HALO EFFECT: STATIC AND DYNAMIC CONNECTEDNESS ANALYSIS ON NEW ZEALAND HOUSING MARKETS

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Abstract

The paper attempt to explore the existence and magnitude of connectedness on New Zealand housing markets, addressing the question of which regions are shock transmitters and which are the receivers. Novel to the literature, we comprehensively examine the network topology by two perspectives; the first is to analyze the connectedness between the individual local housing markets and the national housing market while the second is for the transmission of inter-regional housing growth rate. The former approach not only indicates that national housing market is an important source for variation of local house price growth but also suggests central regions of Auckland, Canterbury, and Wellington having the highest connectedness with the nationwide market. The latter view, then, observes the close linkage amongst regions within the Upper North regions of New Zealand, which is especially found stronger in comparison with the Lower North regions and the South Island regions. The results also confirm the undeniable influence of extreme economic events on connectedness in house price growth. The findings shed new lights on understanding the housing market in New Zealand and state the importance of the ripple effect, especially when having a prediction about the change in house prices.

JEL classification: C32, C58, R21, R30, R31, R32

Key words: connectedness, house price growth, spillover, New Zealand housing markets, ripple effect, vector autoregression model.

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1 Introduction

Prominently gaining attention in recent years, the issue of connectedness in housing markets or the so-called as ripple effect is nothing new. Meen (1999) and Shi, Young, and Hargreaves (2009) defined the ripple effect as the tendency for house price variation in one region and then gradually spreading out to other neighbouring regions over time. Indeed, these movements suggest that there might be a large short-term difference or lead-lag relation among regional housing prices but it has a tendency of restored or converged to normal relative price pattern in the long-term, especially between regions which have close proximity and same level of economic development (Chiang & Tsai, 2016; Teye, Knoppel, de Haan, & Elsinga, 2017; Tsai, 2015). Generally, the literature reveals three main common characters of the ripple effect: time-varying transmission of volatility among markets, lag spillover of price volatility, and higher volatility yielding higher price change correlation. Explaining for such phenomenon, Meen (1999) proposed four reasons, including migration, equity transfer, spatial arbitrage, and spatial pattern.

Analyzing and understanding connectedness among regional housing markets provides insight into the issue of the housing boom. The fact is that the presence of connectedness of house price growth advises some predictability of house prices in other regions (Teye et al., 2017) and delivers an “early warning system” for the growing crisis (Diebold & Yilmaz, 2012). Not only forecasts potential catastrophic and systematic risks in the housing market, the ripple effect also unveils varying regional characteristics (Tsai, 2018). It is, accordingly, of central importance for undertaking connectedness analysis across housing markets, especially when the housing market is believed to critically affect the national and regional overall economy (Tsai, 2014).

Literature studying the ripple effect on housing markets across the world provided mix evidence. The UK is one of the earliest countries where the ripple effect is extensively studied. In particular, the paper by Meen (1999) found the presence of the ripple effect which generated from the South East England causing variation in other housing markets. Holmes and Grimes (2008) confirmed the housing connectedness as London house prices had the strongest influence on close proximity regions when examining 12 UK regions. In the later paper, Tsai (2014) extended the study of UK ripple effect by employing both house price and transaction volume. Generally, the long run equilibrium relationship between regional and national housing market was found, especially during the period of recession. Most recent UK study by
Antonakakis, Chatziantoniou, Floros, and Gabauer (2018) added to the story by emphasizing that any region could be net transmitters and net receivers interchangeably given timing factor. A study in China revealed that economic level between regions was critical for the existence of housing price connectedness (L. Zhang, Hui, & Wen, 2017). The transmission of the ripple effect, identified by Yang, Yu, and Deng (2018), was transferring from coastal developed regions to inland under-developed regions. D. Zhang and Fan (2018) revealed that big cities in term of size and regional core cities were the most influential to small regions. Regarding the U.S, Los Angeles, New York, and Miami were among the most indicative regions in term of ripple effect when they were proved to be the source of shock for variation of housing prices within the Western region, Eastern region and Southern region, respectively (Chiang & Tsai, 2016). Considering Australia, Ma and Liu (2015)’ findings disclosed five of total 8 cities having weak to strong convergence to a steady state while the other three appeared to diverge. Blake and Gharleghi (2017) study focused on Sydney metropolitan areas and there was little evidence of inter-suburban housing ripple effect seen. Indeed, there was no long-run equilibrium of price relativity, which was a marked contrast to most other empirical studies of the UK, the US and other countries. A possible cause is due to the dissimilarity with regards to the economy, geography, distance and culture among these capital cities.

