제도와 경제
제18권 제3호, 2024년 8월, 79-104
(사) 한국제도·경제학회

Review of Institution and Economics
Volume 18, No. 3, August 2024, 79-104
Korea Institution and Economics Association
https://doi.org/10.30885/RIE.2024.18.3.079

Time-varying Analysis of Housing Prices in Korea and the U.S.: Focusing on the Interest Rate Impact *

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Abstract

This study analyzes the impact of interest rates on housing prices in Seoul and four U.S. cities (New York, Los Angeles, Chicago, and Washington D.C.). Using a time-varying VAR model and monthly data from 1991 to 2023, we find that Seoul's housing prices respond more flexibly to interest rate shocks than those in major U.S. cities, particularly since 2008. While U.S. cities showed a rapid reaction to interest rates around 2008, their response has diminished since 2010. In contrast, interest rates and Jeonse prices continue to significantly affect Korean housing prices, especially during periods of lower interest rates. Our findings highlight the increasing impact of interest rates on Korean housing prices over time, suggesting the need for close attention to both interest rates and Jeonse prices in guiding Korean housing market.

Key words: Interest rates, Housing price, Time-varying parameter VAR Model, Impulse response analysis.

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* This paper was written based on part of the doctoral thesis of the first author Chul Hong Min.
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Ⅰ. Introduction

People spend their considerable time in their houses. In addition, house takes large portion of individuals' wealth. Despite such an importance, housing prices are unpredictable. In Korea, housing prices have stayed at high levels for long. Therefore, many Korean households rely on housing loans to purchase homes. For the last two decades, many economies have experienced two deep recessions following the global financial crisis and pandemic. As other economies, Korea also lowered interest rate to nearly zero percent to prevent long lasting recessions.

Several studies suggest that lower interest rates cause substantial increases in housing asset prices (Sutton *et al*., 2017; Park *et al*., 2021; Park & Min, 2022). Since housing supply is relatively inelastic, housing market is more dependent on housing demand, which relies on housing loan. Park *et al*. (2021) find that there exist structural breaks in Korean interest rates and suggest that liquidity expansion from interest rate cut raises housing prices. According to Jing *et al*. (2022), interest rates affects Jeonse prices and house sale prices. In this study, we examine how those interest rate effects change over time and investigate whether those time-varying effects are present in Korea and the US

Lucas (1976) exceptionally articulated concerns about traditional econometric models by emphasizing the evolving nature of economic systems. From this perspective, we investigate whether the effects of interest rate on housing prices can vary across different time periods. We also compare the impacts of interest rates on housing prices between Korea and the U.S.. Our comparative study can provide economic lessons regarding housing markets for Korea and the U.S..

The remainder of this paper is organized as follows. Section Ⅱ reviews the literature. Section Ⅲ explains data and methodology. Section Ⅳ discusses the empirical findings. Finally, section Ⅴ concludes.

Ⅱ. Literature Review

In this section, we provide a literature review on the effects of interest rates on housing prices. Previous research on housing prices employed Granger causality tests, VAR (vector auto-regression), or VECM (vector error correction model) methods. Lim (2015) found that interest rate fluctuations affected consumption and stock prices more significantly than economic growth, housing prices, or exchange rates. Kim e*t al*. (2009) and Lee (2020) demonstrated that higher interest rates stimulated housing sales, and Son (2010) used Bayesian VAR to show the effect of monetary policy on housing prices.

Several studies consider demographic variables in examining housing prices. Chen *et al*. (2011) find that urbanization accelerates housing price in developing countries. Gong & Yao (2022) suggest that life expectancy, international immigration, and fertility affect housing demand for the U.S.. Related to the impact of demographic changes on housing price, Sanchis-Guarner (2023) considers international immigration as a factor for housing price.

Other studies examined relationship between interest rates and housing prices. Kim & Jeong (2012) used VECM for data from 2003 to 2011, finding minimal short-term effects of mortgage rates but noting long-term positive impacts from liquidity and negative ones from interest rates. I & Song (2015) applied FAVAR (factor-augmented VAR) to data from 1998 to 2014, showing that higher rates decreased housing sales and Jeonse prices. Choi & Koh (2015) linked lower base interest rates to higher housing prices and greater liquidity, using the data from 1998 to 2013. Lee & Kim (2016) used VAR models for the data from 1991 to 2015 and found varied effects of interest rate shocks on housing prices. Eom & Jin (2016) found significant effects of liquidity on housing prices using VECM for the data from 1998 to 2015.

Research on the impact of interest rates on housing prices often are practiced at national levels. Sim (2004) used VAR analysis on monthly data from South Korea, finding that money supply had a stronger impact on housing markets than price levels. Park & An (2009) and Park (2022) found short-term apartment price fluctuations due to interest rate shocks. Chun (2012) highlighted that Gangnam in Seoul was more sensitive to mortgage interest rate changes compared to other regions. Previous studies, such as Jorda (2005), argue that major macroeconomic variables should be analyzed using VAR. Jorda (2005) use non-agricultural payroll employment and consumption expenditure in addition to federal funds rate and money stock.

