New Approach to Estimation
of
the Core Inflation

by

Jong Won Lee*

Sang Don Lee**

Ki-Ho Kim***

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* Professor of Economics, Sungkyunkwan University, 3-53, Myoungryun-dong, Chongno-ku, Seoul, Korea, Tel: +82-2-760-0427, Fax: +82-2-763-4941, E-mail: jwlee@yurim.skku.ac.kr

** Associate Research Fellow, Korea Research Institute for Vocational Education & Training, 15-1, Chongdam-dong, Kangnam-ku, Seoul, Korea, Tel: +82-2-3485-5025, Fax: +82-2-3485-5059, E-mail: sdlee@krivet.re.kr

*** Visiting scholar, Indiana University, Bloomington, IN, E-mail: cometdad98@yahoo.co.kr

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ABSTRACT

Recently, the Inflation Targeting System(ITS) has emerged as a major monetary policy scheme in countries like England, Canada, and Australia. Such transition toward the ITS was mainly initiated by the desire to achieve economic stability by using more extensive information variables than a simple traditional money supply variable. The success of the ITS is believed to depend on which variables are utilized as tools, and as the target variable. Variables like monetary aggregates, interest rate, exchange rate and so forth have been extensively used as an information variable, while the so-called core inflation has been utilized as a target variable.

The key issue of the ITS thus comes down to how to define and estimate the core inflation, the target variable. So far, the core inflation has been derived as a quasi-trend after arbitrarily truncating extreme fluctuations. This process obviously causes a serious loss of information. In addition, correlation between the headline inflation and the core inflation becomes rather low. Consequently, even though the monetary authority tries to stabilize the headline inflation by controlling a target variable, i.e., core inflation, leverage will be weakened due to low correlation between the two inflation rates.

The main objective of this study is to derive an alternative core inflation indicator which has a strong correlation to the headline CPI. By doing so, we hope to find a more reliable target variable(a new core inflation) to stabilize the headline inflation. To this end, this paper will derive an unobserved but estimatable core inflation indicator which is cointegrated with the headline CPI. In addition, this study will perform policy simulations to prove that the new inflation variable has an edge over the old one in predicting future headline inflation rates. Further, in order to prove the usefulness of the new inflation variable, this paper will provide empirical evidence that it has a stronger correlation with the headline inflation than the old one has.

I. Introduction

In 1998 Korea changed the framework of its monetary policy to the Inflation Targeting System(ITS). Following the adoption of the ITS, inflation pressure in Korea has been alleviated, although this fact does not necessarily imply that ITS has worked successfully in Korea. Controversies over the success of ITS in Korea are ongoing. Exact evaluations on the performance of ITS in Korea requires further study.

The Inflation Targeting System can be briefly summarized as a system of operating monetary policy in which the central bank sets up an inflation target within a pre-designed time horizon and makes use of the available policy instruments. In ITS, headline CPI or core inflation is used as a target variable. However, headline CPI is not appropriate to ITS because headline CPI includes noises such as seasonal factors, change of relative price, etc. In fact, many ITS countries adopted core inflation as the target variable. Headline inflation had been used in Korea as the target. Since 2000, however, the target variable has been changed to core inflation.

It is necessary to note that the core inflation concept cannot be clearly defined by nature and, further more, as of yet, there is no consensus among people on the definition of core inflation. Several estimation techniques for core inflation are suggested notwithstanding. The most commonly used methods are the method of exclusion, which excludes some items from the basket of CPI. However, this method may suffer information loss due to the exclusion of some informative items, and there is little theoretical rationale for such exclusion. On the other hand, the so-called 'model approach' such as SVAR, P^*, IIP(independent inflation rate) model has more theoretical rationales than the exclusion method and utilizes diverse information.

The primary reason why diverse rationales and estimation methods have been sought for or suggested for core inflation is that core inflation is an inherently unobserved variable. Consequently, estimating job of core inflation comes down to how to find unobserved components.

Some time-series-based conditions which core inflation should have were suggested by Marques(2002). The conditions are in fact based on the assumption that the inflation variable is I(1) variable. Marques stated 1) if inflation is I(1)[1], then core inflation should

[1]) In case of Korea, headline CPI inflation rate is I(0) variable, that is, CPI is I(1) variable.

be cointegrated with inflation; 2) there should be an error correction mechanism; and 3) core inflation is strongly exogenous to the parameters of the error correction equation. The first condition implies that discrepancy between inflation and core inflation reflects temporary disturbance, which is caused by weather, demand and supply of goods, etc. The second condition may be interpreted in such a way that in the long-run, inflation should converge to core inflation. The third condition will be necessary for the path of core inflation not to be influenced by past inflation.

