An Assessment of the New Keynesian Phillips Curve in the Korean Economy

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Abstract

This paper examines the validity of the new Keynesian Phillips curve in the Korean economy, which is characterized by its high dependence on foreign materials as intermediate inputs. A new Keynesian Phillips curve in an open economy is necessary for this purpose, and the attempt is based on the distinction between gross and value-added prices. It is shown that a standard new Keynesian Phillips curve can be interpreted as describing the behavior of gross price inflation and, therefore, it is essential to incorporate intermediate input costs in constructing marginal cost measures. Moreover, from this gross price inflation model, the valued-added price inflation model is derived explicitly, yielding testable equations for the new Keynesian price-setting. This paper’s approach offers an integrated framework to analyse three driving forces of inflation: labor cost, a change in market structure and the movement of the relative price of imported materials. Finally, estimation results show that (1) the new Keynesian Phillips curve can be supported in the Korean economy especially for the period since the early 1980s; (2) backward-looking behavior plays only a minor role in describing inflation dynamics for the

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economy as a whole; (3) there is partial evidence that the Phillips curve became flatter over time. However, considering large uncertainty surrounding the parameter estimates, further research is necessary to address this issue.

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1 Introduction

The determinants of inflation dynamics have long been the subject of macroeconomics. Especially, economists have been interested in explaining how the strength/weakness of economic activities affects inflation, and the relationship between inflation and economic activities is formalized as the Phillips curve, named after the economist (A.W. Phillips) who first documented a relationship between unemployment and the rate of change of nominal wages in the United Kingdom for the period 1861-1957. Although much effort has been devoted to this issue, the dynamics of inflation is not fully understood. Recently, much attention has been paid to the new Keynesian Phillips curve (NKPC), which builds on the works of Taylor (1980) and Calvo (1983). According to the NKPC, current inflation is determined by current economic activities and the expectations of future inflation. This inflation model is somehow successful in that it explains why current inflation is affected by expected future inflation based on the optimizing behavior of individual firms.

There has been much debate on the validity of this inflation equation. In a standard NKPC, economic activities are represented by the output gap or real marginal cost. Gali and Gertler (1999) show that, when current inflation is regressed on future inflation and the output gap, the sign of the coefficient on the output gap is negative, which is contrary to theoretical predictions. However, they argue that this empirical failure arises not from the NKPC itself but from the inappropriateness of the output gap as a proxy for real marginal cost. They instead show that the labor income share (real unit labor
cost) is a better measure of real marginal cost, and provide evidence that the NKPC fits well with U.S. data when the labor income share is used as a proxy for real marginal cost.

Woodford (2001) argues that deterministically detrended real GDP is a poor measure of the output gap. He points out that detrended real GDP does not track the difference between actual output and potential output, i.e., the equilibrium level of output when prices are fully flexible. Noting that the actual driving variable in the NKPC is real marginal cost, he shows that this inflation equation works well when this measure of real marginal cost is used instead of the output gap. Sbordone (2002) also finds evidence that supports the NKPC, based upon the prediction results of this forward-looking inflation model. On the other hand, Rudd and Whelan (2005a, 2005b) find no evidence in favor of the NKPC. Specifically, using another expression for the NKPC, i.e., current inflation as the discounted sum of the current and expected future labor income share, they show that the discounted sum explains actual inflation very poorly, and conclude that backward-looking behavior is more important in describing inflation dynamics.

In contrast to the large literature on the validity of the NKPC, there is not much debate on whether the NKPC works well in the Korean economy. While the U.S. economy can be quite well described as a closed economy, the Korean economy imports a great portion of materials as intermediate inputs. As a result, the inflation dynamics in the Korean economy is considered to be much affected by import price movements, as experiences show during two oil shock periods in the 1970s. On the theoretical front, there have been attempts to explain the behavior of inflation in an open economy context. Balakrishnan and Lopez-Salido (2002) employ a CES production function to incorporate foreign materials, taking into account the fact that the United Kingdom imports a significant amount of materials as production inputs. Batini, Jackson and Nickell (2000, 2005) allow for the relative price of imported materials in constructing a
measure of real marginal cost.

On the empirical front, there are only a limited number of studies investigating whether the NKPC provides a good description of inflation behavior in the Korean economy. Moon, Yun and Lee (2004) estimate the NKPC employing Gali and Gertler’s approach. Since there are only annual data on the labor income share available in the National Account, they use household survey data to construct the labor income share. Their measure of the labor income share is computed as the ratio of labor income to total household income. Yoo and Ahn (2006) consider both Gali and Gertler’s approach and an open economy NKPC as in Batini et al. They use interpolated quarterly series of the labor income share from the National Account adjusted for individuals’ operating surplus to account for self-employment income as proposed by Gollin (2002) while including relative import price as well for the open economy model. Both of these studies use the sample period since 1980:Q1 and find that the NKPC fits well with Korean data, and that forward-looking behavior of inflation is more influential although a backward-looking component is also present.2

It is important to shift attention from value-added output to gross output if intermediate inputs are taken into account. However, Balakrishnan and Lopez-Salido (2002) do not distinguish between gross output and value-added output. Batini et al. (2000, 2005), although there is a conceptual difference between the two, still rely on a simple assumption that gross output is equal to value-added output. This paper’s approach begins with a clear distinction between the price of gross output (hereafter, gross price) and the price of value-added output (hereafter, value-added price) to clarify the role of intermediate inputs in explaining inflation dynamics in an open economy. Since almost all products require both intermediate inputs and primary inputs such


2While Gali and Gertler (1999) employ the GDP deflator as a measure of the price index, Yoo and Ahn (2006) use the consumer price index (CPI) mentioning that the percentage change rate of CPI is also a standard broad measure of inflation. However, there is no remark on which price index they use in Moon, Yun and Lee (2004).
as labor and capital, it is essential to incorporate the movement of intermediate input costs into marginal cost measures. Traditionally, the treatment of intermediate inputs has not been explicit in economic analyses, the practice of which can be justified under the assumption of perfect competition. Under perfect competition, value-added production functions exist and the profit maximization problem of a representative firm can be stated in terms of the price and quantity of value-added output and the cost for primary inputs. As is noted in Rotemberg and Woodford (1993), however, under an imperfect competition environment in which individual firms set their own prices, the traditional practice can no longer be justified. In this case, attention should be shifted to gross output production functions and thus the cost for intermediate inputs should also be included in total production cost. An issue associated with Gali and Gertler’s (1999) approach is to find the microfoundation of using the GDP deflator in estimating the NKPC, which is value-added price. Since the purchasers of products do not face value-added price in the actual world and they pay the whole price including intermediate input costs, it is natural that an individual firm’s demand schedule is expressed as a function of gross price, not as a function of value-added price. In my interpretation, the price in the original profit maximization problem of a representative firm corresponds to gross price conceptually, in the sense that intermediate input costs are embedded in this price.

Major contributions of this paper are the following. First, this paper shows that the standard new Keynesian Phillips curve should be interpreted as inflation behavior for gross price. However, this equation is not testable due to the lack of data on the price index of gross output. But this paper shows that an NKPC for value-added price can be derived from the NKPC for gross price, which has a different specification from that of Gali and Gertler. Furthermore, this NKPC for value-added price provides a testable equation for the new Keynesian price-setting.

Second, it offers an integrated framework to analyse the driving forces of inflation,
and thus provides richer dynamics of inflation in an open economy. According to this generalized NKPC, the driving forces of inflation are not only labor cost, but also a permanent change in market structure and the movement of relative import price. In a related research, Dotsey and King (2005) investigate the macroeconomic implications of the existence of intermediate inputs. They find that the response of inflation to a monetary policy shock is mitigated, and thus the output response becomes more persistent when there are intermediate inputs. However, their model is not general enough to be applied to an open economy directly since their focus is on a closed economy like U.S. In their model, the price of intermediate inputs is always equal to the aggregate price level of the economy, which is not consistent with data in most open economies and even in U.S. As we shall see later, the relative price of intermediate inputs varies all the time, and sometimes undergoes dramatic changes. This paper allows for a variation in the relative price of intermediate inputs. It will turn out later that this variation is one of the sources that induce a non-stationary movement of the markup. Most studies in the NKPC literature assume that the markup (to be exact, the markup of value-added output) is stationary. This assumption turns out not to be the case for the Korean economy. This paper's approach based on the distinction between gross and value-added prices has an advantage in clarifying that the non-stationarity of the markup stems from a permanent shift in market structure and a non-stationary movement of the relative price of imported materials.

Finally, the paper presents better empirical evidence for the NKPC in Korea than the previous studies. Estimation results for the newly derived NKPC for value-added price show that the new Keynesian price-setting can be supported in the Korean economy, especially since the early 1980s. The new NKPC entails more reliable estimates for structural parameters in the model than the previous studies. Moreover, as is expected, the new NKPC better fits actual inflation than a model with only primary inputs considered. Judging from the estimation results of this paper, the backward-
looking behavior of inflation becomes less important for the economy as a whole than
the previous studies testing the NKPC in the Korean economy suggest. Thus it seems
that the forward-looking NKPC gives a good approximation of inflation dynamics in
the Korean economy at least since the early 1980s.

The organization of this paper is as follows. First, I develop a more generalized
NKPC in section 2. In section 3, the newly derived NKPC is tested. Finally, some
conclusions are drawn in section 4.

