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The Estimation of the Closed Form in NKPC Inflation Model: Focusing on the Korean Manufacturing Industries (1975-2010)

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Abstract This paper is to develop and estimate a closed form inflation model using the estimates for real marginal costs in manufacturing industries during the sample period 1975-2010. The production function in manufacturing industry incorporates labor, capital, domestic material, and foreign material, assuming constant returns to scale technology and AR(1) process of technological coefficient. We derive real marginal costs from firm's cost minimization with quarterly data and provide new evidences on the new Keynesian Phillips curve for Korea. The main empirical result is that the closed form coefficients δ_1 and δ_2^{-1} in manufacturing for PPI inflation proved to be 0.5086 and 0.8779 respectively, similar to the estimates in the U.S. case. These results also are consistent with the functional relationship between the coefficients in hybrid model and its closed form. Thus the paper suggests that the empirical studies on inflation dynamics need to focus on the manufacturing industry with market power, treating PPI inflation as the dependent variable.

Key Words: Inflation dynamics, Marginal cost, Markup, New Keynesian Phillips Curve

1. Introduction

One of the main issues in macro- economics has been about inflation dynamics, in which inflation depends on the future inflation, rather than the past inflation, over a few decades. This issue is important for the business cycle and monetary policy implication. The theoretical modelling in inflation dynamics has been established with common grounds while empirical studies still remain at issue in several points.

The data in the U.S., Europe, and Asian countries such as Japan and Korea have seemed to explain to a certain degree the behavior of inflation dynamics which is called new Keynesian Phillips curve.[1] The empirical researches, however, still have been noted to have two problems. First, many of studies have used a labor share as the proxy of marginal cost, but marginal cost actually depends on several factor costs such as labor, capital and material costs. A serious problem of the labor share as a proxy for real marginal cost is the fact that it covers only part of the total cost of production of the firm.

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1] Calvo(1983)[1], Taylor(1980)[2], Rotemberg(1982)[3], and Rotemberg and Woodford(1997)[4] have contributed to the theoretical establishment in inflation dynamics.

That is, it is likely that the labor share does not provide an exact measure of real marginal cost as Gali and Gurtler(1999)[5] recognized. It ignores the costs of material inputs which especially in the manufacturing industry account for a large part of total production costs of firms. Instead of using the proxy for marginal cost there have been necessities to measure the real marginal cost including those factor costs as indicated in the theory. The advantage in estimating marginal costs is that it directly could account for the influence of both actual marginal costs and productivity on inflation.

Second, the NKPC model is based on the firm's optimization pricing behavior with market power. Thus, since the overall economy includes some sectors without market power, marginal costs from overall economy might have a certain degree of bias in being applied to empirical research. For example, average markups in service sectors such as electricity, transport and finance industry in Korea proved to be far less than one. On the other hand average markups in manufacturing industries are likely to be greater than one. Thus marginal costs are required to be estimated with manufacturing industry which shows average markup ratios to be more than one.

This paper is to develop and estimate a closed form inflation model using the estimates for real marginal costs in manufacturing industries during the sample period 1975-2010. The production function in manufacturing industry incorporates labor, capital, domestic material, and foreign material, assuming constant returns to scale technology and AR(1) process of technological coefficient. We derive real marginal costs from firm's cost minimization with quarterly data and provide new evidences on the new Keynesian phillips curve for Korea.

2. Empirical Model

This section is presented on the basis of the paper by Zhu and Kang(2013)[6].

2.1 Baseline model

The New Keynesian Phillips curve is derived from the decisions of both households and firms. Households maximize the expected present discounted value of utility in consumption of a range of goods summarized by composite good C_t, real money balances (M_t/P_t), and labor N_t, each of which is assumed to have a constant intertemporal elasticity:

$$E_t\sum_{i=0}^{\infty}\beta^i\left[\frac{C_{t+i}^{1-\sigma}}{1-\sigma}+\frac{\gamma}{1-b}\left(\frac{M_{t+i}}{P_t}\right)^{1-b}-\frac{N_{t+i}^{1+\eta}}{1+\eta}\right] \qquad (1)$$

where β is the subjective discount rate, σ, b and η are positive parameters on the respective rates of intertemporal substitution. The composite consumption good, C_t stems from household consumption of individual goods, C_{jt} produced by firms $j=1,2,\cdots$:

$$\left(\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}}dj\right)^{\frac{\theta}{\theta-1}}=C_t \qquad (2)$$

