Inflation Targeting, Aggregation, and Inflation Persistence: Evidence from Korean CPI Components

Peter Tillmann *

This paper studies the impact of inflation targeting on the evolution of inflation persistence and the effects of aggregation across expenditure categories. For this purpose we use disaggregate quarterly data on 12 major subcategories of the Korean CPI. We compare persistence in a sample covering 1986Q1-1997Q2 with persistence under inflation targeting between 1999Q1 and 2010Q2. The main results are threefold. First, the persistence of headline inflation as well as most CPI categories falls after the adoption of inflation targeting. Second, the evidence points to a large cross-sectional heterogeneity in the degree of inflation persistence. Third, while aggregation of heterogeneous categories induces additional persistence in the early part of the sample, a "reverse aggregation effect" is found in the second half: the persistence of the aggregate CPI inflation rate is significantly *smaller* than the average of persistence estimates across sectors. This is consistent with the Bank of Korea effectively stabilizing aggregate shocks under inflation targeting. Our paper provides the first evidence of disaggregate inflation persistence for an Asian emerging market economy.

Keywords: Inflation persistence, Sectoral inflation, Aggregation, Inflation targeting, Monetary policy strategy, Dynamic factor model

JEL Classification: C22, E5, E31

* Professor, Department of Economics, Justus-Liebig-University Giessen, Licher Str. 66, 35394 Giessen, Germany, (Tel) +49-641-99-22-170, (Fax) +49-641-99-22-179, (E-mail) peter.tillmann@wirtschaft.uni-giessen.de. I thank Stefan Gerlach, Kum Hwa Oh, and two anonymous referees for very thoughtful comments on an earlier draft.
[**Seoul Journal of Economics** 2012, Vol. 25, No. 3]

I. Introduction

The degree of inflation persistence contains valuable information about the effectiveness of monetary policy. Well-anchored inflation expectations as well as a clear and credible policy mandate to achieve price stability are generally thought of as reducing inflation persistence. Therefore, the evolution of inflation persistence in the aftermath of the adoption of a new monetary policy regime is particularly informative.

Besides the persistence of the aggregate inflation rate, the persistence properties of inflation at a disaggregate level are also a valuable input for monetary policy. The rationale for using disaggregate data is that the aggregation process itself — using heterogeneous individual components — could lead to spuriously high persistence estimates for the aggregate inflation series. Therefore, the assessment of the true degree of inflation persistence using aggregate Consumer Price (CPI) inflation data is obscured by an aggregation bias. The persistence of aggregate inflation is typically found to be substantially higher than the average persistence of the CPI components.

While inflation persistence at the level of the aggregate CPI received considerable attention over the recent years, surprisingly few studies analyze inflation persistence at a disaggregate level. The lack of empirical research in this field is mostly due to data limitations. In fact, most empirical studies focus on either the U.S. economy or selected European economies for which detailed disaggregate data, even for very high levels of disaggregation, is available. For emerging market economies, where data limitations are more severe, even less is known about persistence at a sector level. This is unfortunate since it is in emerging market economies where the cross-sectional heterogeneity in inflation persistence is likely to be particularly large.

This paper studies the evolution of inflation persistence across sectors after the adoption of a new monetary regime and the effects of aggregation for the case of Korea. The adoption of inflation targeting (IT) by the Bank of Korea in 1999 is likely to affect the persistence of inflation both at the aggregate and the disaggregated level and, by doing so, also the quantitative properties of the aggregation bias.[1]

[1] See Ito and Hayashi (2004), Filardo and Genberg (2009), and Gerlach and Tillmann (2012) for survey papers on the effects of inflation targeting in Korea and other Asian economies. Nam (2005) presents an analysis of inflation targeting in Korea within a calibrated New Keynesian model.

We use data on 12 major subcategories of the Korean CPI to establish three key findings: First, persistence of the aggregate as well as most CPI categories falls after the adoption of IT. Second, the evidence points to a large degree of cross-sectional heterogeneity in the degree of inflation persistence. Third, while the aggregation of heterogeneous categories induces additional persistence in the early part of the sample, an observation often referred to as the "aggregation effect," a "reverse aggregation effect" is found in the second half: the persistence of the aggregate CPI inflation rate is significantly *smaller* than the average of persistence estimates across sectors. The paper is the first analysis of Korean inflation persistence at a disaggregate level.

A factor decomposition of sectoral inflation rates reveals that idiosyncratic persistence hardly changes after the adoption of IT. At the same time, the persistence of the common factor falls sharply. This is consistent with the Bank of Korea effectively stabilizing aggregate shocks under inflation targeting.

The paper is organized as follows. Section II surveys the literature and introduces the aggregation effect. In Section III our measure of inflation persistence is introduced. The data set is presented in Section IV. Section V contains a detailed discussion of the results while Section VI uses a factor decomposition to interpret the previous findings. Section VII offers some tentative conclusions.

II. Inflation Persistence and the Aggregation Effect

Recent empirical evidence corroborates the notion that the adoption of a new monetary regime, *e.g.,* inflation targeting, leads to a reduction in inflation persistence. Levin and Piger (2006) find that, conditional on a change in the mean (potentially reflecting a change in monetary policy objectives), inflation is much less persistent than previously thought. Levin, Natalucci, and Piger (2004) and Benati (2008), although using different methods, come to similar conclusions: the adoption of inflation targeting lowered the degree of inflation persistence in major industrial countries.

For emerging economies, however, the evidence is less clear-cut. Siklos (2008) finds that inflation targeting has reduced inflation persistence only in a handful of emerging economies. Filardo and Genberg (2009) survey the experience with inflation targeting in Asia and the Pacific and find a drop in persistence only for Korea, New Zealand, and Australia.

In other countries, most notably Thailand, the Philippines, and Indonesia, persistence increases although inflation targeting is used. In an early case study of Korea, Kim and Park (2006) also find inconclusive evidence on the change in inflation persistence. Systematic evidence on the development of persistence in Asian economies is provided by Gerlach and Tillmann (2012). The authors show that persistence generally falls under IT, but not under alternative monetary regimes. All papers mentioned before focus on aggregate inflation rates, not on disaggregate inflation at a sectoral level.