2 Open Economy Model

2.1 Gross Price Inflation

In this section, an open economy model is considered to characterize the extensive use
of foreign materials in the Korean economy. The economy consists of a representa-
tive household, a continuum of firms and the government. The household purchases
consumption goods and supplies labor. Each firm produces a differentiated product
that can be used either as an intermediate input or for final demand. As in Basu
(1995), products are distinguished by use, not by the type of products. Thus aggregate
demand for gross output consists of intermediate demand, consumption, investment,
government spending and export. The production function exhibits constant returns
to scale with respect to intermediate inputs (henceforth, materials), labor and capital.
Firms use materials both domestic and foreign.

A representative household maximizes lifetime expected utility subject to standard
budget constraints:

$$\text{Max. } E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{1}{1 - \gamma} C_t^{1-\gamma} - v(H_t) \right\}$$ (1)

where $\beta$ is the discount factor; $C_t$ and $H_t$ denote aggregate consumption and hours
worked at time $t$, respectively. Furthermore, $C_t = \left[ \int_0^1 C_t(i)^{(\epsilon_t-1)/\epsilon_t} \, di \right]^{\epsilon_t/(\epsilon_t-1)}$ is a CES

aggregator in which \( \varepsilon_t \) is the time-varying elasticity of substitution among differentiated products and \( C_t(i) \) is consumption demand for the \( i \)-th product. The time-varying \( \varepsilon_t \) is necessary in the model to allow for a markup shock. From the first order conditions we obtain consumption demand for the \( i \)-th product:

\[
C_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon_t} C_t
\]  

(2)

where \( P_t(i) \) is the price of the \( i \)-th product and \( P_t = \left[ \int_0^1 P_t(i)^{1-\varepsilon_t} di \right]^{1/(1-\varepsilon_t)} \) is the corresponding aggregate price index.

It would be interesting to note that there is no need to explain the behavior of aggregate consumption. Since the above and the following arguments are focused on deriving a demand function for gross output of the \( i \)-th product, it suffices to treat aggregate consumption simply as given. Likewise, we can assume that total investment, total government spending and total export are given. Then in order to derive a final demand function for the \( i \)-th product, we can follow the approach of Woodford (2003, p.354) assuming that all economic agents including the government minimize total expenditures given the aggregate demand for final products. On condition that the same elasticity of substitution among differentiated products applies to all components of final demand, we have:

\[
FD_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon_t} FD_t
\]  

(3)

where \( FD_t(i) \) denotes the final demand for the \( i \)-th product and \( FD_t \) is the aggregate final demand of the whole economy.

Now we can extend this result to gross output demand of the \( i \)-th product if we assume that a representative firm minimizes the total cost of materials given the total quantity of materials demand. Moreover, since firms can use both domestic materials and foreign materials, we allow for substitution between domestic materials and foreign materials using a CES aggregator as in Gali and Monacelli (2005). Specifically, let us
consider the following expenditure minimization problem of firm $j$. Taking as given total materials input of firm $j$, $M_{t}(j)$, we solve:

$$\text{Min. } \int_{0}^{1} P_{t}(i)M_{t}^{d}(i,j)di + \int_{0}^{1} P_{t}^{f}(i)M_{t}^{f}(i,j)di$$

$s.t. \begin{equation}
M_{t}(j) = \left[ \psi \frac{1}{\eta} M_{t}^{d}(j)^{\frac{\eta-1}{\eta}} + (1 - \psi) \frac{1}{\eta} M_{t}^{f}(j)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \\
M_{t}^{d}(j) = \left[ \int_{0}^{1} M_{t}^{d}(i,j) \frac{\bar{G}_{t}}{\bar{G}_{t}} di \right]^{\frac{\bar{G}_{t}}{\bar{G}_{t}}} \\
M_{t}^{f}(j) = \left[ \int_{0}^{1} M_{t}^{f}(i,j) \frac{\zeta_{t}}{\zeta_{t}} di \right]^{\frac{\zeta_{t}}{\zeta_{t}}} 
\end{equation}$

where $M_{t}^{d}(i,j)$ is firm $j$'s materials demand for the $i$-th product produced domestically, $M_{t}^{f}(i,j)$ is firm $j$'s materials demand for the $i$-th product imported from abroad, and $P_{t}^{f}(i)$ is import price of the $i$-th product expressed in domestic currency. $M_{t}^{d}(j)$ and $M_{t}^{f}(j)$ are CES aggregators for domestic materials and foreign materials, respectively. Parameters $\eta$ and $\zeta$ measure the substitutability between domestic and foreign materials, and the substitutability among differentiated foreign products, respectively.\(^3\) Parameter $\psi$ is related to preferences in favor of domestic products, and thus $1 - \psi$ can measure the degree of openness.

Then the first order conditions give

$$\begin{align*}
M_{t}^{d}(i,j) &= \left( \frac{P_{t}(i)}{P_{t}} \right)^{-\epsilon_{t}} M_{t}^{d}(j) \\
M_{t}^{f}(i,j) &= \left( \frac{P_{t}^{f}(i)}{P_{t}} \right)^{-\zeta_{t}} M_{t}^{f}(j)
\end{align*}$$

where $P_{t} = \left[ \int_{0}^{1} P_{t}^{f}(i)^{1-\zeta_{t}} di \right]^{1/(1-\zeta_{t})}$ is the aggregate price index of imported materials expressed in domestic currency. Moreover, the optimal allocation of expenditures

\(^3\)We can assume that $\zeta$ is time-varying. However, this setup has no bearing on the derivation of the NKPC.
between domestic and foreign materials implies

\[ M^d_t(j) = \psi \left( \frac{P_t}{P^m_t} \right)^{-\eta} M_t(j), \quad M^f_t(j) = (1 - \psi) \left( \frac{P^f_t}{P^m_t} \right)^{-\eta} M_t(j) \]  

(6)

where \( P^m_t = \left[ \psi(P_t)^{1-\eta} + (1 - \psi)(P^f_t)^{1-\eta} \right]^{1/(1-\eta)} \) is the aggregate price index of materials. Dotsey and King (2005) investigate the importance of materials in generating persistent responses of output to monetary policy shocks. In their setup, the aggregate price of materials is equal to the aggregate price of domestic products (i.e., \( P^m_t = P_t \)), and thus there is no fluctuation in the relative price of materials.\(^4\) However, this no longer holds for an open economy. As figure 1 shows, the price of materials does not move one-for-one with the price of gross output or with the price of value-added output. There are dramatic rises in the relative price of materials during the two oil shock periods. Since then, it keeps declining until around 1997 and starts to rise steadily later on. It should be noted that the share of intermediate inputs in gross output shows a similar trend, which suggests that the substitution between materials and primary inputs is very limited.

By aggregating across all firms, we have demand functions of domestically produced materials and imported materials for the \( i \)-th product:

\[ MD^d_t(i) = \int_0^1 M^d_t(i, j) dj = \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon_t} M^d_t \]  

(7)

\[ MD^f_t(i) = \int_0^1 M^f_t(i, j) dj = \left( \frac{P^f_t(i)}{P^f_t} \right)^{-\zeta} M^f_t \]

where \( M^d_t = \int_0^1 M^d_t(j) dj \) and \( M^f_t = \int_0^1 M^f_t(j) dj \) are the aggregate demand of the whole economy for domestically produced materials and imported materials, respect-

\(^4\) We can think of two sorts of the relative price of materials. One is the price of materials compared to gross price (\( P^m_t / P_t \)), and the other is compared to value-added price (\( P^m_t / P^v_t \)). Since data on gross price are limited, relative price movements can be captured more easily by the latter.
tively. Then demand for gross output of the $i$-th product is given by

$$Q_t(i) = MD_t(i) + FD_t(i) = \left( \frac{P_t(i)}{P_t} \right)^{-\varepsilon_t} Q_t$$

(8)

where the gross output of the whole economy is now defined as $Q_t = M_t + FD_t$.

A representative firm indexed by $i$ is assumed to maximize profits under the Calvo-type environment in which the firm can only adjust its price with probability $1 - \theta$:

$$\text{Max. } \sum_{t=0}^{\infty} \beta^t \left\{ \frac{P_t Q_t(i) - P_t^n M_t(i) - W_t L_t(i) - R_t^k K_t(i)}{P_t} \right\}$$

(9)

where $P_t^n$, $W_t$ and $R_t^k$ are the price of materials, wage rate and the user cost (or rental price) of capital, respectively; $L_t(i)$ and $K_t(i)$ are labor and capital demand of firm $i$, respectively. This firm faces a gross output demand function of the form (8) for the $i$-th product, and the following fixed proportions production technology that has been used by Rotemberg and Woodford (1993), Basu (1996), and Conley and Dupor (2003).

$$Q_t(i) = f(M_t(i), L_t(i), K_t(i))$$

$$= \min \left[ \frac{M_t(i)}{\phi}, g(L_t(i), K_t(i)) \right] = \min \left[ \frac{M_t(i)}{\phi}, A_t L_t(i)^{\alpha} K_t(i)^{1-\alpha} \right]$$

(10)

where $A_t$ is the productivity associated with labor and capital inputs and $\phi$ is a parameter that represents the quantity of materials needed to produce one unit of gross output. Moreover, it is assumed that all firms have the same production technology. This firm chooses a price $P_t^*$ that lasts until it readjusts its price in the future.

