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House Prices and Monetary Policy: A Dynamic Factor Model for Korea*

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This paper investigates the importance of national, regional, and city-specific factors to explain the movement of housing prices across South Korean cities in using the Bayesian approach proposed by Otrok and Whiteman (1998). The variance decomposition analysis illustrates that most of the movement of Korean housing prices are ascribed to the national factor that accounts for 56% of housing price variations and over 70% in 5 cities including Seoul and Pusan. This demonstrates the existence of the co-movement of housing prices in Korean cities, which has been vaguely discussed in both academics and the real estate industry. This paper also finds that the contribution of city-specific factors range from 20% to 70%. However, the regional factors have negligible impacts on housing price fluctuations in all cities. This paper also examines the effects of monetary policy shocks on national-level housing prices measured by the national factor. Employing a structural VAR model to disentangle the structural monetary shocks, the study finds that the effects of monetary policy shocks on national-level housing prices are trivial. This finding reveals that the hike in housing prices observed in recent periods are most likely attributable to macro fundamentals rather than autonomous monetary shocks.

JEL Classification: C11, C32, E52

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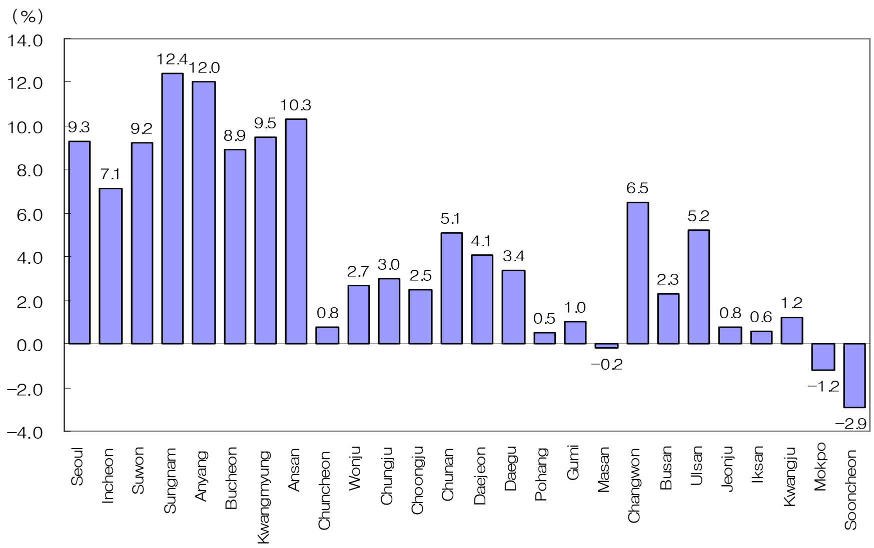
1. INTRODUCTION

House prices in Korea have recently been on a constant rise due to the expansion of housing loans caused by low-interest rates and the prevalence of massive urban redevelopment projects. The price of apartments in Gangnam (a part of Seoul located south of the Han River) rose more than 40% in 2002 compared to the previous year. However, the trends in house prices by city, shows that not all the cities have experienced sharp rises in housing prices. Figure 1 shows the average growth rate of the Korean house purchase price composite index by city from the first quarter of 2000 to the fourth quarter of 2007 and cities in the Gyeonggi area[1)] recorded far higher growth rates than other cities. It also shows that the house prices in other cities like Masan, Mokpo, and Sooncheon had dropped. This means that factors affecting house prices could be different across areas and cities.

Figure 1 Housing Price Growth by City



Note: The sampling period is 2000Q1-2007Q4.
Source: Kookmin Bank.

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1) Gyeonggi area includes Seoul, Incheon, Suwon, Sungnam, Anyang, Bucheon, Kwangmyung, and Ansan.

The recent steep rise in Korean house prices could be explained by local or specific factors relating to respective cities when the house price changes are disintegrated by nationwide factors, regional factors, and city-specific factors. A housing business cycle[2)] does not appear to exist in Korea when analyzing the recent data alone, but this view changes with the long-term time series data.

Understanding the housing business cycle is significant not only in setting a model related to the housing market, but also in establishing government policy. If the sharp rise in house price in certain areas is attributable to the characteristics of the housing market of the area or city itself, justification for the interest rate policy of the central bank or the taxation policy of the central government in stabilizing the housing market would be difficult. This is because the government policy on the interest rate, finances, and taxation is applied nationwide, which is not enough to control for the rise of house prices in certain areas and cities. By applying macroeconomic variables the house price swings of cities needs to have some common features in order for the government housing policy to be rationalized and be applied nationwide and not just to certain areas or cities. Finding out whether a housing business cycle exists or not is one way to rationalize the government macroeconomic policy for a stabilized housing market through interest rates and taxation.

Real estate has been a constant topic for many researchers due to the impact on aggregate economic activities and it makes up a significant share of household assets in most households. Among domestic studies regarding the housing business cycle, Kim (1992) used the residential building permit as a proxy variable of housing business cycle. That study classified elements affecting the housing business cycle of Korea into two variables; a macroeconomic variable (represented by the national income and the aggregate money supply) and a housing policy variable represented by the

[2)] Generally, business condition means the expansionary and contractionary phenomena that take place in the process of economic activity. The business cycle generally tends to have co-movement between auto-correlation and other variables. In this report, housing business cycle refers to the business cycle of housing prices by city.

regulations on home construction permits. The analysis found that the house policy variable had more influence than the macroeconomic variable. According to Hur (1991), the changes in house purchase price were significantly affected by housing investment scale, inflation, land price, construction business, and income level, but not by the aggregate money supply. The study by Hur analyzed that the government housing policy had the greatest influence on house prices. Lee (1992) used VAR model and analyzed that the changes in house prices were affected by the aggregate money supply in a short-term period and by inflation factors in a long-term period. Tcha (2004) finds that the house prices were insignificantly affected by income.

A common feature in preceding studies is that the analyses use aggregate indicators relating to houses. This type of method does not take into account the heterogeneity of different areas and cities in the housing market, and only adopts the aggregate indicator of the national total, which would not fully consider heterogeneity and local characteristics in the housing market. Aggregate indicators negate the consideration of such characteristics, as housing indicators are likely to be determined by housing markets in large cities with relatively large proportion and the empirical analysis based on aggregate indicators will likely fail to reflect the true conditions of the nationwide housing market heterogeneity.