Lünnemann and Mathä (2004) provide evidence using a European cross-country data set containing disaggregate CPI inflation rates.[2] Their evidence is consistent with the presence of aggregation effects. When estimated at the level of CPI components, inflation persistence is low. Large cross-sectional differences in inflation persistence are documented by Bilke (2005) for a data set on disaggregate French consumer prices. Altissimo, Mojon, and Zaffaroni (2009) show that, based on a large data set of over 400 components of the French CPI, aggregation can explain the discrepancy between micro evidence suggesting a low level of inflation persistence and macro evidence consistent with a highly persistent inflation process. For the U.S. economy, the results presented by Clark (2006) strengthen the case for aggregation effects. Using rolling-window estimates of inflation persistence, the author shows that the persistence of the aggregate lies above the mean or median of both weighted and unweighted persistence estimates of the CPI subcomponents. Boivin, Giannoni, and Mihov (2009) study the response of disaggregate inflation shocks. They show that disaggregate inflation data responds sluggishly to aggregate shocks despite sector prices being less sticky than the aggregate price level. Sectoral inflation appears to be much less persistent than aggregate inflation. Their dynamic factor specification suggests that the persistence in inflation is mostly due to fluctuations in the common macroeconomic factor, while the individual components exhibit almost no persistence.

The evidence reviewed thus far unanimously suggests the presence of an aggregation effect: individual sectors appear to respond more quickly to shocks than the aggregate. As explained by Altissimo *et al.* (2006), the aggregation of subindices to an aggregate series has two effects that might be responsible for this observation. First, the aggregation process results in an index whose dynamic properties are a complex function of

[2] The evidence for the euro area is summarized in Altissimo *et al.* (2006).

the persistence properties of the individual components. Second, to the extent both idiosyncratic and common shocks are present, the idiosyncratic shocks tend to wash out in the aggregate leaving only common shocks driving the aggregate. As a result, the aggregate inflation series is smother than its components. We will refer to these factors in the interpretation of our empirical results below.

As a matter of fact, the effect of inflation targeting on inflation dynamics is not limited to inflation persistence. Other dimensions include a change in the level, the variance or the predictability of inflation. Likewise, other macroeconomic variables such as output and unemployment variability could respond to the adoption of inflation targeting. The literature has not yet reached a consensus about the effects of inflation targeting in emerging market economies. Goncalves and Salles (2008) find that developing countries adopting IT experience a significant decline of inflation and growth volatility. Lin and Ye (2009) and Lin (2010) are able to show that the level of inflation and its volatility fall after the adoption of IT. Brito (2010) and Brito and Bystedt (2010), in contrast, find that inflation targeting has no effect on the level and the variance of inflation in emerging countries.

In this paper we use data from Korea to assess the developments of inflation persistence based on disaggregate data. To our knowledge, this is one of the first attempts to analyze the aggregation effect together with the dynamics of sectoral inflation persistence for an emerging market economy.[3]

III. Measuring Inflation Persistence

Following O'Reilly and Whelan (2005) and Levin and Piger (2006), among others, our preferred measure of persistence is the sum of the autoregressive coefficients in a univariate process of inflation. Let c be an intercept term and ε_t a serially uncorrelated shock. An AR(q) process for the inflation rate π_t can then be written as

$$\pi_t = c + \sum_{k=1}^{q} \beta_k \pi_{t-k} + \varepsilon_t \tag{1}$$

[3] Babecký, Coricelli, and Horváth (2009) estimate persistence at a sectoral level for the Czech Republic. They find a small reduction in persistence after the adoption of inflation targeting and evidence for a conventional aggregation bias.

The sum of autoregressive coefficients is $\rho = \sum_{k=1}^{q} \beta_k$. According to Andrews and Chen (1994), ρ is the best scalar measure of persistence in π_t since a monotonic relationship exists between ρ and the cumulative impulse response function of π_t to ε_t. Rewrite this expression as

$$\pi_t = c + \rho\pi_{t-1} + \sum_{k=1}^{q-1} \gamma_k \Delta\pi_{t-k} + \varepsilon_t \tag{2}$$

where $\Delta\pi_t = \pi_t - \pi_{t-1}$. For $\rho = 1$ the inflation process contains a unit root. Put differently, the central bank has only poor control over inflation dynamics. If, in contrast, $|\rho| < 1$, the inflation process is stationary and there is at least some inflation control. In the empirical application below, the appropriate lag length $q \leq q^{\max}$ is chosen according to the Akaike Information Criterion (AIC) with a maximum lag length of $q^{\max} = 6$(quarters).

Estimates of ρ obtained from least squares estimation suffer from a downward bias as the sum of the autoregressive coefficients approaches unity. Furthermore, confidence bands based on a normally distributed ρ do not have the correct coverage. Therefore, we follow the literature and resort to Hansen's (1999) median unbiased estimator of ρ. His grid bootstrap approach is used to construct confidence bands for ρ with correct coverage. The bootstrap calculations are based on 999 draws and 101 grid points over a range spanned by the sample estimate of persistence surrounded by four OLS standard errors.

The presence of structural breaks in the mean of the inflation process can bias the estimates of persistence upwards. To account for this bias we include an appropriate dummy variable d_t in the regression equation, which is unity in $t \geq s$

$$\pi_t = c + \delta d_t + \rho\pi_{t-1} + \sum_{k=1}^{q-1} \gamma_k \Delta\pi_{t-k} + \varepsilon_t \tag{3}$$

where s is the break date, and zero elsewhere.

IV. The Data Set

We use a quarterly data set spanning 1986Q1 to 2010Q2, which is taken from the website of *Statistics Korea*.[4] The data covers aggregate

CPI as well as 12 CPI sub-categories according to the Classification of Individual Consumption by Purpose (COICOP) convention, *i.e.,* price indices for food and non-alcoholic beverages (food), alcoholic beverages and tobacco (alcohol), clothing and footwear (clothing), housing, water, electricity, and other fuels (housing), furnishing and household equipment (furniture), health (health), transport (transport), communication (communication), recreation and culture (recreation), education (education), restaurants and hotels (restaurants), and miscellaneous goods and services (miscellaneous). We focus on CPI inflation rather than inflation derived from other price indices because the monetary policy strategy of the Bank of Korea explicitly refers to a target rate of inflation in terms of the annual change of the CPI. Analyzing the persistence of core inflation would also be interesting. A series of core inflation which is endorsed by policy statements from the Bank of Korea, however, is not available. The weights of these categories in the overall CPI are listed in Table 1. For each series, we compute the inflation rate as the annual percentage change.