Notice that the above mentioned conditions are applicable to I(1) variables. The inflation variable in Korea, however, has turned out to be a I(0) variable. The Marques conditions can no longer be directly applicable to the Korean inflation variable. Instead we may apply the above conditions to CPI(level variable) which is I(1) variable. That is, it is desirable for the core inflation indicator to have common trend with headline CPI(level variable), and have a cointegrated relationship with headline CPI.

In this study, we will propose a new estimation technique for the core inflation indicator, which has a cointegrated relationship with headline CPI. To this end we suggest state space model to estimate unobserved component core inflation indicator, which is cointegrated with headline CPI.

In section II, we will briefly survey definitions and estimation techniques of core inflation. We will suggest an alternative estimation method of core inflation in section III. The empirical support for our estimation model will be sought for in section IV, and major findings, evidences and concluding remarks will be summarized in section V.

II. Definitions and Estimation Techniques of Core Inflation

1. Definitions of Core Inflation

Diverse definitions of core inflation have been suggested. The most meaningful ones are as follows. The first one that deserves attention is the one made by Okun(1970) and Flemming(1976). According to their definition, observed inflation(π_t) can be decomposed into two components. One(π_t^{co}) represents general price change, and the other(ε_t) represents relative price change reflecting supply side shocks. Core inflation can thus be defined as

$$\pi_t = \pi_t^{co} + \varepsilon \text{ or } \pi_t^{co} = \pi_t - \varepsilon \qquad (1)$$

Since π_t^{co} is understood to be related with monetary expansion, core inflation can be thought of as the general price change which is reflected by monetary policy.

On the other hand, Eckstein(1981), and Quah and Vahey(1995) defined core inflation as a persistent component of headline inflation. Eckstein(1981), for example, defined core inflation as a trend of production factor cost, and understood that core inflation would reflect long run inflation expectations in the private sector, while Quah and Vahey(1995) defined core inflation as an inflation which does not affect production in the long run. In other words, their definitions of core inflation focus on cyclical movements in inflation which are related to excess demand. This line of definition for the core inflation can be represented as follows.

$$\pi_t = \pi_t^{co} + \eta \qquad (2)$$

$$\pi_t^{co} = \pi_t^{Long-run} + h(z_{t-1}) \qquad (2)'$$

where, $\pi_t^{Long-run}$ is the long run inflation rate, z_{t-1} is the cyclical movement at time $t-1$, and η_t is the temporary inflation.

The core inflation concept of our estimation model will be based on the first definition because we focus on the long run behavior of inflation, which is reflected by monetary policy. That is, we will estimate core inflation, which reflects the general price changes, so that discrepancy between inflation and core inflation will represent relative price change reflecting supply side shocks.

2. Various Core Inflation Estimation Models

Various core inflation estimation models have been suggested. They can be safely classified into two groups. One of them uses adjustment techniques like exclusion or trimming to calculate core inflation. The other uses economic models to estimate core inflation. The latter is called 'the model approach'. Models such as SVAR(Structural VAR model), IIR(Independent Inflation Rate) model and P^* model belong to this category.

a. Exclusion or Trimming Methods

These methods are the most popular and easily understandable, since they adopt easy calculation processes. In other words, they simply exclude temporary non-monetary change of prices, so that the inflation component, which reflects monetary change of prices, can be eliminated. That is, these methods exclude temporary and transitory factors from CPI index to derive the underlying trend of prices.

The first method of this kind will identify items which are highly volatile among items in the basket of the CPI, and then exclude these items from the basket. The second one suggests to exclude both the largest and smallest fluctuations. The third one suggests to rank fluctuations of items in the CPI basket, and then utilizes their weighted median as the core inflation. The first one is called 'specific adjustment or adjustment by exclusion(or replacement) method'. The second one is the 'trimmed mean method', and the last one is called the 'weighted median method'.

Despite their advantage in easiness of calculation and popularity, these methods have a defect in that they lose information included in the excluded items.

b. Model Approach

These methods use SVAR, IIR(Independent Inflation Rate), or P^* model approach.