This study analyses the Korean housing business cycle by city (which considers the characteristics in local areas) with the co-movement and then it attempts to ponder which macroeconomic variable exerts influence the co-movement. As a way to look into the co-movement of the housing business cycle, the analysis disintegrates the factors behind the changes in the house purchase price by city and province into the nationwide, local, and city-specific factors. The study then adopts a factor model, taking into account the dynamic aspects of these factors and analyzes the each factor contribution in the housing business cycle by city through the impulse response analysis and variance decomposition. This study improves the understanding of the relation with the house price by identifying which macroeconomic variable is sufficient to explain the nationwide factor. Macroeconomic variables have an impact on the nationwide factors but are limited on local or city factors. To look at the degrees of impact of each macroeconomic policy variable it is appropriate to exclude the regional and idiosyncratic city factors to focus on the national factor of house prices alone. This study uses the structural VAR and analyzes the effect of monetary policy in dealing with the recent house price swings to find out what kind of impact was made on the rise in house prices by the monetary policy. This paper closely follows the method applied in Negro and Otrok (2005). They disaggregate the house price data into a global, regional and local factor to investigate the recent U.S. housing boom as a local or global phenomenon. They find that the overall increase in house prices in the periods of 1986-2004 are a national phenomenon, but the latest hikes in house prices during 2001-2004 are mostly attributable to local factors; this paper extends that model with Korean data.

The remainder of the paper is organized as follows. Section 2 lays out the dynamic factor models and the choice of priors used in the Bayesian estimation. Section 3 describes the data set and the empirical results followed by variance decomposition to disentangle the relative importance of the derived factors. Section 4 discusses whether the monetary policy has any bearing on the recent hike in housing prices. Section 5 is the conclusion.

2. MODEL

Let Σ be the variance-covariance matrix of $y_t = [y_{1t}, y_{2t}, \ldots, y_{Qt},]'$ with the following structure

$$\Sigma = \Gamma\Gamma' + U,$$

where Γ denotes a $Q \times K (K < Q)$ matrix and U is a $Q \times Q$ diagonal matrix which has positive entries on the diagonal. This structure implies that y_t can be explained by k factors and idiosyncratic noise, i.e.

$$y_t = \beta_{i1} f_{1t} + \cdots + \beta_{iK} f_{Kt} + u_{it}, \quad i = 1, \ \ldots, \ Q, \ t = 1, \ \ldots, \ T$$
$$= \beta i' f_t + u_{it}.$$

Representing in matrix form

$$y_t = \beta f_t + u_t,$$

where β represents a $Q \times K (K < Q)$ coefficient or factor loading matrix, f_t implies a $K \times 1$ stochastic latent factor vector, and u_t is a $Q \times 1$ idiosyncratic noise vector with the following stochastic properties

$$E(u_t) = 0,$$
$$E(f_t u_t') = 0,$$
$$E(u_t u_t') = U = diag(\sigma_1^2, \ \ldots, \ \sigma_Q^2).$$

Under this setting, the variance-covariance matrix of y_t takes the following form

$$E(y_t y_t') = \beta \Omega \beta' + U,$$

where

$$\beta \Omega \beta' = \Gamma \Gamma'.$$

The dynamic factor model is composed of a K-dimensional stochastic latent factors and noises. The factors and noises are modeled to be serially correlated, to characterize the persistence of the series. The static counterparts of the dynamic factor models usually ignore the serial correlation and they are more popular in the cross-sectional analysis. Factor models identify latent factors that describe the best statistical properties of the data but they do not explicitly describe the causal relationship between the variables. Also, the derived factor does not characterize any economic variables. To make any meaning out of the factor, it is important to find economic variables with statistical properties that are close to the factor.

This study is interested in finding the factor that affects the house price on a national level rather than in characterizing the macroeconomic variables. This paper decomposes housing prices explained by three factors: national, regional, and city. The national factor is the global factor that affects housing prices across the country. The regional factor is the common factor influencing the housing prices in the same administrative region. Finally, the city factor is the unique factor associated with individual cities. Among those factors, the national factor can be considered as the driving force to generate the co-movement of the housing business cycle.

Consider the following dynamic factor model

$$\begin{aligned} y_{i,t} &= \alpha_i + \beta_i^{nation} f_t^{nation} + \beta_i^{region} f_t^{region} + \varepsilon_{i,t}, \\ E[\varepsilon_{i,t}\varepsilon_{j,t-w}] &= 0, \text{ for } i \neq j, \end{aligned} \tag{1}$$

where i denotes the city, r the region, and α_i the average growth rate of house price, which is allowed to differ across cities. It is important note that the city-specific factors are not modeled explicitly in equation (1) as the city factors are implicitly denoted by the error terms.

Let the evolution of error terms be given by the following auto-regression of order p_i

$$\begin{aligned} \varepsilon_{i,t} &= \phi_{i,1}\varepsilon_{i,t-1} + \phi_{i,2}\varepsilon_{i,t-2} + \ \dots \ + \phi_{i,pi}\varepsilon_{i,t-pi} + u_{i,t}, \\ E[u_{i,t}u_{j,t-s}] &= \begin{cases} \sigma_i^2 \text{ if } i{=}j \text{ and } s = 0 \\ 0 \quad \text{elsewhere} \end{cases}. \end{aligned} \tag{2}$$

Notice that the innovations, $u_{i,t}$, are assumed to have a zero mean, serially uncorrelated. However, they are allowed to be heteroskedastic. Likewise, the laws of motion of the factors are assumed to be governed by auto-regressions of order q_k, and the innovations have the same stochastic properties described in the above equation, i.e.

$$f_{k,t} = \phi_{f_k,1} f_{k,t-1} + \phi_{f_k,2} f_{k,t-2} + \ \dots \ + \phi_{f_k,qk} f_{k,t-qk} + u_{f_k,t},$$
$$E[u_{f_k,t} u_{f_k,t-s}] = \begin{cases} \sigma^2_{f_k} & \text{if } s = 0 \\ 0 & \text{elsewhere} \end{cases}, \tag{3}$$

where k implies both nation and region accordingly.

Regarding the identification of the model, it is noted that neither the sign nor the size of the latent factors and the factor loadings are separately identified. In the literature, signs are identified by imposing one of the factor loadings to be positive in each factor. This study follows this convention and requires the factor loadings of each of the factors associated with Seoul metropolitan city to be positive. To fix the scale problem, each $\sigma^2_{f_k}$ is normalized to one.

To estimate the dynamic factor models, most researchers choose one of the following two methods. The first method is the maximum likelihood employing either EM[3)] or Kalman filtering applied in Gregory *et al.* (1997) and Stock and Watson (1993). The alternative uses Bayesian technique via data augmentation process on the latent factors that are treated as missing data used in Kose, Otrok, and Whiteman (2003).

