Cross-regional Spillover Effects in the Korean Housing Market

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Abstract

In this paper, we examine cross-regional spillover effects in the Korean housing market, using the predictive directional spillover index and the connectedness measurement. The basic finding is that Seoul has been the most influential market in Korea among various combinations of regional housing markets. We also presented evidence that other metropolitan cities affect only neighboring regions. As for the results based on the rolling-sample analysis, net directional spillovers of Seoul appear to have declined over the sample period. Although Seoul still remains the center of Korean housing market, neighboring regions have become increasingly more influential in affecting other regional markets.

Keywords: Korean housing market, Cross-regional spillover effects, Forecast error variance decomposition, Connectedness measurement
1. Introduction

The development of housing finance in Korea, together with the low interest rates, has led a rapid increase in the housing prices in Korea since 2000. As the housing prices of Gangnam-district in Seoul have experienced a particularly sharp increase during this period, there have been many empirical and theoretical studies on evidence that the rise in housing prices in Korea was triggered by Gangnam housing market.

In fact, there has been considerable literature which examined whether and to what the extent regional housing markets move together with one another. Earlier papers in this area have mainly used the correlation analysis to discuss the comovement among the Korea regional real estate markets. However, less formal studies have focused on the extent and nature of volatility interdependence and volatility spillovers across regional housing markets. While correlation-based measures remain popular in many empirical studies, they measure only pairwise association. As regional markets have become more correlated and connected than before, we can obtain useful information on market comovement dynamics for investors and/or policy makers by analyzing the nature of volatility transmission and their directions.

The paper attempts to analyze the dynamics of conditional volatility spillover effects among the Korean regional housing markets. In particular, we examine cross-regional spillover effects in the Korean housing market, using the predictive directional spillover index and the connectedness measurement developed in Diebold and Yilmaz (2014). The generalized spillover approach in Diebold and Yilmaz (2014) can estimate variance decompositions which are insensitive to the variable ordering by allowing correlated shocks and using the historically observed distribution of the errors. Such an approach is a significant improvement over the Cholesky-decomposition method in the usual VAR models.

We employ this method to estimate the total volatility spillover indices, both the gross and net directional spillover indices, and rolling spillover indices in the Korean regional housing markets.

The remainder of this paper is organized as follows. Section 2 provides a brief overview on the previous literature in this area. In sections 3, we describe the data and methodology employed for this study. Section 4 discusses evidence on the empirical results, and a brief summary and concluding remarks are presented in Section 5.

2. Literature Review

With the rapid developments of computer and network processing technology, the cross-market comovements in returns and/or volatility have been one of the major research topics in economics and finance literature. As a consequence, an increasing attention has been given in recent literature to the topic of information transmission among financial markets.

Earlier studies in this area have mainly examined whether domestic markets react
promptly to new information from international markets. Examples of this literature include Jaffe and Westerfield (1985), Eun and Shim (1989), Barclay et al. (1990), Hamao et al. (1990), King and Wadhwani (1990), Theodossiou and Lee (1993) and Susmel and Engle (1994). Other studies concerning the international transmissions of stock returns and volatility include Lin et al. (1991), Booth et al. (1997), In et al. (2001) and Nam et al. (2008), which provide new evidence found around the globe on spillover effects.

As such, stock markets in line with new evidence on cross-market linkages have received much attention while the information transmission mechanism across real estate markets has not. In fact, very few attempts have been made to study the cross-regional linkages among housing markets, despite their increasing importance in the fluctuations in economic activities. Empirical research concerning the dynamics of real estate markets is still limited and less formal.

Recently, Liow and Newell (2012) investigated the volatility spillover effects and conditional correlations on the cross-market relationships among the three Greater China public real estate markets. Liow (2012) examined time-varying return co-movements across eight Asian public real estate markets. Using the spillover index methodology of Diebold and Yilmaz (2012), Liow (2013) and Liow (2014) analyzed the volatility spillover effects, as well as the time-varying spillover and directional spillover effects across the international housing markets.