With the production function stated above, real marginal cost of producing one unit of gross output is

$$mc_t = \frac{P_t^n}{P_t} \phi + \frac{1}{\alpha} \frac{W_t L_t}{P_t Q_t}$$

(11)

where $L_t = \int_0^1 L(i) \, di$ is aggregate labor.\footnote{To derive this real marginal cost measure on the aggregate level, we need to define another quantity}
measure is that the variation of production cost is not fully captured by labor cost in
the case that materials are not substitutable with primary inputs. Therefore, we need
an additional term of the real price (or relative price) of materials to reflect changes in
materials cost. The inverse of real marginal cost of gross output is the markup of gross
output (hereafter, gross markup), that is, \( \mu_t = 1/mc_t \). Most studies treat the markup
as stationary. However, this is not the case for the Korean economy. As is seen in
figure 2, the movements of real marginal cost or the gross markup are not stationary
in Korea.\(^6\) One possible source of this non-stationary markup variation is a change in
market structure or a change in price-setting firms’ market power. From the relation
that links the desired gross markup to the price elasticity of demand \( (\mu^*_t = \varepsilon_t/(\varepsilon_t - 1)) \),
it is easily seen that a permanent change in market structure \( (\varepsilon_t) \) causes a permanent
shift in the desired gross markup. In the figure, the desired gross markup is estimated
applying HP-filter to the actual markup. It appears that the desired gross markup has
been declining over time up until the mid-1990s, and starts to rise since then.

\[ Q_t^* = \int_0^t Q(i)\,di \] as is applied by Yun (1996). Then firm \( i \)'s real marginal cost is:

\[
mc_t(i) = \frac{P_m^m}{P_t} \phi + \frac{1}{\alpha} \frac{W_t L_t(i)}{P_t Q_t(i)} = \frac{P_m^m}{P_t} \phi + \frac{1}{\alpha} \frac{W_t L_t Q_t}{P_t Q_t(i)}
\]

These two kinds of quantity indexes have the same value at the steady state and deviations form the
steady state value of two quantity indexes are approximately the same. Therefore, we can measure the
average real marginal cost of the economy by (11). Likewise, \( \phi = M_t(i)/Q_t(i) \) can be measured by
the aggregate data, \( M_t/Q_t \).

\(^6\) Standard unit root tests are strongly in favor of a unit root. Based on annual data, ADF and PP
tests cannot reject the null hypothesis that the log of the markup has a unit root at all conventional
significance levels. Moreover, KPSS test rejects the null hypothesis that the log of the markup is
stationary at 5 percent level. Here are the statistics for the unit root tests:

\[
ADF(1) = -2.020, \quad PP(4) = -1.644, \quad KPSS(4) = 0.496
\]

where the statistics are t-statistics for ADF and PP tests, and an LM-statistic for KPSS test. The
numbers in \( (\quad) \) are optimal lags selected based on Schwarz Information Criterion in ADF test, and by
using Newey-West automatic bandwidth in PP and KPSS tests. Bartlett kernel is used to estimate the
long-run variance of error term for both PP and KPSS tests.
Now the first order condition of the firm’s profit maximization is:

\[
E_t \sum_{j=0}^{\infty} (\beta \theta)^j \left[ (1 - \varepsilon_{t+j}) \left( \frac{P^*_t}{P_{t+j}} \right)^{1-\varepsilon_{t+j}} + \varepsilon_{t+j} \left( \frac{P^*_t}{P_{t+j}} \right)^{-\varepsilon_{t+j}} \frac{MC_{t+j}}{P_{t+j}} \right] = 0
\]  

(12)

Since real marginal cost at each period \((MC_{t+j}/P_{t+j})\) is non-stationary, we need a slightly different strategy to log-linearize the equation (12). Considering that real marginal cost eventually converges to the inverse of the desired gross markup, a new stationary variable \((smc_t)\) is defined as the product of the desired gross markup and real marginal cost \((smc_t = \mu^*_t mc_t)\). Based on this stationary transformation, log-linearization of (12) in combination with \(P_t = \left[ \int_0^1 P_t(i)^{1-\varepsilon_t} di \right]^{1/(1-\varepsilon_t)}\) yields an NKPC of the following form\(^7\):

\[
\hat{\Pi}_t = \beta E_t \hat{\Pi}_{t+1} + \lambda \hat{smc}_t
\]

\[
= \beta E_t \hat{\Pi}_{t+1} + \lambda \log(\mu^*_t mc_t)
\]

(13)

where \(\hat{\Pi}_t\) is defined as \(\hat{\Pi}_t \equiv P_t/P_{t-1}\), and hat variables imply percentage deviations from the steady state values \((\hat{\Pi} = 1, \hat{smc} = 1)\). Here the parameter \(\lambda\) is \((1 - \theta)(1 - \beta \theta)/\theta\) where \(\beta\) is the discount factor and \(\theta\) is the probability of a representative firm’s not adjusting its price. In case that the desired gross markup is constant, the above is equivalent to the standard NKPC. However, it should be noted that the above NKPC describes the inflation dynamics of gross price whereas the standard NKPC deals with inflation behavior of value-added price. Moreover, now the real marginal cost measure incorporates both primary input cost and materials cost.

\(^7\)See Kim (2007) for details.
2.2 Value-Added Price Inflation

When researchers test the new Keynesian Phillips curve, they implicitly assume the following inflation equation for value-added price:

$$\hat{\Pi}_t^v = \beta E_t \hat{\Pi}_{t+1}^v + \lambda \bar{mc}_t^v$$

(14)

where $\Pi_t^v$ denotes the inflation rate of value-added price ($P_t^v / P_{t-1}^v$), and $mc_t^v$ is the real marginal cost of producing one unit of value-added output at time $t$. Empirically, most studies use the GDP deflator or the non-farm business sector GDP deflator as a general measure of the price level, and the labor income share as a proxy for real marginal cost of value-added output.

However, it is unclear whether we can have such a value-added price inflation equation on theoretical grounds. To find a value-added price inflation equation, we start from the following identity:

$$P_t Q_t = P_t^m M_t + P_t^v Y_t$$

(15)

where $M_t$ is materials input of the whole economy, $P_t^v$ is aggregate value-added price and $Y_t$ denotes the value-added output of the whole economy. This identity states that nominal gross output (total revenue) is the sum of nominal materials cost and nominal value-added. Since firms set the prices of their products (gross price) taking as given the prices of materials, the prices of value-added output are determined ex post. Thus value-added price can be expressed by the following relation:

$$P_t^v = \frac{P_t Q_t - P_t^m M_t}{Y_t} = P_t \left[ \frac{Q_t}{Y_t} - \frac{P_t^m M_t}{P_t Q_t Y_t} \right]$$

(16)

$$= \frac{P_t (1 - S_t^m)}{1 - \phi} = \frac{P_t S_t^v}{1 - \phi}$$

where $S_t^m$ and $S_t^v$ denote the shares of materials and value-added in gross output, respectively; and we used the fact that $M_t = \phi Q_t$ and $Y_t = (1 - \phi)Q_t$. The second
line of this equation implies that (i) value-added price rises if firms raise the prices of their product (gross price), and that (ii) value-added price falls if firms do not change their prices (gross price) when the share of materials increases (the share of value-added decreases). For example, suppose that there is an increase in oil prices, resulting in an increase in the share of materials. In this case, if firms do not change their prices, then value-added price deteriorates. Now log-linearization of equation (16) leads to

\[ \tilde{\Pi}_t^v = \tilde{\Pi}_t + \Delta s_t^v \]  

where lower-case letter \( s_t^v \) denotes the log of the share of value-added (\( S_t^v \)).

Let us turn to the relationship between the real marginal cost of producing one unit of gross output (\( mc_t \)) and the real marginal cost of producing one unit of value-added output (\( mc_t^v \)). Note that fixed proportions technology entails a value-added output production function of the Cobb-Douglas form, that is, \( Y_t = \tilde{A}_t L_t^\alpha K_t^{1-\alpha} \) where \( \tilde{A}_t \) is defined by \((1 - \phi)A_t\). In this case, it is shown in Gali and Gertler (1999) that the real marginal cost of producing one unit of value-added output (\( mc_t^v \)) is proportional to labor income share (\( mc_t^v = (1/\alpha)(W_t L_t / P_t^v Y_t) \)). Then from (11),

\[ mc_t = \frac{P_t^m}{P_t} \phi + \frac{1}{\alpha} \frac{W_t L_t}{P_t Q_t} = S_t^m + (1 - S_t^m) mc_t^v \]  

(18)

It is shown that the real marginal cost of gross output is determined not only by the real marginal cost of value-added output, which in turn is affected by real wages and labor productivity, but also by the share of materials. Another interesting point to note can be found from (18). Since the markup is the inverse of real marginal cost, we have

\[ \frac{1}{\mu_t} = S_t^m + (1 - S_t^m) \frac{1}{\mu_t^v} \]  

(19)

where \( \mu_t^v = 1/mc_t^v \) is the markup of value-added output (hereafter, value-added markup).
If we define the desired value-added markup ($\mu_t^{\text{v}}$) as the markup of value-added output that arises when prices are fully flexible (i.e., $\mu_t = \mu_t^*$) conditional on each level of $S_t^m$, then we have the relation

$$\mu_t^{\text{v}} = \frac{1}{mc_t^{\text{v}}} = \frac{1 - S_t^m}{1/\mu_t^* - S_t^m} \quad (20)$$

Moreover, we can show that the share of materials is determined by the relative import price of materials

$$S_t^m = \phi \frac{P_t^m}{P_t} = \phi \left[ \psi + (1 - \psi) \left( \frac{P_t^f}{P_t} \right)^{1-\eta} \right]^{\frac{1}{1-\eta}} \quad (21)$$

Thus equations (20) and (21) tell us two important sources of the variation in the desired value-added markup: a shift in the desired gross markup ($\mu_t^*$) due to a change in market structure ($\varepsilon_t$) and a shock to the relative import price ($P_t^f/P_t$). On this ground, a shock to oil prices can be interpreted either as a shock to real marginal cost of gross output or as a markup shock to value-added price.