The Bayesian method (regarded to have comparative advantage in estimating models with a large set of parameters) is employed in consideration of the number of parameters in the model. The dynamic

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3) EM process can be decomposed into two parts. First, given the initial guess of factors, estimate the factor loading to maximize the likelihood function (M-step). Second, given the estimated factor loading from the M-step, derive the factor via Kalman smoothing (E-step). These steps are repeated until the likelihood function is maximized.

factor analysis can be thought of as a statistical specification of a joint density for the data y_t conditional on a set of parameters and a set of latent factors. The Bayesian method is a sequential process of estimating a certain set of parameters given the rest of parameters or factors. The typical processes of applying the Bayesian method to dynamic factor models are the following. The first step is to estimate the conditional probability density of the parameters given the starting values of factors and data. The second step is to generate a set of factors from the conditional distribution of the parameters and data. Repeating this procedure can generate random samples from the joint posterior distribution for the unknown parameters and factors using a Markov Chain Monte Carlo (MCMC) method.

Detailed procedures to implement the estimation are in order. Given initial values of the parameters and factors, this study first samples the posterior distribution of parameters conditional on the factors. Then, the country factors are drawn from the distribution conditional on the parameters and regional factors. Taking the distribution conditional on the parameters, country factors and regional factors are sampled. This completes one step of the Markov chain. It is well known that the joint posterior distribution of the parameters and latent factor from this sequential sampling converges to limit distribution under regularity conditions satisfied in the above model.

The prior distributions used in the model are similar to those employed in Kose, Otrok, and Whiteman (2003). The lag orders for the error term and latent variables are set to three. The priors for the factor loadings (β_i^{nation}, β_i^{region}) are $N(0,1)$, and the priors for the latent factors are $N(0, \Sigma)$, where Σ takes the following form

$$\Sigma = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0.75 & 0 \\ 0 & 0 & 0.75^2 \end{pmatrix}.$$

The variance of house price of each city (σ_i^2) has the inverse gamma distribution of the form $iG(a, b)$, where a=6, b=0.01.[4)] According to current literature, these priors are regarded as standard. The total number of parameters to be estimated is 209. α_i, β_i^{nation}, β_i^{region}, and σ_i^2 should be estimated for 26 cities, 3 autoregressive coefficients for the national factor,[5)] 3 autoregressive coefficients for the regional factors for 8 regions $(3\times 8 = 24)$, and 3 autoregressive coefficients for the error terms for 26 cities $(3\times 26 = 78)$. Estimating this size of parameter using the classical statistical techniques is a challenge. However, it is possible to do such a task using the appropriate Bayesian technique. This study first derives the posterior distribution after 5,000 repetitions of Monte Carlo sampling to assure the convergence of the posterior distribution. It then extends the length of repetitions to 10,000 and compares this posterior with the previous one to find significant differences between the two. No major differences between these distributions are found after the chain length becomes 50,000 and the empirical results reported in this paper are based on the sampling size of 50,000.[6)]

3. EMPIRICAL RESULTS

3.1. Data

The housing price data is collected from the Kookmin Bank website (http://www.kbstar.com/). Despite the criticism on the banking data for the construction, it is publicly available and the most widely quoted in Korea. The Kookmin Bank (then the Housing Bank) began to collect the house price data of 26 cities in 1986 on a monthly basis. It also publishes the House

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[4)] Relating to Bayesian estimation, it is standard to assume that the prior of parameters takes beta distribution when the parameter values are confined between 0 and 1, and gamma or inverse gamma when the parameter values are bigger than 0.

[5)] The study employs different lag orders (2 and 4) to test the robustness of the model and still find similar results.

[6)] For further discussion regarding Bayesian estimation and MCMC method, see Kim and Nelson (1999) and Gamerman and Lopes (2006).

Table 1 Selected Statistics on House Price Growth in 26 Cities

(YOY, %)

Region (8)	City (26)	Average	Std. Dev	Min.	Max.
Nationwide		4.20	7.84	–12.80	20.81
Kyeonggi	Seoul	5.07	9.09	–14.23	23.97
	Incheon	4.36	8.60	–12.86	23.82
	Suwon	5.40	11.04	–18.37	33.50
	Sungnam	6.16	11.26	–14.93	29.20
	Anyang	6.47	9.98	–17.78	35.15
	Bucheon	5.20	9.41	–10.74	31.37
	Kwangmyung	6.74	11.68	–14.37	34.37
	Ansan	6.57	12.11	–16.72	44.60
Kwangwon	Chuncheon	2.46	9.41	–16.34	33.21
	Wonju	3.44	9.44	–15.00	31.63
Chungbuk	Chungju	2.18	6.53	–11.57	16.17
	Choongju	2.23	7.12	–14.95	28.56
Chungnam	Chunan	2.00	8.87	–12.35	23.13
	Daejeon	2.54	6.14	–10.42	19.73
Kyungbuk	Daegu	3.01	9.16	–15.35	38.67
	Pohang	2.21	7.89	–9.58	34.60
	Gumi	3.48	9.36	–13.68	33.41
Kyungnam	Masan	3.46	11.35	–12.69	50.26
	Changwon	7.05	11.85	–18.72	55.39
	Busan	3.24	9.42	–13.08	29.93
	Ulsan	4.81	9.69	–15.55	31.98
Jeonbuk	Jeonju	0.91	5.84	–14.34	15.33
	Iksan	2.39	7.64	–8.38	34.78
Jeonnam	Kwangju	1.67	7.58	–15.67	29.85
	Mokpo	–0.16	7.28	–9.49	33.24
	Sooncheon	–0.46	6.90	–13.20	19.28

Note: The sample period is 1986Q1-2007Q4.
Source: Kookmin Bank.

