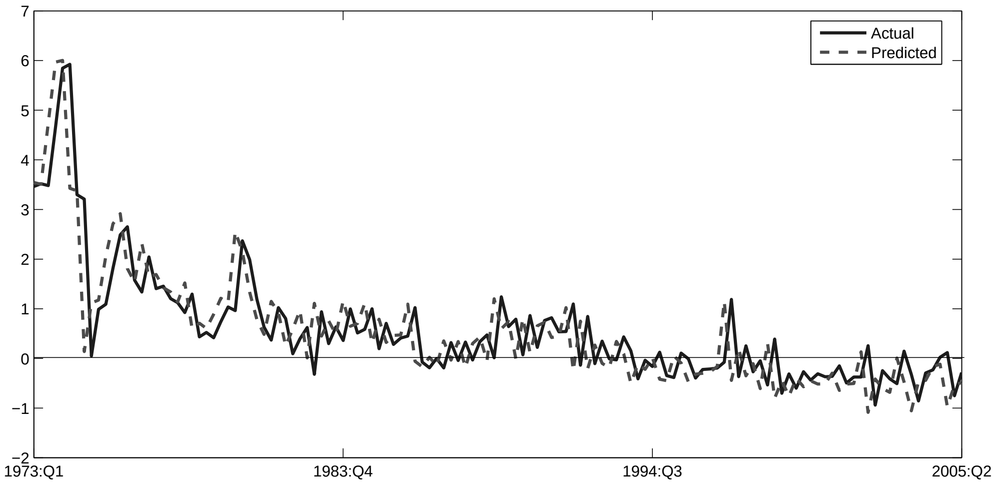

Figure 2: A new Keynesian Phillips Curve for Japan, 1973-2005

Estimates of the Phillips (1958) curve for Japan over the period 1973:Q1-2005:Q2 using

[6]Gali and Gertler (1999) present estimates using four lags, a total of 25 orthogonality conditions for the period 1960:Q1-1997:Q4.

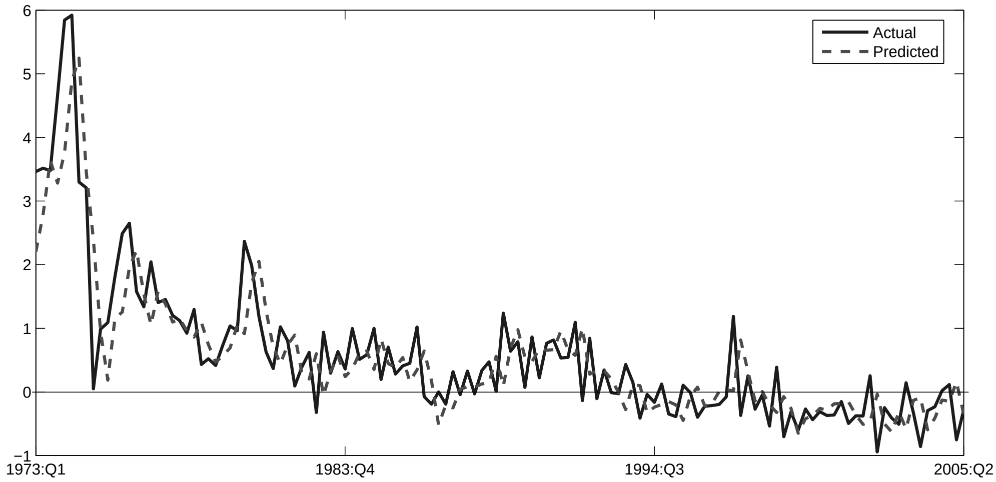

Figure 3: A Phillips (1958) Curve for Japan, 1973-2005

GDP deflator inflation and the HP-filtered output gap yield

$$\begin{array}{llllll} \pi_t = & 0.607\pi_{t-1} + & 0.381\pi_{t-2} - & 0.162\pi_{t-3} + & 0.064\pi_{t-4} + & 0.082\widehat{y}_t \\ & (0.089) & (0.103) & (0.102) & (0.088) & (0.039) \end{array} \quad (5)$$

with the corresponding standard errors reported in parentheses. Based on the Wald test, the hypothesis that the coefficients on lagged inflation sum to one is rejected. For completeness, Figure 3 shows the Phillips (1958) curve for Japan over the sample period which illustrating the well-known criticism that this model lags actual inflation, as indicated by the tendency of the predicted path to lie to the right of actual inflation. Figure 4 shows the Phillips curve and new Keynesian Phillips curves for the years 1990-2005 and suggests that the forward-looking model more closely matches actual inflation.