Figure 3 displays an estimated trend of the desired value-added markup. The dotted line represents the desired value-added markup constructed by assuming that the share of materials is fixed at 65 percent, which is the materials share before the first oil shock. This dotted line only reflects changes in the desired gross markup. Relative to this dotted line, the solid line is constructed by assigning the actual materials share to $S_t^m$ in equation (20). Now the desired value-added markup has more fluctuations. Especially around the two oil shock periods, it rises dramatically. Thus, for an open economy, changes in the relative price of imported materials are sometimes a key driving force of the desired value-added markup.

Due to non-stationary movements of the gross markup and the relative import price, the actual value-added markup (or real marginal cost of value-added output) also exhibits non-stationary movements. Figure 4 shows the trend of real marginal cost of value-added output as proxied by the labor income share in the non-farm business sec-
tor. While the labor income share in U.S. exhibits quite stationary movement, the variation of the labor income share in Korea does not.

Now using the definition of $smc_t$ and the relation (19), we obtain

$$smc_t = \mu^*_t mc_t = \frac{1-S^t_v}{S^t_v} \mu^*_t + \mu^*_t mc^v_t \frac{1-S^t_v}{S^t_v} \mu^*_v + 1 \quad (22)$$

and by defining a new stationary variable ($smc^v_t$) as $smc^v_t = \mu^*_v mc^v_t$ ($smc^v = 1$), we have the following relation in a log-linearized form

$$\tilde{smc}_t = \chi \tilde{smc}^v_t \quad (23)$$

where $\chi = S^v_0 / [(1 - S^v_0) \mu^*_v + S^v_0]$; $S^v_0$ and $\mu^*_v$ are some appropriate values for the share of value-added in gross output and the desired value-added markup, respectively.\(^8\)

Then, by substituting (17) and (23) into (13), we have the following equation for value-added price inflation:

$$\hat{\Pi}^v_t = \beta E_t \hat{\Pi}^v_{t+1} + \lambda \chi \tilde{smc}^v_t - \beta E_t \Delta s^v_t + \Delta s^v_t \quad (24)$$

In the second line, I introduced another notation $\tilde{mc}^v_t \equiv \tilde{smc}^v_t$ to clarify the meaning of $\tilde{smc}^v_t$. Since $\tilde{mc}^v_t \equiv \tilde{smc}^v_t = log(\mu^*_t mc^v_t) = log(mc^v_t/mc^*_t)$, it can be easily seen that $\tilde{mc}^v_t$ is the log deviation of real marginal cost of value-added output from the stochastic trend. On the other hand, $\tilde{mc}^v_t$ is the log deviation of real marginal cost of value-added output from the steady state value as in most studies, which is applicable when the markup is stationary. Thus the new NKPC for value-added price differs from the

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\(^8\)Since both $S^v_t$ and $\mu^*_v$ are non-stationary, there are no unique steady state values for these variables. However, even though these variables are non-stationary, they do not have a deterministic upward or downward trend. Thus, practically sample means of these variables can be computed and used for $S^v_0$ and $\mu^*_v$.\(^8\)
standard NKPC in (14). The differences are three fold: (i) introduction of additional terms in NKPC, (ii) generalization of the forcing variable, and (iii) strengthening the degree of real rigidities. First, as is mentioned previously, a change in the share of value-added ($\Delta s^v_t$) reflects an improvement in value-added when other things are equal. As a result, this terms has a positive effect on value-added inflation. An expected future change in the share of value-added ($E_t \Delta s^v_{t+1}$), all else being equal, implies a decline in expected future gross price inflation ($E_t \Pi_{t+1}$),\(^9\) which lowers current gross price inflation ($\Pi_t$) and, in turn, value-added price inflation ($\Pi^v_t$). Thus an expected future change in the share of value-added has a negative effect on current value-added inflation. Second, if there is no change in the desired value-added markup, then $f_{mc}^v_t$ is equivalent to $c_{mc}^v_t$ in the standard NKPC. Compared to the standard NKPC, the newly derived NKPC can explain inflation responses when there is a permanent shock to the desired markup. Third, taking into account the existence of materials raises the degree of real rigidities. In a special case when real materials price is constant ($P^m_t = P_t$), the above equation reduces to

$$\Pi^v_t = \beta E_t \Pi^v_{t+1} + \lambda \chi \widehat{mc}_t^v$$

This has the same form as the equation (14) with a slight change in the coefficient on the real marginal cost of value-added output. Since $\chi < 1$, the slope coefficient on real marginal cost becomes smaller if we introduce materials in the model. This enables a slower response of inflation and, in turn, a more persistent response of output when there is a shock to monetary policy, as is pointed out by Dotsey and King (2005).

\(^9\)From (16), $P_t = (1 - \phi)P^v_t / S^v_t$. Thus when there is no change in value-added price, a rise in the share of value-added implies a decline in gross price.
3 Estimation of the Phillips Curve

3.1 Benchmark Specification

As is noted by Gali and Gertler (1999), the purely forward-looking inflation model is not appropriate to explain inflation inertia, which is observed in empirical studies. Taking into account this point, they introduce backward-looking agents who set their prices according to the average behavior of the economy in the previous period, and employ adaptive expectations to make a correction for inflation. Assuming that the portion of this type of backward-looking agents is $\omega$, they derive the following hybrid model that can nest both forward-looking and backward-looking expectations:

$$\tilde{P}_t = \beta_1 E_t \tilde{P}_{t+1} + \beta_2 \tilde{P}_{t-1} + \kappa \tilde{m}_c$$  \hspace{1cm} (26)

where $\beta_1 = \beta \theta / [\theta + \omega(1 - \theta(1 - \beta))]$, $\beta_2 = \omega / [\theta + \omega(1 - \theta(1 - \beta))]$ and $\kappa = (1 - \omega)(1 - \theta(1 - \beta)) / [\theta + \omega(1 - \theta(1 - \beta))]$. Their estimation results show that this hybrid inflation model depicts the actual inflation behavior fairly well.

In this respect, evaluating the validity of the new Keynesian Phillips curve is based on testing the hybrid model. In view of the argument of the previous section, this hybrid inflation model is interpreted as describing the behavior of gross price, not value-added price. As a result, the above hybrid NKPC should be modified to

$$\tilde{P}_t = \beta_1 E_t \tilde{P}_{t+1} + \beta_2 \tilde{P}_{t-1} + \kappa \tilde{m}_c$$  \hspace{1cm} (27)

to describe the behavior of gross price inflation. This being the case, we can derive a hybrid NKPC for value-added price using two relations (17) and (23). Then we have

$$\tilde{P}_t^v = \beta_1 E_t \tilde{P}_{t+1}^v + \beta_2 \tilde{P}_{t-1}^v + \kappa \tilde{m}_c^v - \beta_1 E_t \Delta s^v_{t+1} + \Delta s^v_t - \beta_2 \Delta s^v_{t-1} \hspace{1cm} (28)$$

$$= \beta_1 E_t \tilde{P}_{t+1}^v + \beta_2 \tilde{P}_{t-1}^v + \kappa \tilde{m}_c^v - \beta_1 E_t \Delta s^v_{t+1} + \Delta s^v_t - \beta_2 \Delta s^v_{t-1}$$
Compared to (24), we additionally have the lag terms of value-added price inflation \((\hat{\Pi}^v_{t-1})\) and a change in the share of value-added \((\Delta s^v_{t-1})\). Past inflation of value-added price \((\hat{\Pi}^v_{t-1})\) reflects the backward-looking expectations effect on current inflation. An increase in the share of value-added in the previous period \((\Delta s^v_{t-1})\), other things being equal, implies a decline in past inflation of gross price \((\hat{\Pi}^v_{t-1})\), which lowers current gross price inflation \((\hat{\Pi}^v_t)\) due to the backward-looking expectations effect, and thus value-added price inflation \((\hat{\Pi}^v_t)\). As a result, a change in the share of value-added in the previous period has a negative effect on current value-added inflation.