Purchase Price Composite Index (HPCI) based on the collected city-level data. Since September 2003, more cities have been added to the HPCI totaling around 150 cities. The empirical work converts the data into a quarterly frequency to mitigate the volatile feature of original data deflated by the monthly consumer price index. Only 26 cities are included due to the limitation on the length time series. The sample ranges from 1986Q1 to 2007Q4. The data is then transformed into growth rates over a year ago. Table 1 reports selected statistics for the sample. The average growth of house prices during the sample period records 4.2%. The house prices of Gyeonggi province including the Seoul metropolitan city exceeded the national average and reflect that the majority of price hikes in the country are led by this region. A questionable finding is that the increase in house prices in Seoul was lowest except for Incheon in the Gyeonggi region. For the house price increase during the Participatory Government of 2003-2007, the average house price growth in Seoul was 8.13%, compared to 9.23% in other cities in the same region. Also, the house prices of Seoul seemed to be more affected by the financial crisis of 1997. The average house price growth of Seoul during 1998Q1-1999Q1 was 10.32%, while the average price decrease of other cities in the same region was 9.95%. These two effects may partly explain the questionable finding. In the case of other cities, they are well below the national average except for Changwon and Ulsan. In particular for Mokpo and Sooncheon, the average house prices have even decreased. In order to examine the co-movement of house prices in all cities, simple correlations across the cities are reported in table 2.[7] This table shows the correlation between cities within the same region classified by the administrative areas. For example, the correlations between any two cities in Gyeonggi province are higher than 0.7, while most of the correlations between these cities and any other cities outside this region are far below 0.7. It is possible to infer from this finding that the regional factor has a significant influence on explaining the price co-movement within the region. However, this may not always be the case when the global factor is taken into account. Suppose all the cities in a certain region are strongly affected by the global factor, then the correlations

[7] Only 15 selected cities are report due to limitations on space.

Table 2 Correlation among Selected Cities

		All	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	All	1.00															
	A	0.96	1.00														
	B	0.93	0.92	1.00													
	C	0.85	0.89	0.80	1.00												
Gyeonggi	D	0.82	0.89	0.79	0.77	1.00											
	E	0.80	0.86	0.78	0.75	0.88	1.00										
	F	0.87	0.93	0.88	0.93	0.81	0.79	1.00									
	G	0.83	0.88	0.83	0.84	0.79	0.71	0.84	1.00								
	H	0.89	0.84	0.91	0.73	0.70	0.76	0.79	0.68	1.00							
Kwangwon	I	0.72	0.61	0.57	0.63	0.50	0.37	0.55	0.66	0.52	1.00						
Chungbuk	J	0.72	0.67	0.67	0.54	0.61	0.51	0.49	0.74	0.51	0.78	1.00					
Chungnam	K	0.69	0.69	0.63	0.69	0.69	0.47	0.65	0.73	0.51	0.58	0.54	1.00				
Kyungbuk	L	0.80	0.66	0.68	0.45	0.51	0.58	0.50	0.44	0.75	0.55	0.57	0.44	1.00			
Kyungnam	M	0.89	0.75	0.77	0.64	0.55	0.51	0.66	0.61	0.80	0.71	0.63	0.60	0.87	1.00		
Jeonbuk	N	0.80	0.67	0.66	0.63	0.55	0.54	0.58	0.54	0.76	0.74	0.58	0.47	0.75	0.81	1.00	
Jeonnam	O	0.73	0.58	0.61	0.47	0.51	0.53	0.41	0.49	0.71	0.72	0.68	0.32	0.74	0.75	0.84	1.00

Note: To save space, we use the following abbreviation: A(Seoul), B(Incheon), C(Suwon), D(Sungnam), E(Anyang), F(Bucheon), G(Kwangmyung), H(Ansan), I(Chuncheon), J(Chungju), K((Deajeon), L(Daegu), M(Busan), N(Jeonju), O(Kwangju).

among those cities become large not because of regional influences but because of the global factor which affects the house prices in a similar manner.

To clarify the above argument, consider the following factor model

$$y_i = \alpha_i f_1 + \beta_i f_2 + \gamma_i f_3,$$

where f_1 implies national factor, f_2 regional factor, and f_3 city factor. Then, the correlation between two cities *i*, *j* with the same region can be expressed as follows

$$\frac{\alpha_i \alpha_j \text{ var}(f_1) + \beta_i \beta_j \text{ var}(f_2)}{\sigma_{yi} \sigma_{yj}}.$$

If the correlation between two cities is explained mainly by $\alpha_i \alpha_j \text{var}(f_1)$, regional factors will have a limited power in characterizing the co-movement of house prices with the region. It is necessary to come up with sophisticated tools to disentangle the mixed effects from the national and regional effects. In the following, the growth of house prices is decomposed into three factors: national, regional, and city; the relative contributions of each factor on price growth will be discussed in due course.

3.2. Dynamic Factors

The median and 10th and 90th percentiles of the posterior distribution of the autoregressive coefficients of the national factor are presented in table 3.[8] The median value of the coefficient on the first lag marks 0.87 and indicates a high persistence of the national factor. Figure 2 plots the median of the national factor along with the national house sales price composite index. The dotted lines show the 80% posterior confidence band.

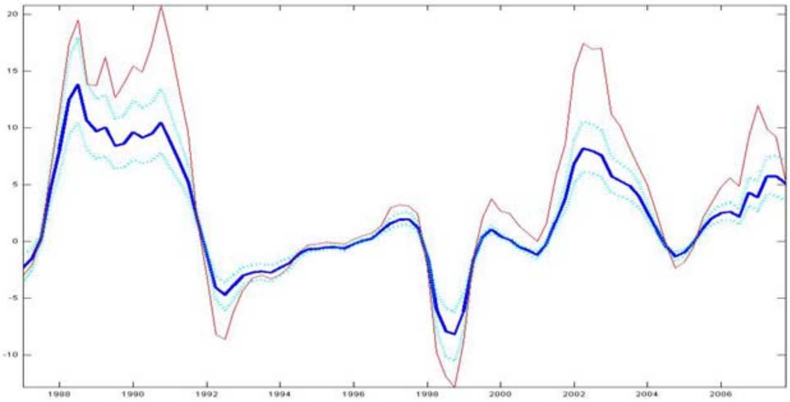
The confidence band gets wider at the peak or trough of the national factor, while the band is quite tight in other periods. This implies that the growth of house prices becomes more volatile around the turning points. The national factor tracks well at both the up-period when the housing prices increased across the nation (in 1987-1989, 2001-2002, and 2006) and the down-period (in 1992-1993, and 1998).

Table 3 Autoregressive Coefficients on the National Factor

$\phi_{f_{nation},1}$			$\phi_{f_{nation},2}$			$\phi_{f_{nation},3}$		
10%	Median	90%	10%	Median	90%	10%	Median	90%
0.75	0.87	0.97	0.14	0.21	0.27	–0.22	–0.18	–0.13

[8] The estimates of factor loadings are presented in the Appendix.