Quah and Vahey(1995) used two variable SVAR model to estimate core inflation. Quah and Vahey used the identification condition that the long run Phillips curve is vertical, assuming that core shock eventually does not affect growth rate. Bjornland(2000), also, used three variable SVAR model. For example, he suggested SVAR model with oil price, GDP, and CPI inflation as follows.

$$\begin{pmatrix} X \\ Y \\ P \end{pmatrix} = \begin{pmatrix} c_{11}(1) & 0 & 0 \\ c_{21}(1) & c_{22}(1) & 0 \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{pmatrix} \begin{pmatrix} \varepsilon_X \\ \varepsilon_{NC} \\ \varepsilon_C \end{pmatrix} \qquad (3)$$

where, X , Y , and P represent oil price, GDP, and CPI respectively, while ε_X , ε_{NC} , and ε_C represent oil price shock, non-core shock, and core shock respectively.

The identification condition $c_{23}(1) = 0$ means core shock does not affect growth rate in the long run, and $c_{12}(1) = 0, c_{13}(1) = 0$ means that oil price is influenced only by oil price shock.

In this model, core inflation is defined as an infinite sum of core shocks, and headline inflation is an infinite sum of all structural shocks. Blix(1995), Claus(1997), and Fase and Folkertsman(1996) have suggested similar SVAR models.

On the other hand, P^* model was developed by FRB in 1989, as another major model approach to estimating core inflation. This model defines core inflation as a change of potential price level derived from the well known Fisher's equation. The potential price level, which is the long run equilibrium price level, can be calculated under the condition that production level matches potential GNP.

Fisher's equation is

$$P^* = \frac{MV^*}{Y^*} \qquad (4)$$

$$\text{or } \dot{P}^* = \dot{M} + \dot{V}^* - \dot{Y}^* \qquad (4)'$$

where, $P^*, M \ , V^*, Y^*$ represent potential price level, money, trend of velocity of money, and potential GNP.

The advantage of this model is that it has a firm theoretical basis for the core inflation concept in comparison with the exclusion methods. Hallman, Porter and Small(1989), Armour(1996), and Attah-Mensah(1996) used this model to estimate core inflation.

Further, there is the Independent Inflation Rate (IIR) model recently developed by Arrazola and Hevia(2002). The motivation of this model is to resolve problems that occur when headline inflation is affected by the change of relative price. In other words, this model estimates inflation variation independent from relative price change.

III. Estimation Model

In the previous section, brief reviews of various core inflation estimation methods revealed that core inflation is regarded as an inflation in which temporary shock is deleted. With this notion in mind, we try to develop a new core inflation estimation method, which does not exclude demand side components, thus has no information loss, but excludes supply side components.

What we intend to propose is a core inflation indicator which has a cointegrated relationship with CPI.[2] We will consider the error correction model to this end. In order to provide a theoretical rationale of our approach, let us briefly review the relationship between VAR and ECM in the first place.

1. VAR and ECM

Consider VAR (p) with a n dimensional vector.

$$X_t = \prod_1 X_{t-1} + \prod_2 X_{t-2} + \ldots + \prod_p X_{t-p} + \varepsilon_t \tag{5}$$

ECM can be derived from VAR(p) by reparameterization as follows.

$$\begin{aligned} \Delta X_t &= \prod^* X_{t-1} + \Gamma^*{}_1 \Delta X_{t-1} + \Gamma^*{}_2 \Delta X_{t-2} + \cdots + \Gamma^*{}_p X_{t-p+1} + \varepsilon_t \\ &= -\alpha\beta' X_{t-1} + \Gamma^*{}_1 \Delta X_{t-1} + \Gamma^*{}_2 \Delta X_{t-2} + \cdots + \Gamma^*{}_p X_{t-p+1} + \varepsilon_t \end{aligned} \tag{6}$$

In equation (6), matrix $\Pi^* = -\alpha\beta'$ reflects a cointegration relationship. That is, $\beta' X_{t-1}$ is the cointegration vector, while α is speed of the adjustment vector, where, α and β are $(n \times r)$ dimensional vector.

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2) If the core inflation indicator does not have a cointegrated relationship with CPI, then the core inflation indicator will eventually diverge from CPI in the long run. In that case, core inflation does not give any useful information on CPI. The government-announced official Core inflation indicator in Korea(CPI_fe) does not have a cointegrated relationship with CPI. For details, see section IV.

ECM explores short run dynamics of variables, and stationary I(0) series can be included so as to explain short run dynamics. It is well known that addition of I(0) series in the dynamic equation does not affect the statistical properties of coefficients. We may include some information variables like GDP, exchange rate, interest rate, or balance of payment into the dynamic equation. These variables will be transformed to be a I(0) variable.