The sectoral inflation rates are depicted in Figure 1. Table 1 also reports some descriptive statistics. A comparison of the first two moments of inflation shows that both the level of inflation across CPI categories as well as the variances are in most cases lower in the post-1999 subsample than in the pre-1997 subsample. Throughout the paper we chose to compare inflation persistence in a sample that starts in 1986Q1 and ends at the onset of the Asian financial crisis in 1997:Q2 with a sample that starts with the adoption of inflation targeting as the new monetary policy strategy by the Bank of Korea in 1999Q1 and ends in 2010Q2. Although IT was officially adopted by the Bank of Korea in April 1998 (see Bank of Korea 2008), the first few months until the start of 1999 were dominated by the impact of the Asian crisis. In fact, the first target rate for inflation in 1998 was 9%, which was reduces to just 3% in 1999. To exclude this transition period, the second sample starts in 1999Q1. I do not formally test for structural stability of inflation dynamics over the entire sample since the Asian financial crisis will certainly obscure any potential break associated with the adoption of IT. Furthermore, I will use rolling-window regressions below which are essentially the most flexible way to deal with structural instability. Not surprisingly, there are large differences in the mean inflation rates and the variances of inflation across subsectors and across subsamples.

[4] See http://kosis.kr/eng/.

TABLE 1
DESCRIPTIVE STATISTICS

CPI category	weight	mean inflation		variance of inflation	
		pre-1997:2	post-1999:1	pre-1997:2	post-1999:1
food	14.00%	6.01	4.23	18.74	8.72
alcohol	1.46%	5.06	3.53	12.40	19.33
clothing	5.84%	4.97	2.53	15.65	2.05
housing	17.04%	5.21	2.65	6.53	5.75
furniture	4.17%	3.78	2.01	3.34	5.40
health	5.16%	4.61	2.98	5.03	14.40
transport	10.90%	6.22	3.57	11.50	13.87
communication	6.02%	-0.65	-2.11	24.81	3.84
recreation	5.63%	3.10	0.14	1.23	2.21
education	11.09%	9.75	4.58	7.63	2.38
restaurants	13.27%	8.91	2.49	24.40	2.68
miscellaneous	5.38%	3.69	3.31	2.92	9.21
aggregate	100%	5.69	2.90	4.36	1.17

Notes: The data are taken from *Statistics Korea*. The exact sectoral definitions are: food and non-alcoholic beverages (food), alcoholic beverages and tobacco (alcohol), clothing and footwear (clothing), housing, water, electricity, and other fuels (housing), furnishing and household equipment (furniture), health (health), transport (transport), communication (communication), recreation and culture (recreation), education (education), restaurants and hotels (restaurants), miscellaneous goods and services (miscellaneous). The weights in the aggregate CPI refer to September 2010.

Compared to the studies on other countries surveyed before, the level of disaggregation in the present data set is still considerably low. Despite these limits to data availability, the data set is believed to contain sufficient information for our purposes.

V. Results

The main results of this paper are derived in three steps. In a first step, we compare the persistence of aggregate and sectoral inflation across subsamples. In a second step, we derive a time-varying measure of inflation persistence from a set of rolling-window regressions to uncover the behavior of inflation persistence over time. Finally, we assess whether an aggregation effect is present.

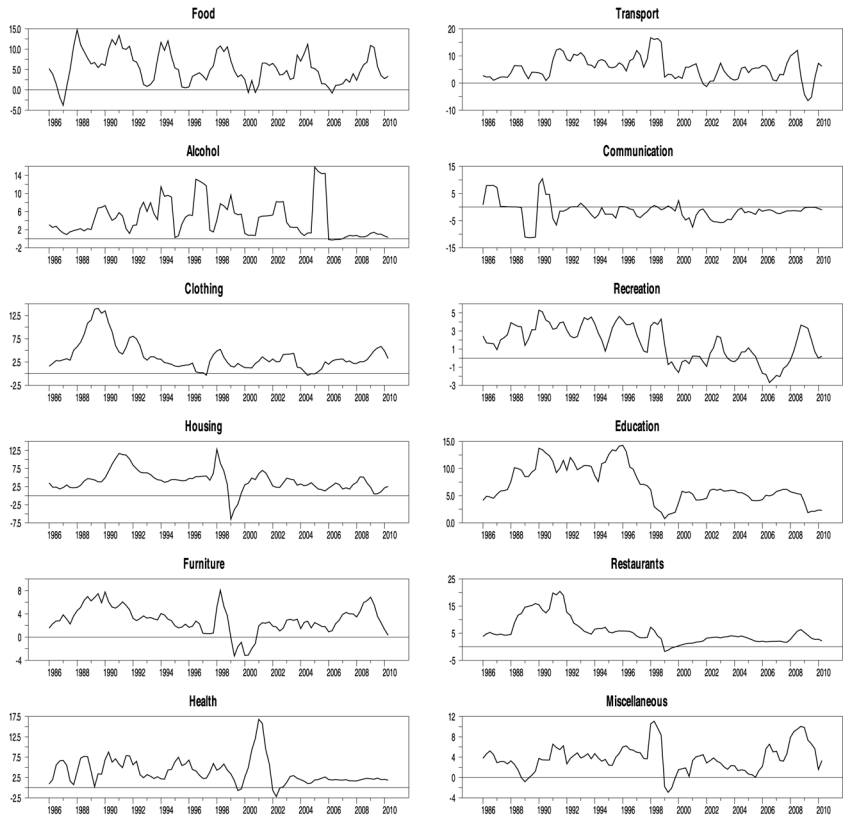

FIGURE 1
INFLATION RATES (IN % P.A.) ACROSS CPI CATEGORIES

A. Sectoral Persistence across Subsamples

Table 2 reports the estimated persistence measures across subsamples together with bootstrapped 90 % confidence bands. Lets us first consider the aggregate inflation series. As the last row of the table shows, persistence falls significantly under the new monetary regime. The sum of the autoregressive coefficients drops from 0.96 in the pre-1997 sample to only 0.26 in the post-1999 sample.[5] The adoption of inflation targeting led to an impressive decline in inflation persistence.[6]

This fall in persistence also characterizes many, but not all, CPI

[5] This reflects the findings in Gerlach and Tillmann (2012).

[6] This stands in contrast to the early findings by Kim and Park (2006).