Lee (2020) pointed out previous misconceptions about policy interest rates' effects on housing prices with a local projection model based on data from 2006 to 2019. Lee (2020) found that positive policy rate shocks significantly reduced apartment sales prices, especially in Seoul and the southeastern region, diverging from the broader national trend. At the national level, various countries have been considered for their housing market analysis. In line with this, some studies use panel data so that they compare and find general evidences from many countries (Ma and Liu, 2010; Mikhed and Zemcik, 2009). More practical approach to the housing market issue can be resolved by scenario analysis and stress tests. Especially, Follain and Giertz (2011) suggest that existing stress test scenarios for housing market reflects housing prices in real terms instead of nominal level.

On the other hand, Sutton *et al*. (2017) highlighted the crucial role of short-term interest rates in various U.S. markets, while Rubio *et al*. (2016) examined the impact of liquidity shocks on European housing prices after the launch of Euro. Similar analysis is provided by Fischer *et al*. (2021). Our study explores the time-varying impacts of interest rates on housing prices, contrasting Sutton *et al.*(2017)'s assertion of a time-invariant relationship in the US. Hanck (2020) used Bayesian VAR in Germany, linking interest rate declines to recent housing price increases. Jarocinski & Smets (2008) and Martin *et al*. (2022) investigate the relationship between housing market and monetary policy in the U.S.. Many studies assume uniform impacts of interest rate shocks over time, highlighting the need for time-varying parameter models (TVP) to capture evolving dynamics accurately. Song (2016), using a TVP-VAR approach on Korea's housing market from 2004 to 2015, uncovered increasing complexities in response to economic variables. While previous studies typically focus on individual countries' housing markets, we use a TVP-VAR approach to analyze Seoul's housing market and compare it to major U.S. cities. This comparison offers valuable insights for the Korean housing market.

Ⅲ. Data and Methodology

1. Data

In this study, we use the data for sales price, macroeconomic activity conditions, and interest rate. In particular, for Seoul housing market, we add Jeonse price data[1). For the Seoul data, we collect sales and Jeonse prices from the KB Bank Database, and take the log-difference of monthly prices to obtain monthly price changes. In this study, Seoul housing price data refer to the prices of Seoul apartments. To assess the macroeconomic conditions of the Korean economy, we consider the coincident index data provided by Statistics Korea, which we also convert into monthly growth rates. Lastly, for the interest rate variable, we select the Certificate of Deposit (CD, hereafter) interest rate from the Bank of Korea's market interest rates.

We gather the US housing price data from the Case-Shiller Price Index for New

1) Jeonse price refers to Jeonse lease deposits. In this study, we use the terms Jeonse price and Jeonse deposit interchangeably.

York, Los Angeles, Chicago, and Washington D.C.. We also use the CD rate and the US Coincident Economic Activity Index data. All the US data for the CD interest rate and coincident index were sourced from the Federal Reserve. All the sample data is ranged from March 1991, coinciding with the availability of Korea's CD interest rate, to December 2023, including 394 observations. Given the monthly frequency, housing prices and the composite economic index exhibit seasonality. Consequently, we applied the X-12-ARIMA seasonal adjustment to filter out potential seasonal effects from these data[2].

<Table 1> Augmented Dickey-Fuller Unit root test results

	Korea				U.S.					
	Seoul		Interest rates (CD)	Coincident Economic Index	Washington	New York	LA	Chicago	Interest rates (CD)	Coincident Economic Index
	Housing prices	Jeonse price			Housing prices					
level	-2.682 (0.245)	-2.793 (0.201)	-3.439** (0.048)	-3.789** (0.018)	-2.553 (0.303)	-1.794 (0.706)	-2.142 (0.520)	-1.478 (0.836)	-1.021 (0.939)	-1.663 (0.766)
difference	-8.460*** (0.000)	-6.248*** (0.000)	-12.434*** (0.000)	-6.342*** (0.000)	-3.934** (0.012)	-4.135*** (0.006)	-3.791** (0.018)	-4.310*** (0.003)	-13.095*** (0.000)	-19.075*** (0.000)

Note: ( ) indicates p-value. *** for p<0.01, ** for p<0.05, * for p<0.1

<Table 1> reports the results of Augmented Dickey-Fuller (ADF) unit root test, which examines the null hypothesis that the time series contain unit roots. Our findings reveal that the housing price and Jeonse price in Korea possess unit roots at their levels, while the Korean CD rate and coincident index do not. We therefore use the differenced data for the housing price and Jeonse price in Korea, and the level data for the Korean CD rate and coincident index. For the US data, we find no evidence on unit roots at the levels, so we use these data in their original form for the regression analysis.

Next, <Table 2> presents the criteria values for selecting the appropriate lag length for the VAR estimation, based on three information criteria: the Akaike

2) We perform this X-12 filtering by Eviews program.

Information Criterion (AIC), the Schwarz Information Criterion (SIC), and the Hannan-Quinn Information Criterion (HQ). Smaller values in Table 2 indicate more suitable time lags for each column of information criterion, with the asterisk symbol denoting the smallest value in each column. Overall, the results suggest that two time lags are the most appropriate, as evidenced by the row with two time lags having the most asterisks.

