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MONETARY POLICY REGIME CHANGE AND REGIONAL INFLATION DYNAMICS: LOOKING THROUGH THE LENS OF SECTOR-LEVEL DATA FOR KOREA

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Abstract. This paper explores the impact of the adoption of inflation targeting (IT) on the dynamics of city-level inflation in Korea using both aggregate and sector-level data. When looking at aggregate regional inflation, we find that the mean, volatility and persistence fell in all cities in the wake of the monetary policy regime change, consistent with other evidence in the literature. Delving more deeply into the disaggregate data reveals additional insights however. For most of the changes we observe in the dynamics of regional inflation, we find that the aggregate effects are being driven primarily by sectors that fall into the 'Services' category. We posit that the impact of better anchored inflationary expectations is primarily on the less-traded services sectors of the economy, where the domestic monetary policy framework has a relatively larger influence. When it comes to the increased co-movement observed across regions under an IT regime, however, it is the 'Commodities' sectors rather than 'Services' that are responsible, probably because services inflation becomes relatively more influenced by local factors once it has stabilized within the target range. Therefore, adoption of IT may not necessarily increase all measures of regional synchronization even when the goal of better-anchored inflationary expectations is achieved.

1. INTRODUCTION

There is a large literature examining the impact of inflation targeting (IT) on inflation performance at the aggregate level (e.g. Mishkin and Schmidt-Hebbel, 2007; Choi *et al.*, 2011). The basic result in the empirical literature is that the adoption of IT is typically followed by a fall in both the level and volatility of macroeconomic measures of inflation such as the CPI, especially in emerging economies. Moreover, a fall in inflation persistence has often been noticed in IT countries, probably due to better-anchored inflationary expectations after an explicit announcement of an inflation target in the medium term. There is ample empirical evidence, however, of a significant degree of heterogeneity in the inflation dynamics of different economic sectors and different geographic regions (e.g. Bils and Klenow, 2004; Beck *et al.*, 2009). In fact, researchers looking at the impact of monetary policy actions have found substantially different responses to a common monetary policy across regions, with these differences often associated with regional differences in sectoral composition

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(e.g. Carlino and DeFina, 1998). Furthermore, recent studies using sectoral data have documented heterogeneous effects of a switch in monetary policy regime on the dynamics of disaggregate inflation (e.g. Choi and O'Sullivan, 2013). In light of the possible interface between sectoral and regional effects, it would be instructive to examine the impact of a change in the monetary policy regime using data disaggregated along both these dimensions in identifying the channels through which the adoption of IT might influence the macroeconomy. Given that large and persistent differences in regional inflation dynamics pose challenges for a one-size-fits-all monetary policy, it is important for policymakers to understand what drives inflation differentials across various regions within a nation. Because these differences may stem from diversity in sectoral composition or the segmentation of labour and product markets, examining the heterogeneity of regional inflation data at the sectoral level seems promising in terms of providing useful policy implications.

The main objective of this study is to explore the responses of disaggregate regional and sectoral inflation measures to a change in monetary policy regime. Our analysis aims to provide evidence on: (i) the disparity in the regional-level response to a change in the national monetary policy regime and the impact on regional inflation co-movement; and (ii) the role of differences in sector-specific responses. This evidence can potentially provide additional insights into possible consequences of changing a country's monetary policy framework. To this end, we study the case of Korea with its official adoption of IT in 1998.[1]

As an emerging market economy, Korea is an interesting country to study, especially given its degree of openness and its potential role as a case study for other Asian economies considering the adoption of IT or that recently adopted IT (such as India). Moreover, the availability of city-level inflation data for various sectors over a reasonably long time span permits a rich analysis of the issues at hand, including the analysis of regional responses across various sectors. Although this is not the first study of the impact of IT adoption on Korea, we are not aware of another study that looks simultaneously at the variation across sectors and regions of the impact of the monetary regime change.[2] Kim and Park (2006) provide an excellent general overview of the effect of IT adoption on Korea, but they use aggregate headline inflation only. Tillmann (2013) studies extensively the impact of IT adoption at the regional level in Korea, but focuses on the response of inflation persistence at the aggregate level without considering sectoral-level developments. In general, these studies conclude that IT was successful in stabilizing inflation in Korea, but not much is known about the extent to which this stabilization was felt broadly at a

[1] Korea formally adopted inflation targeting in late 1997 when the Bank of Korea (BOK) law was revised to explicitly announce a target rate of inflation from April 1998 (see Kim and Park, 2006). At the outset, the country followed a version of IT known as flexible inflation targeting, with M3 still being used as an intermediate target, prior to becoming a 'full-fledged' inflation targeter in 2001. Given that the impact on inflationary expectation formation is most likely to have occurred from the outset, we use April 1998 as the formal adoption date for our analysis.

[2] A similar line of research looking at both regional and sectoral disaggregation has been conducted in a cross-national context among EU countries (e.g. Lunnemann and Matha, 2004), which differs from our focus on intra-national analysis.

disaggregate level. Therefore, it seems a step in the right direction to extend their analyses by looking at the behaviour of regional price data across different sectors, especially in light of the growing interest in sectoral heterogeneity in recent studies (e.g. Carvalho and Nechio, 2011) and the potential link between inflation differentials and welfare costs (e.g. Beck *et al.*, 2009).

Our analysis confirms that the adoption of IT in Korea had a significant effect on regional inflation dynamics, reducing the mean, volatility and persistence of aggregate regional measures and leading to a decline in the cross-city dispersion of inflation. When data disaggregated by sector are examined, they reveal a much greater degree of heterogeneity across sectors than across regions. In sectors where price movements are dominated by quite forward-looking price-setting behaviour, better anchoring of inflationary expectations with the adoption of IT plays a bigger role and resulted in a greater response to the regime change. In contrast, in other sectors where prices are largely determined in global markets, inflation dynamics are governed primarily by external shocks and, therefore, are less responsive to the change in the domestic monetary policy regime. Between the broad sectoral sub-aggregates of commodities versus services, for instance, the change in both the level and volatility of inflation in the wake of IT adoption was much greater for services. For some commodity sectors, city-level inflation rates often fluctuated far outside the target range. This may reflect fundamental differences in the major determinants of the inflation processes in the various sectors.

We also find that the IT adoption in Korea appears to have brought about changes in how inflationary expectations are formed and, in particular, how well-anchored these expectations are, as reflected in measures of inflation persistence. As claimed by Benati (2008), the implementation of a stable monetary policy regime with a well-defined nominal anchor, such as IT, contributes to a decrease in inflation persistence in most developed countries. This finding is borne out in the aggregate regional data for Korea, with persistence falling after the adoption of IT. There was a wide variation across sectors, however, in the response of the city-level inflation, with inflation in some sectors becoming more persistent under IT. The cross-sector heterogeneity is also evident in measures of co-movements and synchronization among regional inflation rates based on spatial correlation. When we employ a factor model framework to further explore the extent to which regional inflation is explained by nationwide or city-specific factors, we find that the share of the variation in aggregate regional inflation due to the national factor increases under the IT regime. When this factor model is applied to sectoral-level data, however, it becomes apparent that the impact of IT adoption is far from uniform, supporting the importance of looking beyond the regional aggregate measures. Given the variation in the sectoral make-up of different regions of the country, sector-specific characteristics may also contribute to understanding variation in aggregate regional inflation. This not only adds to the pervasive evidence of diversity in the response across sectors of the economy to the adoption of IT, but also highlights the potential for gaining a richer understanding of the impact of IT adoption by looking beyond aggregate measures of inflation.

The remainder of the paper is laid out as follows. Section 2 describes the data and provides a preliminary analysis of the heterogeneous patterns observed in the sub-aggregate inflation series. Section 3 extends this analysis using more formal econometric techniques, including structural break tests, an examination of the dynamic properties of the inflation series, and a look at spatial correlation based on a modified Moran's I. This section also delves into the heterogeneous response of regional inflation within the framework of common factor model analysis. Section 4 concludes. The Appendix contains a detailed description of the data.

2. DATA AND PRELIMINARY ANALYSIS

2.1. *Data*

We use monthly indices of the overall consumer price index (CPI) and its sub-aggregates for 30 cities in Korea.[3] We focus on two levels of disaggregation of the CPI here: one that distinguishes between 'Commodities' and 'Services' and the other with a finer-level of disaggregation that includes 12 one-digit sub-categories. Our choice of CPI sectors was motivated by the desire to obtain sufficiently long continuous data series for monthly price indices in as many cities as possible to facilitate our regional analysis. The underlying data have been collected from the Korean Statistical Information Service (KOSIS) homepage at http://kosis.kr/. In our analysis, we consider both the annualized monthly percentage change and 12-month inflation rates in the CPI and its components, after seasonally adjusting the indices using the Census X12-ARIMA method. Unless noted otherwise, we concentrate on the annualized monthly inflation rates.

The Appendix Tables present sectoral and city-level information for the sub-aggregate series that span January 1990 to August 2014, resulting in 296 monthly observations for each of the 30 cities across 14 CPI sectors. As can be seen from Table A.2, the weights attributed to the disaggregate CPI series vary to a non-negligible degree across cities: for example, the weight for 'Commodities' ranges from 43.8 to 51.8% with 'Services' accounting for the balance. At the finer level of disaggregation, a relatively wide range is seen in the weight given to 'Rental for housing' (Item 12), as might be expected, with the weight in Seoul (SEL) being almost four times as large as that in Suncheon (SCN).

2.2. *Preliminary analysis*

Table 1 presents summary statistics on inflation across cities and across sectors for the full sample period and for two subsample periods, using the official

[3] The cities included are: Andong (AND), Boryeong (BOR), Bucheon (BCN), Busan (BSN), Cheonan (CAN), Cheongju (CHE), Chuncheon (CCN), Chungju (CHU), Daegu (DGU), Daejeon (DJN), Gangneung (GNG), Gumi (GUM), Gunsan (GSN), Gwangju (GWJ), Gyeongju (GNJ), Incheon (ICN), Jeju-do (JJD), Jeonju (JEN), Jinju (JIN), Mokpo (MKP), Namwon (NWN), Pohang (PHN), Seongnam (SGN), Seoul (SEL), Suncheon (SCN), Suwon (SWN), Uijeongbu (UJB), Ulsan,(ULS), Wonju (WNJ) and Yeosu (YSU).