To estimate the new NKPC, I apply the generalized method of moments (GMM) based on the following orthogonality condition

\[
E \left[ \pi^v_t - \beta_1 \pi^v_{t+1} - \beta_2 \pi^v_{t-1} - \kappa \chi \hat{m}c^v_t + \beta_1 \Delta s^v_{t+1} - \Delta s^v_t + \beta_2 \Delta s^v_{t-1} \right] Z_t = 0 \tag{29}
\]

where \(\pi^v_t \equiv \Delta \log P^v_t\) is the inflation rate, and \(Z_t\) is a instrument set available as of time \(t\). However, the above equations are not identified unless we assign a specific value to the parameter \(\chi = \frac{S^v_0}{[(1 - S^v_0)\mu_0^v + S^v_0]}\). I use the materials share of 60 percent as the value for \(S^m_0\) (or \(S^v_0 = 0.4\)). The average markup of gross price during the estimation period is about 11 percent over marginal cost (i.e., \(\mu^*_0 = 1.107\)), implying the value-added markup of about 32 percent \((\mu^*_{0v} = 1.319)\), which are in a plausible range for these parameters. Thus \(\chi\) is set to 0.336. This inflation model is tested by directly estimating the structural parameters \((\beta, \theta\) and \(\omega\).

The sample period is 1972:Q2-2005:Q3. I follow the two-step GMM procedure to obtain parameter estimates. The Newey-West estimator of 4 lags is used to estimate the covariance matrix of the GMM disturbance term (the product of forecast error and instrument vector). All data that I employ here are statistics for the non-farm business (NFB) sector. The GVA (Gross Value-Added) deflator is used as a value-added price index \((P^v_t)\), and the labor income share as the real marginal cost of value-added output.
The labor income share is calculated dividing compensation of employees by gross value-added net of all indirect taxes (≡ sum of consumption of fixed capital, compensation of employees, and operating surplus). The share of materials in gross output \( S^m_t \) is computed dividing intermediate consumption by gross output net of all indirect taxes.\(^\text{10}\) All these statistics are available from the National Account (\textit{Gross Value Added and Factor Income by Kind of Economic Activity}). In order to compute \( m^c_t = \log(\mu_t^{mc} \cdot v_t) \), it is necessary to compute data on the desired value-added markup \( \mu_t^{mc} \). The data on the desired gross markup \( \mu_t^* \) are computed first as the trend component of the actual gross markup series applying HP-filtering, and then equation (20) is used to obtain \( \mu_t^{mc} \). The instrument set includes four lags of the value-added price inflation rate, transformed real marginal cost \( \tilde{mc}^v_t \), percent changes in the share of value-added, and the output gap. The output gap is measured with an HP-filtered real GDP.

However, most data are available only on an annual basis. In order to make a meaningful interpretation on a quarterly frequency, I interpolate the annual data with the method proposed by Chow and Lin (1971). This Chow-Lin procedure estimates quarterly data for available annual time series by regression on related series. Therefore, the accuracy of this interpolation method depends on how closely the related series follow the original series both in concept and in actual movements. The data that I use as the related series are summarized in table 1. In addition, since there is no related series for the desired gross markup, quarterly data on this is obtained by interpolating the annual HP-filtered gross markup based on the method of quadratic match.\(^\text{11}\)

Estimation results are shown in tables 2 and 3. In order to compare the differences between Gali and Gertler’s model and the approach taking into account the role of materials, I present estimation results for both approaches. When estimating NKPC

\(^{10}\)More explicitly, gross output net of all indirect taxes = gross output at basic prices — other taxes on production less other subsidies on production.

\(^{11}\)The program for this method is easily available in the statistical package Eviews.
using Gali and Gertler’s model, the instrument set includes four lags of the value-added price inflation rate, real marginal cost ($mc^v_t$), and the output gap. Lagged values of percent changes in the share of value-added are included in the instrument set only for the model incorporating materials. I first present results for the whole sample period, and then divide the sample into two overlapping subsamples. One is a subsample before the currency crisis in Korea (1972:Q2-1996:Q4), and the other is a subsample for the entire low inflation period (1983:Q1-2005:Q3). Additionally, I split the first subsample into two periods, one for the high inflation period (1972:Q2-1982:Q4) and the other for the low inflation period (1983:Q1-1996:Q4), to see whether there is a change in the values of structural parameters depending on inflation status (high vs. low). An attempt to estimate NKPC for the period after the currency crisis (1999:Q1-2005:Q3) is not successful partly because the period is a very small sample (only 27 observations). The GMM estimation procedure could not obtain convergence. Thus, at this moment, I do not attempt to capture any structural changes since the currency crisis.

Estimation results in table 2 show that the slope coefficient on real marginal cost ($\kappa$) is not significant for all sample periods. Estimated $\theta$ implies an implausible degree of price stickiness. The average duration of a newly set price exceeds 10 quarters. Estimation results for equation (28) are shown in table 3. Overall, we obtain a more plausible degree of price stickiness. The average duration of a price is less than one year for any period between 1972:Q2 and 1996:Q4. However, estimated $\theta$ for the period 1983:Q1-2005:Q3 yields an implausibly long duration of a price (12.2 quarters). Thus the estimation result for the sample including the period since the currency crisis may not seem reliable. There is an improvement in the t-statistic for the slope coefficient on real marginal cost. Yet the coefficient is not statistically significant at all conventional levels. It would be interesting to note that estimated $\theta$ is smaller for 1972:Q2-1982:Q4 (0.568) than for 1983:Q1-1996:Q4 (0.731). Smaller $\theta$ is also associated with larger $\kappa$ for the former period, meaning that the Phillips curve became flatter since the early
1980s than before. Moreover, estimated $\omega$ is smaller for the latter period, reducing $\beta_2$ at the same time. Thus there is partial evidence that the magnitude of backward-looking behavior in inflation dynamics is reduced over time. In this respect, there are several differences between the two models. According to the results based on Gali and Gertler’s approach, estimated $\omega$ is larger for 1983:Q1-1996:Q4 than for 1972:Q2-1982:Q4 while estimated $\theta$ remains about the same between the two periods. As a result, the magnitude of backward-looking behavior ($\beta_2$) increases over time, which is contrary to the estimation result based on a model that incorporates materials.

In table 3, the estimate of 0.236 for $\beta_2$ for the period 1983:Q1-1996:Q4 is less than the estimate of about 0.4 in Moon, Yun and Lee (2004). This difference seems to arise from the sample period. They estimate the NKPC using sample period 1980:Q1-2003:Q2. In table 3, estimated $\beta_2$ (0.379) for the period 1983:Q1-2005:Q3 is of a similar size to 0.4, which is roughly the same period as in Moon, Yun and Lee (2004). However, these estimates are likely to be biased considering that estimated $\theta$ and the implied duration of a price are implausible for the sample including the post-crisis period.

### 3.2 Modifications to the Model

The model that incorporates materials is not fully satisfactory in that the slope coefficient on real marginal cost is not significant at all conventional levels. Considering that Korea is a highly export-driven economy, it may be necessary to distinguish pricing-setting behavior between domestic and foreign markets. This possibility of price differentiation suggests a need to focus on pricing-setting behavior in domestic markets since pricing to foreign markets is likely to be more complicated and involves the issue of exchange rate pass-through. For this purpose, I construct the GVA deflators for domestic demand and exports. Since the GVA deflator is the ratio of nominal GVA to real GVA, it is necessary to construct series for nominal and real GVA. First, the share of nominal GVA for exports in nominal GVA for the non-farm business sector is assumed to be the
same as the share of nominal exports in nominal gross output of the non-farm business sector.\footnote{12} Second, real GVA for exports is assumed to be proportional to real exports. Under these assumptions, both nominal and real GVA for exports can be constructed. Moreover, both nominal and real GVA for domestic demand can be computed by subtracting nominal and real GVA for exports from the total, respectively.\footnote{13} Panel A of figure 5 shows the inflation rate of the constructed series for both deflators. The two deflators show quite different movements. Compared to the movement of the GVA deflator for domestic demand, the GVA deflator for exports is highly volatile, which reflects the volatility of exchange rate of the Korean currency. Finally, I assume that both real marginal cost of value-added output and the share of value-added in gross output that are associated with products sold to domestic markets are not much different from those that are associated with all products produced in the non-farm business sector ($mc^v_t$ and $S^v_t$ in our notation). Considering that an individual firm is likely to produce products both for domestic and foreign markets, the discrepancies may not be significant.

With the inflation rate of the GVA deflator for domestic demand replacing the inflation rate of the non-farm business sector GVA deflator, equation (28) is estimated again. Estimation results using Gali and Gertler’s model are presented in table 4. While the slope coefficient on real marginal cost becomes significant for periods 1983:Q1-1996:Q4 and 1983:Q1-2005:Q3, estimated $\theta$ is quite large. Compared to the results in table 4, estimation results in table 5 based on a model incorporating materials present a more plausible picture about the validity of the NKPC. The slope coefficient on real marginal cost is significant for periods 1972:Q2-1996:Q4 and 1983:Q1-1996:Q4. The estimation result for 1983:Q1-2005:Q3 seems very poor in that estimated $\theta$ implies an implausible degree of price stickiness. For the other periods, estimated $\theta$ yields more

\footnote{12}Under this assumption, nominal GVA for exports = nominal GVA for NFB sector x (nominal exports/nominal gross output for NFB sector).