The household's decision uses the Dixit and Stiglitz(1977)[7] approach. First, the household optimally chooses individual goods, C_{jt} to minimize the cost of attaining the composite good, C_t. This stage yields the demand for individual goods and the aggregate price level, P_t. In this stage, the household minimizes its cost for consuming each good:

$$\min \int_0^1 P_{jt}C_{jt}dj \text{ s.t. } \left(\int_0^1 C_{jt}^{\frac{\theta-1}{\theta}}dj\right)^{\frac{\theta}{\theta-1}}=C_t \qquad (3)$$

After some rearranging, the first order conditions implies the demand for good j:

$$C_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\theta} C_t \tag{4}$$

where P_{jt} is the price of the good j in time t, θ is the constant representing the price elasticity of demand for individual goods; it implies that the corresponding demand functions are identically linear, and P_t is the price index level arising from the Lagrangian multiplier in the minimization problem.

Second, given the overall cost of attaining any level of the composite good C_t, the household chooses consumption, leisure and money holdings optimally based on its expected utility in Eq.(1) and its real-valued budget constraint:

$$P_t C_t + M_t + B_t = W_t N_t + M_{t-1} + (1+i_{t-1})B_{t-1} + \Pi_t \tag{5}$$

where M_t and B_t are the households money holding in currency and bonds, respectively. W is the nominal wage, i_t is the nominal interest rate on bonds and Π_t is nominal profits household receives from firms. The three first order conditions follow from this optimization problem.

$$C_t^{-\sigma} = \beta E_t[(1+i_t)\,\frac{P_t}{P_{t+1}}\,C_{t+1}^{-\sigma}\,] \tag{6}$$

$$\gamma(\frac{M_t}{P_t})^{-b}\,C_t^{\sigma} = \frac{i_t}{1+i_t} \tag{7}$$

$$N_t^{\eta}\,C_t^{\sigma} = \frac{W_t}{P_t} \tag{8}$$

The first describes consumption over time, that is Euler's equation, the second relates real money balances to the nominal interest rate, and the third relates real wages to leisure and consumption of the composite good.

Nominal rigidity enters into the framework following Calvo(1983)[1], which divides the firms in the economy into the two groups: those that are able to reset their prices and those that are not. In each period, a fraction $1-\omega$ of firms, drawn at random, are allowed to reset their prices optimally. The others are constrained to keep their prevailing prices, not changing their prices. As a result, the probability of any firm to be able to change its price is independent from the past, and all firms that change their prices choose the same price. In addition, they face identical demand curves with a constant and identical demand elasticity. This means firms are essentially identical and thus, choose the same price if they are adjusting price and they also choose an identical price if they are not setting prices in time t.

Under Calvo(1983)[1], the firm must set its price taking account of the risk that it will not be allowed to change its price in the future. The firm chooses P_{jt}/P_t to maximize the present discounted value of its profits expressed in Eq.(9), given real marginal cost, ϕ_t.

$$E_t\sum_{i=0}^{\infty}(\beta\omega)^i\left[\frac{P_{jt}}{P_{t+i}}-\phi_{t+i}\right]\widetilde{C}_{jt+i} \tag{9}$$

where $\widetilde{C}_{jt+i}=\left(\frac{C_{t+i}}{C_t}\right)^{-\sigma}\left(\frac{P_{jt}}{P_{t+i}}\right)^{-\theta}C_{t+i}$. This implies that the optimal relative price for any firm that adjusts its price in time t is:

$$\frac{P_{jt}^*}{P_t} = \frac{\theta}{\theta-1}\;\frac{E_t\sum_{i=0}^{\infty}(\beta\omega)^i\,\phi_{t+i}\,(\frac{P_{t+i}}{P_t})^{\theta}C_{t+i}^{1-\sigma}}{E_t\sum_{i=0}^{\infty}(\beta\omega)^i\,(\frac{P_{t+i}}{P_t})^{\theta-1}C_{t+i}^{1-\sigma}} \tag{10}$$

where P_{jt}^* is the optimal price charged by price adjusting firms, P_t is the aggregate price level, C_t is the aggregate consumption good and ϕ_t is the firm's real marginal cost at time t. The equation(10) tells us how the optimal price depends on the expected paths of the price level and the real marginal cost. The ratio, $\theta/(\theta-1)$ exceeds one and is interpreted as the constant markup charged by firms due to their monopoly power. The parameter, $\omega \in (0,1)$, denotes the probability that a firm does not adjust its price in time t and it is interpreted as measuring the degree of nominal rigidity. When ω approaches one, it implies that fewer firms adjust prices each period and the time elapsed between adjustments is increased. This means firms place more weight on expected future marginal cost when they are able to set their price. This model implies perfect price flexibility occurs at $\omega=0$ and complete price rigidity at $\omega=1$. In addition, it implies that the expected time between price changes is $1/(1-\omega)$. Equation(10) shows firms which set prices in time t find it optimal to hedge against future changes in real marginal costs that may occur when they are unable to adjust prices.