Table 1. Summary statistics of citywide inflation in Korea

	Full sample			1990:M1–1998:M3			1998:M4–2014:M8		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
By cities									
AND	3.67	–0.08 (7)	7.32 (10)	5.95	0.52 (7)	10.27 (10)	2.64	–0.35 (7)	6.00 (10)
BOR	3.94	0.27 (7)	7.94 (10)	6.31	0.44 (7)	10.89 (10)	2.87	0.19 (7)	6.61 (10)
BCN	3.94	0.27 (7)	7.88 (10)	6.18	0.82 (7)	11.80 (10)	2.93	0.02 (7)	6.12 (10)
BSN	4.02	0.23 (7)	7.53 (10)	6.31	0.10 (7)	10.70 (10)	2.99	0.28 (7)	6.15 (4)
CAN	3.83	0.25 (7)	7.61 (10)	6.07	0.10 (7)	10.78 (10)	2.83	0.32 (7)	6.19 (10)
CHE	3.72	0.03 (7)	7.86 (10)	5.66	0.06 (7)	11.55 (10)	2.85	0.01 (7)	6.20 (10)
CCN	3.93	0.26 (7)	7.53 (10)	6.25	–0.16 (7)	10.47 (10)	2.89	0.45 (7)	6.21 (10)
CHU	3.76	0.05 (7)	7.49 (10)	5.80	–0.32 (7)	10.46 (10)	2.85	0.21 (7)	6.16 (10)
DGU	3.78	–0.14 (7)	7.51 (10)	6.01	–0.20 (7)	11.04 (10)	2.78	–0.11 (7)	5.92 (10)
DJN	4.00	0.01 (7)	7.61 (10)	6.58	–0.11 (7)	11.34 (10)	2.84	0.07 (7)	5.94 (10)
GNG	3.87	–0.06 (7)	8.06 (10)	5.88	–0.23 (7)	12.34 (10)	2.97	0.02 (7)	6.22 (5)
GUM	3.78	–0.01 (7)	7.51 (10)	5.82	–0.31 (7)	10.93 (10)	2.87	0.12 (7)	5.98 (10)
GSN	3.93	–0.02 (7)	7.59 (10)	6.12	–0.26 (7)	11.05 (10)	2.95	0.09 (7)	6.03 (10)
GWJ	3.88	0.08 (7)	7.32 (10)	6.03	–0.16 (7)	10.53 (10)	2.91	0.19 (7)	6.12 (4)
GNJ	3.74	–0.12 (7)	7.61 (10)	5.92	–0.16 (7)	11.03 (10)	2.76	–0.10 (7)	6.07 (10)
ICN	3.82	0.23 (7)	7.63 (10)	5.92	0.26 (7)	11.36 (10)	2.88	0.22 (7)	5.95 (10)
JJD	3.84	–0.26 (7)	8.21 (10)	6.13	–0.40 (7)	12.13 (10)	2.81	–0.19 (7)	6.45 (10)
JEN	3.97	–0.25 (7)	7.58 (10)	6.47	–0.96 (7)	11.03 (10)	2.85	0.06 (7)	6.39 (4)
JIN	3.67	0.27 (7)	7.57 (10)	5.77	0.82 (7)	11.30 (10)	2.73	0.02 (7)	5.90 (10)
MKP	3.95	0.23 (7)	7.44 (10)	6.25	0.51 (7)	10.78 (10)	2.92	0.10 (7)	5.95 (10)
NWN	3.86	–0.10 (7)	8.29 (10)	5.79	–0.14 (7)	12.22 (10)	3.00	–0.09 (7)	6.53 (10)
PHN	3.62	0.18 (7)	7.55 (10)	5.77	0.26 (7)	11.01 (10)	2.66	–0.35 (12)	6.00 (10)
SGN	4.00	–0.01 (7)	7.88 (10)	6.38	–0.20 (7)	11.55 (10)	2.92	0.08 (7)	6.24 (10)
SEL	3.84	0.01 (7)	8.21 (10)	5.68	–0.20 (7)	12.08 (10)	3.02	0.10 (7)	6.47 (10)
SCN	3.86	0.06 (7)	7.58 (10)	5.96	0.21 (7)	10.84 (10)	2.92	0.00 (7)	6.93 (4)
SWN	4.04	0.15 (7)	7.79 (10)	6.37	0.32 (7)	11.46 (10)	2.99	0.07 (7)	6.14 (10)
UJB	3.97	0.08 (7)	7.90 (10)	6.08	0.18 (7)	11.62 (10)	3.02	0.03 (7)	6.23 (10)
ULS	3.75	0.13 (7)	7.98 (10)	5.29	–0.38 (7)	12.35 (10)	3.06	0.35 (7)	6.02 (10)
WNJ	3.93	–0.04 (7)	7.84 (10)	6.08	–0.22 (7)	11.32 (10)	2.96	0.04 (7)	6.28 (10)
YSU	3.73	–0.02 (7)	7.21 (10)	5.45	0.09 (7)	9.85 (10)	2.95	–0.06 (7)	6.02 (10)
By CPI items									
All items	3.85	3.62 [PHN]	4.04 [SWN]	6.01	5.29 [ULS]	6.58 [DJN]	2.89	2.64 [AND]	3.06 [ULS]
Commodities (1)	3.85	3.69 [AND]	4.08 [JEN]	5.01	4.26 [GNG]	5.64 [JEN]	3.33	3.10 [AND]	3.53 [SEL]
Services (2)	4.07	3.73 [PHN]	4.42 [SWN]	7.59	6.44 [ULS]	8.38 [GNG]	2.49	2.09 [PHN]	2.79 [SWN]
Agricultural products (3)	4.97	4.46 [YSU]	5.57 [BCN]	7.19	5.67 [SEL]	8.29 [CHU]	3.98	3.13 [GNJ]	4.79 [GUM]
Stock products (4)	4.60	3.82 [SGN]	5.55 [SCN]	2.60	0.07 [SGN]	4.63 [UJB]	5.49	4.82 [CHU]	6.93 [SCN]
Marine products (5)	5.24	4.10 [YSU]	7.24 [JEN]	7.45	4.38 [SEL]	9.92 [GSN]	4.25	2.37 [CNA]	6.22 [GNG]
Processed food (6)	4.83	4.52 [PHN]	5.18 [YSU]	6.36	5.58 [PHN]	6.97 [SCN]	4.14	3.75 [AND]	4.71 [YSU]
Durable goods (7)	0.06	–0.26 [JJD]	0.27 [BCN]	0.01	–0.96 [JEN]	0.82 [JIN]	0.08	–0.35 [AND]	0.45 [CCN]
Textile products (8)	2.89	2.51 [WNJ]	3.34 [BOR]	3.20	2.17 [WNJ]	4.64 [BOR]	2.74	2.59 [ICN]	2.86 [AND]
Publications (9)	5.06	4.85 [SWN]	5.32 [CCN]	8.13	7.45 [SWN]	8.99 [CCN]	3.68	3.56 [GWJ]	3.76 [PHN]
Oils (10)	7.70	7.21 [YSU]	8.29 [NWN]	11.20	9.85 [YSU]	12.35 [ULS]	6.13	5.88 [GWJ]	6.61 [BOR]
Other industrial products (11)	3.62	3.34 [ULS]	3.89 [ICN]	4.69	4.08 [YSU]	5.39 [JEN]	3.14	2.89 [JIN]	3.46 [ICN]
Rental for housing (12)	2.46	1.42 [JIN]	3.61 [SGN]	5.26	3.29 [CHU]	8.77 [GNJ]	1.20	–0.35 [PHN]	2.57 [SGN]
Public services (13)	3.93	3.43 [GNJ]	4.39 [SGN]	7.09	5.87 [GNJ]	8.17 [AND]	2.50	2.03 [JJD]	2.83 [SWN]
Eating out (14)	4.28	3.72 [JIN]	4.77 [CHU]	8.01	6.50 [JIN]	9.36 [BOR]	2.60	2.26 [SGN]	2.97 [ULS]

Entries are the annualized monthly inflation rates. Entries inside square brackets and parenthesis respectively represent cities and disaggregate CPI items.

adoption date of IT (April 1998) as the break point. Looking across the two subsamples, we observe a notable decline in mean inflation in each city after IT adoption. More importantly, the cross-city dispersion of mean inflation significantly dropped as well, perhaps indicating that the change in monetary policy regime has contributed to intra-national convergence of city inflation rates in Korea.

The bottom panel of the table reveals considerable variation in regional inflation across disaggregate CPI items. It is worth noting that disaggregate inflation is higher than the headline inflation rate in the majority of sectors (in 10 out of 14 disaggregate items) and that disaggregate inflation series display a larger variation across cities compared to the aggregate counterparts. These patterns are also apparent in each of the subsample periods under consideration. More interestingly, there is a marked reduction in mean inflation after IT adoption in almost all the series considered, consistent with a beneficial impact of IT.[4] In headline inflation ('All items'), for instance, the mean inflation rate dropped from more than 6% in the pre-IT period to below 3% in the post-IT period. The significant fall in mean inflation is also observed in all disaggregate items under study, with the exceptions of 'Stock products' (Item 4) and 'Durable goods' (Item 7). Our results indicate that the decline in mean inflation is greater for services than for commodities. Whereas mean inflation for 'Commodities' (Item 1) has declined from 5.01 to 3.33%, that for 'services' (Item 2) has dropped from 7.59 to 2.49%. This is in line with the recent finding by Choi and O'Sullivan (2013) that the adoption of IT in Canada exerted a stronger effect on the products whose prices are adjusted less frequently, such as services. It also accords well with the stylized fact that less tradeable categories, such as services, are more responsive to a change in the domestic policy regime than commodities, such as 'oils', whose price movements are largely influenced by global market developments. To view this through another lens, we plot in Figure 1 the empirical densities of city-level inflation before (dotted line) and after (solid line) IT adoption for each sector. While the distributions for some sectors become slimmer and clearly shift to the left after IT adoption, indicating lower and more stable inflation, distributions for other sectors show little movement between the pre-IT and post-IT periods. Given that the distribution shifts are more pronounced in service-related sectors, we posit that the lower and more stable aggregate inflation under the IT regime may have been driven by these sectors.

[4] Given that the introduction of IT in Korea coincided with the Asian Financial crisis, which had a profound effect on the Korean economy, the marked decline in the level of mean inflation in Korea could have been driven by the crisis. Looking beyond the level of inflation to other measures of inflation dynamics such as persistence, however, the overall patterns in the data appear to be consistent with a significant impact from the adoption of IT. While the impact of the crisis is likely to destabilize the formation of inflationary expectations and, therefore, lead to a rise in inflation persistence, our analysis in the paper points to the opposite impact, with persistence falling for most inflation series in the post-1997 period as inflation expectations become more firmly anchored toward an explicit target. This is in line with the finding by Gerlach and Tillmann (http://www.voxeu.org/article/inflation-targeting-matters-asia) that significant differences exist between ITers and non-ITers in Asia in terms of inflation persistence in the aftermath of the Asian financial crisis.

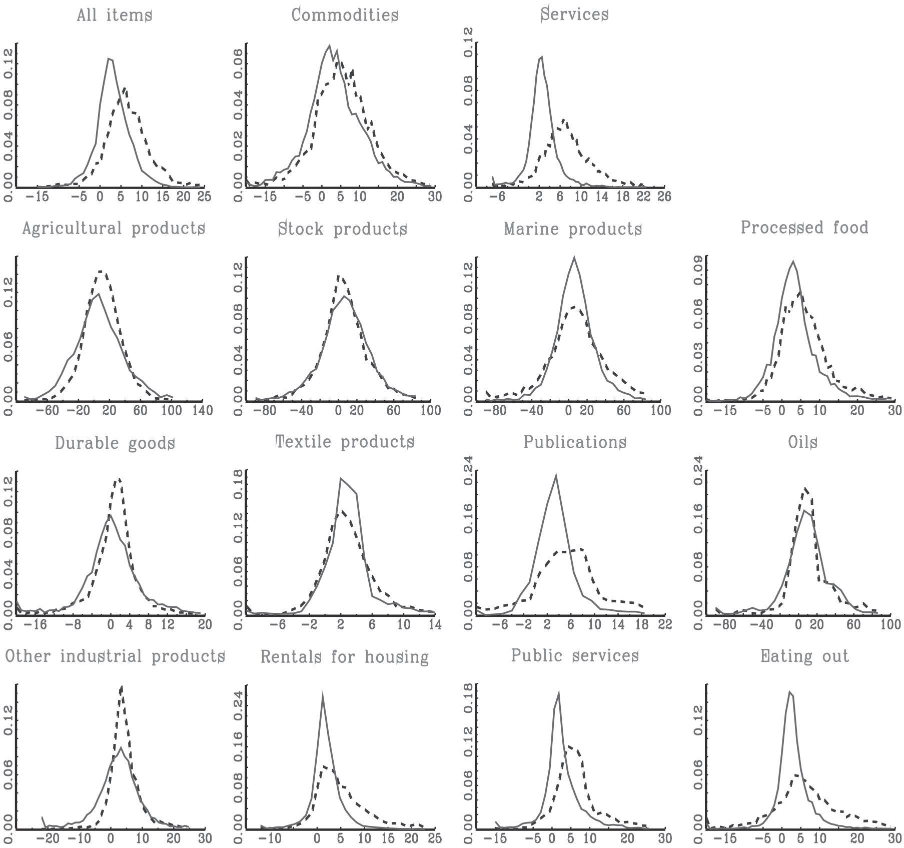

Figure 1. Empirical densities of sectoral inflation before (dotted line) and after (solid line) adoption of inflation targeting

To ensure the robustness of our findings to the choice of sample periods, we display the dynamic behaviour of sectoral inflation in Korean cities in the upper panel of Figure 2, which plots the evolution of city-level inflation for the 30 cities (dotted line) over time, along with the announced target range of inflation (solid line) adopted by the Bank of Korea (BOK) since April 1998.[5] A couple of features of the plots are noteworthy. First, the adoption of IT seems to have affected the dynamics of inflation differently in different sectors. Specifically, in sectors like ‘Public services’ and ‘Eating out’, inflation quickly fell to levels near the targeted range after the adoption of IT. In contrast, such a downward adjustment towards the target range is not seen in ‘Agricultural products’ and

[5] The BOK initially set a target inflation range of 8–10% which was drastically lowered to 2–4% in 1999 and it was re-adjusted to the range of 1.5–3.5% in 2000 before going back to the range of 2–4% in 2001. Since then, the BOK has maintained the medium-run inflation target around 3% with variable ranges between 2.0 and 4.0%.