\footnote{13}Nominal GVA for domestic demand = nominal GVA for NFB sector - nominal GVA for exports;
Real GVA for domestic demand = real GVA for NFB sector - real GVA for exports.
realistic degree of price stickiness with the average duration of a price ranging from 1.9 quarters to 2.9 quarters. At least, the results in this table suggest that there is stronger evidence in favor of the NKPC since the early 1980s. Moreover, the results show a similar pattern to the one observed in table 3. Comparing two subsamples, 1972:Q2-1982:Q4 and 1983:Q1-1996:Q4, estimated \( \theta \) is larger, and estimated \( \omega \) is smaller for the latter period. Larger \( \theta \) implies a flatter Phillips curve (smaller \( \kappa \)) for the latter period. However, according to the results in table 4 based on Gali and Gertler’s model, the Phillips curve becomes steeper for the latter period (estimated \( \kappa: 0.007 \rightarrow 0.048 \)), which is contrary to the results in tables 3 and 5. Smaller \( \omega \) for the latter period in table 5 implies that backward-looking behavior of inflation dynamics is reduced over time. Especially for the period 1983:Q1-1996:Q4, the backward-looking behavior is almost negligible. An interesting point to note is that Gali and Gertler’s model tends to give more forward-looking results than this paper’s approach regardless of the choice between the two deflators. It may be that the higher estimates for \( \beta_1 \) from Gali and Gertler’s model are biased due to misspecification. The estimates for \( \beta_1 \) in tables 2 and 4 tend to be higher than the ones in tables 3 and 5. Overall, although Gali and Gertler’s model explains U.S. inflation fairly well, a model that incorporates materials as a factor of production seems to be better in the open economy context.

Another modification to the model is to estimate an inflation equation for consumer price index (CPI). The monetary authority would be more interested in explaining the dynamics of CPI inflation since its target inflation is set based on the CPI measure in Korea. Since prices in CPI basket embed materials cost, CPI is similar to gross output price of the sector that produces consumer goods and services. However, CPI includes agricultural products, imports and house rent. The prices of agricultural products are more likely to be determined in competitive markets. The prices of imports are not related to domestic producers’ price-setting behavior. The movement of house rent is quite complicated to explain. The price-setting behavior of an individual
firm underlying the NKPC is not appropriate to explaining inflation dynamics of these products. Furthermore, since we do not have data on the cost structure of the sector that produces consumer goods and services, we need a stronger assumption that CPI sector has the same cost structure as the whole economy. Keeping in mind the weakness of this approach, I estimate the following NKPC for gross price (equation 27) using GMM to see how well the NKPC explains the dynamics of CPI inflation.

\[
\pi_t = \beta_1 E_t \pi_{t+1} + \beta_2 \pi_{t-1} + \kappa \tilde{mc}_t \\
= \beta_1 E_t \pi_{t+1} + \beta_2 \pi_{t-1} + \kappa \tilde{mc}_t^v
\]  

(30)

The sample period is the same as above. The instrument set includes four lags of CPI inflation, transformed real marginal cost (\(\tilde{mc}_t^v\)) used to estimate (28), and the output gap. Estimation results are reported in table 6. One salient feature of the results is that the magnitude of backward-looking behavior (\(\beta_2\)) is larger than that of NKPC based on the GVA deflators. Comparing two subsamples, 1972:Q2-1982:Q4 and 1983:Q1-1996:Q4, once again we find that the Phillips curve became more forward-looking (larger \(\beta_1\)) and flatter (smaller \(\kappa\)) over time. However, the slope coefficient on real marginal cost is not significant at all conventional levels. As is mentioned previously, CPI includes agricultural products, imports and house rent, the price movement of which is hard to be explained by the new Keynesian price-setting. Moreover, we employed a stronger assumption that the cost structure of the CPI sector is the same as that of the whole economy. It seems that these limitations have contributed to the insignificance of the slope coefficient on real marginal cost.

Reasons for the greater role played by backward-looking behavior in explaining CPI inflation than in explaining GVA deflator inflation can be found by examining the time series properties of CPI inflation. Although GVA deflator inflation and CPI inflation are not much different based on a visual inspection in panel B of figure 5, their time
series properties are quite different. In figure 6, autocorrelation coefficients of GVA deflator inflation and CPI inflation are shown for the period 1983:Q1-1996:Q4. While persistence in GVA deflator inflation is low, CPI inflation is highly persistent. Some clues for explaining higher persistence in CPI inflation can be found by looking at CPI components. In figure 7, autocorrelation coefficients of the inflation rates of CPI components by special groups are shown for the period 1983:Q1-1996:Q4. Unlike the inflation rate of manufactured products and public services, those of house rent and personal services are highly persistent. Pricing of house rent is quite different from the price-setting behavior of domestic producers who have market power. Absent any theories on the determination of house rent, it is uncertain what causes inertia in the movement of house rent. Relative to producers in the manufacturing sector, producers in personal services lack business accounting. For example, self-employed businesses such as small restaurants and retail stores seem to be the source of rule-of-thumb behavior. Since the share of house rent and personal services is greater in CPI basket than in GVA deflator basket, past dependence of inflation dynamics is stronger in CPI inflation. However, for the economy as a whole that is reflected in GVA deflator inflation, the role of backward-looking behavior becomes less important.

3.3 Comparison of Fit

To see whether a model incorporating materials is better in explaining inflation dynamics than Gali and Gertler’s model, I compare how closely those models fit actual inflation. One way is to compute theoretical inflation that expresses the NKPC in terms of the discounted sum of current and expected future real marginal cost, and then to compare correlation between actual and theoretical inflation, and standard deviations of actual and theoretical inflation as is done in the literature (Kurmann, 2005; Sbordone, 2005). Another simple way to do this is to compare correlation between actual and fitted inflation, and standard deviations of actual and fitted inflation. First,
I regress future inflation (inflation at time $t+1$) on the instrumental variables used in GMM estimation, and take the fitted value as expected future inflation. Second, I use estimates for $\beta_1$, $\beta_2$ and $\kappa$ for the period 1972:Q2-1996:Q4 to compute fitted values for current inflation.\footnote{Estimation results for Gali and Gertler’s hybrid NKPC using CPI are not reported in tables. The estimation result for the period 1972:Q2-1996:Q4 is:}

$$\pi_t = 0.488E_t \pi_{t+1} + 0.468 \pi_{t-1} - 0.0003 m_{c_t}$$

(0.077) (0.060) (0.008)

Figures 8 to 10 show actual and fitted inflation series for the non-farm business GVA deflator, the non-farm business GVA deflator with exports excluded and CPI, respectively. In the figures, column A is for the period 1972:Q2-1982:Q4, and column B is for the period 1983:Q1-1996:Q4 while the upper panels show the fit of the NKPC with materials and the lower panels are related to the fit of Gali and Gertler’s model. As is apparent from figures 8 and 9, an inflation model incorporating materials tracks actual inflation more closely than Gali and Gertler’s model regardless of the period. However, figure 10 shows that there is not much difference between the two models. It seems that this partially reflects the fact that real marginal cost is not significant enough in the estimated NKPC based on CPI. A quantitative analysis is reported in table 7 that shows correlation coefficients and standard deviations of actual and fitted inflation. Here again, inflation series predicted by a model incorporating materials is more closely related to actual inflation in terms of correlation and volatility (standard deviation) regardless of the sample period.

4 Conclusions

To examine inflation dynamics in the Korean economy that is characterized by its high dependence on foreign materials as intermediate inputs, this paper offers a new approach based on the distinction between gross and value-added prices. In this paper’s
interpretation, a standard new Keynesian Phillips curve describes the inflation behavior of gross price. Therefore, a measure of real marginal cost should incorporate intermediate input costs as well as primary input costs. Starting from this NKPC for gross price, new testable equations for value-added price inflation are developed.

Test results show that the NKPC can be supported for the period since the early 1980s although there is no strong evidence for the NKPC before the early 1980s. Moreover, the paper points out that incorporating materials in the model raises the degree of real rigidities, which is in line with Dotsey and King (2005). Thus more realistic estimates for the structural parameter can be obtained that governs the average duration of a newly set price. The contributions of this paper are the following. The paper generalizes the NKPC in an open economy and explains how a change in market structure and movements of relative import price affect inflation dynamics in the economy. Judging from the estimation results based on this generalized NKPC, forward-looking behavior in individual firms’ price-setting is quite dominant for the economy as a whole.

One of the related issues is how to reconcile a significant role played by past inflation in explaining CPI inflation. An intuitive answer to this question might be the importance of personal services in explaining the dynamics of CPI inflation. The agents in this sector are more likely to behave in a rule-of-thumb fashion, suggesting a possible source of inertia in inflation dynamics.