In the context of the Korean housing market, Chang (2014) and Lee and Lee (2014) found strong volatility spillover effect among the Korean regional housing markets, based upon the spillover index methodology developed in Diebold and Yilmaz (2012). The spillover index measures are useful in capturing the interdependence among the markets under consideration. From their framework, we can examine the time-varying pattern of spillover effects, and we can also estimate different directional volatility spillover measures.

In this paper, we examine cross-regional spillover effects in the Korean housing market, using various connectedness measures developed in Diebold and Yilmaz (2014). The approach in Diebold and Yilmaz (2014) is particularly useful, as it is a unified framework for conceptualizing and empirically measuring connectedness at various levels, from pairwise to system-wide, via variance decompositions of VAR models.

3. Empirical Method

To examine volatility spillover effects across the fifteen housing markets, we employ generalized VAR methodology, variance decomposition and the generalized spillover index of Diebold and Yilmaz (2012). This generalized spillover index methodology is based upon generalized forecast error variance decomposition method in Pesaran and Shin (1998), which is insensitive to the variable ordering by allowing correlated shocks and using the historically
observed distribution of the errors. Such an approach is a significant improvement over the Cholesky-decomposition method in the usual VAR models.

With the variance decompositions which denotes what fraction of the h-step ahead forecast error variance in one housing market is due to the shocks from other markets in the VAR system, we can estimate the generalized spillover index which summarizes the resulting information into an aggregate measure and captures the degree of spillovers within the markets under consideration. The spillover index indicates the degree of cross-market spillovers (as captured by the share of cross-market error variance in the variance decomposition) relative to the total error variance of the markets.

First, consider a covariance stationary VAR process of dimension $m$ written as:

$$X_t = \sum_{i=1}^{\varphi_i} \Phi_t X_{t-i} + \epsilon_t, \quad t = 1, 2, \ldots, T, \quad \epsilon_t \sim i.i.d.(0, \Sigma)$$

(1)

Where, $X_t = (X_{1t}, X_{2t}, \ldots, X_{mt})^\prime$ is an $m \times 1$ vector of covariance stationary variables, $\{\Phi_t, i = 1, 2, \ldots, \varphi\}$ is an $m \times m$ coefficient matrix. For a covariance stationary process, we have its moving average representation

$$X_t = \sum_{f=0}^{\infty} A_t \epsilon_{t-f}$$

(2)

Where, the coefficient matrices $A_t$ obey the recursion

$$A_t = \Phi_1 A_{t-1} + \Phi_2 A_{t-2} + \ldots + \Phi_{\varphi} A_{t-\varphi}, \text{ with } A_0 = I_m \text{ and } A_{i} = 0 \text{ for } i < 0.$$

As discussed in Sims (1980), precise orthogonalization of VAR shocks is often required for analyzing impulse response function and calculating variance decompositions. Cholesky factor may achieve orthogonality, but such an approach depends largely on the ordering of the variables. Hence whenever no reasoning or theory is available for the ordering of the variables, the Cholesky decomposition is unattractive to empirical researchers.

In this paper, we use the generalized approach developed in Koop et al. (1996) and Pesaran and Shin (1998), which allows for correlated shocks but accounts for them appropriately. The generalized impulse response can be defined as follows.

$$\psi_j^\varphi(\varphi) = \sigma_i \frac{1}{2} A_{t}^n \sum_{t} \epsilon_t$$

(3)

Where, $\sigma_{ij}$ is the standard deviation of $\epsilon_t$, and $e_i$ is the selection vector with $i$th element unity and zeros elsewhere. The generalized forecast error variance is derived as:

$$\Theta^\varphi_{ij}(\varphi) = \frac{\sigma_{ij}^2 \sum_{t=0}^{n} (e_i \sum_{t} A_t A_t \sum_{t} e_j)^2}{\sum_{t=0}^{n} (e_i \sum_{t} A_t A_t \sum_{t} e_j)}$$

(4)