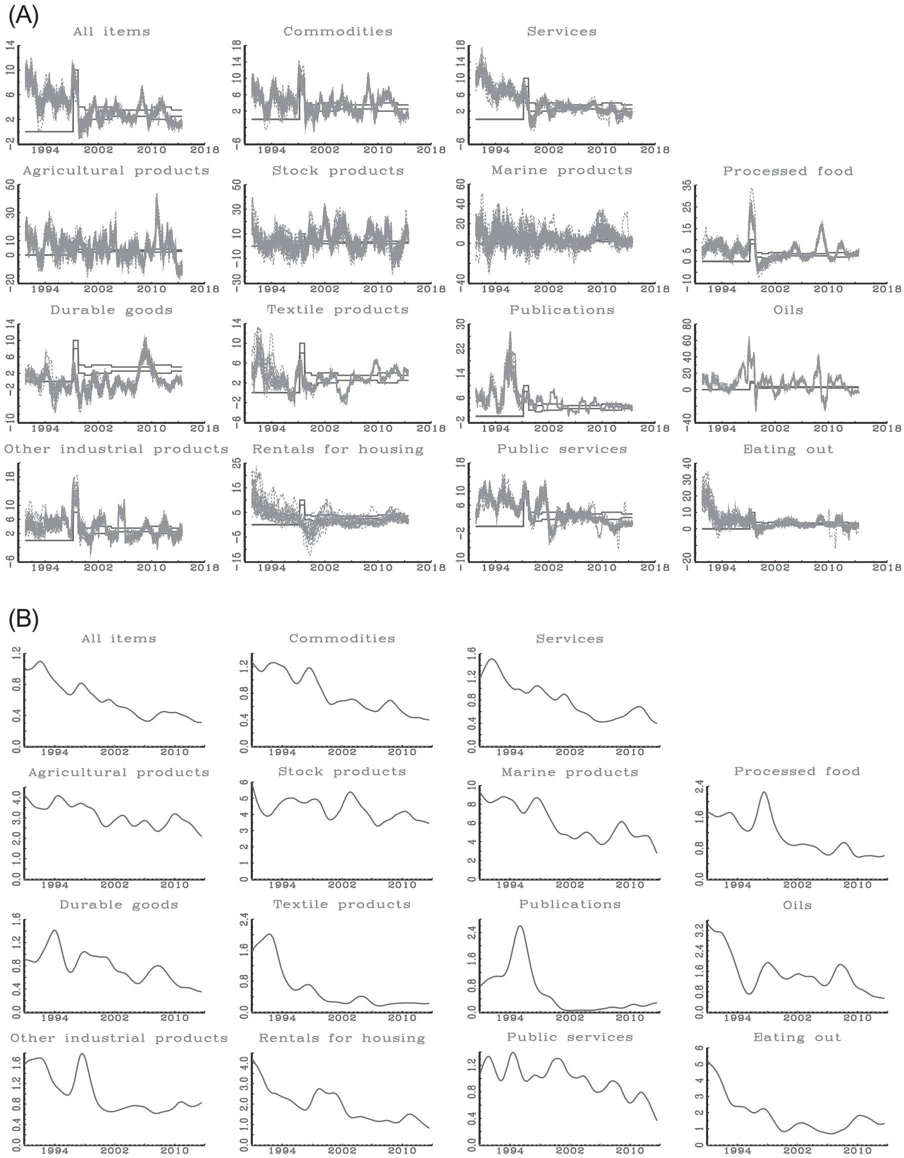

Figure 2. City-level inflation rates and cross-city dispersion

'Oils', where city-level inflation rates frequently deviate from the upper and lower bounds of the target range under the IT regime. Second, the plots show a high degree of co-movement across the 30 cities, especially in the headline inflation series and the highly aggregated commodities and services series. From the early 1990s onwards, headline inflation rates of all the cities appear to move together closely and, hence, seem to have a significant common component throughout the entire sample period. The degree of synchronization of inflation, however, appears to vary significantly across disaggregate CPI items. While city-level inflation is highly synchronized over time in 'Oils', other disaggregate CPI series, such as 'Marine products' (Item 5) and 'Rentals for housing' (Item 12), exhibit much less spatial synchronization, in view of the wide dispersion of city-level inflation rates.

An essentially similar story is told in the lower panel of Figure 2, which portrays the cross-city dispersion of inflation rates measured by the cross-sectional standard deviation over the sample period. While there is considerable heterogeneity across sectors in the measure of rolling spatial correlation among cities, a peak coinciding with the mid-1990s is observable in most sectors, reflecting the time of IT adoption. The dispersion of aggregate inflation across cities declined substantially in the late 1990s when the BOK adopted the new monetary policy regime. The decline in cross-city dispersion is not equally apparent in all CPI sectors, however, with a marked fall observed for manufacturing sectors such as 'Processed food' and 'Textile products' but no clear shift for sectors such as 'Agricultural products' and 'Stock products'.

Overall, our results strongly suggest that the adoption of IT contributed to a reduction in headline aggregate inflation at the regional level and to a reduction in the dispersion of city-level inflation. The nature and extent of the impact of IT adoption, however, is highly heterogeneous across sectors, with a clear distinction between the service and commodity sectors. This implies that aggregate inflation may mask huge cross-city differences in regional inflation dynamics at the sectoral level. A deeper understanding of the behaviour of city-level disaggregate inflation series, therefore, may prove useful in deciphering the channels through which the change in monetary policy regime operated. To throw additional light on this issue, we next turn to more formal econometric analysis.

3. ECONOMETRIC ANALYSIS OF CITY-LEVEL INFLATION BY SECTOR

The descriptive statistics discussed in the previous section imply that the adoption of IT has had a significant but heterogeneous impact on inflation dynamics at the sectoral/regional level. Given the limited information in summary statistics, we build on our analysis by utilizing a range of more formal econometric methods: (i) structural break tests; (ii) measures of the dynamic properties of city-level inflation; (iii) spatial co-movements of inflation; and (iv) common factor model analysis.

3.1. *Structural changes in inflation*

We first look at whether a regime change in monetary policy induces any structural shift in the dynamics of city-level inflation at both the aggregate and sectoral level. To the extent that a structural change in the mean of inflation reflects a shift in economic agents' perceptions of the policy target for inflation (e.g. Choi, 2010; Kozicki and Tinsley, 2001), one may expect to see evidence of structural changes in some or all of the city inflation series around the time of IT adoption. To this end, we utilize a battery of the popular multiple structural break tests developed by Bai and Perron (1998) in which break points are identified by applying the sequential multiple break point test to the 30 city-level inflation series in each CPI sector under study. Specifically, we consider the following two structural change models to identify a structural break in either the level or persistence of the city-level inflation series. For the level of inflation, we use a pure structural change model,

$$\pi_t = \delta^{(j)} + \varepsilon_t,$$

where the breaks are assumed to be in the mean of inflation ($\delta^{(j)}$). For the persistence of inflation we employ a partial structural change model of

$$\pi_t = x_t'\beta + z_t'\delta_j + u_t,$$

with $x_t = \{\pi_{t-2} \ldots, \pi_{t-p}\}$ and $z_t = \{c, \pi_{t-1}\}$ such that the coefficients for both the constant term and the first lag of inflation are allowed to shift.[6]

Figure 3 displays the frequency of estimated structural break points in the city inflation series for 'All items', 'Commodities' and 'Services' as well as for the entire 12 more finely disaggregated CPI items (labeled as '12 subaggregates'). In the case of mean inflation, a couple of structural break points stand out, as shown in the left-hand panels of Figure 3. For both aggregate regional inflation and the disaggregate series, structural breaks were most frequent around the time of IT adoption and no clear difference was discernible between the commodities and services categories.[7] When it comes to the persistence of the inflation series, the right-hand panels of Figure 3 show that the breaks were more frequent compared with the mean across both the aggregate and disaggregate series. Again, the dominant break point in the aggregate series was around the time of IT adoption. Looking at the disaggregate series, a distinction between the commodities and services sectors becomes apparent, with breaks more frequent in the persistence of services inflation around the time of IT adoption. It should be noted that a number of unsynchronized break points emerged in the disaggregate series throughout the whole sample, indicating that idiosyncratic sectoral influences on persistence remained even after the adoption of the IT regime.[8]

Overall, the Bai–Perron tests indicate that the introduction of inflation targeting coincided with structural changes in the dynamics of inflation in some

[6] The lag length (p) is selected by the AIC rule. Following the guidelines from Bai and Perron, the break is assumed not to occur during the initial 15% nor the final 15% of the sample period in testing for structural breaks. The maximum number of breaks is set to five and the minimum regime size is set to 5% of the sample. Robust standard errors are based on a quadratic spectral kernel HAC estimator with AR(1) prewhitening filters.

[7] Another dominant break point was evident in 2001, which may reflect the onset of an expansionary monetary policy stance by the Bank of Korea (e.g. Kim and Park, 2006).

[8] A detailed version of Figure 3 for each disaggregate CPI item is available at CY Choi's website: http://wweb.uta.edu/faculty/cychoi/research.htm.

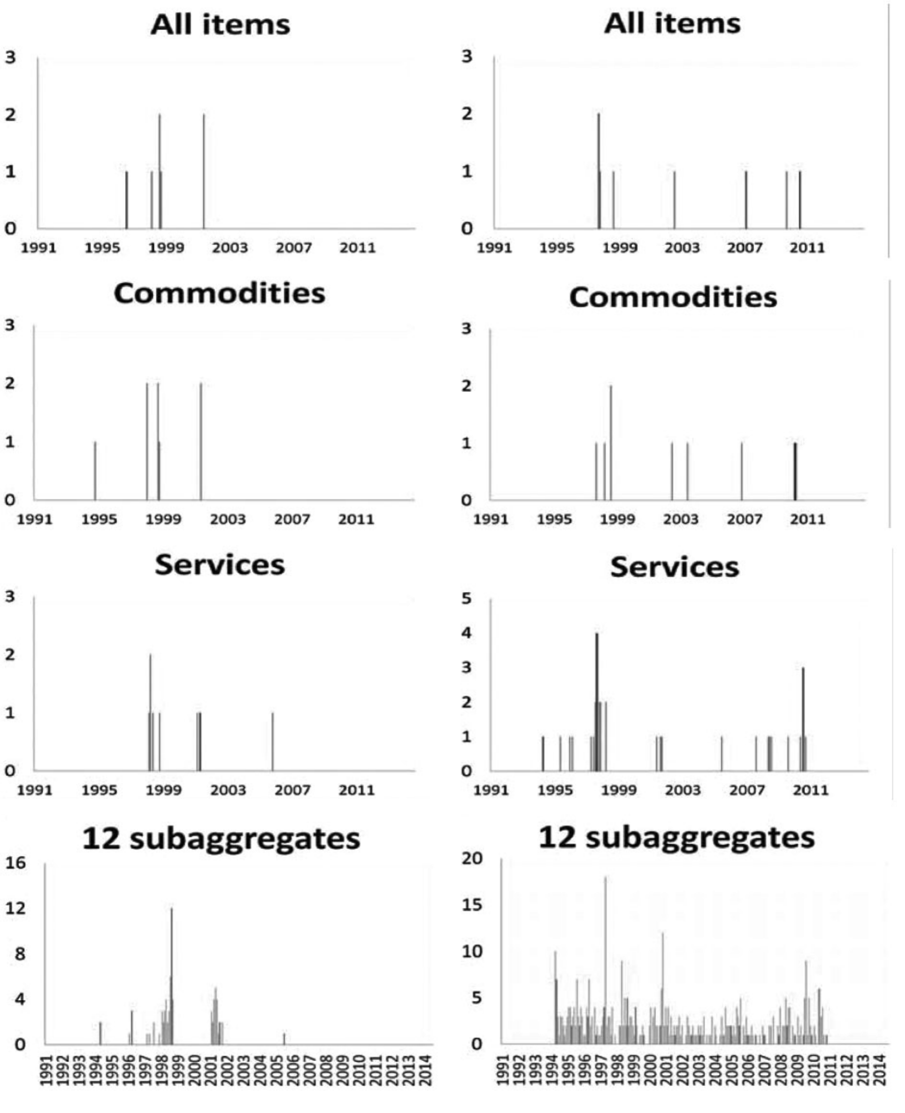

Figure 3. Frequency of estimated break points for mean inflation (left) and inflation persistence (right)

regions. In the case of persistence, the tests reveal a greater impact on the services sectors than on commodities, a finding that recurs throughout much of our analysis.