Since monopolistic competition implies the presence of a large number of firms, $(1-\omega)$ indicates both the probability and share of firms that reset their prices in t. Under Calvo pricing, the dynamics of the price index is:

$$P_t = [\,(1-\omega)\,(P_t^*)^{1-\theta} + \omega\, P_{t-1}^{1-\theta}\,]^{\frac{1}{1-\theta}} \qquad (11)$$

Equation(11) expresses the dynamics of the aggregate price level as a function of the optimal reset price. In time t, adjusting firms charge the optimal price, P_t^* while those unable to do so charge last period's aggregate price, P_{t-1}.

Since no closed form solution exist, an approximate one is derived by log-linearing before solving. Log-linearizing equations (10)-(11) around a zero average inflation rate yields the New Keynesian Phillips Curve:

$$\pi_t = \beta\, E_t\,(\pi_{t+1}) + k\,\widehat{\phi}_t, \qquad (12)$$

where $E_t\,(\pi_{t+1})$ denotes next period's inflation rate expected in time t, β the subjective discount rate, $\hat{\phi}_t$ is average real marginal cost expressed as a percent deviation from its steady state, and the slope parameter, k is given by structural parameters: ω and β, with $k=\omega^{-1}(1-\omega)(1-\beta\omega)$ where ω is the probability that a firm will leave its price unchanged, that is the degree of nominal rigidity.

2.2 The Hybrid Model

One of the criticisms of the new Keynesian Phillips curve is the absence of inflation persistence in the model. Gali and Gertler(1999)[5] 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. They extend Calvo's price timing model by dividing the set of firms that are able to adjust prices into those choosing prices optimally and those who choose a backwards looking price instead. Let optimal price setters choose price p^f:

$$p_t^f = (1-\beta\omega)\sum_{i=0}^{\infty}(\beta\omega)^i E_t\,(\hat{\phi}_{t+i} + p_{t+i}) \qquad (13)$$

The remaining price adjusting firms, denoted χ, choose a backwards looking price that is based on information from the previous period:

$$\bar{p}_t^* = \chi\, p_t^b + (1-\chi)\, p_t^f \qquad (14)$$

where p_t^b is the price set according to the rule of thumb, which is assumed to be the average reset price of the previous period and last period's inflation rate.

$$p_t^b = p_{t-1}^* + \pi_{t-1} \qquad (15)$$

Combining equations (13)-(15), Gali and Gertler (1999)[5] form a hybrid Phillips curve[2]:

$$\pi_t = \tilde{k}\,\hat{\phi}_t + \gamma_f E_t\,\pi_{t+1} + \gamma_b \pi_{t-1} \tag{16}$$

where $\tilde{k} = (1-\chi)(1-\omega)(1-\omega\beta)\phi^{-1}, \gamma_b = \chi\phi^{-1}$,
$\gamma_f = \beta\omega\phi^{-1}, \quad \phi = \omega + \chi[1-\omega(1-\beta)]$

2.3 The Closed Form in NKPC

Let $\hat{\phi} = mc_t$. Replacing $\tilde{k}$ by λ, Eq.(16) could be rewritten

$$\pi_t = \lambda mc_t + \gamma_f E_t\,\pi_{t+1} + \gamma_b \pi_{t-1} \tag{17}$$

Using the lag operator, the closed form could be derived from Eq.(17)

$$(1-\frac{1}{\gamma_f}L + \frac{\eta_b}{\gamma_f}L^2)\pi_t = -\frac{\lambda}{\gamma_f}mc_{t-1}$$

$$(1-\delta_1 L)(1-\delta_2 L)\pi_t = -\frac{\lambda}{\gamma_f}mc_t$$

$$(1-\delta_1 L)\pi_t = -\frac{\lambda}{\gamma_f}\frac{1}{1-\delta_2 L}mc_{t-1}$$

$$= \frac{\lambda}{\gamma_f}\frac{(\delta_2 L)^{-1}}{1-(\delta_2 L)^{-1}}mc_{t-1}$$

$$\pi_t = \delta_1 \pi_{t-1} + \frac{\lambda}{\delta_2 \eta_f}\sum_{j=0}^{\infty}\left(\frac{1}{\delta_2}\right)^j E_t\,mc_{t+j} \tag{18}$$

where δ_1 and δ_2 are the roots of the characteristic equation. These roots have the functional relationship with the parameters in the hybrid model.