2. State Space Representation of ECM

ECM in equation (6) can be transformed into a state space model. To represent the state space model, it is necessary to set up the state vector($\Delta\Xi_t$), transition equation and observation equation. Let the state vector be $\Delta\Xi_t = ((\beta' X_{t-1})', \Delta\xi'_t, \Delta\xi'_{t-1}, \cdots, \Delta\xi_{t-p+2})'$. Then the corresponding transition matrix T can be depicted as follows;

$$T = \begin{pmatrix} I_r & \beta' & 0 & \cdots & 0 & 0 \\ -\alpha & (-\alpha\beta' + \Gamma^*{}_2) & \Gamma^*{}_2 & \cdots & \Gamma^*{}_{p-2} & \Gamma^*{}_{p-1} \\ 0 & I_n & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \cdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & I_n & 0 \end{pmatrix} \tag{7}$$

where, I_r is a r dimensional identity matrix, r is a cointegration rank, and Γ_i s are $(n \times n)$ coefficient matrices.

3. Assumptions on the State Vector

Cointegration relationship between non-stationary variables implies that there exists a stationary linear relationship between non-stationary variables. Such a linear combination of non-stationary variables has properties of I(0) stationarity. Consequently, the state space model needs some assumptions on the state vector. For example, the assumption that all state variables should be a I(1) variable is needed. In our model, we are going to find a linear combination of core inflation, which is a non-stationary unobserved state variable, and headline CPI, which is a non-stationary observed variable. The condition that core inflation is a non-stationary I(1) variable is an essential assumption to the ECM model.

4. Model Specification and Data

a. Model Specification

In our model, the observed variable is headline CPI, while the unobserved state variable is core inflation. Let optimal lag length of VAR(p) be, for example, 2, and let the cointegration rank be 1. State space representation of ECM then can be depicted as follows.

To be specific, the corresponding (4×4) transition matrix to the state vector $\Delta\Xi_t = ((\beta' X_{t-1})', \Delta\xi_t')'$ becomes

$$T = \begin{pmatrix} I_r & \beta' \\ -\alpha & (-\alpha\beta' + \Gamma^{*}{}_1) \end{pmatrix} \tag{8}$$

or

$$T = \begin{pmatrix} 1 & 0 & \beta_1 & 0 \\ 0 & 1 & 0 & \beta_2 \\ -\alpha_1 & -\alpha_1 & -(\alpha_1\beta_1) + \Gamma^{11*}{}_1 & -(\alpha_1\beta_2) + \Gamma^{12*}{}_1 \\ -\alpha_2 & -\alpha_2 & -(\alpha_2\beta_1) + \Gamma^{21*}{}_1 & -(\alpha_2\beta_2) + \Gamma^{22*}{}_1 \end{pmatrix} \tag{9}$$

where, $\Delta\Xi_t = (\beta_1 C_{t-1}, \beta_2 C^{CO}{}_{t-1}, \Delta C_t, \Delta C^{CO}{}_t)$ (10)

The only observed variable is headline CPI, and the observation matrix would be

$$O = (0,0,1,0) \tag{11}$$

Finally we would include I(0) variables such as GDP growth rate, exchange rate, GDP gap, interest rate spread, etc. to explain short run dynamics. Let z_t denote such I(0) variables.

Based on the above representation, the transition equation and observation equation can be derived as follows;

Transition equation :

$$\begin{pmatrix} \beta_1 C_{t-1} \\ \beta_2 C^{CO}{}_{t-1} \\ \Delta C_t \\ \Delta C^{CO}{}_t \end{pmatrix} = \begin{pmatrix} 1 & 0 & \beta_1 & 0 \\ 0 & 1 & 0 & \beta_2 \\ -\alpha_1 & -\alpha_1 & -(\alpha_1\beta_1)+\Gamma^{11*}{}_1 & -(\alpha_1\beta_2)+\Gamma^{12*}{}_1 \\ -\alpha_2 & -\alpha_2 & -(\alpha_2\beta_1)+\Gamma^{21*}{}_1 & -(\alpha_2\beta_2)+\Gamma^{22*}{}_1 \end{pmatrix} \begin{pmatrix} \beta_1 C_{t-2} \\ \beta_2 C^{CO}{}_{t-2} \\ \Delta C_{t-1} \\ \Delta C^{CO}{}_{t-1} \end{pmatrix} + \Phi z_t + \begin{pmatrix} 0 \\ 0 \\ \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$$

Observation equation :

$$\Delta C_t = \begin{pmatrix} 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} \beta_1 C_{t-2} \\ \beta_2 C^{CO}{}_{t-2} \\ \Delta C_{t-1} \\ \Delta C^{CO}{}_{t-1} \end{pmatrix}$$

b. Data

One of the practical issues in the measurement of core inflation is to find the appropriate periodicity of the data for policy purposes. For timeliness of policy, monthly-based core inflation would be favorable. However, monthly CPI has noises due to the process of surveying and constructing a consumer price index. For example, property taxes are reported only once a year. Such low frequency yearly data does not provide timely information for the policy purposes. For this reason we used quarterly data for the estimation of core inflation.