As the row sums of the variance decomposition matrix are not necessarily unity, i.e,
\[ \sum_{j=1}^{m} \Theta_{ij}(\tau) \neq 1, \] we normalize each entry by the row sum so that \( \sum_{j=1}^{m} \tilde{\Theta}_{ij}(\tau) = 1 \) and \( \sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau) = m \) in the following equation.

\[
\tilde{\Theta}_{ij}(\tau) = \frac{\Theta_{ij}(\tau)}{\sum_{j=1}^{m} \Theta_{ij}(\tau)}
\]

(5)

The spillover index developed in Diebold and Yilmaz (2012) is very useful in characterizing the connectedness among the variables under analysis via the variance decomposition. In fact, they proposed various connectedness measures built from pieces of variance decompositions such own variance shares cross variance shares, and spillovers.

### 3.1 Total Spillovers

Total Spillover, or system-wide connectedness, is the ratio of the sum of the off-diagonal elements of the variance decomposition matrix to the sum of all its elements.

\[
S^o(\tau) = \frac{\sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{\sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau)} \times 100 = \frac{\sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{m} \times 100
\]

(6)

### 3.2 Directional Spillovers

We can aggregate partially to arrive at total directional spillovers. There are two versions, ‘from’ and ‘to’. The spillovers from others can be defined as:

\[
S^f_{ij}(\tau)_{\text{from}} = \frac{\sum_{j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{\sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau)} \times 100 = \frac{\sum_{j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{m} \times 100
\]

(7)

Similarly, spillovers from others can calculated as:

\[
S^f_{ij}(\tau)_{\text{to}} = \frac{\sum_{j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{\sum_{i,j=1}^{m} \tilde{\Theta}_{ij}(\tau)} \times 100 = \frac{\sum_{j=1}^{m} \tilde{\Theta}_{ij}(\tau)}{m} \times 100
\]

(8)

### 3.3 Net Directional Spillovers

Net pairwise directional connectedness cab be derived as the difference between the spillovers ‘to’ others and those ‘from’ others.
3.4 Net Pairwise Spillovers

Sometimes we are also interested in net pairwise directional connectedness defined as:

\[ S_{ij}^{\text{net}}(n) = S_{ij}^{\text{to}}(n) - S_{ij}^{\text{from}}(n) \quad (9) \]

\[ S_{ij}^{\text{net}}(n) = \left( \frac{\bar{\Theta}_{ij}(n)}{\sum_{k=1}^{m} \bar{\Theta}_{jk}(n)} - \frac{\bar{\Theta}_{ji}(n)}{\sum_{k=1}^{m} \bar{\Theta}_{kj}(n)} \right) \times 100 = \left( \frac{\bar{\Theta}_{ij}(n) - \bar{\Theta}_{ji}(n)}{m} \right) \times 100 \quad (10) \]

4. Empirical Results

4.1. Data Description

The data used in this study are monthly housing price indices over the period from January 1986 through December 2014, which span 348 observations in each regional markets. The data are available from KB housing price data base. In order to examine cross-regional spillover effects in the Korean housing market, we divide the Korean housing markets into 15 regional markets, namely: Seoul (Gangnam, Gangbuk), Capital metropolitan area (Gyeonggi, Inchun), 5 Metropolitan cities (Busan, Daegu, Gwangju, Deajun, Ulsan), and other regional markets (Gangwon, Choongnam, Choongbuk, Jeonnam, Jeonbuk, Gyeongbuk).

The monthly return series are calculated as the difference in the natural logarithm of two consecutive housing price indices. Table I presents the descriptive statistic of the 15 index series. The return series for all regions show (+) values in averages, indicating that the Korean housing prices have been increasing during the sample period, although they vary in magnitude across regions. Specifically, Gangnam and Ulsan regions display relatively higher growth rates than other regions, whereas Jeonnam and Jeonbuk show lower returns. These results indicate that housing prices in Korea are much affected by regional factors.
Table 1: Summary statistics