3.2. *Dynamic properties of inflation series*

In the literature, an enormous effort has been devoted to the analysis of the dynamic properties of inflation, with particular emphasis placed on volatility and persistence. Not surprisingly, the success of inflation targeting as a monetary policy framework is often assessed based on its impact on these dynamics.[9] Benati (2008), for example, studies a number of industrialized countries and finds a notable fall in inflation persistence in all the countries that have adopted IT. Because inflation persistence is known to reflect the formation of inflation expectations, such a decline in persistence under an IT regime is often attributed to a quick transition of inflation expectations formation from backward-looking indexation to a forward-looking mechanism after the establishment of a clearly defined nominal anchor (e.g. Erceg and Levin, 2003; Orphanides and Williams, 2005). While much of the existing research is concerned with the persistence of aggregate inflation, a growing literature at the disaggregate level, including Bilke (2005) and Altissimo *et al.* (2009), uncovers the presence of widely different degrees of inflation inertia across sectors, with sectoral rates generally exhibiting a much lower degree of inertia than their aggregate counterparts. Moreover, there is also some evidence that a change in monetary regime can impact regional differences in inflation persistence (e.g. Meller and Nautz, 2009; Tillmann, 2013).

In this section, we evaluate the extent to which IT exerts a measurable influence on inflation volatility and persistence in Korean cities. We first compare the temporal volatility of each city-level inflation series, measured using its standard deviation, for the sub-periods before and after the adoption of IT. For aggregate regional inflation, we observe a marked reduction in volatility after the regime change and this decrease in aggregate inflation volatility is also observed in each of the 30 cities (see Table 3). As a result, there is a noticeable narrowing of the cross-city dispersion in the volatility of aggregate inflation.[10] While the volatility of monthly inflation for both 'Commodities' and 'Services' fell in every city, the data in Tables 2 and 3 again point to a relatively greater impact on the services sector. In fact, Table 2 shows that for some commodity sectors such as 'Agricultural Products', volatility actually increased in the post-IT period. This can be viewed as saying that while a consistent pattern emerged across regions in the behaviour of aggregate inflation volatility after the monetary regime change, the more disaggregate data indicate a relatively greater response in the services sector.

For inflation persistence, we use the reduced-form (intrinsic) persistence of each city-level inflation series measured by the of sum of autoregressive coefficients (SARC) in the AR(p) representation,

[9] See, for example, Mishkin and Schmidt-Hebbel (2007) on the reduction of inflation volatility in countries that adopted IT and Altissimo *et al*. (2006), Benati (2008) and Levin and Piger (2004) on the impact of monetary policy regime change on the persistence of the inflation process.

[10] The Asian financial crisis and its aftermath no doubt also contributed to the stabilization of inflation in the second sub-period. To further investigate the timing of the fall in volatility, we plot 5-year rolling standard deviations of the monthly inflation rates for the 30 cities, computed using a centred 61-month window, showing the median, 25th and 75th percentiles. The plot for aggregate inflation shows a sharp, almost discrete decline in city-level inflation volatility around 1998, coinciding well with the official adoption date of IT. These plots are also available at the aforementioned author's website.

Table 2. Volatility and persistence of city inflation by consumer price items

	Full sample				Pre-IT period				Post IT-period			
	12-month		month-to-month		12-month		month-to-month		12-month		month-to-month	
	ALL	(min, max)	ALL	(min, max)	ALL	(min, max)	ALL	(min, max)	ALL	(min, max)	ALL	(min, max)
Volatility												
All items	2.1	(2.0, 2.6)	4.1	(4.0, 5.6)	1.8	(1.5, 2.9)	4.7	(4.7, 7.3)	1.4	(1.3, 2.0)	3.3	(3.0, 4.4)
Commodities	2.3	(2.1, 3.0)	7.0	(6.9, 8.8)	2.3	(1.7, 3.5)	7.6	(7.6, 11.0)	2.2	(2.1, 2.8)	6.5	(6.3, 8.0)
Services	2.8	(2.5, 3.5)	3.7	(3.7, 5.7)	2.2	(1.5, 3.5)	4.0	(3.6, 7.1)	1.3	(1.2, 1.8)	2.1	(2.1, 4.4)
Agricultural products	7.6	(7.4, 9.1)	28.0	(28.0, 36.3)	6.5	(5.7, 9.6)	19.3	(19.3, 31.7)	7.9	(7.7, 9.6)	31.5	(31.3, 40.3)
Stock products	7.0	(6.8, 9.3)	20.9	(20.9, 38.2)	4.7	(4.2, 9.6)	18.8	(18.8, 37.3)	7.6	(6.8, 10.3)	22.0	(22.0, 38.7)
Marine products	5.1	(5.1, 10.9)	14.7	(14.7, 40.8)	6.8	(6.6, 14.9)	18.1	(18.1, 57.0)	4.1	(4.1, 9.8)	12.6	(12.6, 32.4)
Processed food	4.2	(4.1, 6.1)	7.1	(7.1, 10.6)	3.1	(2.9, 4.8)	9.2	(9.1, 15.2)	4.5	(4.4, 6.6)	5.3	(5.3, 7.5)
Durable goods	2.5	(2.3, 2.9)	6.2	(6.0, 7.4)	1.8	(1.5, 3.3)	4.9	(4.1, 7.2)	2.8	(2.4, 3.1)	6.8	(6.3, 8.2)
Textile products	1.9	(1.7, 2.8)	4.7	(4.6, 5.9)	2.4	(1.8, 4.1)	6.0	(5.5, 8.6)	1.6	(1.6, 1.8)	3.9	(3.7, 4.6)
Publications	3.6	(3.2, 4.3)	8.6	(8.3, 10.8)	4.6	(3.4, 6.1)	11.3	(10.7, 16.1)	1.7	(1.5, 1.8)	6.3	(6.2, 6.5)
Oils	11.2	(10.7, 12.2)	37.7	(35.7, 41.2)	11.9	(11.3, 13.0)	52.9	(49.4, 57.8)	10.5	(9.9, 11.5)	26.8	(25.0, 30.1)
Other industrial products	2.9	(2.6, 3.7)	9.2	(9.2, 11.2)	1.9	(1.8, 3.1)	7.5	(7.1, 10.9)	3.1	(2.6, 3.9)	9.8	(9.5, 11.6)
Rental for housing	3.1	(2.2, 5.1)	3.7	(3.7, 11.9)	3.0	(1.9, 7.2)	4.2	(4.2, 19.5)	2.4	(1.1, 3.8)	2.6	(2.4, 6.6)
Public services	3.3	(2.9, 4.0)	6.2	(6.2, 9.0)	2.0	(1.7, 2.9)	6.8	(6.7, 10.2)	2.8	(2.4, 3.3)	5.3	(5.0, 9.0)
Eating out	4.1	(3.5, 6.4)	5.7	(5.7, 17.0)	5.2	(4.3, 9.8)	7.7	(7.7, 21.8)	1.6	(1.6, 3.0)	2.7	(2.7, 16.2)
Persistence												
All items	0.925	(0.894, 0.948)	0.620	(0.235, 0.631)	0.913	(0.837, 0.933)	0.625	(−0.087, 0.628)	0.828	(0.772, 0.898)	0.071	(−0.098, 0.245)
Commodities	0.853	(0.814, 0.904)	0.281	(0.020, 0.333)	0.900	(0.740, 0.937)	0.206	(−0.331, 0.529)	0.859	(0.790, 0.887)	−0.027	(−0.442, 0.130)
Services	0.977	(0.934, 0.981)	0.858	(0.608, 0.858)	0.955	(0.864, 0.977)	0.680	(−0.275, 0.752)	0.925	(0.815, 0.927)	0.570	(−0.134, 0.695)
Agricultural products	0.823	(0.756, 0.867)	−0.029	(−0.346, 0.060)	0.866	(0.749, 0.890)	0.031	(−0.425, 0.295)	0.835	(0.785, 0.883)	−0.303	(−0.539, −0.022)
Stock products	0.880	(0.781, 0.896)	0.097	(−0.490, 0.182)	0.771	(0.670, 0.871)	−0.253	(−0.671, 0.191)	0.862	(0.802, 0.916)	0.107	(−0.563, 0.169)
Marine products	0.840	(0.690, 0.911)	0.070	(−0.587, 0.215)	0.833	(0.684, 0.919)	0.288	(−0.589, 0.288)	0.930	(0.721, 0.933)	0.052	(−0.961, 0.360)
Processed food	0.950	(0.896, 0.954)	0.566	(0.380, 0.586)	0.964	(0.704, 1.036)	0.452	(0.252, 1.014)	0.941	(0.877, 0.941)	0.708	(0.495, 0.744)
Durable goods	0.932	(0.903, 0.947)	0.406	(0.033, 0.422)	0.926	(0.803, 0.938)	0.267	(−0.052, 0.493)	0.945	(0.923, 0.952)	0.329	(0.127, 0.480)
Textile products	0.930	(0.901, 0.960)	0.355	(0.023, 0.547)	0.947	(0.858, 0.966)	0.354	(−0.245, 0.440)	0.923	(0.910, 0.948)	0.512	(0.072, 0.561)
Publications	0.919	(0.887, 0.946)	0.393	(0.048, 0.524)	0.931	(0.822, 0.935)	0.358	(−0.067, 0.552)	0.805	(0.800, 0.815)	−0.133	(−0.195, −0.086)
Oils	0.835	(0.819, 0.846)	−0.006	(−0.193, 0.093)	0.938	(0.907, 1.001)	−0.096	(−0.127, 0.113)	0.809	(0.753, 0.825)	0.258	(0.177, 0.300)
Other industrial products	0.899	(0.812, 0.912)	−0.047	(−0.273, 0.145)	0.837	(0.731, 0.927)	0.436	(−0.150, 0.572)	0.882	(0.774, 0.887)	−0.288	(−0.525, −0.216)
Rental for housing	0.987	(0.928, 0.987)	0.906	(0.340, 0.906)	0.969	(0.774, 0.984)	0.738	(−0.543, 0.890)	0.979	(0.872, 0.979)	0.871	(−0.076, 0.871)
Public services	0.949	(0.926, 0.967)	0.657	(0.389, 0.657)	0.864	(0.801, 0.908)	0.117	(−0.356, 0.272)	0.925	(0.877, 0.931)	0.487	(0.096, 0.489)
Eating out	0.971	(0.835, 0.971)	0.816	(0.120, 0.816)	0.956	(0.848, 0.956)	0.759	(−0.196, 0.765)	0.952	(0.814, 0.952)	0.571	(−0.734, 0.586)

Volatility represents temporal volatility of inflation rates measured by standard deviation. '(min,max)' represent the minimum and maximum values among 30 cities. MUB (median unbiased) estimates are for the sum of the AR coefficient in the AR(p) model where the lag length (p) is selected using the Bayesian information criterion. Both MUB and the 90% confidence bands are estimated with Hansen's (1999) grid bootstrap. The table reports Hansen's (1999) mean unbiased estimator of the sum of autoregressive coefficients ρ and the bootstrapped 90% confidence bands based on 101 grid points and 999 replications. IT, inflation targeting.