In ITS, information variables like monetary aggregates, interest rate, exchange rate, growth rate and so forth are used to monitor inflation pressure. In this study, these information variables are used in the short-run dynamic equation of ECM.

Quarterly data, e.g., CPI, and core inflation indicator announced by the Korean government(CPI_ef), 3-year corporate bond rate, and GDP for 1982. 1Q - 2001. 4Q are used to estimate the state space model. CPI_ef is calculated by an exclusion method which excludes supply side components such as prices of agricultural, marine products, and energy.

ADF unit root test statistics for those variables are represented in Table 1. Table 1 proves that these variables are all I(1) variables.

<Table 1> ADF Unit Root Test Results

Variable / Lag	CPI	GDP	CPI_fe	Yield of Corporate Bonds
1	1.189	0.974	0.182	2.724
2	1.113	0.868	0.197	1.672
3	0.865	1.386	0.189	1.954
4	0.581	1.103	0.422	1.380
5	0.652	1.010	0.334	1.139
6	0.559	1.021	0.329	1.068

IV. Empirical Results

We considered information variables like GDP growth rate, yields of corporate bonds(3-year), GDP gap, interest rate spread(yields of corporate bonds – call rates), exchange rate(Won/Dollar), etc. GDP growth rate and yields of corporate bonds were found to be statistically most significant in the estimation model. In other words, that model turned out to be the best among all diverse combinations of models that were considered for model selection. We utilized a LR(Likelihood Ratio) test to select information variables and optimal lag length.

<Table 2> Model Selection and Likelihood Ratio

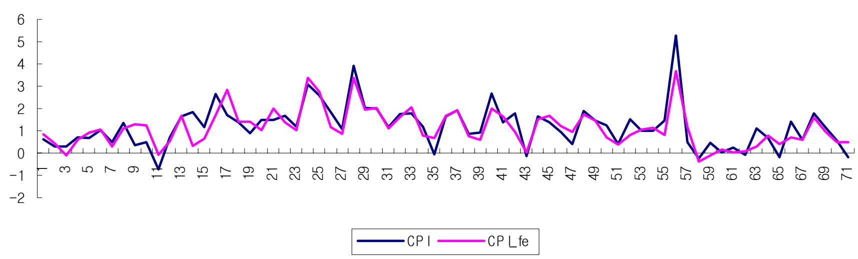
lag	Likelihood	p-value of LR Test Statistics
1	-58.463	
2	-99.004	1.00
3	-45.244	1.00
4	1.563	0.00
5	-90.435	1.00
6	-122.319	1.00

Note : H_0 : lag=j vs. lag=j-1.

The model that was finally selected includes both GDP growth rate and yield of corporate bonds, and its optimal lag turns out to be 4. Now then we need to test whether calculated core inflation is useful for monetary policy. For this purpose, we compared the derived core inflation(core inflation indicator) with government-announced official core inflation in Korea(CPI_fe).

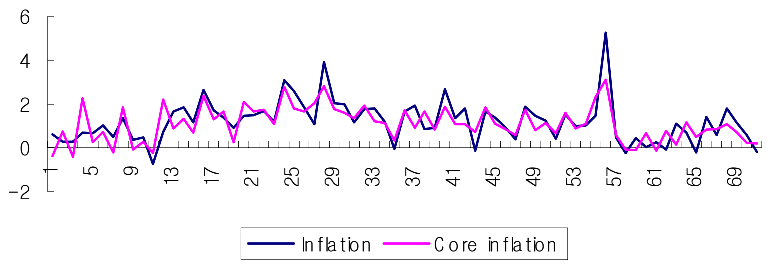
Figure 1 shows CPI inflation and CPI_fe inflation(old definition of core inflation in Korea), while Figure 2 shows CPI inflation and core inflation. First of all, we can see that core inflation is less volatile than headline CPI inflation. The superiority of our core inflation, however, can not be easily visualized by simple comparison of these two diagrams. For better detection of the superiority, we then utilized level values of these variables. Definitely, Figure 4 reveals closer correlation between headline inflation and core inflation(see Figure 3 and Figure 4).[3]