The results for Japan's new Keynesian Phillips curve can be compared with those found for other countries. Using data for the U.S. for 1959:Q1-2001:Q4 and the moment condition in

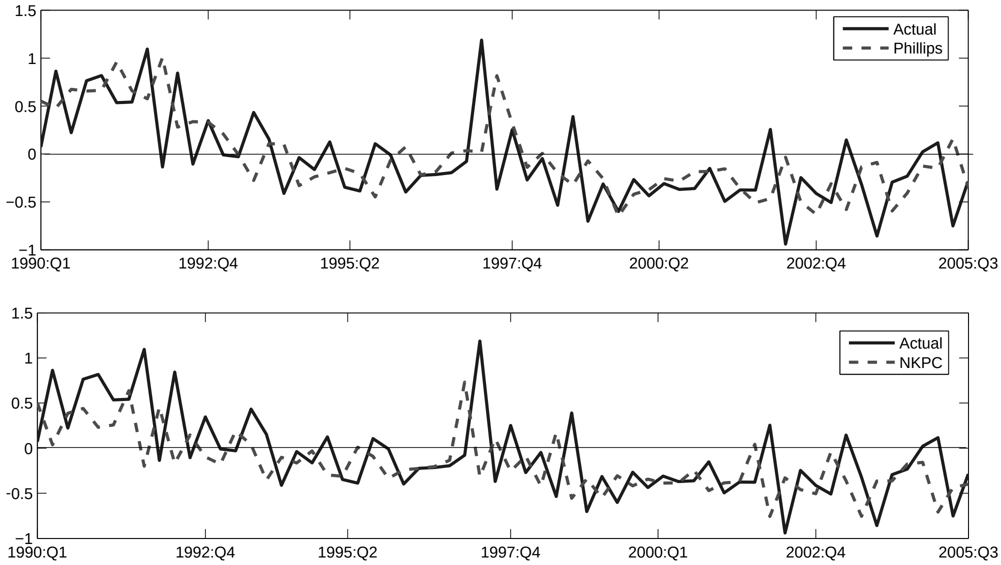

Figure 4: The Phillips Curve (above) and new Keynesian Phillips Curve (below), 1990-2005

equation (2) with a similarly sized instrument set, Eichenbaum and Fisher (2003) find $\alpha = 0.89$ for GDP deflator inflation and $\alpha = 0.88$ for CPI inflation. These values imply that $\kappa = 0.012$ for GDP deflator π and $\kappa = 0.0176$ for CPI π and that U.S. firms adjust prices every eight to nine quarters, unrealistically long period. In their open-economy model estimated for the United Kingdom for 1972:Q3-1999Q2, Batini et al. (2005) show that $\kappa = 0.16$, which is equivalent to the value for Japan shown in Table 1 for the baseline model with wage share and GDP deflator inflation. The unit labor cost per hour is not considered in the other new Keynesian Phillips curve studies mentioned in this paper.

Table 2: The Hybrid New Keynesian Phillips Curve for Japan, 1973-2005

$$\pi_t = \eta_f \pi_{t+1} + \eta_b \pi_{t-1} + \tilde{\kappa}\widehat{\psi}_t$$

	α	β	ω	η_f	η_b	$\tilde{\kappa}$	$\frac{1}{1-\alpha}$	J_T
Wage Share $\widehat{\psi}_t$								
GDP Deflator π_t	0.703^{**}	1.014^{**}	-0.185^{**}	1.380	-0.358	0.196	3.370	8.248
	(0.035)	(0.041)	(0.056)					[0.605]
CPI π_t	0.687^{**}	1.016^{**}	-0.056	1.108	-0.089	0.159	3.190	8.595
	(0.044)	(0.027)	(0.040)					[0.659]
Hourly Wage Share $\widehat{\psi}_t$								
GDP Deflator π_t	0.542^{**}	1.048^{**}	-0.087	1.255	-0.192	0.476	2.182	7.940
	(0.043)	(0.029)	(0.069)					[0.719]
CPI π_t	0.574^{**}	1.023^{**}	-0.066^{**}	1.159	-0.131	0.369	2.350	5.848
	(0.037)	(0.036)	(0.032)					[0.883]
Output Gap $\widehat{\psi}_t$								
GDP Deflator π_t	0.821^{**}	1.055^{**}	-0.216	1.457	-0.364	0.049	5.583	6.920
	(0.109)	(0.026)	(0.140)					[0.806]
CPI π_t	0.734^{**}	1.038^{**}	-0.025	1.003	0.033	0.082	3.754	5.015
	(0.037)	(0.036)	(0.032)					[0.931]