<Table 2> Appropriate analysis time difference test

	Seoul housing price						4 US cities housing price											
	Interest rate			Jeonse price			Interest rate											
	Seoul			Seoul			New York			LA			Chicago			Washington		
	AIC	SIC	HQ	AIC	SIC	HQ	AIC	SIC	HQ	AIC	SIC	HQ	AIC	SIC	HQ	AIC	SIC	HQ
0	9.804	9.835	9.816	6.471	6.502	6.483	8.111	8.142	8.124	9.112	9.143	9.124	8.272	8.303	8.284	8.497	8.528	8.509
1	4.369	4.493	4.418	4.290	4.414	4.339	2.222	2.346	2.271	2.437	2.561	2.486	2.948	3.072	2.997	2.358	2.482	2.407
2	4.080	4.296*	4.166	4.191	4.407*	4.277	1.947	2.164*	2.033*	2.280*	2.497*	2.366*	2.738	2.955*	2.824*	2.167	2.384*	2.253*
3	4.006	4.315	4.129	4.135	4.445	4.258	1.977	2.287	2.100	2.282	2.592	2.405	2.755	3.065	2.878	2.163*	2.473	2.286
4	3.968	4.371	4.128	4.093	4.495	4.252*	1.943*	2.346	2.103	2.299	2.701	2.458	2.708*	3.111	2.868	2.168	2.571	2.328
5	3.920*	4.416	4.117*	4.058	4.553	4.254	1.950	2.445	2.146	2.298	2.794	2.495	2.719	3.215	2.916	2.179	2.675	2.376
6	3.933	4.521	4.166	4.039	4.628	4.273	1.970	2.559	2.204	2.334	2.922	2.567	2.750	3.339	2.984	2.210	2.798	2.443
7	3.922	4.604	4.193	4.034	4.715	4.304	1.981	2.662	2.251	2.363	3.045	2.634	2.779	3.461	3.050	2.209	2.891	2.480
8	3.905	4.680	4.212	4.014*	4.789	4.321	2.006	2.781	2.313	2.371	3.146	2.679	2.805	3.580	3.113	2.252	3.027	2.559
9	3.906	4.774	4.250	4.040	4.907	4.384	2.014	2.882	2.358	2.396	3.264	2.741	2.834	3.701	3.178	2.289	3.157	2.633
10	3.924	4.884	4.305	4.049	5.009	4.430	2.034	2.994	2.415	2.420	3.380	2.801	2.857	3.818	3.238	2.315	3.275	2.696
11	3.905	4.959	4.323	4.061	5.114	4.479	2.053	3.106	2.471	2.441	3.494	2.859	2.879	3.932	3.297	2.335	3.388	2.752
12	3.910	5.056	4.365	4.072	5.218	4.526	2.057	3.204	2.512	2.478	3.625	2.933	2.882	4.028	3.336	2.371	3.517	2.825

Note: * for the most appropriate lag in each column, AIC(Akaike information criterion), SIC(Schwarz information criterion), HQ(Hannan-Quinn information criterion).

2. Methodology

In this study, we adapt a TVP-VAR model proposed by Primiceri (2005) and Nagajima (2011). To explain the model, we start with the following k-variable VAR model:

$$Y_t = \sum_{k=1}^{s} B_{k,t} Y_{t-k} + u_t \tag{1}$$

where Y_t is a vector of $(k \times 1)$ endogenous variables, s is the time lag, B_t is the $(k \times k)$ time-varying coefficient matrix, and u_t is a vector of heterogeneous unobserved shocks with a variance–covariance matrix Ω_t. For the TVP-VAR model in Equation (1), we assume that the variance–covariance matrix is structured as follows:

$$Var(u_t) = \Omega_t = A_t^{-1} \Sigma_t \Sigma_t{}' (A_t^{-1})' \tag{2}$$

The matrix A_t in Equation (2) is assumed to be the following lower triangular matrix:

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{2\,1,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{k\,1,t} & \cdots & \alpha_{k\,(k-1),t} & 1 \end{bmatrix} \tag{3}$$

In addition, the matrix Σ_t in Equation (2) is assumed to be the diagonal matrix as below.

$$\Sigma_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{k,t} \end{bmatrix} \tag{4}$$

To proceed with, we assume that a vector of some $(k \times 1)$ stochastic terms for time t, ϵ_t has its variance-covariance matrix equal to an identity matrix, I_k.Then, we can express u_t as $u_t = A_t^{-1}\Sigma_t\epsilon_t$, and thus obtain the following:

$$Y_t = \sum_{k=1}^{s} B_{k,t} Y_{t-k} + A_t^{-1}\Sigma_t\epsilon_t \tag{5}$$

Following Primiceri (2005) and Nakajima (2011), we rewrite Equation (5) in a stacked form as follows:

$$Y_t = X_t\beta_t + A_t^{-1}\Sigma_t\epsilon_t \tag{6}$$

where X_t is defined to equal the Kronecker product of I_k and $(Y'_{t-1}, \ldots, Y'_{t-s})$, that is, $I_k \otimes (Y'_{t-1}, \ldots, Y'_{t-s})$, and Equation (6) is defined for $t = s+1, \ldots, n$. Matrix algebra implies that X_t is a $(k \times k^2 s)$ matrix, and β_t is a $(k^2 s \times 1)$ vector of the parameters. Despite the subscript t in the notations, $X_t\beta_t$ includes lagged ones for the variable vector Y_t, not a contemporaneous variable vector, and thus the parameter vector β_t represents the coefficient vector for the lagged variable vector.