$$\delta_1 + \delta_2 = -\frac{1}{\gamma_f}, \quad \delta_1 \cdot \delta_2 = \frac{\gamma_b}{\gamma_f}$$

$$\delta_1 = \frac{1-\sqrt{1-4\gamma_b\gamma_f}}{2\gamma_f} \quad \delta_2 = \frac{1+\sqrt{1-4\gamma_b\gamma_f}}{2\gamma_f} \tag{19}$$

2] For the detailed derivation of the hybrid model see Gali and Gertler(1999)[5], and Gali et. al.(2005)[8].

The closed form of the hybrid NKPC shows that inflation persistence can arise from the influence of lagged inflation or the slow evolution of the present value of marginal costs.

3. The Measurement of Marginal Cost

3.1 Production Function

In order to estimate time series for real marginal cost, we specify constant returns Cobb-Douglas technology as follows.[3]

$$C_t = Z_t\,(K_t^{\alpha}\,L_t^{1-\alpha})^{\gamma}(M_{dt}^{\beta}\,M_{ft}^{1-\beta})^{1-\gamma}$$
$$0 < \alpha,\,\beta,\,\gamma < 1 \tag{20}$$

where C_t, K_t, L_t, M_{dt} and M_{ft} denote, respectively, real output, real value of capital stock, and labor, domestic and foreign intermediate goods. Z_t represents Hicks- neutral technical progress coefficient, $\alpha\gamma$ and $\beta(1-\gamma)$ denote respectively, the elasticity of output with respect to capital stock and domestic intermediate input. γ denotes the capital and labor income share of output, $1-\gamma$ is the intermediate inputs share of output, and t denotes time.

Firm's cost minimization with the above production function yields the following marginal cost function.

$$\phi_t = Z_t^{-1} P_{ft}^{(1-\gamma)(1-\beta)} P_{dt}^{\beta(1-\gamma)} W_t^{\gamma(1-\alpha)} R_t^{\gamma\alpha} \tag{21}$$

$$\alpha^{-\gamma\alpha}\gamma^{-\gamma}(1-\alpha)^{-\gamma(1-\alpha)}\beta^{-\beta(1-\gamma)}$$

$$(1-\gamma)^{-(1-\gamma)}(1-\beta)^{-(1-\gamma)(1-\beta)}$$

3] Our method is similar to Leith and Malley(2007)[9], Batini et al (2005)[10], and Rumler (2007)[11] in that the foreign intermediate goods are included in the production function. But our empirical model is different from theirs in measuring real marginal costs directly using published data in manufacturing industry.

where ϕ_t, R_t, W_t, P_{dt} and P_{ft} denote marginal cost, nominal interest rate, nominal hourly wage, the price of domestic intermediate goods and the price of imported intermediate goods respectively. As shown in Eq.(21), marginal cost(MC_t) is expressed as a function of four observed time series for input factor prices, coefficients(α, β, γ), and unobserved series for Z_t, which will be estimated from production function. We assume that the log form of technical progress follows AR(1) process for all t;

$$\ln Z_t = \theta \ln Z_{t-1} + \nu_t \quad 0 < \theta \le 1 \qquad \nu_t : i.i.d. \tag{22}$$

For statistical estimation the production function may be expressed in log form. Using Eqs.(20) and (22), the production function to be estimated becomes:

$$\begin{aligned}\ln(\frac{C_t}{L_t}) = & \ \theta \ln(\frac{C_{t-1}}{L_{t-1}}) + \alpha\gamma \ln(\frac{K_t}{L_t}) \\ & + \beta(1-\gamma)\ln(\frac{M_{dt}}{L_t}) + (1-\gamma)(1-\beta)\ln(\frac{M_{ft}}{L_t}) \\ & - \theta\alpha\gamma \ln(\frac{K_{t-1}}{L_{t-1}}) - \theta\beta(1-\gamma)\ln(\frac{M_{d,t-1}}{L_{t-1}}) \\ & - \theta(1-\gamma)(1-\beta)\ln(\frac{M_{f,t-1}}{L_{t-1}}) + \nu_t \end{aligned} \tag{23}$$