<table>
<thead>
<tr>
<th></th>
<th>Gangnam</th>
<th>Gangbuk</th>
<th>Gyeonggi</th>
<th>Inchon</th>
<th>Busan</th>
<th>Daegu</th>
<th>Gwangju</th>
<th>Daejeon</th>
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<tbody>
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<td>Mean</td>
<td>0.355</td>
<td>0.192</td>
<td>0.319</td>
<td>0.250</td>
<td>0.268</td>
<td>0.243</td>
<td>0.159</td>
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<td>Median</td>
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<td>0.083</td>
<td>0.166</td>
<td>0.100</td>
<td>0.075</td>
<td>0.053</td>
<td>0.071</td>
<td>0.086</td>
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<td>0.926</td>
<td>1.007</td>
<td>0.920</td>
<td>0.770</td>
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<td>1.638</td>
<td>2.297</td>
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<td>9.527</td>
<td>5.730</td>
<td>15.474</td>
<td>18.065</td>
<td>47.923</td>
<td>11.083</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>Ulsan</th>
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<th>Choongbuk</th>
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<th>Jeonbuk</th>
<th>Jeonnam</th>
<th>Gyeongbuk</th>
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<tr>
<td>Mean</td>
<td>0.346</td>
<td>0.212</td>
<td>0.202</td>
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<td>0.156</td>
<td>0.017</td>
<td>0.216</td>
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<td>Median</td>
<td>0.196</td>
<td>0.104</td>
<td>0.145</td>
<td>0.104</td>
<td>0.037</td>
<td>-0.060</td>
<td>0.091</td>
</tr>
<tr>
<td>Max</td>
<td>4.773</td>
<td>5.960</td>
<td>3.829</td>
<td>5.107</td>
<td>4.115</td>
<td>5.581</td>
<td>5.073</td>
</tr>
<tr>
<td>Min</td>
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<td>-2.673</td>
<td>-5.620</td>
<td>-3.609</td>
<td>-4.076</td>
<td>-5.414</td>
<td>-3.125</td>
</tr>
<tr>
<td>Std Dev</td>
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<td>0.856</td>
<td>0.770</td>
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<td>0.684</td>
<td>0.837</td>
<td>0.827</td>
</tr>
<tr>
<td>Skewness</td>
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<td>1.811</td>
<td>-0.240</td>
<td>0.616</td>
<td>0.888</td>
<td>1.446</td>
<td>1.593</td>
</tr>
</tbody>
</table>

42. Cross-Regional Spillover Effects

Table 2 presents the estimation results on the spillover indices for the 15 regions under analysis. Its main upper-left $m \times m$ block contains the variance decompositions. The off-diagonal entries of the $15 \times 15$ matrix are the parts of the $m$ forecast-error variance decompositions of relevance from a connectedness perspective, which measure pairwise directional spillover effects.

The grand total of the off-diagonal entries in the matrix, which is the sum of the ‘from’ column or ‘to’ row, measures total connectedness. Similarly to pairwise directional spillovers, we are sometimes interested in net total effects. We define net total directional connectedness as the difference between the sum of the ‘from’ column and ‘to’ row except the diagonal elements.

As with the previous results in Chang (2014) and Lee and Lee (2014), the total spillover index is 64.5%, which indicates that the connectedness among the Korean regional housing markets is high. As for the Gangnam district, own variance accounts for 32.7%, and ‘to’ and ‘from’ spillover indices are 150.1% and 67.3%, respectively, which implies that the net spillover effect is 82.8%(150.1% - 67.3%). Hence Gangnam district has been the most influential market affecting other regional housing markets in Korea.