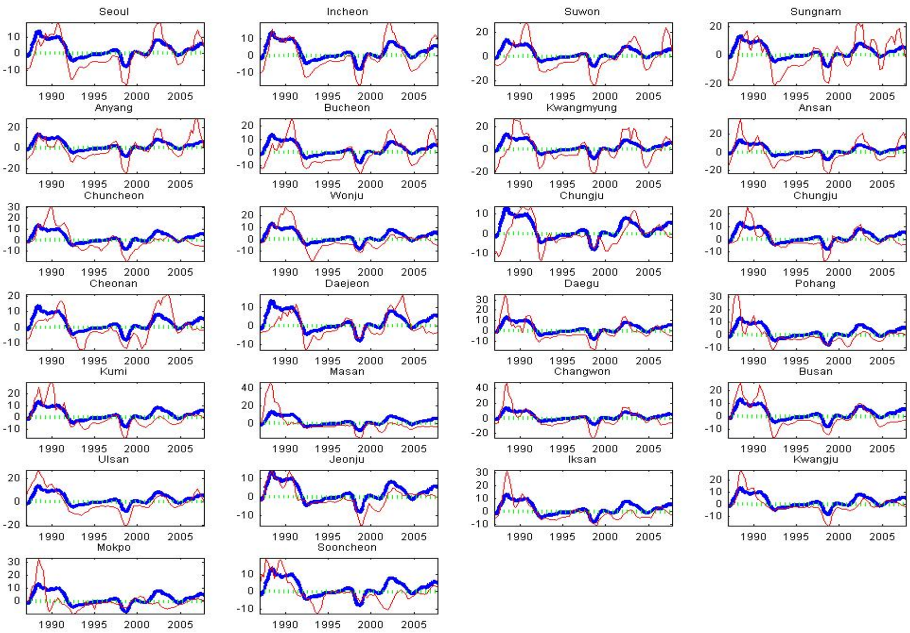
Figure 2 National Factor and Housing Price Composite Index



Note: The bold line indicates the median values of the posterior distribution of the national factor, the dotted lines are 80% of the confidence band and the thin line is the growth rate of housing price of composite index.

Another feature observed in figure 3 was the similar moving patterns of the growth rate of the national house purchase price composite index and the national factor. Given the fact that the national index was the weighted sum of the nationwide, local, and city factors, the gaps between these indicators are mostly the ups or downs driven by the local and city factors. Based on this figure, the periodical trends in house price changes caused by housing factors can be described as follows. In 1987, due to a series of bullish factors such as the "three low periods of the low oil price, the low value of the US dollar, and the low interest rates," the increased money supply, and the 1988 Seoul Olympics, the house prices across the country had climbed sharply. After 1988, as several regulations and the plan for the supply of 2 million houses during the start of the Roh Administration, the house prices driven by the nationwide factor began to fall. However, as shown in the case of the overheated subscription for new houses in the five new towns (including Bundang and Ilsan in the capital region) the upward trend driven by local or city-specific factors had continued, pushing the national house purchase price composite index over 13%. Later, as the public concept of

Figure 3 National, Regional Factor and Growth of House Price by City



Note: The bold line indicates the national factor, the dotted line is regional factor and the thin line is the growth rate of house price of individual city.

land ownership[9)] was carried out on a full scale, house price dropped rapidly. Considering the movement of the national house purchase price composite index and the nationwide factor, it was assumed that the public concept of land had a nationwide influence. House prices across the country had continued to stabilize after the Kim Young-sam Administration in 1993. In particular, the effect of supply of 2 million houses contributed to the downward stabilization of house prices in certain areas. During this period,

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9) Systems related to the public concept of land ownership include the residential land ceiling, the excessively increased valuable land tax, and the contribution system for development. The residential land ceiling along with the excessively increased valuable land tax were both abolished in December 1998, after the Constitution Court ruled it unconstitutional. The contribution system for development was suspended in 2004, but reinstated in 2005 after the August 31st 2005 package was announced.

the gap between the growth rate of house prices driven by a nationwide factor and the national house purchase price composite index in real terms had widened, which seemed because of the expanded explanatory power driven by the local factor of supply of 2 million houses. The Kim Dae-jung Administration in 1998 encouraged the revitalization of the real estate business as a way to help the Korean economy recover from the financial crisis and house prices began to recover. A number of policies implemented in the early stage of the Kim Administration include the deregulation of the price ceiling policy, a temporary exemption on the capital gains tax, the elimination of the period limit on re-acquiring the right to buy new apartments offered by the private sector, and the alleviated requirements for the rental housing business. These policies served to slow down the downward trend in the house prices, which can be explained by a nationwide factor. The rise in house prices after 2002 led by the reconstruction of apartment complexes in Gangnam is largely attributable to the city-specific factor rather than the nationwide factor. This could be presumed from the fact that since 2002 the gap between the growth rate of the national house purchase price index and the nationwide factor has widened. The house prices fell again in 2003, as the Roh Administration pushed for strengthened real estate regulations, including heavier capital gains tax, the newly launched Comprehensive Property Tax (CPT), and the loan-to-value (LTV) and the debt-to-income (DTI) regulations. However, in 2006, the house prices started rise again due to excessive purchase orders for new houses in new towns including Pangyo and the soaring prices of local lands and the reflux of land compensation costs into the capital region, brought by the plan for creating a new administrative city, innovation cities, and enterprise cities. However, the rise of house prices during this period was driven by the bullish factors of certain areas and cities, not by a nationwide factor.

Figure 3 is made by the growth rates of house prices by the city, nationwide, and local factors. Of note is that local factors have made negligible contributions to the growth rate of house prices. For instance, with the local factor of province, there were few that explain the rise of house prices in Daegu, Pohang, and Gumi in the northern province of Gyeongsang. Since these cities are located far from each other, there is no appreciable mutual effect on house prices. If a phenomenon like this is observed in one particular area, this could be considered as the characteristics of the house prices in that area. However, given the fact that such trend is observed in all subject areas, it can be analyzed that when it comes to the rise in house prices, the co-movement by the city within the same province is insignificant.

Along with that, figure 3 suggests a high possibility that the soaring house prices observed in 2006 was probably a local bubble and not nationwide. During the same period, the growth rate of the house price in the cities of Gyeonggi province rose above the nationwide factor, while most other cities showed a similar pattern or fell. This means that the rise in house prices in cities of Gyeonggi province was largely driven by the city-specific factors.