In addition, we stack lower triangular elements of the matrix A_t in a vector and denotes it by α_t in Equation (6). Therefore, α_t is a column vector with the rows of $k(k-1)/2$. We also define h_t as a $(k \times 1)$ vector of log-transformed values of the diagonal elements in Equation (4). Following Nakajima (2011), we assume random walk processes for β_t, α_t, and h_t:

$$\beta_t = \beta_{t-1} + \nu_t \tag{7}$$

$$\alpha_t = \alpha_{t-1} + \zeta_t \tag{8}$$

$$\log \sigma_t = \log \sigma_{t-1} + \eta_t \tag{9}$$

Following Primiceri (2005) and Nagajima (2011), we assume that the error term vectors ϵ_t, ν_t in Equation (7), ζ_t in Equation (8), and η_t in Equation (8) are jointly normally distributed with the variance-covariance matrix in Equation (10):

$$V = Var\left(\begin{bmatrix} \epsilon_t \\ \nu_t \\ \zeta_t \\ \eta_t \end{bmatrix}\right) = \begin{bmatrix} I_k & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_\alpha & 0 \\ 0 & 0 & 0 & \Sigma_h \end{bmatrix} \tag{10}$$

As outlined by Nakgajima (2011), the TVP-VAR estimation employs Bayesian methods to evaluate the posterior distributions of key time-varying parameters β_t, α_t, and h_t. Utilizing Gibbs sampling, we draw a sufficient number of parameter samples, enabling the construction of their posterior distributions. Ultimately, we estimate the time-varying parameter vectors β_t, α_t, and h_t by calculating the mean values of those posterior distributions, and compute the impulse response functions using each combination of β_t, α_t, and h_t for each time period t.

Next, following Nagajima (2011), we describe the Gibbs sampling procedure for the posterior distribution of time-varying parameter vectors: β_t, α_t, and h_t. As implied in Equation (6), β_t is defined for $t = s+1, \ldots, n$. Then, we repeatedly sample β_{s+1}, ... , and β_n for each routine, following Nagajima (2011). Together with the sampling of β_{s+1}, ... , and β_n, we also sample α_{s+1}, ... , and α_n; h_{s+1}, ... , and h_n. To start with the sampling procedure, we estimate the VAR model in Equation (6) by using the OLS estimation. As the initial values for the sampling routine, we use the OLS estimates for (i) β_{s+1}, ... , and β_n; (ii) α_{s+1}, ... , and α_n; (iii) h_{s+1}, ... , and h_n. Further, we assume that variance-covariance matrices Σ_β, Σ_α, and Σ_h are diagonal and each of the diagonal elements follow Gamma distributions, following Nagajima (2011). For notational convenience, we simply denote a matrix of (β_{s+1}, ... , β_n) by β. Similarly, we denote (α_{s+1}, ... , α_n) by α, (h_{s+1}, ... , h_n) by h, and (Y_{s+1}, ... , Y_n) by Y. Then, following Nagajima (2011), we sketch the sampling procedure as follows[3]:

Step (1): Generate a matrix of β conditional on α, h, Σ_β, Y, that are available as of this step.

Step (2): Generate a vector of Σ_β, using the matrix of β generated from the Step (1).

Step (3): Generate a matrix of α conditional on β generated from the Step (1); h, Σ_α, and Y available as of this step.

Step (4): Generate a vector of Σ_α, using the matrix of α generated from the Step (3).

Step (5): Generate a matrix for h conditional on β generated from the Step (1); α generated from the Step (3); Σ_h, Y available at this step.

Step (6): Generate Σ_h, using the matrix of h generated from the Step (5).

Step (7): Go to the Step (1) and repeat the procedure.

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3) More details for the sampling procedures are presented in the Appendix of Nagajima (2011)

In this study, we repeat this routine 50,000 times to build the posterior distributions for β, α, h, Σ_β, Σ_α, and Σ_h[4]. Those 50,000 values for each element of β, α, h, Σ_β, Σ_α, and Σ_h can be plotted in the posterior distributions, which often can be obtained by using kernel empirical distributions. We use the mean values of those posterior distributions as the time-varying parameters of TVP-VAR model in Equation (6). Using the estimated parameters from the Gibbs sampling procedure, we construct time-varying impulse response functions and present those results in section Ⅳ.