TABLE 2

INFLATION PERSISTENCE ACROSS CPI CATEGORIES

CPI category	pre-1997:2			post-1999:1		
	lag order	sum of AR coefficients	confidence band	lag order	sum of AR coefficients	confidence band
food	5	0.86	[0.61,1.09]	4	0.52	[0.33,0.71]
alcohol	1	0.81	[0.60,1.06]	5	0.70	[0.44,1.07]
clothing	2	1.01	[0.89,1.05]	5	0.82	[0.62,1.06]
housing	6	0.95	[0.87,1.02]	6	0.45	[0.19,0.77]
furniture	1	1.04	[0.88,1.12]	6	0.84	[0.69,1.03]
health	5	0.93	[0.48,1.20]	5	0.89	[0.73,1.06]
transport	6	0.86	[0.65,1.08]	5	0.43	[0.17,0.70]
communication	5	0.54	[0.23,1.05]	1	0.73	[0.53,0.97]
recreation	6	0.54	[0.26,0.89]	5	0.81	[0.64,1.04]
education	1	0.82	[0.65,1.05]	6	0.83	[0.68,1.04]
restaurants	2	1.00	[0.86,1.06]	6	0.83	[0.69,1.03]
miscellaneous	1	0.89	[0.71,1.08]	5	0.87	[0.65.1.08]
mean (unweighted)		0.85			0.73	
median (unweighted)		0.87			0.81	
mean (weighted)		0.87			0.65	
median (weighted)		0.53			0.47	
aggregate	5	0.96	[0.80,1.07]	6	0.26	[0.00,0.51]

Notes: The table reports the mean unbiased estimator of the sum of autoregressive coefficients and the bootstrapped 90% confidence bands based on 101 grid points and 999 replications. The lag order is chosen according to the AIC. The weights in the aggregate CPI refer to September 2010.

categories. Four (food, housing, transport, and restaurants) out of five major components, *i.e.*, those with two-digit weights in the aggregate, also experience a substantial reduction in persistence. In other sectors, however, persistence increases, most notably in communication and recreation. Prices of educational expenses exhibit an unchanged degree of inflation persistence. We conclude that, first, aggregate persistence drops after the adoption of inflation targeting and, second, the evolution of inflation persistence is fairly heterogeneous across CPI categories.

The extent of cross-section heterogeneity matters for monetary policy. A monetary policy shock has larger effects on the aggregate price level in a situation in which the degree of price stickiness is heterogeneous across sectors compared to a case in which nominal rigidities were identical in all sectors.[7]

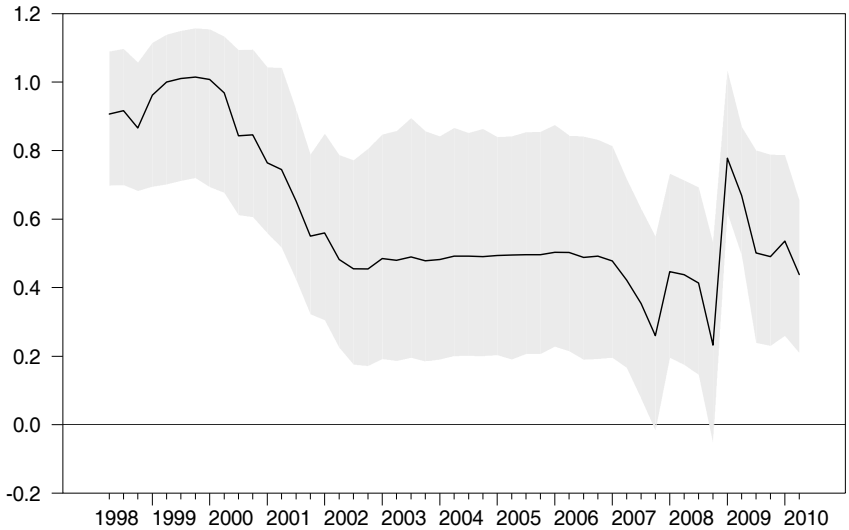

FIGURE 2

SUM OF AUTOREGRESSIVE COEFFICIENTS FROM A 10-YEAR ROLLING WINDOW FOR AGGREGATE CPI INFLATION (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS

B. Rolling-window Estimates of Sectoral Persistence

To illustrate the behavior of the persistence measure over time, we next estimate the model using a moving 10-year window. For each window, we compute confidence intervals as explained above. We also allow for the lag length of the AR models to vary across samples as determined by the AIC since the adoption of IT could lead to fewer lags being sufficient to describe the inflation process. As mentioned before, neglecting a structural break in the mean inflation rate can lead to spuriously high estimates of inflation persistence. Thus far the literature on the performance of inflation targeting in Asian emerging market countries does not take account of this problem. As the estimation window moves over the sample period, the impact of structural breaks is reduced. Nevertheless, most estimation windows include the Asian crisis in 1997-98. Therefore, we control for a structural break in 1998:3 when the fallout from the Asian financial crisis was apparent, without explicitly testing whether such a break occurred at this time.

Figure 2 illustrates the decline in inflation persistence — based on

[7] See Altissimo, Mojon, and Zaffaroni (2009) and the references therein.