3.3. Variance Decomposition

To measure the relative contributions of the national, regional and city factors to variations in the growth rate of house price, the shares of the variance of each factor to the house price are estimated. The variance of house price was decomposed into the fraction of each factor. With orthogonal factors, the variance of the growth of house price of city *i* can be decomposed as follows

$$\text{var}(y_{i,t}) = (\beta_i^{nation})^2 \, \text{var}(f_t^{nation}) + (\beta_i^{region})^2 \, \text{var}(f_{r,t}^{region}) + \text{var}(\varepsilon_{i,t}).$$

Then, the variance contributions due to the national and regional factors can be written

$$\frac{(b_i^k)^2 \, \text{var}(f_t^k)}{\text{var}(y_{i,t})}, \quad k = narion, \ region.$$

The fraction of variance explained by city specific factors were defined as

Table 4 Variance Decomposition

	National			Regional			City		
	10%	Median	90%	10%	Median	90%	10%	Median	90%
Seoul	0.689	0.715	0.738	0.001	0.002	0.003	0.258	0.281	0.307
Incheon	0.702	0.729	0.748	0.001	0.002	0.003	0.248	0.268	0.294
Suwon	0.535	0.560	0.581	0.002	0.003	0.004	0.413	0.435	0.459
Sungnam	0.504	0.530	0.551	0.002	0.003	0.005	0.443	0.464	0.489
Anyang	0.465	0.488	0.507	0.002	0.003	0.005	0.487	0.506	0.529
Bucheon	0.536	0.563	0.587	0.002	0.003	0.004	0.408	0.431	0.458
Kwangmyung	0.533	0.559	0.580	0.002	0.003	0.004	0.414	0.435	0.460
Ansan	0.705	0.729	0.747	0.001	0.002	0.003	0.249	0.267	0.292
Chuncheon	0.542	0.563	0.579	0.002	0.004	0.006	0.411	0.428	0.448
Wonju	0.608	0.629	0.646	0.002	0.003	0.005	0.346	0.362	0.383
Chungju	0.391	0.411	0.427	0.002	0.004	0.006	0.564	0.581	0.600
Choongju	0.496	0.513	0.526	0.002	0.003	0.005	0.468	0.481	0.497
Cheonan	0.497	0.516	0.532	0.002	0.004	0.006	0.458	0.473	0.492
Deajeon	0.380	0.397	0.411	0.003	0.005	0.007	0.578	0.592	0.608
Daegu	0.613	0.639	0.660	0.001	0.002	0.004	0.335	0.356	0.382
Pohang	0.403	0.426	0.446	0.002	0.004	0.006	0.545	0.565	0.589
Gumi	0.613	0.637	0.656	0.001	0.002	0.004	0.339	0.358	0.381
Ansan	0.364	0.389	0.410	0.003	0.004	0.007	0.578	0.600	0.624
Changwon	0.638	0.661	0.680	0.001	0.002	0.004	0.315	0.334	0.357
Busan	0.744	0.772	0.792	0.001	0.002	0.003	0.204	0.225	0.252
Ulsan	0.669	0.704	0.734	0.001	0.002	0.004	0.261	0.290	0.324
Jeonju	0.669	0.695	0.713	0.002	0.003	0.006	0.277	0.294	0.319
Iksan	0.572	0.596	0.615	0.002	0.004	0.006	0.374	0.393	0.417
Kwangju	0.600	0.624	0.645	0.002	0.003	0.005	0.347	0.367	0.392
Mokpo	0.258	0.275	0.291	0.003	0.006	0.009	0.694	0.711	0.728
Sooncheon	0.300	0.322	0.344	0.003	0.006	0.009	0.639	0.660	0.683

$$\frac{\mathrm{var}(\varepsilon_{i,t})}{\mathrm{var}(y_{i,t})}.$$

Table 4 displays the variance shares of each factor in 26 cities. The average median share of the national factor stands at 56%, indicating the existence of co-movement of housing business cycle in Korea. Especially, the fraction of volatility due to the national factor on Seoul, Incheon, Ansan, Busan, and Ulsan was more than 70%, accounting for the high correlation observed in table 2. Note that the contribution of the national factor to house prices in Daejeon was relatively small compared to other big cities. Looking at figure 3, the house prices in Daejeon tend to be isolated from the national factor in periods after 2003. In particular, house prices of this city increase while the national factor points to decline in 2004. This might be related with the construction of a new administrative city that projected that 49 government institutions were to be relocated near the Daejeon area. While the variance shares attributable to the regional factors are minuscule, the contributions from the city-specific factors range from 20% to 70%. This suggests that housing-related policies of local governments have a significant influence along with those of the central government.

The identification of the sources of changes of house prices was important. When house price hikes are caused by the policy imposed by the local government, the macroeconomic policies by the central government to unwind the course of the house prices will have limited effect. Macroeconomic policy interventions to fend off soaring house prices could be rationalized only when the changes in house prices are nationwide.

4. HOUSE PRICES AND MONETARY POLICY

Of macroeconomic variables, the fact that the explanatory power of the interest rate indicator is high on a nationwide factor means that the interest rate policy of the central bank that has the right to make decisions on short-term interest rates is closely related to the rate of the house price rise. The interest rate policy of the central bank can be divided into two parts: One equivalent to the reaction function that is determined depending on the market conditions and the other equivalent to a pure monetary shock. Noted was the actual effect that the pure shock (one of the low interest rate policies of the central bank) has made on house prices nationwide. The preceding studies on house prices and the interest rate focused on knowing the relation between the two through a regression analysis. However, these analyses have a problem of improperly considering the response function that exists in the interest rate. A problem could occur in the econometrics side as well since the response function is endogenous. The coexistence of endogenous and exogenous functions makes it difficult to accurately analyze the effect of the interest rate policy that is recognized as an external shock.

This study uses the structural vector auto-regression model to identify a pure monetary shock. The study answers the following question based on the identified monetary shock:

Question: If there had not been an exogenous monetary shock of the central bank, what would have happened to the growth rate of the house prices that are explained by a national factor after the second quarter of 2003? To what degree did the exogenous monetary policy of the central bank contribute to the rise in house prices represented by a national factor after the second quarter of 2003?

To find the answer to this question, a counterfactual historical simulation needs to be conducted. This simulation is carried out by making the monetary policy central bank as purely determined by the endogenous function, after eliminating the structural monetary shock later than the second quarter of 2003. In this case, the difference between the growth rate of house prices by a national factor and the counterfactual historical simulation can be understood as the growth rate of house prices caused by a purely exogenous monetary shock. The reason for using the growth rate of house prices by a national factor instead of the national growth rate of house prices was because the growth rate of house prices driven by the local and city-specific factors has no significant relation with the monetary policy since the effect of monetary policy occurs across the nation.