Table 3. Change in inflation dynamics by city

	Volatility (monthly inflation)						Persistence (12-month inflation)					
	All items		Commodities		Services		All items		Commodities		Services	
Cities	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
ALL	4.69	3.30	7.65	6.52	4.04	2.07	0.913	0.828	0.900	0.859	0.955	0.925
AND	4.79	3.03	7.84	6.30	5.05	2.42	0.887	0.851	0.877	0.887	0.956	0.866
BOR	5.67	3.60	8.89	6.82	4.86	2.29	0.899	0.831	0.792	0.829	0.919	0.912
BCN	5.40	3.44	8.69	6.88	4.32	2.26	0.919	0.801	0.804	0.840	0.957	0.913
BSN	5.07	3.72	7.76	7.17	4.94	2.80	0.890	0.814	0.908	0.844	0.962	0.868
CNA	5.14	3.42	8.86	6.89	4.38	2.57	0.845	0.867	0.768	0.867	0.940	0.927
CHE	6.12	3.90	10.12	7.43	4.50	2.70	0.878	0.840	0.864	0.855	0.954	0.860
CCN	5.61	3.85	7.85	7.19	6.00	2.77	0.871	0.888	0.845	0.877	0.931	0.874
CHU	5.03	3.58	8.14	6.96	3.56	2.79	0.880	0.814	0.852	0.847	0.924	0.910
DGU	5.85	4.09	9.85	6.74	5.36	4.43	0.882	0.813	0.827	0.859	0.964	0.880
DJN	5.50	3.71	7.98	7.72	5.78	2.65	0.860	0.844	0.834	0.857	0.977	0.911
GNG	5.93	3.59	9.46	7.18	5.19	2.96	0.912	0.841	0.870	0.880	0.945	0.903
GUM	5.83	3.88	9.23	7.27	5.08	2.89	0.881	0.811	0.853	0.850	0.910	0.853
GSN	6.46	3.88	9.74	6.93	5.15	3.29	0.841	0.807	0.786	0.848	0.925	0.897
GWJ	6.68	4.44	9.87	7.73	6.94	3.71	0.876	0.832	0.848	0.863	0.945	0.906
GNJ	5.57	3.83	8.90	6.98	4.03	2.73	0.853	0.848	0.817	0.840	0.935	0.903
ICN	6.45	4.18	10.10	7.64	5.05	2.74	0.893	0.822	0.798	0.848	0.941	0.914
JJD	7.25	4.12	10.98	7.29	5.82	3.20	0.915	0.834	0.887	0.879	0.952	0.847
JEN	6.30	4.29	9.88	7.47	5.61	2.96	0.889	0.895	0.850	0.826	0.923	0.893
JIN	5.51	4.10	9.02	7.31	4.19	3.42	0.933	0.779	0.925	0.790	0.944	0.887
MKP	6.05	4.44	9.19	7.88	5.46	3.54	0.853	0.865	0.868	0.863	0.935	0.864
NWN	6.52	4.19	9.42	7.71	6.84	3.69	0.849	0.823	0.740	0.874	0.952	0.869
PHN	6.30	4.14	9.34	7.72	5.84	2.99	0.875	0.820	0.886	0.843	0.864	0.852
SGN	6.11	4.05	9.73	7.61	5.56	3.22	0.837	0.839	0.856	0.839	0.947	0.898
SEL	6.33	4.02	9.32	7.69	5.58	2.89	0.932	0.835	0.937	0.866	0.932	0.918
SCN	5.89	4.07	9.38	7.51	5.25	2.98	0.899	0.772	0.851	0.834	0.943	0.872
SWN	6.17	4.38	8.92	7.97	6.21	3.28	0.864	0.898	0.848	0.846	0.964	0.907
UJB	5.83	4.38	8.23	7.59	5.75	3.24	0.864	0.844	0.822	0.841	0.939	0.900
ULS	6.27	4.40	8.73	8.05	7.15	2.71	0.925	0.885	0.889	0.834	0.941	0.860
WNJ	7.03	4.07	10.15	7.59	5.76	2.74	0.847	0.832	0.822	0.873	0.923	0.906
YSU	5.21	3.68	8.06	7.27	6.15	2.72	0.863	0.808	0.813	0.862	0.947	0.815

'Pre' and 'post' respectively denote the pre-IT period spanning 1990:M1–1998:M3 and the post-IT period of 1998:M4–2014:M8. IT, inflation targeting.

$$\pi_t = \beta_0 + \sum_{j=1}^{p} \beta_j \pi_{t-j} + \varepsilon_t = \alpha + \rho \pi_{t-1} + \sum_{k=1}^{p-1} \zeta_k \Delta \pi_{t-k} + \varepsilon_t, \tag{1}$$

where $\rho = \sum_{j=1}^{p} \beta_j$ denotes the SARC and the lag length (p) is selected by using the Bayesian information criterion. To deal with the well-known downward small sample bias embedded in the OLS estimation of ρ, we follow the common practice in previous studies (e.g. Clark, 2006; Benati, 2008) and employ Hansen's (1999) 'grid bootstrap'-based median-unbiased (MUB) estimator.

The first thing to note is that regional aggregate inflation becomes significantly less persistent in the wake of IT adoption, with the MUB estimate of ρ in equation 1 for monthly inflation falling from 0.63 to 0.07 across the two subperiods, as reported in Table 2. This fall in persistence is evident in 24 of the 30 cities (Table 3). Our results reinforce the view of Benati (2008) that inflation targeting is successful at anchoring inflationary expectations by helping to dampen shocks which might otherwise have initiated a persistent departure from explicit target values. It is particularly interesting to look at the behaviour of persistence across sectors, given the wide range spanned by the MUB estimates. The disparity between the commodities and services sectors over the full sample is stark (0.28 versus 0.85 for monthly inflation) and, as in volatility, the change between subsamples is more pronounced in the services sector. The greater fall in persistence in the services sector is also consistent with the result reported in the previous subsection pointing to more frequent structural breaks in services versus commodities inflation around the time of IT adoption. Our findings are not very surprising in light of the characteristics of commodities markets, in which prices are typically determined by ever-changing global market conditions and, hence, are subject to less influence from national monetary policy decisions. This is especially the case for some commodities sectors such as 'Agricultural Products' and 'Oils', where the MUB estimates are so low, or even negative, that their inflation processes are almost indistinguishable from white noise.

To sum, our results in this section confirm the findings of previous studies that IT adoption lowers volatility and persistence of aggregate inflation in Korea. The more detailed disaggregate analysis, however, provides further evidence of a dichotomy between the impact of IT adoption on the commodities and services sectors, with the benefit of the new monetary regime appearing to work to a greater degree through services inflation.

3.3. *Impact of inflation targeting on spatial co-movements of inflation*

In earlier sections, we documented positive effects on inflation dynamics in the form of reduced volatility and persistence in the wake of IT adoption at the regional level. These effects are consistent with IT anchoring regional inflationary expectations around a common targeted level. Does this imply that regional inflation rates should co-vary to a greater degree post-IT adoption? In view of the heterogeneity across sectors observed in other measures, does the impact on co-movement differ across commodities and services? Little attention appears to have been paid to these regionally-focused questions in the literature to date. A notable exception is Tillmann (2013), who uses aggregate regional price data to show that the adoption of IT in Korea was followed by a much more homogeneous inflation process across regions as measured by the cross-regional standard deviation of persistence. We expand on that work by using an alternative measure of co-movement and examining sectoral-level data in addition to the aggregate series used in that study.

We first look at the co-movements of city-level inflation series using the following modified Moran's I statistic (e.g. Stock and Watson, 2010),

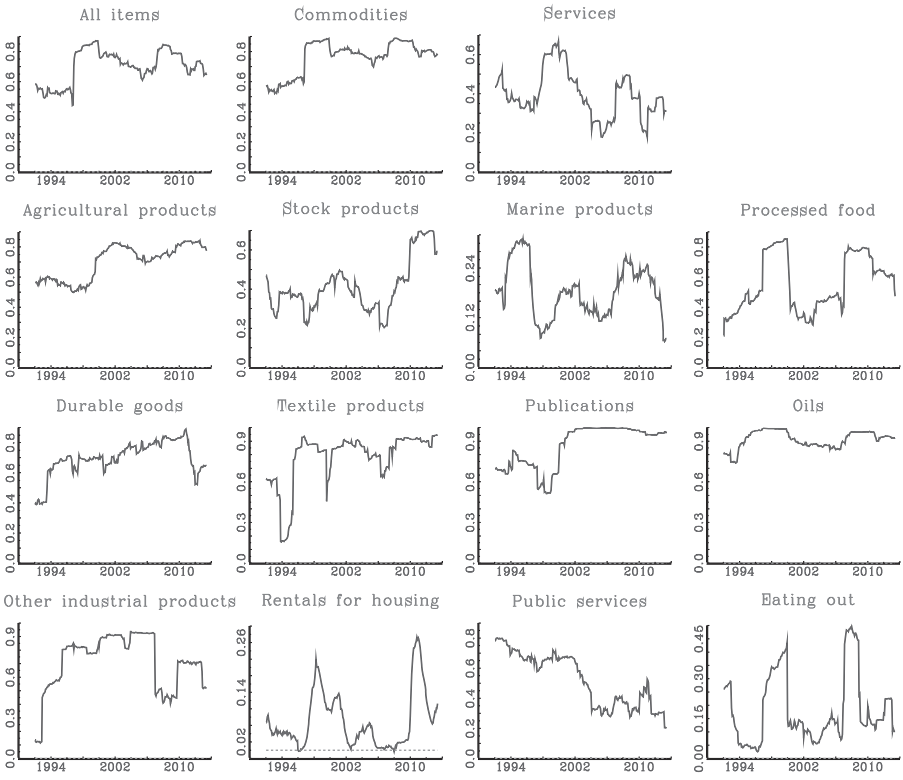

Figure 4. Spatial correlation of monthly inflation rates of 30 cities (3-year rolling average)

$$\tilde{I}_t = \frac{\sum_{i=1}^{N}\sum_{j=1}^{i-1} cov(\pi_{it}, \pi_{jt}) \cdot 2N}{\sum_{i=1}^{N} var(\pi_{it}) \cdot N(N-1)}, \quad N = 30, \tag{2}$$

where π_{ht} denotes city h's inflation rate at t. The basic function of this statistic is to capture spatial correlation, or the strength of co-movements, among city-level inflation rates in a given time period. Figure 4 plots the evolution of the modified Moran's I $\tilde{I}_t$ over time for both aggregate and disaggregate inflation series. In each panel, the line represents $\tilde{I}_t$ in equation 2 using a centred 37-month window, such that the numbers on the horizontal axis represent the middle point of each 3-year window. For instance, 1994 captures the subsample period of 1993–5, and so on. As shown in the first panel of Figure 4, the spatial correlation of aggregate city-level inflation rose sharply around the adoption of IT, jumping from 0.5 to 0.8. This corroborates the finding by Tillmann (2013) that the aggregate inflation process has become more homogeneous across regions after IT adoption. Given the global influences on the price dynamics for many commodities discussed earlier, it is not surprising that the degree of co-movement across regions in these sectors was relatively high compared with services even before IT adoption. After IT adoption, commodities inflation continued to fluctuate outside the target range for inflation but with increased spatial correlation, suggesting that inflation movements in these sectors continued to be dominated by sector-specific global factors. In contrast, after an initial increase around the time of IT adoption, 'Services' exhibited weaker regional co-movement under the IT regime. At first glance, this may appear to be counter-intuitive, given that 'Services' were the driving force behind changes in aggregate inflation post-IT discussed in previous sections. On closer examination, however, a potentially logical explanation comes to the fore. Looking back at Figure 2, we see that 'Services' inflation fell quickly into the target range after the adoption of IT and has remained more or less within the range since. Remaining fluctuations in services inflation are therefore likely to heavily reflect region-specific factors, such as wage costs and rents that are, to a large degree, determined locally.