Notes: GMM Estimates using quarterly data over the full sample period 1973:Q1-2005:Q2. π is quarterly inflation, α is the degree of nominal rigidity, β is the subjective discount rate, and ω is the share of firms that use a backward looking rule of thumb to set prices. Prices are increasingly rigid as α approaches 1. κ is the elasticity of inflation with respect to real marginal cost, where $\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}$. $\frac{1}{1-\alpha}$ is the number of quarters between price adjustments. J_T is the test of overidentifying restrictions. Standard errors are shown in parentheses; the p-value for the J-statistic is in brackets. ** and * indicate a significant t-test at the 1 and 5 percent significance levels, respectively. The instrument set is comprised of 2 lags for the following: inflation, unit labor cost, wage growth, output gap and the real interest rate. Inflation is measured as the log of the first difference in the GDP deflator or CPI.

5 Robustness Tests

The estimates of the hybrid model, shown in Table 2, suggest that inflation is not persistent. The share of backward-looking firms, ω, is negative and in most cases not statistically significant. As a direct result, η_b, the parameter on backward-looking behavior, does not have the hypothesized sign and is not statistically different from zero in most instances. With respect to the remaining parameters, nominal rigidity, α, and the subjective discount rate, β, are statistically significant and have magnitudes similar to those shown in Table 1.

Andrews (1993) designs tests of structural stability for parameters estimated using the GMM. These are similar in nature to Chow tests for structural breaks in the OLS context and allow one to test for structural change when the date of the break point is unknown. The date of structural change is identified through the estimation of the test statistic recursively over partition of the sample and ranking the resulting vector of test statistics by magnitude. If the largest test statistic is statistically significant, then the corresponding time period is the date of the break point. For this exercise, we focus on the partition of 1983-1998, which includes the asset and land price bubble, 1988-1991, and deflationary episodes. In addition, we focus on pure rather than partial structural change. Rossi (2004) extends Andrews (1993) by providing a test that evaluates the estimated parameters jointly for statistical significance and stability, a test that is also used in this study.

Table 3 reports results of the Andrews (1993)and Rossi (2004) tests for pure structural change when inflation is measured as the quarterly growth in the GDP Deflator. For the Andrews (1993) test, the structural breaks occur in 1997 and 1998 during the deflationary episode when $\widehat{\psi}_t$ is wage-based, and during the asset price bubble in 1989 for output gap. Under Rossi (2004), the break point for the wage share and real output gap occurs during the asset price bubble, whereas for hourly unit labor cost, the break point occurs in 1984.

Table 4 shows estimates for the new Keynesian Phillips curve based on the break points

Table 3: Parameter Stability Tests

	Statistical Test	
	Andrews	Rossi
Labor's Income Share $\widehat{\psi}_t$		
GDP deflator π_t	228.08	867.07
	(0.00)	(0.00)
Date of Structural Break	*1997:Q4*	*1989:Q3*
Hourly Wage Share $\widehat{\psi}_t$		
GDP deflator π_t	9.046	353.83
	(0.231)	(0.00)
Date of Structural Break	*1998:Q3*	*1984:Q3*
Output Gap $\widehat{\psi}_t$		
GDP deflator π_t	28.25	931.7
	(0.231)	(0.00)
Date of Structural Break	*1988:Q4*	*1990:Q3*

Notes: (p-value) New Keynesian Phillips Curve test statistics for parameter stability based on Andrews (1993) supremum likelihood ratio test and Rossi's (2004) optimal supremum likelihood ratio test.

identified by the Andrews (1993) and Rossi (2004) tests shown in Table 3. The first group shows subsample estimates for the unit labor cost or wage share, the second shows the results for the hourly unit labor cost or hourly wage share. The third grouping shows estimates based on the real output gap.