From the Eq.(23), we can get enough coefficients to measure marginal cost. Having estimated the values of coefficients we can recover α, β, and γ. By substituting α, β, and γ into the production function, we can obtain a time series of the technological coefficient, $\ln Z_t$:

$$\begin{aligned}\ln Z_t = & \ln(\frac{C_t}{L_t}) - \alpha\gamma \ln(\frac{K_t}{L_t}) \\ & - \beta(1-\gamma)\ln(\frac{M_{dt}}{L_t}) \\ & - (1-\gamma)(1-\beta)\ln(\frac{M_{ft}}{L_t}) \end{aligned} \tag{24}$$

We finally construct marginal cost series by substituting estimates $\ln Z_t$ into Eq.(21).

3.2 Data

For the estimation of the marginal cost we use quarterly data over the sample period 1975:Q1～2010:Q4. The estimation is to be done for the three cases: manufacturing all, nondurables, and durables. All data come from quarterly and monthly reports issued by the Economic Statistical System(ECOS) at the Bank of Korea and Korean Statistical Information Service(KSIS) at the Bureau of Statistics.

The data we use are quarterly, being both aggregated from monthly original data and disaggregated down from yearly data. The data on labor hour, employers, wages, and interest rate are available on a monthly basis, so we have aggregated them up to quarterly. Capital stocks are issued on a yearly basis, so we have disaggregated them down to quarterly by using a quarterly Industrial Production Index in manufacturing industry and the following formula:

$$K_{it} = K_t + [K_t - K_{t-1}] \times \frac{i}{4}, \qquad i = 1, 2, 3, 4 \tag{25}$$

where K_{it} indicates the capital stock at ith quarter and year t. In order to divide intermediate inputs into domestic and imported shares, we use the ratios derived from the Input-Output Tables issued by the Bank of Korea. The data on input-output tables which are available only annually are disaggregated into quarterly data using a quarterly Industrial Production Index in manufacturing industry.

4. Estimation Results

4.1 Estimates for production fundtion and marginal costs

To measure marginal cost, first we need to estimate coefficients in the production function. The regression results are presented in <Table 1>. It shows the coefficient of production function mentioned as Eq.(20) in the previous section. All of the coefficients are estimated to be statistically significant with correctly expected signs except $\alpha\gamma$ in manufacturing and durables, and $\theta\alpha\gamma$ in manufacturing. The estimation for production function proved to be stable as it appears in high R^2, high t-ratio, and no autocorrelation.

<Table 1> Estimates for Production Function

Parameters	Manufacturing	Nondurables	Durables
$\alpha\gamma$	0.0169 (0.0122)	0.0476*** (0.0174)	0.0074 (0.0090)
$\beta(1-\gamma)$	0.5210*** (0.0323)	0.4920*** (0.0356)	0.5568*** (0.0330)
$(1-\gamma)(1-\beta)$	0.2867*** (0.0258)	0.2942*** (0.0311)	0.2745*** (0.0191)
θ	0.9914*** (0.0074)	0.9992*** (0.0063)	0.9817*** (0.0078)
$\theta\alpha\gamma$	−0.0162 (0.0123)	−0.0475*** (0.0174)	−0.0020 (0.0090)
$\theta\beta(1-\gamma)$	−0.5055*** (0.0331)	−0.4900*** (0.0358)	−0.5225*** (0.0353)
$\theta(1-\gamma)(1-\beta)$	−0.2960*** (0.0259)	−0.2978*** (0.0310)	−0.2820*** (0.0191)
R^2	0.99	0.99	0.99
$D.W.$	2.08	2.10	2.12

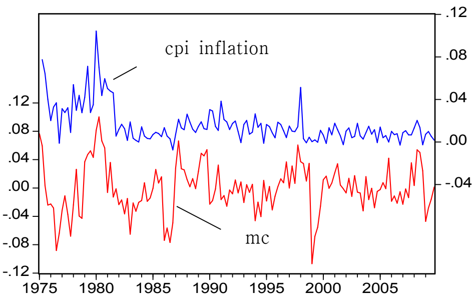
Standard errors are shown in brackets. *** indicates a significant t-test at the 1% significance level,

We can recover α, β, and γ from estimated coefficients in <Table 1>. The coefficients β and γ have similar magnitudes among industries. The estimate of β has a range from 0.6258 to 0.6698, while the estimate of γ has a range, 0.1687-0.2139, but the coefficients α has relatively a large value 0.2224 in nondurables, being 0.0888 in manufacturing and 0.0438 in durables.