The next largest net spillover index is 48.53% for Daegu, whereas the smallest net spillover indices are −40.96% for Jeonnam, and −45.51% for Gangwon. The net pairwise directional spillover indices suggest that Gangnam district is by far the most influential market which lead other regional housing markets in Korea, as evidenced in previous studies.
Using the spillover indices in the $15 \times 15$ matrix in Table 2, we can further discuss various features of the spillovers in details, as suggested by Diebold and Yilmaz (2015). That is, we can derive cross-zone connectedness measures by grouping the regions into neighboring geographical zones, and aggregating their spillover indices accordingly. We discuss the cross-zone spillover effects in the next sub-section.
Table 2: Spillover Indices among Korean Regional Housing Markets (1986.02 ~ 2014.12)

<table>
<thead>
<tr>
<th></th>
<th>Gangnam</th>
<th>Gangbuk</th>
<th>Gyeonggi</th>
<th>Incheon</th>
<th>Busan</th>
<th>Daegu</th>
<th>Gwangju</th>
<th>Daegu</th>
<th>Ulsan</th>
<th>Gyeongbok</th>
<th>Chungbuk</th>
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<th>Jeonnam</th>
<th>Gyeongbok</th>
<th>From</th>
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<td>Gangnam</td>
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<td>19.12</td>
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<td>6.48</td>
<td>0.67</td>
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<td>2.93</td>
<td>0.53</td>
<td>1.63</td>
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<td>0.21</td>
<td>2.32</td>
<td>67.29</td>
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<td>25.68</td>
<td>15.72</td>
<td>10.48</td>
<td>4.44</td>
<td>5.04</td>
<td>1.03</td>
<td>2.87</td>
<td>2.55</td>
<td>0.85</td>
<td>1.40</td>
<td>2.90</td>
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<td>0.41</td>
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<td>28.03</td>
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<td>4.63</td>
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<td>0.45</td>
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<td>1.58</td>
<td>2.79</td>
<td>5.54</td>
<td>1.69</td>
<td>1.37</td>
<td>4.94</td>
<td>1.60</td>
<td>0.60</td>
<td>46.12</td>
<td>53.88</td>
</tr>
<tr>
<td>To</td>
<td>150.12</td>
<td>79.99</td>
<td>86.31</td>
<td>63.37</td>
<td>78.98</td>
<td>108.20</td>
<td>44.66</td>
<td>68.15</td>
<td>56.87</td>
<td>30.50</td>
<td>51.91</td>
<td>32.41</td>
<td>9.05</td>
<td>70.53</td>
<td>966.84</td>
<td></td>
</tr>
<tr>
<td>Net</td>
<td>82.83</td>
<td>5.66</td>
<td>14.35</td>
<td>-10.53</td>
<td>6.00</td>
<td>48.53</td>
<td>-18.97</td>
<td>17.40</td>
<td>-10.55</td>
<td>-45.51</td>
<td>-30.52</td>
<td>1.68</td>
<td>-36.07</td>
<td>-40.96</td>
<td>16.65</td>
<td>64.5%</td>
</tr>
</tbody>
</table>

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4.3 Cross-zone Spillover Effects

In this study, we zone the regions into 7 areas, by grouping nearby regions. This zoning is different from the approach in Chang (2014), which grouped the regions according to their sizes. As the connectedness of the housing markets may depend on the distance among regions, we can expect that our zoning based on geographical areas is more useful in analyzing cross-zone spillover effects.

Table 3 presents the spillover indices for the 7 zones, which can be obtained by aggregating each regional spillover indices within the zone. Panel A explains how the 15 regions are grouped into 7 zones, and Panel B shows the spillover indices for each zones.

In this case, the first zone \( \sum_{i,j=1}^{2} \tilde{G}_{ij} \) represents Seoul, and the next follows the metropolitan area \( \sum_{i,j=3}^{4} \tilde{G}_{ij} \). The main results observed from Table 3 can be summarized as follows.

Table 3: Cross-Zone Spillover Indices in Korean Housing Markets

<table>
<thead>
<tr>
<th>Panel A: Zoning</th>
<th>Seoul (2)</th>
<th>Metropolitan (2)</th>
<th>Gangwon / Gyeongbuk (2)</th>
<th>Chungnam / Jeonnam (2)</th>
<th>Honam (3)</th>
<th>Daegyeung (2)</th>
<th>Dongnam (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gangnam</td>
<td>Seoul</td>
<td>Gangbuk</td>
<td>Gyeonggi</td>
<td>Incheon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gyeongbuk</td>
<td>Gangwon</td>
<td>Gwangju</td>
<td>Jeonnam</td>
<td>Jeonbuk</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incheon</td>
<td>Daegu</td>
<td>Gyeongbuk</td>
<td>Ulsan</td>
<td>Busan</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Panel B: Cross-Zone Spillover Indices (1986.02 ~ 2014.12)