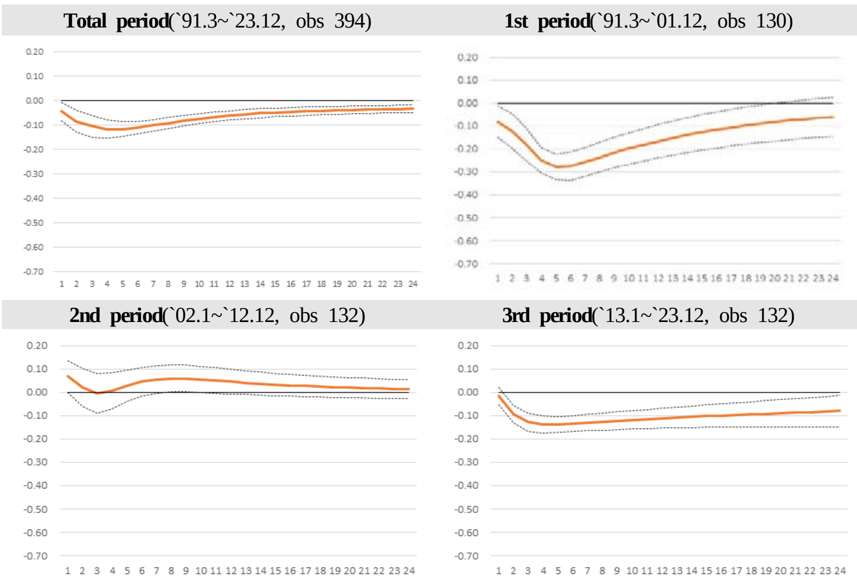
Ⅳ. Empirical Results

1. Constant VAR Impulse Response Function

To compare the time-varying VAR model results, we first calculate the impulse response function for a constant VAR. In doing so, we focus on the Seoul housing market while omitting the US data results to conserve space. Two constant VAR models are specified for the Seoul data: the first one with the coincident index, interest rate, and sales price change and the second one for with coincident index, Jeonse price change, and sales price change.

4) More details about the procedure can be available upon request to the authors.

<Figure 1> Effect of interest rate level on sales price change for Seoul



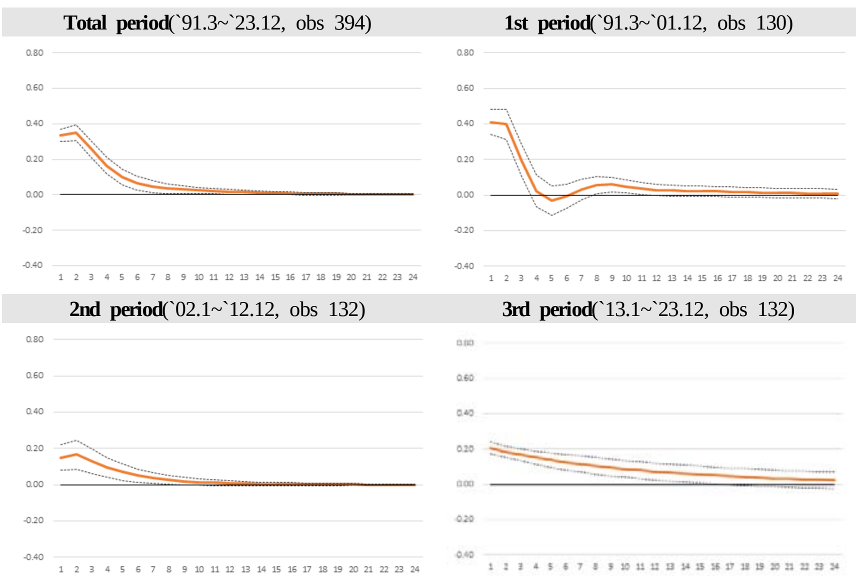
Note: The dotted line is the confidence interval based on the standard error calculated through 10,000 Monte Carlo simulations (same hereinafter).

For the first specification, <Figure 1> shows that housing sales price change reduces in response to a one standard deviation increase in interest rates. On the other hand, <Figure 2> graphs the response function for the second specification, which includes the coincident index, Jeonse price change, and sales price change. <Figure 2> reveals that a positive shock to Jeonse price change enlarges sales price change in Seoul. The price response is observed to peak approximately two months after the initial shock over the entire time span.

To illustrate the limitation of the constant parameter assumption, we divide the whole period into three intervals (1991 to 2001; 2002 to 2012; 2013 to 2023) and present the impulse response for each interval. Since time span for each interval is shorter than the whole period, the impulse response results may be less reliable. However, Figures 1 and 2 demonstrate that the impulse response patterns can significantly differ across those intervals.

In <Figure 1>, the impulse response for the first interval is more pronounced than for the rest intervals. In the first interval, the negative response peaks at approximately -0.3, while the responses in the second period are predominantly positive, and the third period's response peaks at a value slightly greater than −0.2. In <Figure 2>, the impulse response for the first sub-sample period peaks at nearly 0.4, whereas the responses for the second and third periods peak slightly below 0.2. Notably, the first period in <Figure 2> exhibits a negative response at five lags, while the second and third periods show no negative response. These findings suggest that the constant VAR modeling may be inadequate for the pursuit of accurate dynamic analysis of the housing market.

<Figure 2> Effect of Jeonse price change on sales price change for Seoul

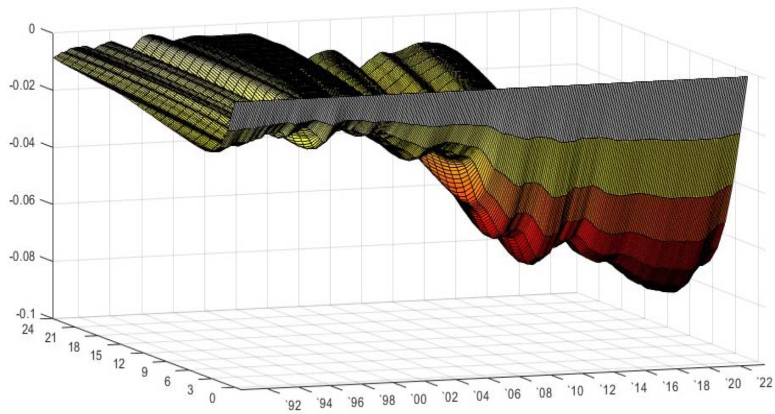


2. TVP-VAR Impulse Response Function

In this section, we present the impulse response results based on the time-varying VAR model. Given that the time-varying impulse responses are plotted for each month, these responses are illustrated in three-dimensional graphs, in contrast to the two-dimensional graphs for the constant VAR models.