Another issue is whether there are structural changes in parameters associated with the Phillips curve. According to the estimation results, there is partial evidence that shows a behavioral difference in price-setting between during the high inflation period and during the low inflation period. During the high inflation period, individual firms tend to adjust their prices more frequently, which supports state-dependent pricing models as in Dotsey, King and Wolman (1999). Due to this change, the Phillips curve became flatter since the early 1980s than before. However, considering large uncertainty surrounding the parameter estimates, further research is necessary to address these
Finally, one reason for the poor fit of the NKPC for the sample including the post-crisis period is that there may have been noticeable changes in the way that individual firms utilize the factors of production since the currency crisis. For example, labor adjustment cost may have been reduced due to the enhanced flexibility of labor markets. As a result, the labor income share may not be a good measure of real marginal cost. Further research should be laid down to investigate a more appropriate measure of real marginal cost in the Korean business cycles.
References


Table 1
Related Series for Interpolation by Chow-Lin Procedure (Non-Farm Business Sector)

<table>
<thead>
<tr>
<th>Available annual data</th>
<th>Related quarterly data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_t^nY_t$</td>
<td>Sum of consumption of fixed capital, compensation of employees, and operating surplus</td>
</tr>
<tr>
<td></td>
<td>Gross value-added (GVA) at basic prices</td>
</tr>
<tr>
<td>$W_tL_t$</td>
<td>Compensation of employees</td>
</tr>
<tr>
<td></td>
<td>Average wage per regular employee $\times$ regular employees</td>
</tr>
<tr>
<td>$S_{it}^{m}$</td>
<td>Intermediate consumption</td>
</tr>
<tr>
<td></td>
<td>Relative price index of materials divided by (gross output at basic prices $=$ materials price index/GVA deflator $-$ other net taxes on production)</td>
</tr>
</tbody>
</table>

Note: Materials price index is the index for raw materials and intermediate materials in the stage of processing indexes compiled under the producer price index program of the Bank of Korea. However, the series only starts from 1980. I extended this series back to 1971 by the following method. Materials price index is a weighted average of an index for domestic materials and an index for imported materials. I extended the index for domestic materials using the growth rates of producer price index for commodities, and the index for imported materials using the growth rates of import price index for materials. I then constructed a weighted average of the two indexes applying year 2000 weights published by the Bank of Korea.
Table 2
Estimation of Hybrid NKPC by Gali-Gertler’s Model (Value-Added Price)

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\kappa$</th>
<th>$\beta$</th>
<th>$\theta$</th>
<th>$\omega$</th>
<th>$J$-stat.</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Sample</td>
<td>0.902**</td>
<td>0.100</td>
<td>0.001</td>
<td>1.003**</td>
<td>0.950**</td>
<td>0.105</td>
<td>3.351</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>(0.160)</td>
<td>(0.141)</td>
<td>(0.013)</td>
<td>(0.046)</td>
<td>(0.163)</td>
<td>(0.166)</td>
<td>[0.948]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1996:Q4</td>
<td>0.967**</td>
<td>0.048</td>
<td>0.007</td>
<td>1.016**</td>
<td>0.903**</td>
<td>0.045</td>
<td>3.367</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>(0.218)</td>
<td>(0.197)</td>
<td>(0.014)</td>
<td>(0.041)</td>
<td>(0.075)</td>
<td>(0.196)</td>
<td>[0.947]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1982:Q4</td>
<td>0.900**</td>
<td>0.109</td>
<td>0.005</td>
<td>1.012**</td>
<td>0.913**</td>
<td>0.112</td>
<td>3.504</td>
<td>11.5</td>
</tr>
<tr>
<td></td>
<td>(0.222)</td>
<td>(0.205)</td>
<td>(0.040)</td>
<td>(0.086)</td>
<td>(0.314)</td>
<td>(0.230)</td>
<td>[0.940]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-1996:Q4</td>
<td>0.776**</td>
<td>0.208†</td>
<td>0.008</td>
<td>0.976**</td>
<td>0.901**</td>
<td>0.236</td>
<td>7.941</td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td>(0.124)</td>
<td>(0.123)</td>
<td>(0.009)</td>
<td>(0.071)</td>
<td>(0.049)</td>
<td>(0.176)</td>
<td>[0.540]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-2005:Q3</td>
<td>0.554**</td>
<td>0.408**</td>
<td>0.006</td>
<td>0.864**</td>
<td>0.900**</td>
<td>0.573**</td>
<td>10.140</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
<td>(0.075)</td>
<td>(0.013)</td>
<td>(0.177)</td>
<td>(0.096)</td>
<td>(0.139)</td>
<td>[0.339]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in ( ) and [ ] are standard errors and p-values, respectively. **, * and † denote significance levels of 1%, 5% and 10%, respectively. $D = 1/(1 - \theta)$ is the duration of a price (quarters) implied by estimated $\theta$. 
Table 3
Estimation of Hybrid NKPC (Value-Added Price)

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\kappa$</th>
<th>$\beta$</th>
<th>$\theta$</th>
<th>$\omega$</th>
<th>$J$-stat.</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Sample</td>
<td>0.722**</td>
<td>0.265**</td>
<td>0.031</td>
<td>0.977**</td>
<td>0.790**</td>
<td>0.284*</td>
<td>7.093</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>(0.084)</td>
<td>(0.078)</td>
<td>(0.075)</td>
<td>(0.044)</td>
<td>(0.223)</td>
<td>(0.118)</td>
<td>[0.897]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1996:Q4</td>
<td>0.688**</td>
<td>0.298**</td>
<td>0.092</td>
<td>0.973**</td>
<td>0.662**</td>
<td>0.279**</td>
<td>6.638</td>
<td>3.0</td>
</tr>
<tr>
<td></td>
<td>(0.077)</td>
<td>(0.072)</td>
<td>(0.079)</td>
<td>(0.043)</td>
<td>(0.120)</td>
<td>(0.085)</td>
<td>[0.919]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1982:Q4</td>
<td>0.603**</td>
<td>0.378**</td>
<td>0.143</td>
<td>0.956**</td>
<td>0.568**</td>
<td>0.341**</td>
<td>6.186</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>(0.069)</td>
<td>(0.061)</td>
<td>(0.163)</td>
<td>(0.061)</td>
<td>(0.176)</td>
<td>(0.095)</td>
<td>[0.939]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-1996:Q4</td>
<td>0.745**</td>
<td>0.236**</td>
<td>0.063</td>
<td>0.968**</td>
<td>0.731**</td>
<td>0.224*</td>
<td>8.436</td>
<td>3.7</td>
</tr>
<tr>
<td></td>
<td>(0.081)</td>
<td>(0.082)</td>
<td>(0.047)</td>
<td>(0.048)</td>
<td>(0.082)</td>
<td>(0.107)</td>
<td>[0.814]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-2005:Q3</td>
<td>0.597**</td>
<td>0.379**</td>
<td>0.004</td>
<td>0.923**</td>
<td>0.918</td>
<td>0.537</td>
<td>9.894</td>
<td>12.2</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.086)</td>
<td>(0.059)</td>
<td>(0.120)</td>
<td>(0.724)</td>
<td>(0.471)</td>
<td>[0.702]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in ( ) and [ ] are standard errors and p-values, respectively. **, * and † denote significance levels of 1%, 5% and 10%, respectively. $D = 1/(1 - \theta)$ is the duration of a price (quarters) implied by estimated $\theta$. 
Table 4
Estimation of Hybrid NKPC by Gali-Gertler’s Model (Value-Added Price, Exports Excluded)

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\kappa$</th>
<th>$\beta$</th>
<th>$\theta$</th>
<th>$\omega$</th>
<th>$J$-stat.</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Sample</td>
<td>0.914**</td>
<td>0.083</td>
<td>0.014</td>
<td>0.997**</td>
<td>0.879**</td>
<td>0.080</td>
<td>6.284</td>
<td>8.3</td>
</tr>
<tr>
<td></td>
<td>(0.209)</td>
<td>(0.181)</td>
<td>(0.018)</td>
<td>(0.052)</td>
<td>(0.072)</td>
<td>(0.190)</td>
<td>[0.711]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1996:Q4</td>
<td>1.065**</td>
<td>-0.031</td>
<td>0.018</td>
<td>1.032**</td>
<td>0.863**</td>
<td>-0.025</td>
<td>4.182</td>
<td>7.3</td>
</tr>
<tr>
<td></td>
<td>(0.227)</td>
<td>(0.203)</td>
<td>(0.019)</td>
<td>(0.037)</td>
<td>(0.064)</td>
<td>(0.165)</td>
<td>[0.898]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1982:Q4</td>
<td>0.827**</td>
<td>0.173</td>
<td>0.007</td>
<td>1.002**</td>
<td>0.896**</td>
<td>0.188</td>
<td>4.846</td>
<td>9.6</td>
</tr>
<tr>
<td></td>
<td>(0.208)</td>
<td>(0.182)</td>
<td>(0.042)</td>
<td>(0.092)</td>
<td>(0.290)</td>
<td>(0.240)</td>
<td>[0.847]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-1996:Q4</td>
<td>0.946**</td>
<td>-0.090</td>
<td>0.048*</td>
<td>0.875**</td>
<td>0.856**</td>
<td>-0.071</td>
<td>7.318</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>(0.157)</td>
<td>(0.163)</td>
<td>(0.022)</td>
<td>(0.067)</td>
<td>(0.029)</td>
<td>(0.120)</td>
<td>[0.604]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-2005:Q3</td>
<td>0.707**</td>
<td>0.133†</td>
<td>0.042†</td>
<td>0.794**</td>
<td>0.855**</td>
<td>0.127</td>
<td>7.758</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>(0.115)</td>
<td>(0.078)</td>
<td>(0.022)</td>
<td>(0.107)</td>
<td>(0.036)</td>
<td>(0.085)</td>
<td>[0.558]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in ( ) and [ ] are standard errors and p-values, respectively. **, * and † denote significance levels of 1%, 5% and 10%, respectively. $D = 1/(1 - \theta)$ is the duration of a price (quarters) implied by estimated $\theta$. 
Table 5

Estimation of Hybrid NKPC (Value-Added Price, Exports Excluded)