In Table 4, when $\widehat{\psi}_t$ is the wage share, the subjective discount rate, β, is statistically significant under both types of structural break tests but has the wrong sign under the Andrews (1993) test for 1997:Q2-2005:Q2. The degree of nominal rigidity, α, increases after the break point under both tests. Together, the Andrews (1993) and Rossi (2004) tests imply price changes occurred about every 2.5 quarters before the break point and slowed to once every 4-5 quarters afterward. The importance of real marginal cost, drops from $\kappa = 0.290$ in the first subsample, 1973:Q1-1998:Q3, to $\kappa = 0.006$ for the rest of the sample, based on Rossi's (2004) test. The pattern of increased nominal rigidity also appears when $\widehat{\psi}_t$ is the output gap, although the break point occurs during the land and asset price bubble. When $\widehat{\psi}_t$ is the hourly wage share, however, the degree of nominal rigidity, α, decreases from 0.522 to 0.413 after the break point. This reflects the impact of shortened work-hours, which dropped from a monthly average of 171 for 1973:Q1-1998:Q3 to 154 for the rest of the sample.

6 Conclusion

This study provides evidence that the new Keynesian Phillips curve is a good approximation of Japan's inflation and that it is robust to alternative measures of inflation and real marginal cost. The study also shows that the predicted path of the new Keynesian Phillips curve captures Japan's inflation more closely in recent years than the Phillips curve. In addition, the study investigates the model's sensitivity to inflation persistence and structural change. Specifically, for GDP deflator inflation and the unit labor cost measure of real marginal cost, a 1 percent increase in the wage share implies a 0.16 percent increase in inflation. These results also imply

Table 4: Structural Change in the New Keynesian Phillips Curve

	α	β	κ	$\frac{1}{1-\alpha}$	J_T
Wage Share $\widehat{\psi}_t$					
Andrews					
1973:Q1-1997:Q1	0.588**	0.958**	0.306	2.427	6.537
	(0.027)	(0.024)			[0.835]
1997:Q2-2005:Q2	0.749**	-0.501**	0.462	3.977	3.844
	(0.008)	(0.136)			[0.974]
Rossi					
1973:Q1-1998:Q3	0.600**	0.941 **	0.290	2.500	9.195
	(0.027)	(0.017)			[0.604]
1998:Q4-2005:Q2	0.823**	0.902**	0.006	5.651	03.960
	(0.060)	(0.557)			[0.235]
Hourly Wage Share $\widehat{\psi}_t$					
Andrews					
1973:Q1-1998:Q3	0.522**	1.044**	0.417	2.092	6.861
	(0.036)	(0.033)			[0.810]
1998:Q4-2005:Q2	0.413**	0.944**	1.124	1.704	3.042
	(0.027)	(0.046)			[0.990]
Rossi					
1973:Q1-1984:Q1	0.555**	0.944**	0.380	2.250	18.838
	(0.027)	(0.017)			[0.077]
1984:Q2-2005:Q2	0.385**	1.670**	0.569	1.627	31.305
	(0.054)	(0.188)			[0.001]
Output Gap $\widehat{\psi}_t$					
Andrews					
1973:Q1-1988:Q4	0.714**	1.029**	0.106	3.502	3.349
	(0.043)	(0.024)			[0.985]
1989:Q1-2005:Q2	0.772**	0.904**	0.089	4.380	7.997
	(0.023)	(0.049)			[0.714]
Rossi					
1973:Q1-1990:Q3	0.735**	1.040**	0.085	3.773	5.394
	(0.052)	(0.033)			[0.911]
1990:Q4-2005:Q2	0.758**	0.865**	0.110	4.132	
	(0.028)	(0.086)			[0.948]

Notes: GMM Estimates using quarterly data over for 1973:Q1-2005:Q2. π is quarterly GDP Deflator inflation, β is the subjective discount rate and α is the degree of nominal rigidity. J$_T$ is the test of overidentifying restrictions. Standard errors are shown in parentheses; the p-value for the J-statistic is in brackets. ** and * indicate a significant t-test at the 1 and 5 percent significance levels, respectively.

that firms adjust prices every three to four quarters. The degree of price rigidity decreases when the hourly wage share is used and implies Japanese firms change prices every two to three quarters. The hourly unit labor cost also predicts that a 1 percent increase in real marginal cost will result in a 0.424 percent change in inflation with price adjustments occurring every two to three quarters. In a nested model, which allows a role for lagged inflation, the new Keynesian Phillips curve implies that Japan's inflation is not persistent. Finally, tests for structural change identify breakpoints during the land and asset price bubble and the deflationary episode near the time of the Asian financial crisis. Future work includes estimating the baseline model using maximum likelihood as well as incorporating the new Keynesian Phillips curve in a small macro monetary model for Japan over the same sample period used in this study.

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