This posited greater role of region-specific factors in driving services inflation is supported by the evidence based on an alternative measure of co-movement that looks at pair-wise correlations across cities. Given the well-established role of geographical distance in market segmentation (e.g. Choi and Choi 2014), we expect the correlation coefficient between regional inflation rates to be inversely associated with the physical distance between the regions, i.e. city-pairs that are further apart are likely to have a lower correlation coefficient reflecting bigger differences in region-specific drivers. If regional influences play a great role in services inflation under IT, then this negative relationship between the city-pair correlation coefficients for services inflation and geographic distance should be strengthened after IT adoption. Figure 5 shows that this is indeed the case for Korea as the slope representing the relationship between the correlation coefficient and distance appears to have become steeper in 'Services' after IT adoption.

The outcome of this analysis indicates that the better anchoring of inflationary expectations through the adoption of IT should not necessarily be expected to enhance the co-movement in regional inflation rates. The overall increase in co-movement found amongst aggregate regional inflation rates under the IT regime was driven primarily by the commodities sectors, in contrast to the effects reported earlier in the paper. It seems that the stabilization of services inflation within the target range after IT adoption has led to a greater role for region-specific factors, thus reducing the degree of co-movement across regions for these sectors. These idiosyncratic shocks could lead to a fall in co-movement, for example, as inflation rates in an affected region adjust to return to the target range. Or, if initial inflation rates differ across regions upon the adoption of IT, then convergence towards the common target could result in a lower degree of co-movement. These findings underscore the potential importance of the distinction between common and idiosyncratic shocks. We therefore turn next to a model that decomposes inflation movements along those lines.

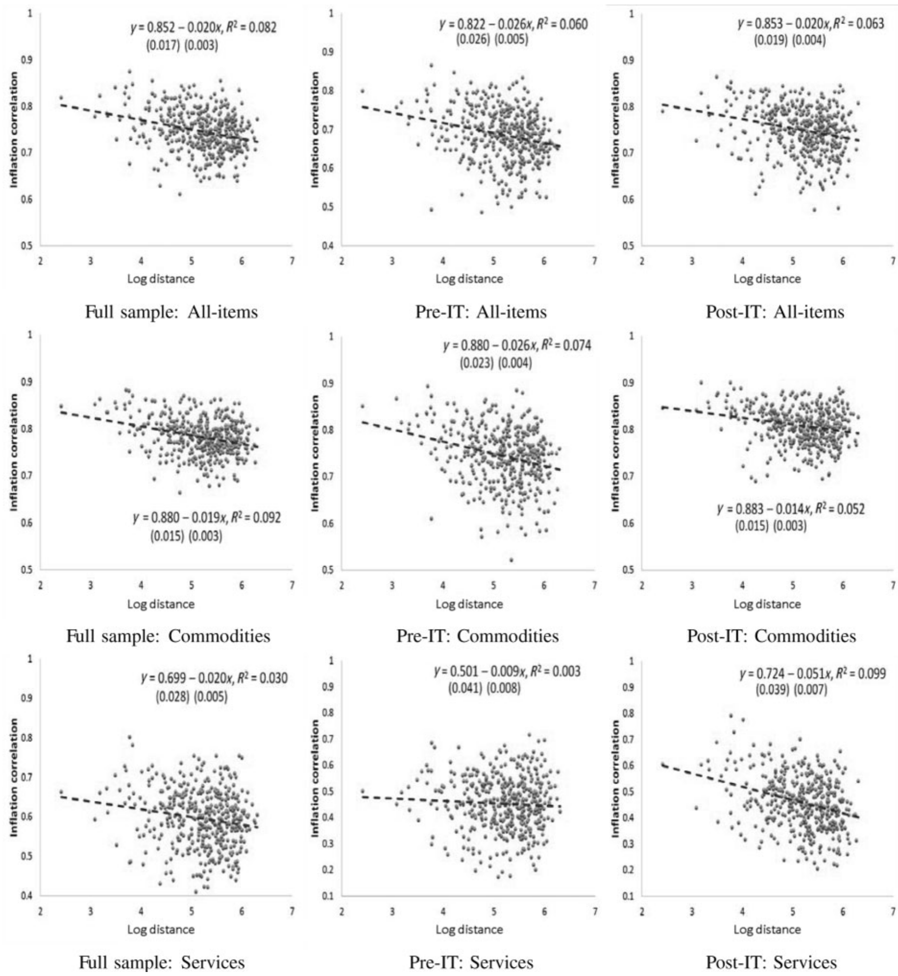

Figure 5. Association between distance (on the horizontal axis) and city inflation correlation (on the vertical axis)

3.4. *Common factor model analysis*

The basic idea of a common factor model is to decompose the volatility of city-level inflation into two components: one reflecting nationwide shocks that commonly affect all cities, and the other reflecting idiosyncratic regional shocks that are specific to each region. This decomposition allows us to evaluate the relative importance of aggregate and city specific shocks in explaining the variability of regional inflation and how that breakdown changed after the adoption of IT. Evidence in the previous section points to the possibility of a greater role for idiosyncratic shocks post-IT, at least for some sectors. Another possible impact would be that regional inflation would respond more homogeneously to common aggregate shocks, given better anchored inflationary expectations around an explicit inflation target common to all regions.

We consider the following prototypical factor representation,[11]

$$\pi_{it} = a_i + \underbrace{\lambda_i' F_t}_{C_{it}} + e_{it}, \tag{3}$$

where π_{it} denotes either the aggregate or a sectoral inflation rate in city i in period t, a_i represents an individual fixed effect, C_{it} is common component, and e_{it} is an idiosyncratic error associated with idiosyncratic city-specific events or measurement error. Note that the common component (C_{it}) is the product of F_t and λ_i, where the former is the $r \times 1$ vector of common factors (F_t) that captures common sources of variation in city-level inflation driven by aggregate shocks, and the latter are factor loadings that measure the 'sensitivity' of city inflation to the common shocks. In this model, city inflation may exhibit different dynamics due either to different idiosyncratic shocks (e_{it}) or to different responses to common aggregate shocks captured by factor loadings (λ_i). To remove city-specific effects and to deal with cross-sectional heteroskedasticity, we use demeaned standardized inflation rates $\tilde{\pi}_{it} = (\pi_{it} - \mu_i)/\sigma_{\pi_{it}}$ to estimate the model based on the principal component method. The 'minimum rule' proposed by Greenaway-McGrevy *et al.* (2012) for the selection of the number of factors suggests that one factor is sufficient for all sectors under study.

We estimate the factor model for each of the 14 disaggregate sectoral series as well as for aggregate inflation using the 30 city inflation series. For the disaggregate data, therefore, the common and idiosyncratic components represent what is common across regions or specific within a region for that particular sector. From Table 4, we can see that some three quarters of the variation in aggregate regional inflation can be accounted for by the common component and that this share increases for the post-IT sub period. This is consistent with our finding of greater co-movement across aggregate regional inflation series after IT adoption. Unsurprisingly, the role of the common component is more dominant in 'Commodities' than in 'Services', reflecting the role of global factors in determining price movements in many commodity markets. Looking at the results for individual service sectors towards the bottom of the table, we see a fall in the share of the post-IT common component, and, therefore, a relatively larger share for region-specific shocks, as conjectured earlier in the paper.

To look further at the potential sources of changes to the relative importance of common versus idiosyncratic shocks in the post-IT adoption period, we note that, as stipulated in equation 3, the common component of the inflation series (C_{it}) consists of both the common factor (F_t) and the factor loadings (λ_i) that capture the sensitivity of the inflation series to the common factor. Because the

[11] Our approach closely follows the studies by Altissimo *et al.* (2009) and Reis and Watson (2010), who construct factor models based on sub-aggregate prices without including any other macroeconomic variables as in Boivin *et al.* (2009).

Table 4. Share of common (aggregate) shock across cities before and after IT adoption

	Full sample			Pre-IT			Post-IT		
Items	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
All items	0.756	0.656 [CNA]	0.849 [DGU]	0.699	0.529 [CNA]	0.831 [DGU]	0.759	0.586 [SGN]	0.839 [DJN]
Commodities	0.791	0.690 [CNA]	0.879 [DGU]	0.755	0.595 [CNA]	0.887 [DGU]	0.815	0.700 [NWN]	0.873 [SWN]
Services	0.612	0.454 [GNJ]	0.742 [DJN]	0.478	0.260 [GNJ]	0.647 [ICN]	0.483	0.230 [SGN]	0.701 [DJN]
Agricultural products	0.747	0.658 [JJD]	0.860 [DGU]	0.570	0.364 [JIN]	0.724 [DGU]	0.794	0.705 [JJD]	0.891 [DGU]
Stock products	0.505	0.365 [SCN]	0.670 [SEL]	0.436	0.158 [ULS]	0.701 [JEN]	0.540	0.389 [MKP]	0.713 [SEL]
Marine products	0.251	0.092 [JJD]	0.488 [ICN]	0.267	0.061 [JJD]	0.577 [SWN]	0.234	0.079 [MKP]	0.422 [ICN]
Processed food	0.703	0.595 [AND]	0.869 [SEL]	0.706	0.516 [JJD]	0.880 [SEL]	0.672	0.571 [DGU]	0.843 [SEL]
Durable goods	0.750	0.554 [JIN]	0.853 [PHN]	0.617	0.220 [JIN]	0.792 [SWN]	0.799	0.652 [CCN]	0.881 [BCN]
Textile products	0.796	0.620 [GUM]	0.911 [BSN]	0.740	0.504 [BCN]	0.903 [WNJ]	0.893	0.755 [JJD]	0.950 [BSN]
Publications	0.819	0.703 [UJB]	0.935 [GWJ]	0.730	0.548 [GUM]	0.916 [GWJ]	0.974	0.951 [SGN]	0.989 [WNJ]
Oils	0.965	0.943 [GNG]	0.983 [CHE]	0.980	0.952 [GNG]	0.994 [CHE]	0.939	0.902 [JJD]	0.968 [BSN]
Other industrial products	0.811	0.711 [JIN]	0.891 [GWJ]	0.739	0.569 [SWN]	0.891 [DGU]	0.837	0.747 [JIN]	0.921 [GWJ]
Rental for housing	0.333	0.088 [JJD]	0.689 [DGU]	0.271	0.008 [GUM]	0.682 [SEL]	0.253	0.000 [NWN]	0.632 [SEL]
Public services	0.668	0.422 [YSU]	0.765 [GWJ]	0.714	0.484 [SEL]	0.849 [GUM]	0.585	0.273 [YSU]	0.747 [ICN]
Eating out	0.354	0.117 [SGN]	0.611 [SEL]	0.322	0.049 [GNJ]	0.627 [SCN]	0.273	0.015 [SGN]	0.496 [SEL]

The ‘Pre-IT’ period spans 1990:M1–1998:M3. IT, inflation targeting.