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\kappa$</th>
<th>$\beta$</th>
<th>$\theta$</th>
<th>$\omega$</th>
<th>$J$-stat.</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Sample</td>
<td>0.746**</td>
<td>0.232*</td>
<td>0.154</td>
<td>0.965**</td>
<td>0.620**</td>
<td>0.187*</td>
<td>10.890</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>(0.108)</td>
<td>(0.094)</td>
<td>(0.103)</td>
<td>(0.050)</td>
<td>(0.098)</td>
<td>(0.094)</td>
<td>[0.620]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1996:Q4</td>
<td>0.733**</td>
<td>0.250**</td>
<td>0.220†</td>
<td>0.973**</td>
<td>0.559**</td>
<td>0.185*</td>
<td>8.899</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
<td>(0.091)</td>
<td>(0.115)</td>
<td>(0.048)</td>
<td>(0.086)</td>
<td>(0.080)</td>
<td>[0.780]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1982:Q4</td>
<td>0.568**</td>
<td>0.402**</td>
<td>0.245</td>
<td>0.928**</td>
<td>0.484**</td>
<td>0.318**</td>
<td>6.705</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>(0.089)</td>
<td>(0.077)</td>
<td>(0.194)</td>
<td>(0.070)</td>
<td>(0.137)</td>
<td>(0.074)</td>
<td>[0.917]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-1996:Q4</td>
<td>0.890**</td>
<td>0.082</td>
<td>0.167†</td>
<td>0.967**</td>
<td>0.655**</td>
<td>0.058</td>
<td>9.318</td>
<td>2.9</td>
</tr>
<tr>
<td></td>
<td>(0.128)</td>
<td>(0.125)</td>
<td>(0.099)</td>
<td>(0.061)</td>
<td>(0.089)</td>
<td>(0.094)</td>
<td>[0.749]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-2005:Q3</td>
<td>0.597**</td>
<td>0.329**</td>
<td>0.017</td>
<td>0.829**</td>
<td>0.876†</td>
<td>0.400*</td>
<td>10.002</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>(0.072)</td>
<td>(0.052)</td>
<td>(0.100)</td>
<td>(0.120)</td>
<td>(0.484)</td>
<td>(0.194)</td>
<td>[0.694]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in ( ) and [ ] are standard errors and p-values, respectively. **, *, and † denote significance levels of 1%, 5% and 10%, respectively. $D = 1/(1 - \theta)$ is the duration of a price (quarters) implied by estimated $\theta$. 
Table 6
Estimation of Hybrid NKPC (CPI)

<table>
<thead>
<tr>
<th></th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>$\kappa$</th>
<th>$\beta$</th>
<th>$\theta$</th>
<th>$\omega$</th>
<th>J-stat.</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Sample</td>
<td>0.541**</td>
<td>0.422**</td>
<td>0.004</td>
<td>0.850**</td>
<td>0.924</td>
<td>0.613</td>
<td>7.301</td>
<td>13.2</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.065)</td>
<td>(0.062)</td>
<td>(0.196)</td>
<td>(0.784)</td>
<td>(0.433)</td>
<td>[0.605]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1996:Q4</td>
<td>0.478**</td>
<td>0.481**</td>
<td>0.012</td>
<td>0.796**</td>
<td>0.835</td>
<td>0.670†</td>
<td>5.916</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.059)</td>
<td>(0.080)</td>
<td>(0.251)</td>
<td>(0.608)</td>
<td>(0.374)</td>
<td>[0.748]</td>
<td></td>
</tr>
<tr>
<td>1972:Q2-1982:Q4</td>
<td>0.481**</td>
<td>0.481**</td>
<td>0.075</td>
<td>0.861**</td>
<td>0.617†</td>
<td>0.532†</td>
<td>5.642</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>(0.070)</td>
<td>(0.058)</td>
<td>(0.177)</td>
<td>(0.159)</td>
<td>(0.325)</td>
<td>(0.279)</td>
<td>[0.775]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-1996:Q4</td>
<td>0.635**</td>
<td>0.339*</td>
<td>0.035</td>
<td>0.940**</td>
<td>0.767**</td>
<td>0.385</td>
<td>7.152</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>(0.160)</td>
<td>(0.158)</td>
<td>(0.042)</td>
<td>(0.073)</td>
<td>(0.100)</td>
<td>(0.272)</td>
<td>[0.621]</td>
<td></td>
</tr>
<tr>
<td>1983:Q1-2005:Q3</td>
<td>0.770**</td>
<td>0.213*</td>
<td>0.017</td>
<td>0.973**</td>
<td>0.855**</td>
<td>0.230*</td>
<td>7.616</td>
<td>6.9</td>
</tr>
<tr>
<td></td>
<td>(0.093)</td>
<td>(0.083)</td>
<td>(0.047)</td>
<td>(0.049)</td>
<td>(0.191)</td>
<td>(0.113)</td>
<td>[0.573]</td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in ( ) and [ ] are standard errors and p-values, respectively. **, *, and † denote significance levels of 1%, 5% and 10%, respectively. $D = 1/(1 - \theta)$ is the duration of a price (quarters) implied by estimated $\theta$. 

39
Table 7
Comparison of Fit of Alternative Models

<table>
<thead>
<tr>
<th>A. $\pi_t = \text{inflation rate of NFB GVA deflator}$</th>
<th>1972:Q2~1982:Q4</th>
<th>1983:Q1~1996:Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho(\pi_t, \pi_t^m)$</td>
<td>0.311</td>
<td>0.488</td>
</tr>
<tr>
<td>$\rho(\pi_t, \pi_t^{gg})$</td>
<td>0.255</td>
<td>0.259</td>
</tr>
<tr>
<td>$\sigma(\pi_t)$</td>
<td>0.024</td>
<td>0.008</td>
</tr>
<tr>
<td>$\sigma(\pi_t^m)$</td>
<td>0.019</td>
<td>0.007</td>
</tr>
<tr>
<td>$\sigma(\pi_t^{gg})$</td>
<td>0.014</td>
<td>0.006</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. $\pi_t = \text{inflation rate of NFB GVA deflator (exports excluded)}$</th>
<th>1972:Q2~1982:Q4</th>
<th>1983:Q1~1996:Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho(\pi_t, \pi_t^m)$</td>
<td>0.321</td>
<td>0.233</td>
</tr>
<tr>
<td>$\rho(\pi_t, \pi_t^{gg})$</td>
<td>0.254</td>
<td>0.169</td>
</tr>
<tr>
<td>$\sigma(\pi_t)$</td>
<td>0.026</td>
<td>0.011</td>
</tr>
<tr>
<td>$\sigma(\pi_t^m)$</td>
<td>0.020</td>
<td>0.010</td>
</tr>
<tr>
<td>$\sigma(\pi_t^{gg})$</td>
<td>0.014</td>
<td>0.007</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. $\pi_t = \text{inflation rate of CPI}$</th>
<th>1972:Q2~1982:Q4</th>
<th>1983:Q1~1996:Q4</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho(\pi_t, \pi_t^m)$</td>
<td>0.577</td>
<td>0.529</td>
</tr>
<tr>
<td>$\rho(\pi_t, \pi_t^{gg})$</td>
<td>0.577</td>
<td>0.474</td>
</tr>
<tr>
<td>$\sigma(\pi_t)$</td>
<td>0.024</td>
<td>0.007</td>
</tr>
<tr>
<td>$\sigma(\pi_t^m)$</td>
<td>0.019</td>
<td>0.006</td>
</tr>
<tr>
<td>$\sigma(\pi_t^{gg})$</td>
<td>0.018</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Note: $\rho(\cdot)$ is a correlation coefficient between two variables, and $\sigma(\cdot)$ is the standard deviation of each variable. $\pi_t$, $\pi_t^m$ and $\pi_t^{gg}$ are the actual inflation rate, the inflation rate predicted by a model incorporating materials and the inflation rate predicted by Gali-Gertler’s model, respectively.
Figure 1
Trend of Relative Price of Materials and Share of Intermediate Inputs in
Gross Output (Non-Farm Business Sector)


B. Share of intermediate inputs (1970~2005)

Note: The relative price of materials is computed by dividing the price index of
materials by GVA deflator in non-farm business sector (2000=1). The share of
intermediate inputs is from the National Account.
Figure 2
Trend of Real Marginal Cost of Gross Output and Gross Markup
(Non-Farm Business Sector)

A. Real marginal cost (1970~2005)

Figure 3
Trend of Desired Value-Added Markup (Non-Farm Business Sector)

Note: Shaded areas denote oil shock periods.
Figure 4
Trend of Real Marginal Cost of Value-Added Output (Non-Farm Business Sector)


B. Korea (1970~2005)

Note: The labor income share is used as a proxy for real marginal cost. U.S. data: index (1992=100) in log scale. Korean data: labor income share in log scale
Figure 5

A. GVA deflator inflation

B. CPI inflation
Figure 6


A. NFB GVA deflator inflation

B. NFB GVA deflator inflation (exports excluded)

C. CPI inflation
Figure 7

A. Manufactured products

B. House rent

C. Public services

D. Personal services
Figure 8
Comparison of Fit (NFB GVA deflator)

A. 1972:Q2~1982:Q4

B. 1983:Q1~1996:Q4
Figure 9
Comparison of Fit (NFB GVA deflator, Exports Excluded)

A. 1972:Q2~1982:Q4
B. 1983:Q1~1996:Q4
Figure 10
Comparison of Fit (CPI)

A. 1972:Q2~1982:Q4

B. 1983:Q1~1996:Q4