<Figure 1> CPI inflation and CPI_fe inflation

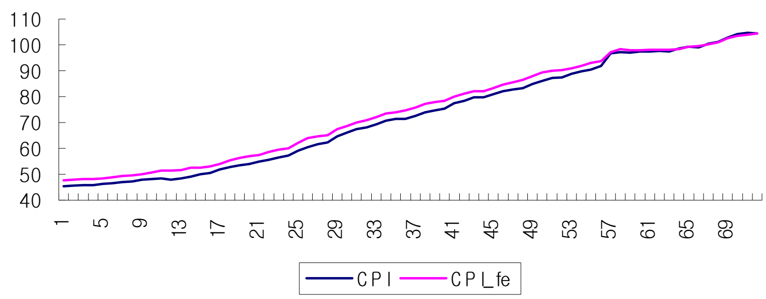


<Figure 2> CPI inflation and Core inflation

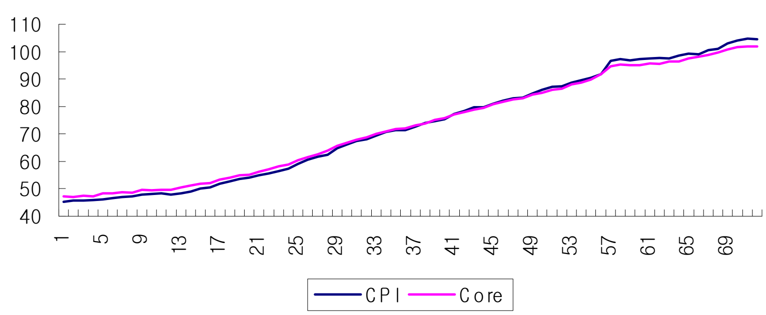
[3]) Standard deviations are compared. And the volatility of the core inflation was found to be the smallest among all. To be specific, standard deviation of the core inflation was 0.802, while those of CPI and CPI_fe were 0.964 and 0.830 respectively.



<Figure 3> CPI and CPI_fe



<Figure 4> CPI inflation and Core inflation



1. Cointegration between CPI and Core Inflation Indicator

In order to prove usefulness of the new method we need to check whether CPI and core inflation indicators have a cointegrated relationship.

We used the Engle-Granger 2-step method and Johansen's procedure to test a cointegrated relationship between CPI and core inflation. The cointegration tests between CPI and CPI_ef, and between CPI and the core inflation indicator in our model are presented in Table 3-1 and Table 3-2..

Tests show that there is no cointegration relationship between CPI and CPI_ef, while there is a strong cointegrated relationship between CPI and our core inflation indicator.

<Table 3-1> ADF Unit Root Test for Cointegration : ADF Statistic

Lag	1	2	3	4	5	6
CPI_fe	-1.499 (-128.156)	-1.453 (-119.902)	-1.559 (-112.260)	-1.760 (-105.098)	-1.331 (-98.684)	-1.266 (-90.439)
Core Indicator	-4.294* (-122.550)	-3.917* (-114.808)	-4.129* (-110.018)	-3.496* (-102.542)	-3.481* (-95.126)	-2.434 (-94.420)

Note : Numbers in parentheses denote value of SIC.

<Table 3-2> Results of Johansen Cointegration Test : λ_{trace} and $\lambda_{\max}$

Lag			1	2	3	4	5	6
CPI_fe	$r=0$	λ_{trace}	4.079	4.842	4.577	4.204	5.300	5.760
		$\lambda_{\max}$	3.598	4.045	4.424	4.109	5.284	5.554
	$r=1$	λ_{trace}	0.481	0.796	0.152	0.094	0.015	0.206
		$\lambda_{\max}$	0.481	0.796	0.152	0.094	0.015	0.206
Core Indi-cator	$r=0$	λ_{trace}	39.275	19.711	36.567	23.790	20.005	18.961
		$\lambda_{\max}$	39.274	19.693	36.441	23.596	19.928	18.633
	$r=1$	λ_{trace}	0.001	0.017	0.126	0.193	0.077	0.328
		$\lambda_{\max}$	0.001	0.017	0.126	0.193	0.077	0.328

2. Properties of Excluded Components

True core inflation is supposed to exclude all of the components that come from the supply side, so that the resulting difference between headline inflation and core inflation reflect temporary movements in inflation.

If the suggested core inflation successfully excluded supply side components, the core inflation and excluded components would be independent. Thus we need to check whether the core inflation and the excluded component are independent.

Before getting into the independence test, we need to find out whether the excluded component is an unbiased predictor of the temporary component of inflation. In order to test whether the excluded component over(under)-predicts the temporary component of the CPI inflation, we utilized a variation of the Cogley(1998) test.

Test procedure is as follows.