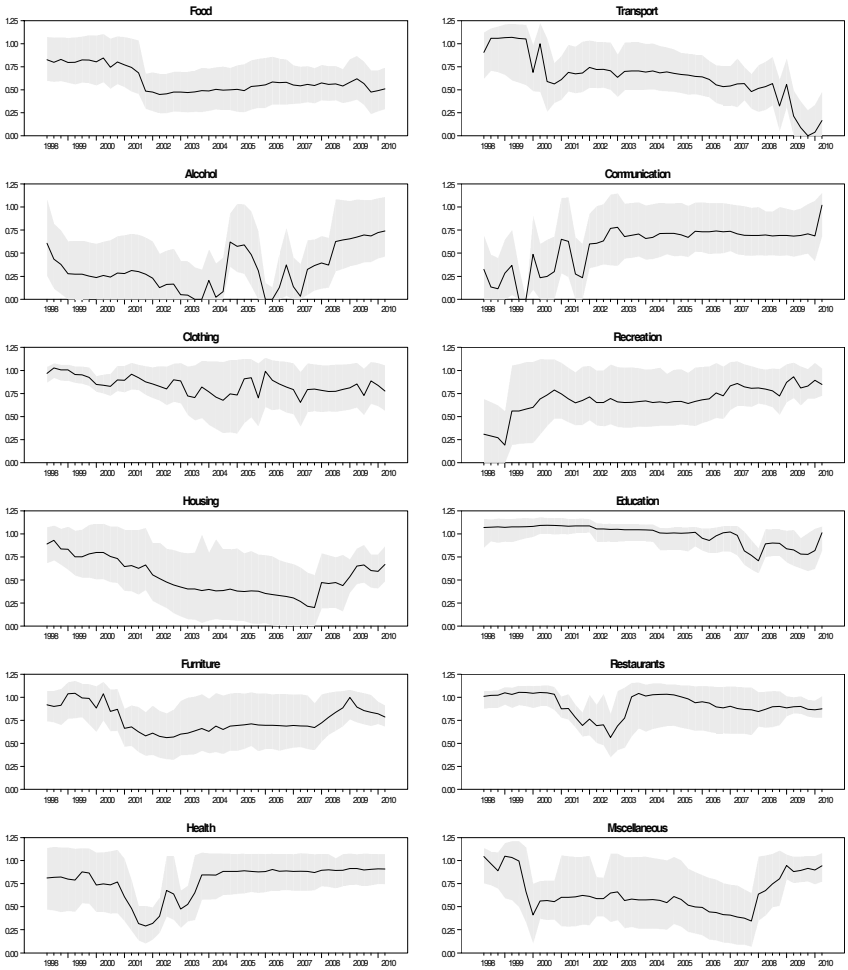

FIGURE 3

SUM OF AUTOREGRESSIVE COEFFICIENTS FROM A 10-YEAR ROLLING WINDOW FOR CPI CATEGORIES (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS

the aggregate CPI — that occurs immediately after the adoption of inflation targeting in 1999. Since then the level of persistence remains significantly below its pre-inflation targeting level. Only towards the very end of the sample period does persistence pick up somewhat — possibly reflecting the repercussions of the financial crisis in 2008.

The time-varying persistence measures on a sectoral level are shown in Figure 3. Price changes for food, furniture, miscellaneous services,

and transportation expenses fall shortly after the new monetary regime became effective. Restaurant prices and prices for health expenses also exhibit a drop in persistence, which is, however, reversed after a few years. Interestingly, inflation in the sector for miscellaneous services and in the housing sector became more persistent since mid-2007. With the latter also comprising fuel prices, the increase in persistence reflects the surge in oil prices in 2007/08 before the recent financial crisis.

C. The Effect(s) of Aggregation

Interestingly, in the post-1999 sample the degree of persistence of the aggregate inflation rate is far below the persistence estimate of any subcategory, see Table 2. In the pre-1997 sample, in contrast, aggregate persistence appears to be fairly representative for the average of sectoral persistence estimates. In Table 2, the persistence estimate for the aggregate series is contrasted with both the weighted and the unweighted average of sectoral persistence estimates. The early sample period exhibits the aggregation effect that is well-known from the literature about inflation persistence and aggregation: the persistence of the aggregate is larger than the average persistence of its components. This effect, however, turns upside down in the later sample. After 1999 the aggregate inflation rate is much less persistent (0.26) than the average of persistence of the components (0.65 and 0.73, respectively). This effect is significant as both the weighted and the unweighted average of persistence are not covered by the confidence band around the estimated aggregate persistence, *i.e.,* [0.00, 0.51].

The time-varying measure of persistence sheds light on the date this aggregation effect changes sign. Figure 4 plots the rolling-window estimate of persistence for the aggregate inflation rate against the averages of rolling-window persistence estimates across CPI components. Before 2001, the conventional finding holds and the aggregation process biases persistence upwards relative to sectoral averages. Since then, however, the opposite is true. Towards the end of the sample, this effect becomes particularly large with the averages of persistence estimates lying outside the confidence bands surrounding the series of aggregate persistence. Since the rolling-window evidence cannot pin down an exact date of structural change, the evidence suggests that the change in the role of aggregation roughly coincides with the adoption of inflation targeting.

As a robustness check, Figures 5 and 6 depict the time-varying persistence estimates for the aggregate CPI against the average of sector

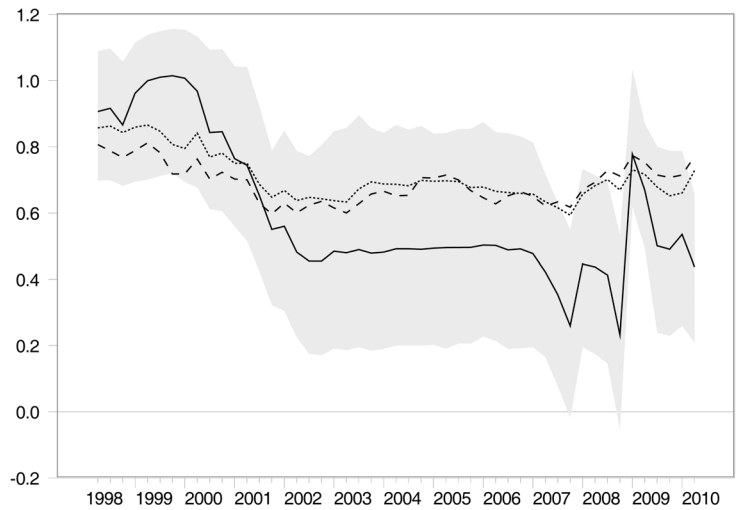

FIGURE 4

PERSISTENCE OF AGGREGATE CPI INFLATION (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS, WEIGHTED PERSISTENCE OF CPI COMPONENTS (DOTTED LINE) AND UNWEIGHTED PERSISTENCE OF CPI COMPONENTS (DASHED LINE) OVER A 10-YEAR WINDOW

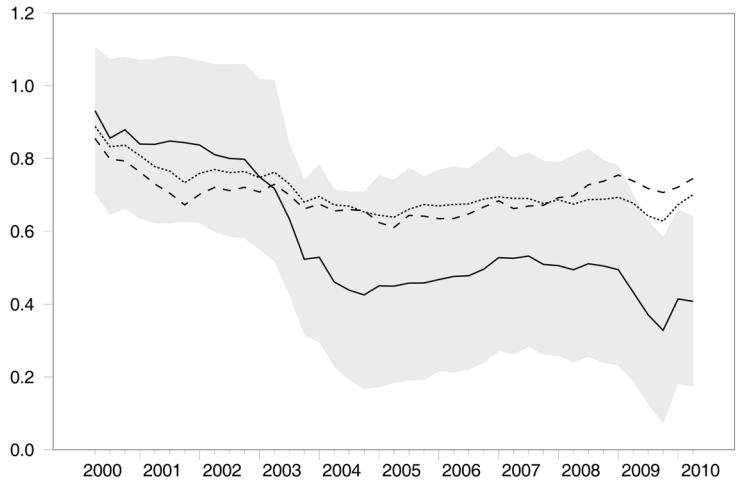

FIGURE 5

PERSISTENCE OF AGGREGATE CPI INFLATION (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS, WEIGHTED PERSISTENCE OF CPI COMPONENTS (DOTTED LINE), AND UNWEIGHTED PERSISTENCE OF CPI COMPONENTS (DASHED LINE) OVER A 12-YEAR WINDOW