<Table 2> Coefficients for Production Function

Parameters	Manufacturing	Nondurables	Durables
α	0.0888	0.2224	0.0438
β	0.6449	0.6258	0.6698
γ	0.1924	0.2139	0.1687

Marginal costs time series data are constructed using coefficients estimated in the production function and technological coefficient estimated in Eq.(24). Fig.1 displays the estimated real marginal costs for manufacturing industry with CPI inflation.



<Fig. 1> CPI Inflation and marginal costs

<Fig. 1> depicts real marginal cost in nondurables and CPI inflation. As was the case in every industrialized nation, the two oil crisis in 1970s shows inflation was very high and then over the last 30 years inflation had a little downward trend. The marginal costs in manufacturing and non-durables are likely to have similar patterns. As shown in <Fig. 1> we can make sure there are especially close co- movements among 2nd oil shock, Asian foreign exchange crisis in 1997 and world financial crisis in 2008.

4.2 Estimates for the hybrid model

Now we discuss GMM estimates for the hybrid model expressed in Eq.(16).[4] The results are reported in <Table 3> with the two cases of CPI inflation and PPI inflation used as the dependent variable. The first three columns present estimates of the parameters χ, ω and β with their standard errors below. The next four columns give the values of the parameters, γ_b, γ_f, κ, and the duration of fixed price D. The final column shows Hansen's J-statistics on the overidentifying restrictions. From the theoretical perspectives the use of PPI in manufacturing industry is more appropriate than that of CPI. A known shortcoming of GMM estimator is its sensitivity to instrument variables. We use four lags of inflation, output gap, labor income share, and wage inflation. Inflation is measured as the log difference in the CPI deflator and PPI deflator: $\pi_t = 100(\ln P_t - \ln P_{t-1})$. Output gap is measured as log deviation of real GDP from its one-sided Hodrick-Prescott(HP) filter. That is, $\hat{y_t} = 100(\ln Y_t - \ln Y_t(hp))$. Wage inflation is the quarterly growth rate of compensation of employees: $w_t = 100(\ln W_t - \ln W_{t-1})$. Marginal costs are deviated values from its steady state (HP trend).

As shown in <Table 3>, the coefficients on real marginal costs for CPI inflation are estimated to be 0.0743 in manufacturing industry, 0.0513 in nondurable industry, and 0.0089 in durable industry respectively. On the other hand the slope coefficient on marginal costs λ proved to be statistically significant and positive in PPI inflation as is consistent with the a priori theory. Furthermore the magnitude of λ as a driving variable proved to be relatively even larger than that in the many previous studies.[5]

The value of λ is 0.0812 in manufacturing, 0.1773 in nondurables, and 0.2962 in durables[6] while the data in U.S. and Europe shows 0.023 and 0.088 respectively.These empirical evidences could support the argument that real marginal cost is a driving factor in determining the PPI inflation. As the theory indicates, the parameter ω reflects the degree of price rigidity and $1/(1-\omega)$ means the number of quarters between price adjustments. The value of ω in CPI inflation proved to be 0.8209 in nondurables and 0.8491 in durables, a little higher than 0.8209.

<Table 3 > GMM estimates for the hybrid model 1975-2010

Industries	χ	ω	β	λ	γ_f	γ_b	D	J
CPI Inflation								
manufacturing	0.4351*** (0.0559)	0.7232*** (0.0525)	0.8452*** (0.0780)	0.0743*** (0.0198)	0.5720*** (0.0471)	0.3519*** (0.0347)	3.61	0.13
nondurables	0.4660*** (0.0574)	0.8209*** (0.0825)	0.8569*** (0.0771)	0.0513 (0.0349)	0.6392*** (0.1087)	0.3464*** (0.0829)	5.58	0.32
durables	0.5853*** (0.0761)	0.8491*** (0.0939)	0.7845*** (0.0830)	0.0089 (0.0070)	0.5597*** (0.0480)	0.3522*** (0.0423)	6.62	0.13
PPI Inflation								
manufacturing	0.4205*** (0.0962)	0.8568*** (0.1475)	0.7458*** (0.1167)	0.0812** (0.0402)	0.6315*** (0.1090)	0.3519*** (0.0911)	6.94	0.09
nondurables	-	-	-	0.1773** (0.0842)	0.7207*** (0.1227)	0.3996*** (0.0793)	-	0.12
durables	-	-	-	0.2962*** (0.1151)	0.3040*** (0.0912)	0.2113*** (0.0654)	-	0.09

J is the test of overidentifying restrictions. Standard errors are shown in ( ). *** and ** indicate a significant t-test at the 1% and 5% significance level respectively.