First, regress the following equation.

$$(\pi_{t+k} - \pi_t) = \alpha + \beta(\pi_t^{core} - \pi_t) + u_t \tag{12}$$

where, π represents headline inflation

Second, test the null hypothesis $H_0 : \alpha = 0$ and $\beta = 1$. If, by chance, $\beta > (<) 1$, then it over-estimates(under-estimates) the transitory movement. We cannot then accept that the excluded component is an unbiased predictor of the temporary component of inflation.

Table 5 presents regression results over the whole sample period, that is, from 1982. 2Q to 2001. 4Q. Regression results show that null hypotheses are not rejected in all k. This implies that our core inflation excludes temporary components successfully.[4] Tests in other model approaches(e.g., SVAR model) for Korean core inflation were, however, not successful.

<Table 5> Results of Estimation for Cogley Equation

a. Core Inflation

k	α	β	$\bar{R}^2$	Wald Test Statistic $H_0 : \alpha = 0$ and $\beta = 1$
1	0.104	1.153	0.353	0.529
2	0.104	1.160	0.311	0.584

[4]) CPI_fe was also found to exclude supply side components as well.

3	0.065	0.652	0.087	0.285
4	0.110	1.075	0.337	0.615
5	0.099	0.899	0.150	0.737
6	0.112	1.074	0.231	0.745

b. CPI_fe Inflation

k	α	β	$\overline{R}^2$	Wald Test Statistic $H_0 : \alpha = 0$ and $\beta = 1$
1	0.053	0.811	0.101	0.695
2	0.044	0.645	0.049	0.449
3	0.100	1.215	0.212	0.622
4	0.098	1.004	0.184	0.745
5	0.116	1.236	0.189	0.613
6	0.089	0.918	0.100	0.820

3. Predictability for Future Trends of Inflation

Now let us turn our attention to the predictive power of core inflation. To this end, we can utilize the correlation between core inflation and headline inflation. Low correlation does not, however, necessarily mean that core inflation does not predict future inflation well, since successful inflation targeting monetary policies have a tendency to derive correlation to zero.

For this reason, we need to adopt another method to check the predictive power of core inflation. To this end, we employed the following form of equations:

$$\pi_t = \alpha + \beta_1 \pi_{t-1} - \beta_2 \pi_{t-1}^{core} + u_t \tag{13}$$

Table 6 shows that the suggested core inflation has better ability to predict future inflation trends in ex-post forecast simmulations(see $\overline{R}^2$ values in estimation equations).

<Table 6> Regression Results : $\overline{R}^2$

Core Inflation	α	β_1	β_2	$\overline{R}^2$
CPI	0.227 (0.120)	0.920 (0.184)	-	0.615
CPI_fe	0.150 (0.231)	0.104 (0.266)	0.896 (0.195)	0.610
Core indicator	-0.230 (0.170)	0.719 (0.204)	0.677 (0.183)	0.671

We made a similar test, using an ex-ante forecast this time. Calculated RMSE for each regression model is presented in Table 7. As can be seen from Table 7, the suggested core inflation indicator has the lowest RMSE. This also reflects that the suggested core inflation predicts future inflation trends better.

<Table 7> Forecast Error : RMSE

	CPI	CPI_fe	Core Indicator
1	1.150	1.198	0.651
2	1.346	1.250	0.707
3	1.369	1.255	0.765
4	1.594	1.510	0.939
5	1.697	1.537	0.963
6	1.872	1.715	1.092
7	2.150	1.948	1.302
8	2.155	1.947	1.302

4. Relations with Monetary Policy

In ITS countries, it is core inflation rather than CPI inflation that is used as an intermediate target. Thus, in order to prove its usefulness as a target variable we need to check Granger-causalities between core inflation and monetary aggregates, and between interest rates(call rate) and core inflation. If change of monetary aggregates(or call rate) causes future core inflation it will be highly likely to control core inflation with monetary aggregates(or call rate). On the other hand, we expect that core inflation does not cause direct changes in monetary aggregates(or call rate).

First, in order to check that the change rate of monetary aggregates(or call rate) significantly influence future core inflation, we estimated the following equation.

$$\frac{1}{J}\sum_{j}^{J}\pi^{*}{}_{t+j} = \alpha + \sum_{i}^{n}\beta_{i}\left(\frac{M_{t-i+1} - M_{t-i}}{M_{t-i}}\right) + \varepsilon_{t} \tag{14}$$

where, π^{*} is a core inflation, and $n = 4$.

Equation (14) is constructed in such a way that change in annual money supply can affect the first J quarter future core inflation rates. Table 8 proves that, among all, monetary base and call rates best fit the suggested core inflation among all.