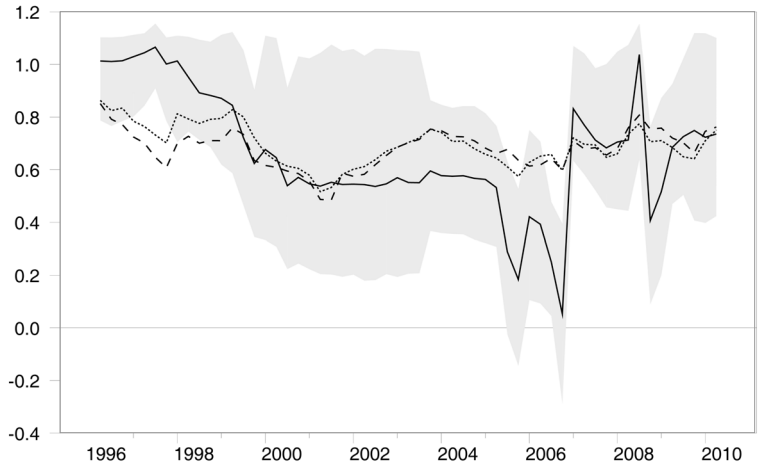

FIGURE 6

PERSISTENCE OF AGGREGATE CPI INFLATION (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS, WEIGHTED PERSISTENCE OF CPI COMPONENTS (DOTTED LINE), AND UNWEIGHTED PERSISTENCE OF CPI COMPONENTS (DASHED LINE) OVER AN 8-YEAR WINDOW

estimates for a 12- and an 8-year sample, respectively. Although the timing of the "reversed aggregation effect" changes somewhat across specifications, the basic finding remains unaffected.

What explains our finding of a "reversed aggregation effect"? As discussed before, on a theoretical level the aggregation effect might be disentangled into two factors. First, the aggregation process generates an aggregate whose persistence properties are a complex amalgam of the components. This factor is most likely to be present throughout the sample period and roughly stable over time, hence it cannot explain why the aggregation effect changes sign. This leaves the second factor, *i.e.,* the interaction of idiosyncratic and common shocks. If sector-specific shocks cancel out in the aggregate, the aggregate is more persistent than the components and driven only by aggregate shocks. The opposite is true if aggregate shocks are stabilized effectively by the central bank while idiosyncratic shocks do not wash out completely. In this case the persistence of the aggregate inflation series lies below that of its components. Effective inflation targeting as in the case of Korea, therefore, could lead to a reversal of the aggregation effect.

VI. Common vs Sector-specific Components

To shed light on the role of common shocks for the evolution of persistence, this section employs a simple decomposition of disaggregate inflation rates into a common and a sector-specific component. The common factor f_t is driven by aggregate shocks to the economy, *i.e.,* monetary policy shocks, aggregate demand, or aggregate technology shocks. Technically, we represent the common factor by the first principal component of our 12 sectoral inflation rates.[8] For each sector $i=1, \ldots, N$ with $N=12$, the inflation rate π_{it} is driven by q lags of this common component plus an idiosyncratic component u_{it}

$$\pi_{it} = \Lambda_i' F_t + u_{it} \tag{4}$$

where the $1 \times q$ vector of factor loadings is given by Λ_i and the matrix F_t contains up to q lags of the common factor. Thus, the model corresponds to an approximate dynamic factor model proposed by Stock and Watson (2002a, 2002b). The main advantage of this static representation of the dynamic factor model is that the factors can be estimated using principal components. We present the main results for $q=0$ and $q=3$.

The sector-specific component of each inflations series is the residual from regressing sectoral inflation on the common factor. Sector-specific technology or demand shocks could be responsible for variation in the idiosyncratic components. For both the resulting common factor and each series of idiosyncratic components we apply our measure of persistence from the previous sections.

Tables 3 and 4 present the results of this decomposition for $q=0$ and $q=3$. The persistence of the common factor sharply declines in the second subsample, while in most sectors the persistence of the sector-specific component remains roughly unchanged. If the common factor would be equally important in driving inflation across subsamples, this would result in a homogeneous fall of persistence at the disaggregate level of inflation. However, the share of variation of each sector inflation rate accounted for by the common factor actually declines, see for example price changes for food or health expenditures. As a result, the less persistent common factor does not drive down persistence at the aggregate level. This is

[8] See Elmer and Maag (2009) for a similar approach using disaggregate data for Switzerland.

TABLE 3

PERSISTENCE OF IDIOSYNCRATIC COMPONENTS OF SECTORAL INFLATION FOR $q=0$

CPI category	pre-1997:2				post-1999:1			
	R^2	lag order	sum of AR coefficients	confidence band	R^2	lag order	sum of AR coefficients	confidence band
food	0.35	6	0.40	[0.10,0.73]	0.22	4	0.47	[0.27,0.68]
alcohol	0.01	6	0.74	[0.37,1.12]	0.00	5	0.72	[0.44,1.07]
clothing	0.44	2	0.93	[0.84,1.04]	0.40	5	0.62	[0.37,0.93]
housing	0.64	2	0.88	[0.76,1.03]	0.61	6	0.70	[0.45,1.04]
furniture	0.63	4	0.96	[0.75,1.09]	0.46	6	0.92	[0.76,1.06]
health	0.35	5	0.70	[0.33,1.13]	0.10	5	0.91	[0.76,1.06]
transport	0.13	6	1.02	[0.76,1.10]	0.27	5	0.65	[0.40,0.96]
communication	0.00	5	0.54	[0.20,1.05]	0.02	1	0.73	[0.53,0.97]
recreation	0.49	6	0.79	[0.58,1.05]	0.63	6	0.77	[0.57,1.04]
education	0.50	2	0.86	[0.72,1.03]	0.76	2	0.70	[0.55,0.84]
restaurants	0.94	5	1.02	[0.79,1.12]	0.90	5	0.44	[0.20,0.69]
miscellaneous	0.00	1	1.00	[0.78,1.10]	0.22	5	0.91	[0.69,1.09]
mean (unweighted)			0.82				0.71	
median (unweighted)			0.87				0.71	
mean (weighted)			0.82				0.66	
median (weighted)			0.54				0.48	
common factor	-	5	0.97	[0.82,1.06]	-	6	0.43	[0.18,0.70]

Notes: The table reports the mean unbiased estimator of the sum of autoregressive coefficients and the bootstrapped 90% confidence bands based on 101 grid points and 999 replications. The lag order of the AR(q) model is chosen according to the AIC. The weights in the aggregate CPI refer to September 2010. The share of variation of each sectoral inflation rate explained by the common factor is represented by the R^2 from the regression of sectoral inflation on the common factor.

consistent with the results presented in the previous section.