The following 4-variable structural VAR was construct to answer this question

$$A(L)y_t = u_t,$$

where $y_t =$ [real GDP growth, CPI inflation, national factor, Call rate]. Sign restriction methods introduced by Faust (1998), Uhlig (1999), and Canova and De Nocolo (2002) are employed to identify monetary shocks. In many structural VARs, the identification problems are tackled by introducing restrictions on covariance matrices or by imposing zero restrictions on contemporaneous relations. Under sign restrictions, identification problems are tackled by letting impulse responses restricted to match the stylized facts under a given structural shock. To verify, impulse responses were simulated from a multivariate normal random draw based on the covariance of the residuals estimated after a Bayesian VAR. Then, the study records the draw to be structural when the corresponding impulse responses meet the sign restrictions and discard it otherwise. This process is repeated 10,000 times to identify technological and monetary shocks.

The sign restrictions imposed to identify technological shocks are as follows: real GDP growth should be non-negative and CPI inflation should be non-positive at least after the first 2 quarters after the shock.[10)] Figure 4 exhibits the impulse responses up to 20 quarters after technological shocks. The median shows as well as the 10% and the 90% quintiles for the sample of impulse responses. The technology shock increases house prices denoted by the national factor for 3 quarters, although the impact seems to be limited considering confidence bands. Call rate declines after the shock, which is consistent with earlier findings.

In order to identify monetary shocks, the study imposes the following sign restrictions: real GDP growth and CPI inflation should be non-positive at least for 2 quarters after the shock.[11)] The impulse responses as well as the 10% and the 90% confidence bands are presented in figure 5. The results show that contractionary monetary shocks affect the house prices explained

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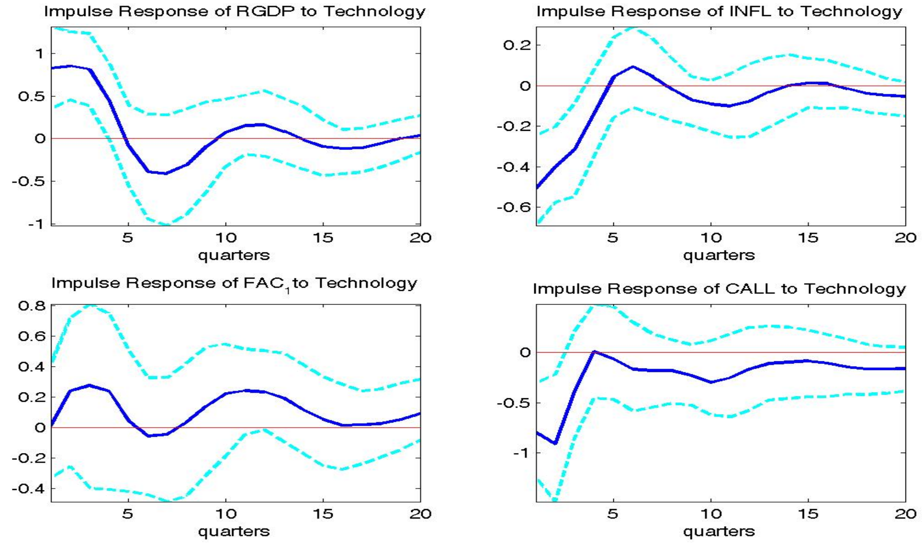
10) The study adopts those used in Uhlig (1999) in regards to the lag structures on sign restrictions.

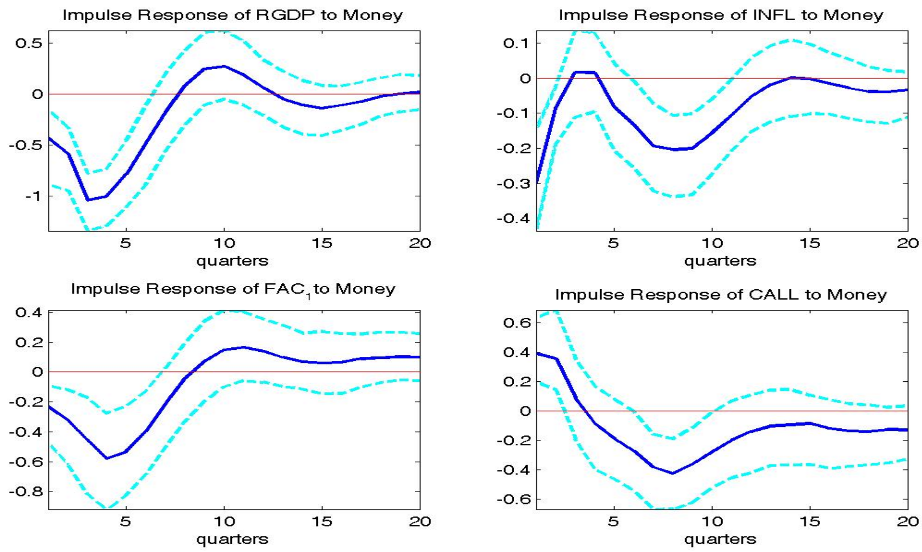
11) These restrictions are considered to avoid price puzzle problems known as perverse in VAR literature. Directed by AIC, the time lag is set to 3.

Figure 4 Impulse Responses to Technology Shocks



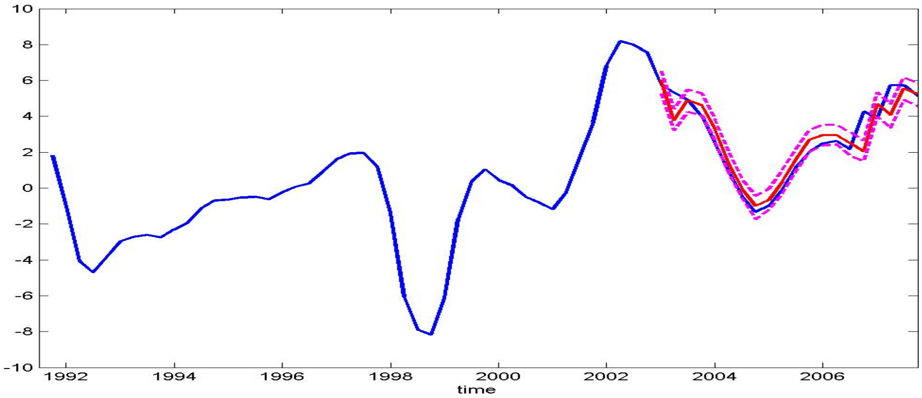
Note: The dotted lines denote the 10% and the 90% confidence bands.

Figure 5 Impulse Responses to Monetary Shocks



Note: The dotted lines denote the 10% and the 90% confidence bands.