Table 5. Sensitivity of sectoral inflation to common factor (F_t*)*

	$\hat{\lambda}_{1,GM}$	$\hat{\lambda}_{2,GM}$
All items	0.867*** (0.000)	0.000 (0.000)
Commodities	0.887*** (0.000)	0.000* (0.000)
Services	0.780*** (0.000)	–0.001 (0.001)
Agricultural products	0.862*** (0.000)	0.000 (0.001)
Stock products	0.704*** (0.001)	0.003*** (0.001)
Marine products	0.488*** (0.001)	0.002*** (0.001)
Processed food	0.835*** (0.000)	0.002*** (0.000)
Durable goods	0.865*** (0.000)	–0.002*** (0.001)
Textile products	0.889*** (0.000)	0.002*** (0.000)
Publications	0.902*** (0.000)	0.002*** (0.000)
Oils	0.981*** (0.000)	0.000** (0.000)
Other industrial products	0.898*** (0.000)	0.001 (0.001)
Rental for housing	0.569*** (0.001)	–0.023*** (0.004)
Public services	0.815*** (0.000)	–0.001* (0.001)
Eating out	0.580*** (0.001)	0.013*** (0.002)

Regression equation is $\pi_{it} = \alpha_i + \lambda_{1i}\hat{F}_t + \lambda_{2i}\hat{F}_t h_t + \varepsilon_{ij}$, where $\hat{F}_t$ denotes the estimated common factor from the full sample and D_t is a time dummy variable which takes the value of one for t > 1998:M3. $\hat{\lambda}_{k,GM} = \frac{1}{N}\Sigma_{i=1}^{N}\lambda_{k,i}$, where $k = 1, 2$. $\sqrt{N}\left(\hat{\lambda}_{2,GM} - \lambda_2\right) \to^d N(0, \Sigma)$ where $\Sigma = \frac{1}{N}\Sigma\left(\hat{\lambda}_{2i} - \frac{1}{N}\Sigma\hat{\lambda}_{2i}\right)^2$. ***, ** and * indicate significance at the 1, 5 and 10% level, respectively.

common factor is, by definition, *common* to every individual city inflation series, we view the change in the sensitivity (λ_i) to aggregate shocks as the likely source of the change in the common share. To investigate this, we implement a basic regression analysis as follows by relating aggregate and sectoral inflation rates to the estimated common factor augmented with a time-dummy for IT adoption:

$$\pi_{it} = \alpha_i + \lambda_{1i}\hat{F}_t + \lambda_{2i}\hat{F}_t D_t + \varepsilon_{it},$$

where π_{it} represents the regional inflation rate for city i in time t, $\hat{F}_t$ denotes the common factor estimated from the full sample, and D_t is a time dummy variable which takes the value of one for t > 1998:M3. This specification allows us to measure the effect of IT adoption on the sensitivity to common factor (F_t).[12]

The results reported in Table 5 reveal a wide dispersion in sensitivity to common shocks across sectors. While the sensitivity for aggregate inflation increases after the adoption of IT, the rise is not statistically significant. Services sectors such as ‘rental for housing’ and ‘public services’, however, show a fall in sensitivity, perhaps because of the additional clarity brought about by the new monetary regime regarding the expected central bank response to the effects of

[12] The parameter of interest is λ_{2i}, which measures the change in the sensitivity of sectoral inflation to the estimated common factor $\hat{F}_t$ associated with the adoption of IT. Using the properties of the group-mean estimator, $\hat{\lambda}_{2,GM} = \frac{1}{N}\Sigma_{i=1}^{N}\lambda_{2,i}$, statistical significance of the parameter of interest can be tested based on its sampling distribution of $\sqrt{N}\left(\hat{\lambda}_{2,GM} - \lambda_2\right) \to^d N(0, \Sigma)$, where $\Sigma = \frac{1}{N}\Sigma\left(\hat{\lambda}_{2i} - \frac{1}{N}\Sigma\hat{\lambda}_{2i}\right)^2$.

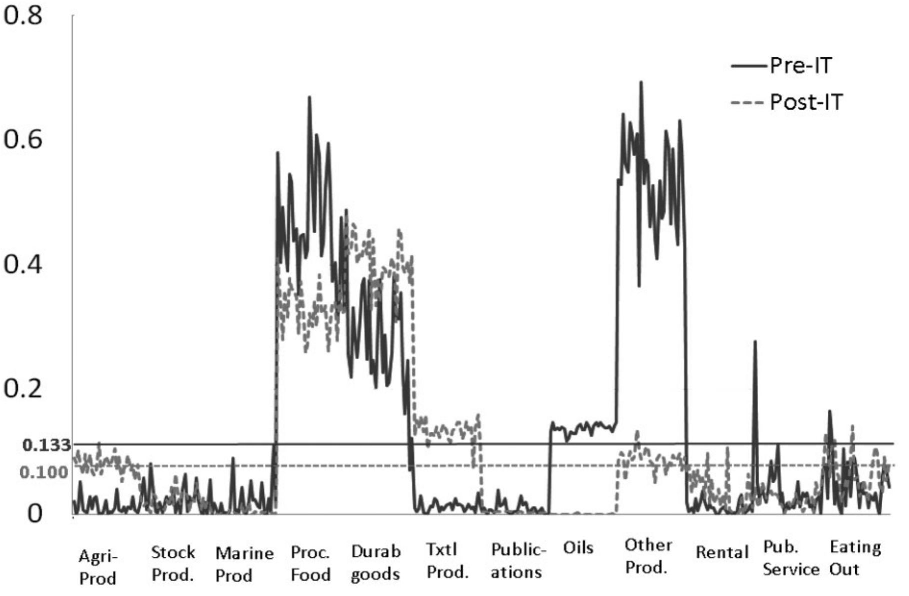

Figure 6. Share of common component in 12 consumer price items across 30 cities

exogenous disturbances. Looking at the dispersion of the sensitivities across regions, we notice that this decreases for services sectors but increases for commodities in the post-IT adoption period.[13] This is consistent with our earlier finding of a fall in the co-movement across regions in services inflation.

In addition to looking across regions on a sector-by-sector basis, we apply the common factor framework to investigate what happens to the share of the common component after the monetary regime change when all sectors are taken into account. To rephrase, we would like to see what happens to the relative importance of the factor that is common both across regions and across sectors. We estimate the following factor model by combining all disaggregate CPI sectors,

$$\pi_{it}^k = a + \lambda_i^{k\prime} F_t + e_{it}^k, \quad k = 1, \ldots, 12, \tag{4}$$

where π_{it}^k denotes the inflation rate in city i for sector k at time t. Figure 6 displays the estimates of the common component share from city inflation for all CPI sectors before (solid line) and after (dotted line) IT adoption. We find a relatively low common factor share once all sectors are considered, in line with the growing empirical literature (e.g. Altissimo *et al.*, 2009; Boivin *et al.*, 2009) that the variance of sectoral inflation is attributable more to sector-specific shocks than to common aggregate shocks. Our estimates are similar to what is

[13] Estimates of λ for each sector by region are available from the authors upon request.

found by Boivin *et al*. (2009) in the US data and by Choi and O'Sullivan (2013) in the Canadian data. Moreover, the overall common component share has decreased from 13.3% in the pre-IT period to 10.0% in the post-IT period, with the share lower under the IT regime in most sectors. Such a decline in the common component share implies that sectoral inflation became less responsive to aggregate national macro shocks once inflation expectations became better anchored under the new monetary regime. The decrease in the overall common component share after IT adoption accords well with the findings by Ciccarelli and Mojon (2010) and Choi and O'Sullivan (2013) that the common factor has less impact in countries with a stronger commitment to price stability.

Overall, the results from the factor model analysis are consistent with inflationary expectations becoming better anchored under the IT regime. They support the conjecture that sector-specific shocks have played a larger role in the services sectors under the IT regime and reiterate the point from the previous section that successful implementation of IT does not necessarily lead to a greater degree of homogeneity in all measures of regional inflation dynamics. The smaller role played by common shocks in the inflation dynamics in some sectors may arise from a stronger belief under IT that the central bank will offset those shocks to return to the inflation target.

4. CONCLUDING REMARKS

A growing consensus has emerged in the literature regarding the importance of disaggregate analysis in the study of inflation dynamics. Inspired by this, we examined the impact of the adoption of IT on regional inflation dynamics using disaggregate sectoral price data for Korea. Our aims were to assess the regional inflation responses to the adoption of IT and to identify the sectors of the economy that were more responsive to the change in the monetary regime. By looking at the response to IT across different regions for a multitude of sectors, therefore, we attempt to add to empirical findings in the existing literature, allowing us to analyse more precisely the impact of IT on regional inflation.

The change in the national monetary policy framework in Korea had a significant impact on the dynamics of city-level inflation. At the aggregate level, our results in general confirm the findings of previous studies that a change in monetary regime that leads to better anchored inflationary expectations results in lower volatility and persistence in inflation. We also find that such a change leads to convergence of aggregate measures of regional inflation under IT, judging from a lower dispersion of mean inflation. The results from factor model analysis were also supportive of inflationary expectations becoming better anchored under the IT regime. At the sectoral level, however, substantial heterogeneity exists in the response of city inflation rates across disaggregate CPI items, with a clear dichotomy emerging between the commodities and services sectors. This would have been masked in any analysis confined to the aggregate level. For most of the changes we observe in the dynamics of regional inflation, we find that the aggregate effects are being driven primarily by the 'services' category. Our interpretation of these findings is that the impact of the monetary regime change in terms of expectation formation is primarily through sectors that are less-tradable, such as services (e.g. rental for housing), rather than globally traded commodities, such as 'oils', whose inflation dynamics reflect global market developments. When it comes to the increased co-movement observed across regions under an IT regime, however, it is the 'Commodities' sectors rather than 'Services' that are responsible, probably because services inflation becomes relatively more influenced by local factors once it has stabilized within the target range.

We see several key lessons to take from our analysis. The first reiterates the importance of accounting for monetary regime changes when conducting economic research. In view of the pervasive evidence that the adoption of IT in Korea had a fundamental impact on inflation dynamics at both the aggregate and disaggregate level, it is advisable to take into account potential structural breaks in modeling inflation series for a country that has undergone a monetary regime change. In terms of policy lessons, our examination of Korea adds to the already substantial body of evidence that an inflation targeting framework can be an effective means of achieving greater inflation stability and better anchored inflationary expectations, including in relatively small emerging market economies with a high degree of openness. The sectoral heterogeneity found in the effect of IT on the economy could also prove useful to a country in determining the optimal design for an IT regime. Specifically, given the dichotomy observed between the behaviour of the services and commodities sectors, a country considering IT adoption could take account of its economy's sectoral composition in determining whether to use a point or range for its medium term inflation target, or whether escape clauses would be an appropriate design feature. For example, in a country where commodity-type products whose prices are determined globally constitute a significant portion of the economy, a wider range for the inflation target might be more appropriate compared with a country where sectors more influenced by domestic monetary policy dominate. In an extreme case, a country whose economy is exceptionally dominated by these types of commodities may not have sufficient control over domestic inflation to reap the benefits of an IT regime. As the services sectors in many economies become increasingly dominant, they may help enhance the role of the domestic monetary policy framework to affect inflation dynamics and provide somewhat of a counter-balance to the increasingly globalized nature of the market for many products.

Another policy implication of these results relates to the potential usefulness of monitoring regional measures of the economy. The impact of adopting a new monetary regime may vary across regions due to differences in their sectoral composition, segmentation of markets and other region-specific characteristics. These differences can create challenges for a one-size-fits-all national monetary policy and, if they spill over into the real economy, may warrant regionally focused policy responses. Finally, the successful implementation of an IT framework may not necessarily result in a greater degree of co-movement in regional inflation as is sometimes perceived. Co-movements may become less synchronized in some sectors even as mean inflation becomes less dispersed and inflation persistence falls. This was particularly true for the services sectors in the Korean data. Depending on the sectoral composition of the economy in question, therefore, a fall in co-movement of aggregate regional inflation rates may be observed when the benefits of IT in anchoring expectations are present. Taken together, our results highlight the potential usefulness for macroeconomic policy of analysing data disaggregated along both the regional and sectoral dimensions.

REFERENCES

Altissimo, F., L. Bilke, A. Levin, T. Mathä and B. Mojon (2006) ‘Sectoral and Aggregate Inflation Dynamics in the Euro Area’, *Journal of the European Economic Association* 4, 585–93.

Altissimo, F., B. Mojon and P. Zaffaroni (2009) ‘Can Aggregation Explain the Persistence of Inflation?’, *Journal of Monetary Economics* 56, 231–41.

Bai, J. and P. Perron (1998) ‘Estimating and Testing Linear Models with Multiple Structural Changes’, *Econometrica: Journal of the Econometric Society* 66, 47–78.