4] We use a 12-lag Newey and West Heteroscedasticity and Autocorrelation Consistent (HAC) estimate of the variance of the moment conditions. The Bartlett kernel is used to weight the covariances with Newey-West fixed bandwidth.

5] See Gali et. al.(2001)[12] and Sbordone(2002)[13].

6] Zhu and Kang(2013)[6] reports the value of λ is 0.032 in manufacturing, 0.032 in non-durables, and 0.027 in durables.

The higher value in ω implies that prices in durable goods are stickier than those in nondurable goods. The estimates 0.8209 and 0.8491 mean that firms change their prices every 5.58 quarters and 6.62 quarters respectively. In the case of PPI inflation ω is estimated to be 0.8568 in manufacturing which is very similar to the estimates around 0.83-0.88 in the U.S.(See Gali and Gertler(1999)[4]). The degree of back- wardness in price setting χ is estimated to be around 0.4351-0.5853 in CPI inflation case and 0.4205 in PPI inflation case, which suggests that roughly 40-50 percent of manufacturing firms are using backward-looking price- setting rules in the hybrid model.

4.3 Estimation results for closed form

<Table 4> shows GMM estimates for the closed form expressed in Eq.(18). The coefficients δ_1 and δ_2^{-1} in the closed form of hybrid model are estimated to be around 0.76-0.79 and 0.27-0.55 in the case CPI inflation respectively.

<Table 4> GMM estimates for closed form of the hybrid model

Parameters	δ_1	δ_2^{-1}	J
CPI Inflation			
manufacturing	0.7919^{***} (0.0240)	0.2739^{**} (0.1081)	0.1657
nondurables	0.7771^{***} (0.1200)	0.2681^{**} (0.1203)	0.1803
durables	0.7602^{***} (0.1200)	0.5507^{**} (0.2516)	-
PPI Inflation			
manufacturing	0.5086^{***} (0.00451)	0.8779^{***} (0.0366)	0.1399
nondurables	0.4778^{***} (0.0758)	0.4658^{***} (0.1363)	-
durables	0.2036^{***} (0.0580)	0.6758^{***} (0.0702)	0.1126

J is the test of overidentifying restrictions. Standard errors are shown in ( ). *** and ** indicate a significant t-test at the 1% and 5% significance level respectively.

On the other hand, the PPI inflation case shows the estimates to be around 0.20-0.51 and 0.47-0.88 respectively. The coefficients δ_1 and δ_2^{-1} in manufacturing for PPI inflation proved to be 0.5086 and 0.8779 respectively, similar to the estimates in the U.S. case.

<Table 5> provides the comparative lists in order to evaluate the functional relationship between the coefficients in hybrid model and it's closed form. In the case of CPI inflation $1/\gamma_f$ and γ_b/γ_f in manufacturing show 1.7483 and 0.6152 respectively while $\delta_1+\delta_2$ and $\delta_1 \cdot \delta_2$ are 4.429 and 2.8912 respectively. Thus the results do not satisfy the relationships, $1/\gamma_f=\delta_1+\delta_2$ and $\gamma_b/\gamma_f=\delta_1 \cdot \delta_2$. The only case in <Table 5> is the manufacturing case for PPI inflation in which $1/\gamma_f$ and γ_b/γ_f show 1.5836 and 0.5572 with $\delta_1+\delta_2$ and $\delta_1 \cdot \delta_2$ being 1.6477 and 0.5793 respectively. These results also empirically are consistent with the functional relationship between the coefficients in hybrid model and it's closed form. Thus the paper suggests that the empirical studies on inflation dynamics should focus on the manufacturing industry with market power, considering PPI inflation as the dependent variable.