Figure 6 Actual and Counterfactual House Prices Induced by the National Factor



Note: The dotted lines indicate the 10% and the 90% confidence intervals.

by the national factor negatively for around 8 periods and lower inflation for about 5 periods. The results are reasonable in that they confirm the stylized facts illustrated in undergraduate textbooks.

Based on the monetary shocks identified under the sign-restricted VAR, figure 6 presents the results of a historical counterfactual exercise to answer the question laid out at the beginning of this section. According to results, the house prices would have lowered by around 1 percentage point during 2003Q2-2003Q3, had there not been an exogenous monetary shock of the monetary authority. Afterwards, the impact on house prices becomes weak until the mid 2006. During this period, the house prices under the counterfactual experiment moves almost in tandem with the historical prices, suggesting monetary policy shocks have little contribution on the house prices.

As the house prices rebounded at the end of 2005, the monetary authorities became more contractionary and started to raise benchmark interest rates, rendering the actual prices move below the counterfactual prices. Despite the continued contractionary policy of the central bank, the impacts are contrary to that expected under purely exogenous monetary policy shocks after the second half of 2006. If the contractionary monetary policy shocks had been exogenous apart from the feedback from the underlying economic conditions, the actual prices should have been below the counterfactual prices. This finding gives weak evidence for the argument that the monetary tightening observed after 2006 is purely exogenous. Rather, it seems to be more reasonable to claim that the contractionary policy in this period is based on the feedback rule of the central bank, i.e., endogenous responses to the underlying macroeconomic fundamentals such as CPI inflation, real estate taxes, and real GDP. The counterfactual experiment reveals that the tightening of the monetary policy witnessed since 2006 is the result of accommodating the economic status rather than purely exogenous monetary shocks.

5. CONCLUSION

Of the national wealth, the proportion of the real estate such as houses was significantly larger than that of financial assets such as stocks and bonds. In particular, the house price has a potentially higher ripple effect than general macroeconomic variables since it directly exerts an influence on the resource allocation within the national economy and the quality of life through the residential service. In this regard, identifying whether the changes in house prices are local phenomenon or nationwide is of great importance in terms of establishing a real estate-related model or macroeconomic policy.

This paper investigates the relative importance of national, regional, and city-specific factors on explaining the movement of housing prices across Korean cities; a dynamic factor model using a Bayesian approach was employed to measure the contributions of each factor for this purpose. The variance decomposition analysis illustrates that most of the movement of Korean housing prices are ascribed to the national factor that accounts for 56% of housing price variations on average and over 70% in 5 cities including Seoul and Pusan. This demonstrates the existence of co-movement of housing prices in Korean cities, which has been discussed in both academics and the real estate industry without providing any solid evidence. This paper also finds that the contribution of city-specific factors ranges from 20% to 70%. However, the regional factors have negligible impacts on housing price fluctuations in all cities.

According to a counterfactual historical simulation on the effect of the low interest rate since 2003 on the house price (which uses the structural VAR) it was found that the exogenous monetary shock in the late 2003 affected the rise in house prices. However, until late 2005 the monetary shock had not made a notable impact on house prices. In particular, the high interest rate situation after 2006 was found to be driven more by the response function of the interest rate determined based on the economic status at that time than by the exogenous monetary tightening policy of the central bank. This paper concludes that the changes in house prices at that time were affected more by other macroeconomic variables, such as CPI inflation, real estate taxation, and real GDP than by autonomous monetary shocks.

APPENDIX

Table A1 Estimation Results of Dynamic Factor Model

Model: $y_{i,t} = \alpha_i + \beta_i^{nation} f_t^{nation} + \beta_i^{region} f_{r,t}^{region} + \varepsilon_{i,t}$

	α_i			β_i^{nation}			β_i^{region}		
	10%	Median	90%	10%	Median	90%	10%	Median	90%
Seoul	0.41	0.65	0.89	0.48	0.60	0.73	0.03	0.04	0.05
Incheon	0.57	0.81	1.04	0.30	0.38	0.46	–0.01	0.00	0.02
Suwon	0.38	0.63	0.89	0.16	0.26	0.37	–0.01	0.00	0.02
Sungnam	0.22	0.46	0.72	0.53	0.67	0.80	–0.02	0.01	0.04
Anyang	0.42	0.68	0.94	0.56	0.70	0.85	–0.02	0.01	0.04
Bucheon	0.52	0.75	0.99	0.36	0.45	0.55	–0.01	0.01	0.02
Kwangmyung	0.35	0.60	0.85	0.56	0.69	0.83	–0.02	0.01	0.04
Ansan	0.39	0.65	0.90	0.58	0.73	0.89	–0.02	0.01	0.03
Chuncheon	–0.12	0.12	0.36	0.24	0.29	0.36	–0.02	0.01	0.04
Wonju	0.07	0.32	0.56	0.22	0.27	0.33	–0.03	0.01	0.06
Chungju	0.23	0.44	0.65	0.11	0.15	0.19	–0.02	0.00	0.04
Choongju	0.11	0.32	0.52	0.36	0.44	0.53	–0.04	0.01	0.07
Cheonan	–0.02	0.22	0.45	0.18	0.23	0.29	0.00	0.00	0.01
Deajeon	0.22	0.44	0.67	0.23	0.29	0.36	0.00	0.00	0.02
Daegu	0.15	0.38	0.61	0.40	0.49	0.58	–0.03	0.01	0.05
Pohang	0.14	0.36	0.58	0.20	0.25	0.31	–0.02	0.01	0.04
Gumi	0.06	0.28	0.52	0.40	0.50	0.60	–0.06	0.01	0.08
Masan	–0.07	0.16	0.42	0.41	0.50	0.61	–0.03	0.01	0.05
Changwon	0.44	0.69	0.93	0.67	0.83	0.99	–0.05	0.02	0.09
Busan	0.06	0.29	0.52	0.36	0.45	0.54	–0.02	0.01	0.04
Ulsan	0.06	0.29	0.53	0.10	0.15	0.21	–0.03	0.00	0.03
Jeonju	–0.19	0.02	0.22	0.15	0.19	0.23	–0.02	0.02	0.08
Iksan	0.20	0.41	0.63	0.15	0.20	0.25	–0.04	0.02	0.08
Kwangju	–0.07	0.14	0.36	0.15	0.19	0.24	–0.03	0.01	0.06
Mokpo	–0.51	–0.29	–0.08	0.17	0.23	0.29	–0.04	0.02	0.09
Sooncheon	–0.42	–0.19	0.03	0.14	0.19	0.24	–0.05	0.02	0.09

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