For the Seoul data, <Figure 3> indicate that the negative effect of interest rates shock was weaker before 2007-2008, but became more pronounced thereafter. Before the global crisis bursted out in 2008, Korea's CD interest rate hovered around 5 percent, but afterward fell to between 2 and 3 percent from 2009 to 2012. Since 2013, the CD rate has dropped below 2 percent and housing finance cost has also reduced. Less financing costs are likely to lead more Korean households to take out housing loans. As a result, enlarged loans increased exposure to interest rate risks. This situation is evident in the increased response observed after 2007-2008 in <Figure 3>.

<Figure 3> Time-varying impulse response: Interest Rate→Seoul Housing Price

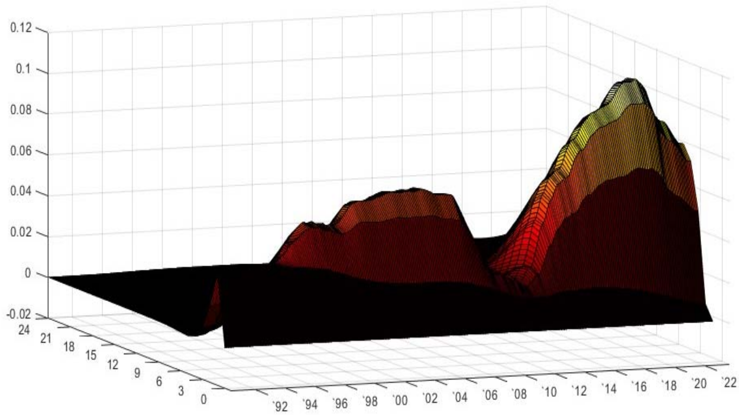


Note: The vertical axis indicates the impulse response to one standard deviation increase of the Korean CD interest rate shock while the plane has two axis for time period (scaled from 92 to 22) and time lag (scaled from 0 to 24).

<Figure 4> shows that higher Jeonse price changes increase sales price changes in Seoul. Homeowners in advance lease their properties to Jeonse tenants and use Jeonse deposits collected from tenants when they purchase their own houses. By this token, it can be implied that, if Jeonse prices (Jeonse deposits) rise, homeowners can finance more of their housing costs by using Jeonse deposits.

<Figure 4> features two adjacent peaks with a valley in between, which coincides with the 2008 global financial crisis. During the crisis in 2007 and 2008, the Korean housing market, like other asset markets, experienced a freeze. Under this circumstance, Jeonse prices did not boost housing demand during the crisis. However, post to the crisis, Jeonse price regained its influence on sales prices. In addition, there was a regime change in Jeonse loan in Korea. Before 2008, Jeonse loans were mostly accessible to low-income households. However, after the crisis, Jeonse loan became widely available to households across various income levels. This policy change contributed to the increased responses shown in <Figure 4>, which continued to increase until 2020.

<Figure 4> Time-varying impulse response: Seoul Jeonse Price→Seoul Housing Price



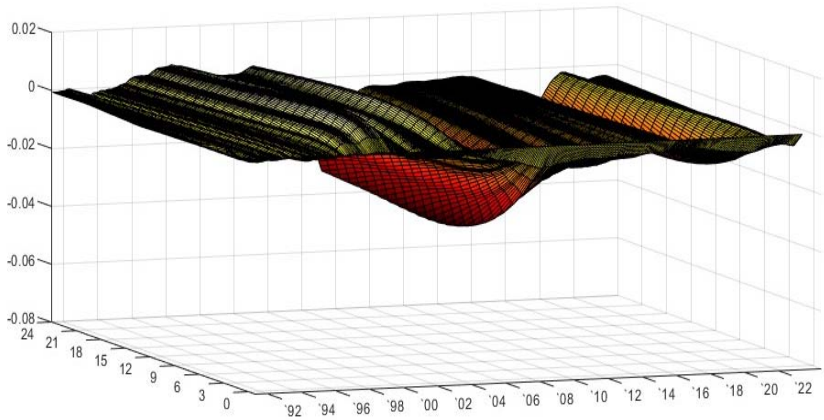
Note: The vertical axis indicates the impulse response to one standard deviation of monthly change for Jeonse price while the plane has two axis for time period (scaled from 92 to 22) and time lag (scaled from 0 to 24).

Figures 5 and 6 depict the impulse responses of housing price in the major US cities. Unlike Korea, Jeonse lease does not exist in the U.S.. We therefore focus on the impulse response to interest rate shock, instead of any response to Jeonse price shocks. Our analysis covers New York, Los Angeles, Chicago, and Washington D.C. <Figure 5> specifically presents the time-varying impulse response for New York and Los Angeles. Similarly to the response patterns for Seoul, the housing prices in New York and Los Angeles exhibit predominantly negative responses.