Beck, G., K. Hubrich and M. Marcellino (2009) ‘Regional Inflation Dynamics within and Across Euro Area Countries and a Comparison with the US’, *Economic Policy* 24, 141–84.

Benati, L. (2008) ‘Investigating Inflation Persistence Across Monetary Regimes’, *Quarterly Journal of Economics* 123, 1005–60.

Bilke, L. (2005) Break in the mean and persistence of inflation – A sectoral analysis of French CPI. ECB Working Paper No. 463, European Central Bank.

Bils, M. and P. J. Klenow (2004) ‘Some Evidence on the Importance of Sticky Prices’, *Journal of Political Economy* 112, 947–85.

Boivin, J., M. P. Giannoni and I. Mihov (2009) ‘Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data’, *American Economic Review* 99, 350–84.

Carlino, G. and R. DeFina (1998) ‘The Differential Regional Effects of Monetary Policy’, *Review of Economics and Statistics* 92, 572–87.

Carvalho, C. and F. Nechio (2011) ‘Aggregation and the PPP Puzzle in a Sticky-Price Model’, *American Economic Review* 101, 2391–424.

Choi, C. Y. (2010) ‘Reconsidering the Relationship Between Inflation and Relative Price Variability’, *Journal of Money, Credit and Banking* 42, 769–98.

Choi, C. Y. and H. Choi (2014) ‘Does Distance Reflect More Than Transport Costs?’, *Economics Letters* 125, 82–6.

Choi, C. Y. and R. O’Sullivan (2013) ‘Heterogeneous Response of Disaggregate Inflation to Monetary Policy Regime Change: The Role of Price Stickiness’, *Journal of Economic Dynamics and Control* 37, 1814–32.

Choi, C. Y., Y. S. Kim and R. O’Sullivan (2011) ‘Inflation Targeting (IT) and Relative Price Variability (RPV): What Difference Does IT Make?’, *Southern Economic Journal* 77, 934–57.

Ciccarelli, M. and M. Mojon (2010) ‘Global Inflation’, *Review of Economics and Statistics* 92, 524–35.

Clark, T. E. (2006) ‘Disaggregate Evidence on the Persistence of Consumer Price Inflation’, *Journal of Applied Econometrics* 21, 563–87.

Erceg, C. J. and A. T. Levin (2003) ‘Imperfect Credibility and Inflation Persistence’, *Journal of Monetary Economics* 50, 915–44.

Greenaway-McGrevy, R., C. Han and D. Sul (2012) ‘Standardization and Estimation of the Number of Factors for Panel Data’, *Journal of Economic Theory and Econometrics* 23, 79–88.

Hansen, B. (1999) ‘The Grid Bootstrap and the Autoregressive Model’, *Review of Economics and Statistics* 81, 594–607.

Kim, S. and Y. C. Park (2006) Inflation targeting in Korea: A model of success? BIS Papers No.31, Bank for International Settlements.

Kozicki, S. and P. A. Tinsley (2001) ‘Term Structure Views of Monetary Policy Under Alternative Models of Agent Expectations’, *Journal of Economic Dynamics and Control* 25, 149–84.

Levin, A. T. and J. M. Piger (2004) Is inflation persistence intrinsic in industrial economies? ECB Working Paper No. 334, European Central Bank.

Lunnemann, P. and T. Matha (2004) How persistent in disaggregate inflation? An analysis across EU15 countries and HICP sub-indices. ECB Working Paper No. 466, European Central Bank.

Meller, B. and D. Nautz (2009) The impact of the European Monetary Union on inflation persistence in the euro area. Discussion Paper 2009-037, Humboldt-Universitat zu Berlin.

Mishkin, F. S. and K. Schmidt-Hebbel (2007) Does inflation targeting make a difference? NBER Working Paper No. 12876, National Bureau of Economic Research.
Orphanides, A. and J. C. Williams (2005) 'The Decline of Activist Stabilization Policy: Natural Rate Misperceptions, Learning, and Expectations', *Journal of Economic Dynamics and Control* 29, 1927–50.
Reis, R. and M. W. Watson (2010) 'Relative Goods' Prices, Pure Inflation, and the Phillips Correlation', *American Economic Journal: Macroeconomics* 2, 128–57.
Stock, J. H. and M. W. Watson (2010) 'The Evolution of National and Regional Factors in U.S. Housing Construction', in J. R. Bollerslev, T. Russell and M. Watson (eds), *Volatility and Time Series Econometrics: Essays in Honor of Robert Engle*, Oxford: Oxford University Press.
Tillmann, P. (2013) 'Inflation Targeting and Regional Inflation Persistence: Evidence from Korea', *Pacific Economic Review* 18, 147–61.

APPENDIX: DATA DESCRIPTION

Table A.1. Data description by consumer price index items

Number	Items	Weight	Included items
0	All items	1000.0	All 481 items (Commodities plus Services)
1	Commodities	453.2	327 items
2	Services	546.8	154 items
3	Agricultural products	44.1	51 items including grain, fruit, and vegetable
4	Stock products	22.2	6 items including beef, pork, chicken, egg, honey
5	Marine products	11.3	14 items including fresh fish, dried squid, laver, seaweed
6	Processed food	71.8	73 items including flour, noodle, cereal, canned fruits, spirits
7	Durable goods	51.6	48 items including eletronics, cars, personal ornaments
8	Textile products	58.3	27 items including clothing, bedding, curtain
9	Publications	7.9	10 items including textbooks, newspaper, magazines
10	Oils	56.7	6 items including gasoline, light oil
11	Other industrial products	53.7	65 items including cigarette, shoes, utencils
12	Rental for housing	92.8	2 items including deposit money for the lease, monthly rent
13	Public services	142.6	29 items including public service fee, transportation fee
14	Eating out	119.0	38 items including restaurant menus, franchise food prices

Table A.2. Data description by cities and consumer price index weights

Cities (Abbreviation)	Population (2014)	Income (2010)	Weights of consumer price index items														
			Total	comm.	serv.	item3	item4	item5	item6	item7	item8	item9	item10	item11	item12	item13	item14
All cities (ALL)	46,002	23.7	1000	453.2	546.8	44.1	22.2	11.3	71.8	51.6	58.3	7.9	56.7	53.7	92.8	142.6	192.4
Andong (AND)	180	15.0	1000	508.2	491.8	48.7	23.8	16.4	76.3	56.6	59.4	7.5	83.7	59.5	45.6	142.0	184.8
Boryeong (BOR)	114	25.4	1000	512.7	487.3	46.3	24.4	14.7	76.6	74.7	61.1	7.1	76.1	56.8	59.5	140.0	173.8
Bucheon (BCN)	780	14.9	1000	438.4	561.6	40.6	21.2	8.3	70.7	49.2	56.9	8.1	56.2	53.2	102.5	136.0	209.3
Busan (BSN)	3,654	17.5	1000	464.3	535.7	49.6	21.6	17.5	78.6	51.2	58.1	7.5	46.6	54.7	62.2	154.4	182.7
Cheonan (CNA)	431	31.8	1000	512.7	487.3	46.3	24.4	14.7	76.6	74.7	61.1	7.1	76.1	56.8	59.5	140.0	173.8
Cheongju (CHE)	581	17.5	1000	504.6	495.4	47.0	25.7	8.5	73.5	65.7	63.0	8.0	78.5	56.7	51.2	140.6	182.5
Chuncheon (CCN)	248	15.8	1000	517.7	482.3	49.1	24.7	10.1	76.6	65.3	61.0	7.6	87.3	61.4	54.0	145.9	176.7
Chungju (CHU)	204	19.5	1000	504.6	495.4	47.0	25.7	8.5	73.5	65.7	63.0	8.0	78.5	56.7	51.2	140.6	182.5
Daegu (DGU)	2,432	14.7	1000	460.1	539.9	44.6	23.2	12.3	75.8	41.1	61.0	9.0	61.2	55.0	66.4	145.1	192.7
Daejeon (DJN)	1,326	17.7	1000	484.6	515.4	45.1	23.2	9.0	73.2	58.9	62.6	8.7	62.4	58.2	81.7	134.0	185.9
Gangneung (GNG)	223	15.2	1000	517.7	482.3	49.1	24.7	10.1	76.6	65.3	61.0	7.6	87.3	61.4	54.0	145.9	176.7
Gumi (GUM)	341	63.2	1000	508.2	491.8	48.7	23.8	16.4	76.3	56.6	59.4	7.5	83.7	59.5	45.6	142.0	184.8
Gunsan (GSN)	267	28.5	1000	507.9	492.1	53.0	22.5	13.1	68.9	60.4	66.9	9.3	77.7	56.2	47.1	142.0	201.7
Gwangju (GWJ)	1,328	17.1	1000	472.3	527.7	46.1	23.0	14.6	67.7	54.7	63.3	10.2	61.1	56.2	56.5	158.5	198.2
Gyeongju (GNJ)	268	26.0	1000	508.2	491.8	48.7	23.8	16.4	76.3	56.6	59.4	7.5	83.7	59.5	45.6	142.0	184.8
Incheon (ICN)	2,379	21.6	1000	445.1	554.9	44.1	21.9	9.7	75.1	49.4	56.3	6.8	45.7	54.2	85.9	146.6	194.4
Jeju-do (JJD)	519	18.5	1000	488.3	511.7	42.0	23.1	13.7	81.3	71.6	51.1	7.7	87.3	60.9	49.1	135.9	181.3
Jeonju (JEN)	593	12.7	1000	507.9	492.1	53.0	22.5	13.1	68.9	60.4	66.9	9.3	77.7	56.2	47.1	142.0	201.7
Jinju (JIN)	334	16.6	1000	488.3	511.7	42.6	20.7	16.2	78.7	56.2	61.3	8.6	75.6	59.7	59.6	142.4	181.1
Mokpo (MKP)	247	13.0	1000	509.7	490.3	50.1	24.5	21.1	73.5	61.1	67.7	7.3	78.3	59.4	38.6	151.3	188.4
Namwon (NWN)	97	18.4	1000	507.9	492.1	53.0	22.5	13.1	68.9	60.4	66.9	9.3	77.7	56.2	47.1	142.0	201.7
Pohang (PHN)	501	34.5	1000	508.2	491.8	48.7	23.8	16.4	76.3	56.6	59.4	7.5	83.7	59.5	45.6	142.0	184.8
Seongnam (SGN)	841	17.8	1000	438.4	561.6	40.6	21.2	8.3	70.7	49.2	56.9	8.1	56.2	53.2	102.5	136.0	209.3
Seoul (SEL)	10,070	28.2	1000	403.5	596.5	41.7	21.6	9.1	66.6	43.0	53.6	7.2	36.3	47.9	150.1	143.6	187.9
Suncheon (SCN)	261	17.8	1000	509.7	490.3	50.1	24.5	21.1	73.5	61.1	67.7	7.3	78.3	59.4	38.6	151.3	188.4
Suwon (SWN)	895	18.3	1000	438.4	561.6	40.6	21.2	8.3	70.7	49.2	56.9	8.1	56.2	53.2	102.5	136.0	209.3
Uijeongbu (UJB)	332	12.8	1000	438.4	561.6	40.6	21.2	8.3	70.7	49.2	56.9	8.1	56.2	53.2	102.5	136.0	209.3
Ulsan (ULS)	983	55.2	1000	474.8	525.2	39.7	21.0	13.0	68.3	70.9	61.9	6.9	64.4	56.1	58.9	134.6	193.2
Wonju (WNJ)	263	16.7	1000	517.7	482.3	49.1	24.7	10.1	76.6	65.3	61.0	7.6	87.3	61.4	54.0	145.9	176.7
Yeosu (YSU)	294	69.6	1000	509.7	490.3	50.1	24.5	21.1	73.5	61.1	67.7	7.3	78.3	59.4	38.6	151.3	188.4

Population is in thousand people. Income is the per capita gross regional product in million Korean won. See Table A.1 for the descriptions of consumer price index items.