<Table 5> Comparative Analysis in Coefficients for Closed Form

Industries	$1/\gamma_f$	γ_b/γ_f	$\delta_1+\delta_2$	$\delta_1 \cdot \delta_2$
CPI Inflation				
manufacturing	1.7483	0.6152	4.4429	2.8912
nondurables	1.5645	0.5419	4.5071	2.8985
durables	1.7867	0.6293	2.5761	1.3804
PPI Inflation				
manufacturing	1.5835	0.5572	1.6477	0.5793
nondurables	1.3875	0.5545	2.6246	1.0258
durables	3.2895	0.6951	1.6833	0.3013

5. Conclusion

This paper is to develop and estimate a closed form in inflation model using the estimates for real marginal costs in manufacturing industries during the sample period 1975-2010. The production function in manufacturing industry incorporates labor, capital, domestic material, and foreign material, assuming constant returns to scale technology and AR(1) process of technological coefficient. We derive real marginal costs from firm's cost minimization with quarterly data and provide new evidences on the new Keynesian phillips curve for Korea.

We find several pieces of empirical results for the estimation of the closed form in NKPC. First, the coefficients in real marginal costs for CPI inflation are estimated to be 0.074 in manufacturing industry, 0.0513 in nondurable industry, and 0.0089 in durable industry respectively. On the other hand the coefficients for PPI inflation were estimated to be higher values than those in the previous studies, showing 0.082 in manufacturing, 0.1773 in nondurable goods, and 0.2962 in durable goods. These empirical evidences could support the argument that real marginal cost is a driving factor in determining the PPI inflation.

Second, the coefficient ω that reflects the degree of price stickiness proved to be 0.8209 in nondurables and 0.8491 in durables, a little higher than 0.8209. The higher value in ω implies that prices in durable goods are stickier than those in nondurable goods. Third, the coefficients δ_1 and δ_2^{-1} in the closed form of hybrid model are estimated to be around 0.76-0.79 and 0.27-0.55 in the case CPI inflation respectively. On the other hand, the PPI inflation case shows the estimates to be around 0.20-0.51 and 0.47-0.88 respectively.

Third, the coefficients δ_1 and δ_2^{-1} in manufacturing for PPI inflation proved to be 0.5086 and 0.8779 respectively, similar to the estimates in the U.S. case. These results also empirically are consistent with the functional relationship between the coefficients in hybrid model and it's closed form. Thus the thesis suggest that the empirical studies on inflation dynamics should focus on the manufacturing industry with market power, considering PPI inflation as the dependent variable.

Reference

[1] Calvo, Guilermo, "Staggered Prices in a Utility Maximizing Framework," Journal of Monetary Economics, Vol.12, pp.383-398, 1983.

[2] Taylor, John B., "Aggregate Dynamics and Staggered Contracts," Journal of Political Economy, Vol.88, pp.1-22, 1980.

[3] Rotemberg, Julio J., "Sticky Prices in the United States," Journal of Political Economy, Vol.90, pp.1187-1211, 1982.

[4] Rotemberg, Julio J. and Michael Woodford, "An Optimization-Based Econometric Frame work for the Evaluation of Monetary Policy," NBER Macroeconomics Annual, Vol.12. 1997.

[5] Galí, J and Gertler, M., "Inflation dynamics: a structural econometric analysis," Journal of Monetary Economics, Vol. 44, pp.195-222, 1999.

[6] Zhu Yan H. and J. H. Kang, "Inflation Dynamics in Korea: Estimation of Marginal Costs in Manufacturing Industries (1975-2010)," International Ares Studies Review, Vol.17, No.1, pp.55-73, 2013.

[7] Dixit, Avinash K. and Joseph E. Stiglitz, "Monopolistic Competition and Optimum Product Diversity," American Economic Review, Vol.67, No.2, pp.297-308, 1977.

[8] Galí, J, Gertler, M and López-Salido, "Robustness of the Estimates of the Hybrid New Keynesian Phillips Curve," Journal of Monetary Economics, Vol.52, pp.1107-1118, 2005.

[9] Leith, C. and Malley, C., "Estimated Open

Economy New Keynesian Phillips Curves for the G7," Open Economies Review, Vol.18, pp.405-426, 2007.
[10] Batini, N, Jackson, B and Nickell, S., "An open-economy new Keynesian Phillips Curve for the United Kingdom," Journal of Monetary Economics, No.52, pp.1,061-71, 2005.
[11] Rumler, Fabio, "Estimates of the Open Economy New Keynesian Phillips Curve for Euro Area Countries," ECB Working Paper No.496, 2005.
[12] Galí, J, Gertler, M and López-Salido, J D., "European inflation dynamics," European Economic Review, Vol.45, pp.1237-1270, 2001.
[13] Sbordone, Argia, "Prices and Unit Labor Costs: A New Test of Price Stickiness," Journal of Monetary Economics, Vol.49, pp. 265-292, 2002.

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