<table>
<thead>
<tr>
<th></th>
<th>Seoul</th>
<th>Metropolitan</th>
<th>Gangwon / Gyeongbuk</th>
<th>Chungnam / Jeonnam</th>
<th>Honam</th>
<th>Daegyeung</th>
<th>Dongnam</th>
</tr>
</thead>
<tbody>
<tr>
<td>To</td>
<td>195.9</td>
<td>125.18</td>
<td>57.18</td>
<td>104.43</td>
<td>61.83</td>
<td>151.87</td>
<td>124.63</td>
</tr>
<tr>
<td>Net</td>
<td>88.5</td>
<td>3.81</td>
<td>-76.03</td>
<td>19.08</td>
<td>-95.99</td>
<td>65.19</td>
<td>-4.55</td>
</tr>
</tbody>
</table>

First, Seoul has been the most influential market affecting other zones in the Korean housing markets, with the net spillover effect is 88.5% (195.9%~107.4%). Next to Seoul, Daegyung area appears to lead other zones in the Korean housing markets, with the net spillover effect is 65.2% (151.9%~86.7%). On the other hand, Honam area seems to be
dependent to variation to other housing markets in Korea, with the net spillover effect is 
−95.9%.

These results are different from those presented in Chang (2014), which grouped the regions according to their sizes. In fact, by grouping into 4 zones (Seoul, Gyeonggi, 5-metropolitan city, small-medium city), Chang (2014) showed that 5-metropolitan city might lead other regional housing markets in Korea, next to Seoul.

4.4 Rolling-Sample Spillover Effects

Although the result for the full-sample connectedness provides a good characterization of average aspects of spillovers across regional markets, they are not useful in examining connectedness dynamics. In this sub-section, we provide a dynamic analysis by using rolling estimation windows. We include the same 15 regional housing markets as in the full-sample analysis.

Figure 1 shows the time-varying aspects of the spillovers using the rolling-sample analysis as suggested in Diebold and Yilmaz (2012, 2015). We can observe that the foreign exchange crisis in 1997 appears to have an big impact on the Korean housing market, when the estimated spillover indices showed a rapid increase and varied between 60% and 90%. The total spillover indices have stabilized during early 2000s, until the global financial crisis in 2008 caused another big increase in the spillover indices, which remain as high as around 80%. This observation shows that the connectedness across regional housing markets in Korea is time-varying, and hence we need to examine the connectedness dynamics as well as the average spillover effect over the full sample.

Figure 1: Rolling Total Spillover Indices

Figure 2 displays the rolling-sample analysis of the directional connectedness of
Seoul, which is the center of Korean housing market. We can observe that both ‘to’ and ‘from’ directional spillover effects tend to decline over the sample period. In particular, directional spillovers to other regional housing markets showed a dramatic decrease. This result indicates that the effects of Seoul on other regional housing markets have been decreasing over time, whereas neighboring regions have become increasingly more influential in affecting other regional markets.

Figure 2: Rolling Net Directional Spillover Indices of Seoul

5. Concluding Remarks

This study attempts to analyze the spillover effects among the Korean regional housing markets, using the spillover indices based upon the generalized variance decomposition. The basic finding is that Seoul has been the most influential market in Korea among various combinations of regional housing markets. We also presented evidence that other metropolitan cities affect only neighboring regions.

As for the results based on the rolling-sample analysis, net directional spillovers of Seoul appear to have declined over the sample period. Although Seoul still remains the center of Korean housing market, neighboring regions have become increasingly more influential in affecting other regional markets.

These results may suggest important implications for policy makers as well as fund managers for the real estate. Real estate policies should take into account of the fact that Seoul still remains the center of Korean housing market, while neighboring areas have become increasingly more influential in affecting other regional markets.

References

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