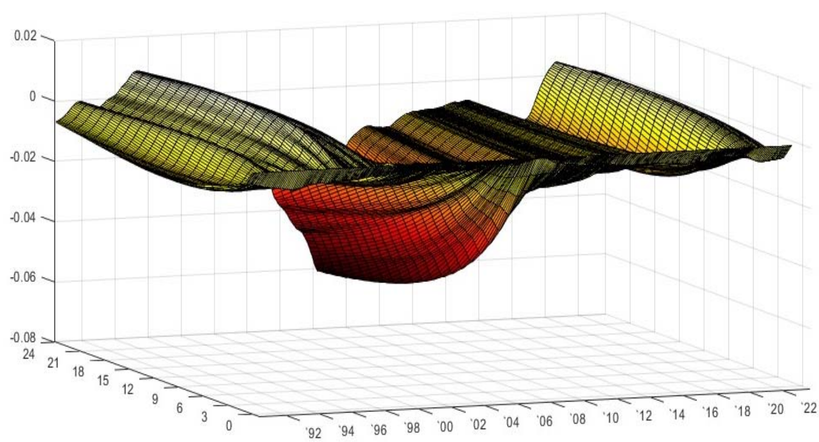
The impulse responses to the interest rate are similar between New York and Los Angeles. <Figure 5> shows that interest rate hike strongly affected housing markets in New York and Los Angeles during the crisis. By the way, valley-shaped graphs in <Figure 5> implies that housing prices for New York and Los Angeles regained their usual responses immediately after the crisis. Next, <Figure 6> illustrates the impulse responses for Chicago and Washington D.C. The responses in <Figure 6> resemble those shown in <Figure 5> for New York and Los Angeles.

<Figure 5> Time-varying impulse response: Interest Rate→ Housing Price for New York and Los Angeles

New York



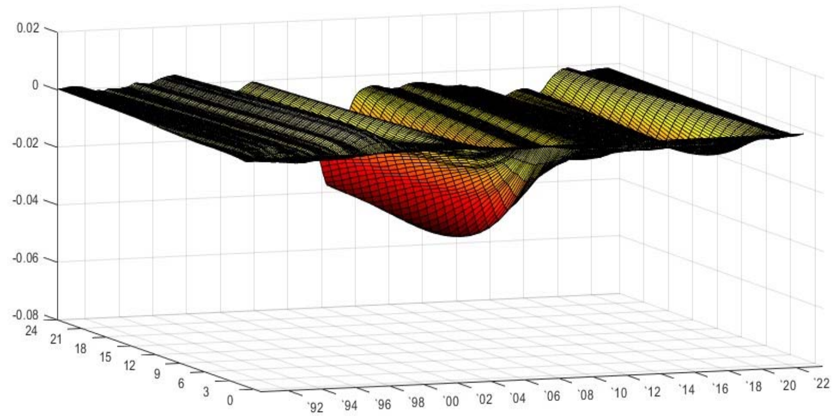
Los Angeles



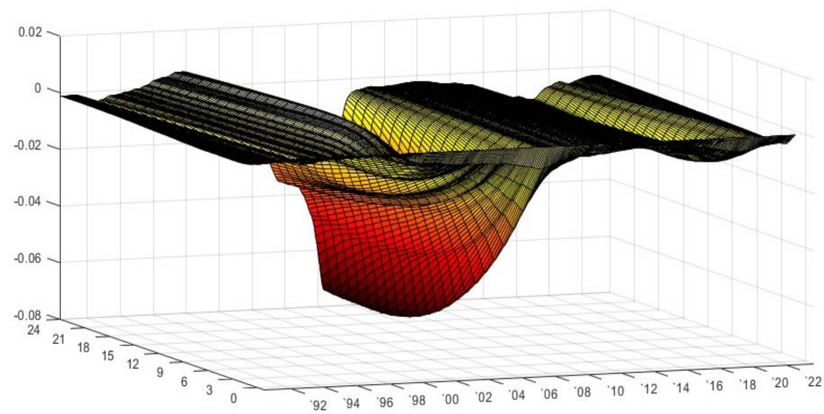
Note: The vertical axis indicates the impulse response to one standard deviation of the CD interest rate while the plane has two axis for time period (scaled from 92 to 22) and time lag (scaled from 0 to 24).

<Figure 6> Time-varying impulse response: Interest Rate→ Housing Price for Chicago and Washington D.C.

Chicago



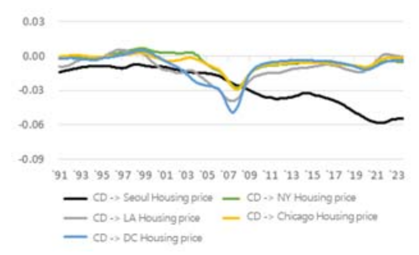
Washington D.C.



Note: The vertical axis indicates the impulse response to one standard deviation of the CD interest rate while the plane has two axis for time period (scaled from 92 to 22) and time lag (scaled from 0 to 24).