Despite the fact that the factor loadings fall in only three categories (food, clothing, restaurants) and increase in the remaining nine categories across subsamples, the smaller persistence of the common factor does not translate into less persistent sectoral inflation rates. The factor loadings are related to the weights of the components in the aggregate CPI. In the pre-1997 period, the correlation between factor loadings and expenditure weights is 0.57. This increases to 0.68 in the post-1999 period. Table 5 reveals that the relative volatility of the common factor falls over time. For almost all CPI categories the ratio of the standard deviations of the common component and the idiosyncratic component

TABLE 4

PERSISTENCE OF IDIOSYNCRATIC COMPONENTS OF SECTORAL INFLATION FOR $q=3$

CPI category	pre-1997:2				post-1999:1			
	R^2	lag order	sum of AR coef-ficients	confidence band	R^2	lag order	sum of AR coef-ficients	confidence band
food	0.51	6	0.40	[0.10,0.71]	0.42	4	0.44	[0.21,0.68]
alcohol	0.08	1	0.82	[0.60,1.08]	0.10	5	0.73	[0.45,1.10]
clothing	0.46	2	0.94	[0.84,1.02]	0.45	5	0.68	[0.43,1.01]
housing	0.73	2	0.90	[0.76,1.05]	0.90	5	0.90	[0.66,1.09]
furniture	0.72	1	0.90	[0.69,1.09]	0.49	6	0.92	[0.72,1.08]
health	0.39	5	0.54	[0.17,1.17]	0.20	5	0.95	[0.76,1.08]
transport	0.24	6	1.01	[0.77,1.09]	0.39	5	0.63	[0.38,1.02]
communication	0.01	5	0.25	[-0.1,0.60]	0.21	5	0.87	[0.53,1.14]
recreation	0.50	6	0.79	[0.57,1.06]	0.75	5	0.90	[0.67,1.09]
education	0.55	2	0.85	[0.71,1.04]	0.77	4	0.65	[0.45,0.87]
restaurants	0.94	5	1.07	[0.87,1.16]	0.93	4	0.26	[0.01,0.51]
miscellaneous	0.09	1	1.01	[0.80,1.11]	0.30	1	0.93	[0.77,1.07]
mean (unweighted)			0.79				0.74	
median (unweighted)			0.87				0.80	
mean (weighted)			0.80				0.68	
median (weighted)			0.55				0.50	
common factor	-	1	1.04	[0.90,1.12]	-	2	0.77	[0.64,0.93]

Notes: The table reports the mean unbiased estimator of the sum of auto-regressive coefficients and the bootstrapped 90% confidence bands based on 101 grid points and 999 replications. The lag order of the AR(q) model is chosen according to the AIC. The weights in the aggregate CPI refer to September 2010. The share of variation of each sectoral inflation rate explained by the common factor is represented by the R^2 from the regression of sectoral inflation on the common factor.

is lower after the adoption of inflation targeting.

Figure 7 depicts the persistence of the common factor obtained from a rolling-window regression. The common factor persistence moves in tandem with the persistence of headline inflation, thus suggesting that less persistent aggregate shocks are the key to the fall in persistence of headline inflation. Since the Bank of Korea's mandate is specified in terms of aggregate CPI inflation and aggregate macroeconomic condition, the falls in persistence in the common factor reflects the success of monetary policy after 1999.

TABLE 5

THE RELATIVE VARIANCE OF THE COMMON COMPONENT FOR $q=0$

CPI category	pre-1997:2			post-1999:1		
	Sd($\Lambda_i' F_t$)	Sd(u_{it})	Relative Sd(.)	Sd($\Lambda_i' F_t$)	Sd(u_{it})	relative Sd(.)
food	1.78	3.37	0.53	1.00	2.76	0.36
alcohol	0.36	3.66	0.10	0.20	4.43	0.05
clothing	1.63	3.34	0.48	0.91	1.54	0.59
housing	1.87	1.71	1.09	1.06	1.75	0.60
furniture	1.33	1.26	1.06	0.75	1.85	0.41
health	0.96	1.89	0.51	0.54	3.70	0.15
transport	1.65	3.44	0.48	0.93	3.55	0.26
communication	0.15	4.53	0.03	0.09	1.93	0.04
recreation	1.16	1.38	0.85	0.66	1.29	0.51
education	1.97	2.55	0.77	1.11	1.33	0.84
restaurants	3.65	1.79	2.04	2.06	1.20	1.72
miscellaneous	0.61	1.91	0.32	0.35	2.82	0.12

Notes: The table reports the standard deviation of the common component $\Lambda_i' F_t$, the idiosyncratic component u_{it} and the ratio thereof.

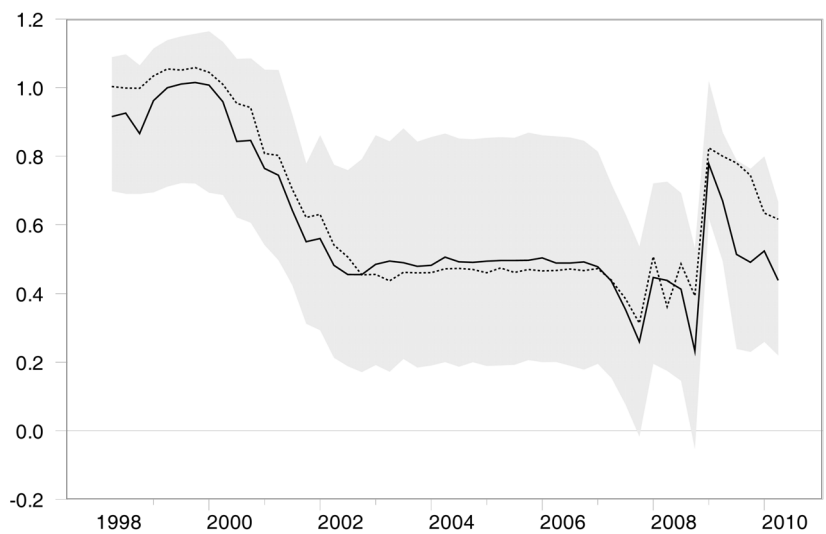

FIGURE 7

PERSISTENCE OF AGGREGATE CPI INFLATION (SOLID LINE) WITH BOOTSTRAPPED 90% CONFIDENCE BANDS AND PERSISTENCE OF COMMON FACTOR (DOTTED LINE)