<Table 8> Regression Results($\overline{R}^{2}$) for Equation (14)

	J	CPI	CPI_fe	Core Indicator
MB	5	0.808	0.813	0.822
	6	0.812	0.818	0.825
	7	0.817	0.823	0.830
	8	0.821	0.828	0.830
M3	5	0.632	0.622	0.625
	6	0.635	0.627	0.629
	7	0.638	0.633	0.633
	8	0.640	0.638	0.634
Call	5	0.926	0.923	0.934
	6	0.932	0.929	0.942
	7	0.938	0.935	0.949
	8	0.943	0.942	0.962

Second, we tested Granger-causality between monetary aggregates (and call rate). The Granger causality test is made by employing the following equation.

$$X_t = \alpha + \sum_i^n \beta_i X_{t-i} + \sum_i^n \gamma_i Y_{t-i} + \upsilon_t \qquad (15)$$

Test statistics for the null hypothesis($H_0 : \gamma_i = 0 (i = 1,...,n)$) are presented in Table 9. Results reveal that Granger-causality from monetary aggregates to the suggested core inflation is proved to be statistically significant, while the reverse turned out to be insignificant. [5] On the other hand, causalities from both directions were proved significant, when CPI_fe was used.

<Table 9> Granger-causality test results : Wald test(p-value)

a. Core Indicator

i	MB		M3		Call rate	
	$MB \rightarrow \pi$	$\pi \rightarrow MB$	$M3 \rightarrow \pi$	$\pi \rightarrow M3$	$r \Rightarrow \pi$	$\pi \Rightarrow r$
1	0.046	0.853	0.014	0.245	0.019	0.004
2	0.000	0.667	0.013	0.155	0.326	0.053
3	0.000	0.387	0.010	0.367	0.229	0.087
4	0.000	0.038	0.234	0.423	0.017	0.097
5	0.000	0.140	0.104	0.329	0.163	0.063
6	0.000	0.067	0.171	0.305	0.587	0.071

b. CPI_fe

i	MB		M3		Call rate	
	$MB \rightarrow \pi$	$\pi \rightarrow MB$	$MB \rightarrow \pi$	$\pi \rightarrow MB$	$r \Rightarrow \pi$	$\pi \Rightarrow r$
1	0.387	0.169	0.044	0.016	0.112	0.068
2	0.000	0.014	0.002	0.016	0.039	0.394
3	0.000	0.001	0.029	0.030	0.163	0.464

[5]) The overall performance of the suggested core inflation in call rates is not so good. The null hypothesis can not be rejected at a 5% significance level.

4	0.000	0.038	0.147	0.164	0.004	0.607
5	0.002	0.110	0.119	0.093	0.016	0.598
6	0.000	0.032	0.020	0.178	0.033	0.641

c . CPI

i	MB		M3		Call rate	
	$MB \rightarrow \pi$	$\pi \rightarrow MB$	$M3 \rightarrow \pi$	$\pi \rightarrow M3$	$r \Rightarrow \pi$	$\pi \Rightarrow r$
1	0.615	0.436	0.053	0.034	0.091	0.098
2	0.028	0.287	0.041	0.146	0.144	0.581
3	0.001	0.179	0.096	0.326	0.189	0.856
4	0.001	0.482	0.196	0.463	0.049	0.890
5	0.010	0.381	0.137	0.215	0.078	0.881
6	0.003	0.514	0.043	0.255	0.122	0.889

V. Concluding Remarks

Recently, the Inflation Targeting System(ITS) has emerged as a major monetary policy scheme in countries like England, Canada, and Australia. However, the success of the ITS is believed to depend on which variables are utilized as tools, and as the target variable. The key issue of the ITS thus comes down to how to define and estimate the core inflation, the target variable.

So far, the core inflation has been derived as a quasi-trend after arbitrarily truncating extreme fluctuations. This process obviously causes a serious loss of information. In addition, correlation between the headline inflation and the core inflation becomes rather low.

The main objective of this study is to derive an alternative core inflation indicator which has a strong correlation to the headline CPI. To this end, we suggested a state space model designed to estimate an unobserved hidden core inflation indicator which is cointegrated with the headline CPI. The suggested model does not suffer from the information loss problem, which is a main defect of the old definition of core inflation.

In addition, we performed policy simulations to prove that the new core inflation has an edge over the old one in predicting future headline inflation rates. Further, in order to prove the usefulness of the new core inflation, this paper gave empirical evidences that it has a stronger correlation with the headline inflation than the old one has.

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