According to Figures 5 and 6, housing prices in the US cities show significantly negative responses during the crisis but, after the crisis, turn to the stable response. This pattern is in a sharp contrast to Seoul housing market. To visualize such a difference, we plot the maximum and average responses for each month of the whole period in two-dimensional graphs in <Figure 7>.

<Figure 7> Maximum response and average response to interest rate shock: Seoul and major U.S. cities

Maximum response comparison	Average response comparison
	

The left panel of <Figure 7> illustrates the maximum responses and the right panel depicts the average responses for the whole period. In the left panel, the maximum responses for Seoul (black dotted line), although negatively valued, exhibit an increase in their absolute values in the post-crisis era. Similarly, the right panel indicates an increasing influence of the average response for Seoul (black line). In contrast, the maximum and average responses for the US cities remain relatively stable, with the exception of the period around 2007 and 2008.

We propose two possible explanations for the contrast between Seoul and the US cities, as illustrated in <Figure 7>. First, the Seoul housing market is more sensitive to interest rates due to its higher reliance on housing loans, given that Korean household income levels are relatively low compared to housing prices. As of May 2024, the price-to-income ratio (PIR) for Seoul stands at approximately 26, significantly higher than the ratios for New York (13.54), Los Angeles (8.40), Chicago (4.02), and Washington D.C. (7.02)[5].

Second, Jeonse system plays a crucial role for Korean housing market while it

5) NUMBEO site (https://www.numbeo.com/cost-of-living/)

does not exist in the US. Since 2000, greater supply of Jeonse loans have raised Jeonse demand and Jeonse deposit. With this setting, Jeonse price propped up housing price in Korea. Such a tight link between Jeonse price and sales price makes sale price more sensitive to the interest rate.

Ⅴ. Conclusion

In this study, we analyze the time-varying impact of interest rates on housing prices in Seoul and four major U.S. cities. Most studies use a constant VAR model for the interest rate effect on housing prices, assuming uniform effects over time. In contrast to those previous studies, we examine time-varying impulse responses to interest rate shocks for Seoul and the major U.S. cities. Taking advantage of the time-varying approach, we investigate how the effects of interest rate on housing prices evolve over time.

We find that higher interest rates depress Seoul housing prices, while higher Jeonse prices raise Seoul housing prices. In particular, the interest rate shocks on Seoul housing market has amplified post to the global crisis. On the other hand, the major U.S. cities responded significantly only during the crisis period and reverted to their normal pace after the crisis. Such a contrast can be explained by systemic differences: Seoul housing market is heavily dependent on housing loans due to lower household income relative to housing prices.

In addition, Korea’s Jeonse lease system became popular in the 2000s, and sparked Jeonse demand and Jeonse prices. Higher Jeonse prices, that is, Jeonse deposits, enables landlords to leverage their housing purchases. This phenomenon strengthens the link between Seoul housing market and interest rate.

Our findings have several policy implications. Firstly, the effect of interest rates on the housing market suggests that monetary authorities must consider housing conditions when adjusting interest rates. Secondly, the Jeonse lease system can magnify interest rate impacts, requiring careful oversight. This caution is justified by our evidence on tight linkage between Jeonse lease contract and housing price for Korea.

This study can be extended in several ways. Further variables, including income, employment rates, and demographic changes, can be incorporated into the time-varying analysis, offering a more comprehensive analysis on the housing market. Also, consideration of more regions and panel data can reveal regional and national differences in housing price determinants. Scenario analysis or stress testing can directly provide more policy implications for many possible situations. Another possible extension is to relate LTV (Loan-to-Value) and DTI (Debt-to-Income), which are housing demand-side variables, to housing prices. All the issues are left for future studies.

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〈한글초록〉

한국과 미국의 주택가격의 시간가변적 영향 분석: 이자율 효과를 중심으로

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본 연구는 시간가변 벡터 자기회귀 모형을 사용하여 서울과 미국의 주요 도시인 뉴욕, 로스엔젤레스, 시카고, 워싱턴 D.C.의 주택 가격에 대한 금리의 영향을 분석한다. 1991년부터 2023년까지의 월간 데이터를 이용한 실증 분석 결과는 다음과 같다. 첫째, 서울의 주택 가격은 특히 2008년 이후 주요 미국 도시들보다 금리 충격에 더 유연하게 반응하는 것으로 나타났다. 둘째, 미국 도시는 2008년 글로벌 금융위기 기간 중 금리에 빠르게 반응했으나 2010년 이후 반응이 감소하였다. 셋째, 한국의 주택 가격은 금리와 전세 가격이 여전히 크게 영향을 미치며, 특히 글로벌 금융위기 이후 금리가 주택 매매가격에 미치는 영향은 확대되었다. 따라서 본 연구의 실증분석 결과에 따르면, 시간이 지남에 따라 금리가 한국의 주택 가격에 미치는 영향이 '증가'하고 있다. 이러한 분석 결과는 주택 시장 정책에 있어서 통화정책 등 '금리 관련 변수'의 중요성을 암시한다.

주제어(key words): 금리, 주택가격, 시간가변모수 VAR 모형, 충격반응 분석.

【2024. 7. 27. 접수】【2024. 8. 22. 수정】【2024. 8. 23. 게재확정】