VII. Conclusions

Aggregating price indices across heterogeneous sectors is known to generate an upward bias in the aggregate's degree of persistence. This paper uses disaggregate data on Korean consumer prices to study the cross-sectional evolution of inflation persistence and the resulting aggregation bias. Our main results are threefold. First, aggregate persistence falls drastically after the adoption of inflation targeting by the Bank of Korea in 1999. Second, we find an important cross-sectional heterogeneity in the degree inflation persistence. Third, we establish a new result on the effect of aggregation on persistence. After the adoption of inflation targeting, the aggregation effect changes sign, *i.e.*, the conventional aggregation effect is reversed. A factor decomposition suggests that the persistence of the common factor declines while the persistence of idiosyncratic inflation movements remains unchanged. Taken together, these results indicate the effectiveness of inflation stabilization under the Bank of Korea's new inflation targeting regime.

(Received 5 March 2012; Revised 9 July 2012; Accepted 16 July 2012)

References

Altissimo, F., Bilke, L., Levin, A., Mathä, T., and Mojon, B. "Sectoral and Aggregate Inflation Dynamics in the Euro Area." *Journal of the European Economic Association* 4 (Nos. 2-3 2006): 585-93.

Altissimo, F., Mojon, B., and Zaffaroni, O. "Can Aggregation Explain the Persistence of Inflation." *Journal of Monetary Economics* 56 (No. 2 2009): 231-41.

Andrews, D. W. K., and Chen, H. Y. "Approximately Median-unbiased Estimation of Autoregressive Models." *Journal of Business and Economics Statistics* 12 (No. 2 1994): 187-204.

Babecký, J., Coricelli, F., and Horváth, R. "Assessing Inflation Persistence: Micro Evidence on an Inflation Targeting Economy." *Czech Journal of Economics and Finance* 59 (No. 2 2009): 102-27.

Bank of Korea. *Monetary Policy in Korea.* Available on the Bank of Korea Website, 2008.

Benati, L. "Investigating Inflation Persistence across Monetary Regimes." *Quarterly Journal of Economics* 123 (No. 3 2008): 1005-60.

Bilke, L. Break in the Mean and Persistence of Inflation. A Sectoral

Analysis of the French CPI. ECB Working Paper No. 463, European Central Bank, 2005.

Boivin, J., Giannoni, M. P., and Mihov, I. "Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data." *American Economic Review* 99 (No. 1 2009): 350-84.

Brito, R. D. Inflation Targeting Does Not Matter: Another Look at OECD Economies' Output Sacrifice Ration. Unpublished, 2010.

Brito, R. D., and Bystedt, B. "Inflation Targeting in Emerging Economies: Panel Evidence." *Journal of Development Economics* 91 (No. 2 2010): 198-210.

Clark, T. E. "Disaggregate Evidence on the Persistence of Consumer Price Inflation." *Journal of Applied Econometrics* 21 (No. 5 2006): 563-87.

Elmer, S., and Maag, T. The Persistence of Inflation in Switzerland: Evidence from Disaggregate Data. KOF Working Paper No. 235, Swiss Federal Institute of Technology, 2009.

Filardo, A., and Genberg, H. Targeting Inflation in Asia and the Pacific: Lessons from the Recent Past. Unpublished, Bank for International Settlements, 2009.

Gerlach, S., and Tillmann, P. "Inflation Targeting and Inflation Persistence in Asia-Pacific." *Journal of Asian Economics* 23 (No. 4 2012): 360-73.

Goncalves, C. E. S., and Salles, J. M. "Inflation Targeting in Emerging Economies: What Do the Data Say?" *Journal of Development Economics* 85 (Nos. 1-2 2008): 312-18.

Hansen, B. E. "The Grid Bootstrap and the Autoregressive Model." *The Review of Economics and Statistics* 81 (No. 4 1999): 594-607.

Ito, T., and Hayashi, T. Inflation Targeting in Asia. HKIMR Occasional Paper No. 1, Hong Kong Institute for Monetary Research, 2004.

Kim, S., and Park, Y. C. "Inflation Targeting in Korea: a Model of Success?" In *Monetary policy in Asia: approaches and implementation.* BIS Papers No. 3, Bank for International Settlements, 2006.

Levin, A. T., and Piger, J. M. Is Inflation Persistence Intrinsic in Industrial Economies? Unpublished, Board of Governors of the Federal Reserve System, 2006.

Levin, A. T., Natalucci, F. M., and Piger, J. M. "The Macroeconomic Effects of Inflation Targeting." *Federal Reserve Bank of St. Louis Review* 86 (No. 4 2004): 51-80.

Lin, S. "On the International Effects of Inflation Targeting." *The Review of Economics and Statistics* 92 (No. 1 2010): 195-99.

Lin, S., and Ye, H. "Does Inflation Targeting Make a Difference in Developing Countries?" *Journal of Development Economics* 89 (No. 1 2009): 118-23.

Lünnemann, P., and Mathä, T. Y. How Persistent is Disaggregate Inflation? An Analysis across EU15 Countries and HICP Sub-indices. ECB Working Paper No. 415, European Central Bank, 2004.

Nam, K. "The Performance of Targeting Monetary Policies in a Small Open Economy." *Seoul Journal of Economics* 18 (No. 2 2005): 147-72.

O'Reilly, G., and Whelan, K. "Has Euro-area Inflation Persistence Changed Over Time?" *The Review of Economics and Statistics* 87 (No. 4 2005): 709-20.

Siklos, P. L. "Inflation Targeting around the World." *Emerging Markets Finance and Trade* 44 (No. 6 2008): 17-37.

Stock, J. H., and Watson, M. W. "Macroeconomic Forecasting Using Diffusion Indexes." *Journal of Business and Economic Statistics* 20 (No. 2 2002a): 147-62.

_____. "Forecasting Using Principal Components from a Large Number of Predictors." *Journal of the American Statistical Association* 97 (No. 460 2002b): 1167-79.