Despite the phenomenon of ripple effect on the housing market has been explored across the world, evidence of the ripple effect in New Zealand has been relatively scarce to date. So-called as “halo effect”, it mainly describes the phenomenon that the initial increase in Auckland house price sends other nearby regions’ property prices to new high. In fact, the period of 2014 to 2016 recorded a substantial increase in nominal house price in Auckland, causing substantial dispersion between Auckland house prices and the rest in New Zealand (RBNZ). Halo effect was gaining its strength as in nearby regions consequently experienced an increase in house sales and prices. Nevertheless, in literature, the existence of a potential ripple effect in the New Zealand housing market is far from certain. Shi et al. (2009) claimed weak ripple effect when scrutinizing the ripple effect among 10 selected urban areas in Auckland, Wellington, and Christchurch regions from 1994 to 2004. Qiao (2016)’s recent paper documented the price ripple effect originated in Auckland that, however, was restricted

to the North Island regions. The price volatility ripple effect is mostly spilling over to the Northland and Waikato regions but rarely to the Hawkes Bay region.

The topic of connectedness in housing markets has been discussed by a great number of authors, yet the literature has divided into two streams to analyze. The first stream is interested in the analysis between regions and nationwide to explore the relationship between local and national housing markets (Tsai, 2015) while the second stream is to determine the inter-region connectedness (Montagnoli & Nagayasu, 2015; Yang et al., 2018). However, a more comprehensive examination should look at both of these aspects.

Considering this story, the aim of this study is to explore the presence and degree of the time-varying connectedness of the New Zealand housing market, identifying the key markets that provide leadership in the price discovery process within a particular geographical region. We adopt the methodology proposed by Diebold and Yilmaz (2012) to be able to measure both static and dynamic connectedness. Our paper contributes to the literature by several points as follows.

Given the fact that housing market in New Zealand in general and in main centers such as Auckland, in particular, have peaked over the past decade, studying the issue of connectedness for the context of New Zealand is of central interest. Several studies have searched for the ripple effect, yet no study provided a completed picture of ripple effect amongst all New Zealand regions. Our paper extends the literature by having a comprehensive nationwide investigation for every region from the North to the South of New Zealand. Additionally, geographic closeness and economic similarity are proved to be the decisive factors affecting house price ripple effect given transmission mechanism of information in housing markets (Blake & Gharleghi, 2017; Montagnoli & Nagayasu, 2015; Yang et al., 2018; D. Zhang & Fan, 2018). All New Zealand regions, thus, is segmented into three regional groups, namely the Upper North, the Lower North, and the South Island.

What is more, as noted previously, in order to have a comprehensive examination, we make an integrative approach by analyzing housing connectedness not only between the regional and the national house price growth, but also across regions themselves. It, hence, would deliver a bigger picture in term of connectedness in the housing markets. Another critical point our paper made is to include the global financial crisis into the sample. Prior studies provide evidence that financial crises usually results in the sharp growth of volatility and connectedness across markets (Lee & Lee, 2018; Tsai, 2014; D. Zhang & Fan, 2018). Having
both calm phase and active phase (economic and financial downturn) in our analysis, therefore, is essential to test whether these events play important role in connectedness in housing markets.

Complementing the study for the UK by Tsai (2015) and for China by Yang et al. (2018), our paper closely follows Diebold and Yilmaz (2012) methodology of the generalized vector autoregression (VAR) approach to study the case of New Zealand housing markets. In particular, a connectedness across housing markets measure based on forecast error variance decompositions from vector autoregressions (VARs) lets us define whether regions are net receivers or net transmitters of shock. Diebold and Yilmaz (2012)’ methodology also fills the gap of Diebold and Yilmaz (2009) in which forecast error variance decompositions are invariant to variable ordering, and explicitly including both static and dynamic connectedness. Such methodology is suggestable given any systematic risk triggering a change in housing markets. It also enables to disclose the house price pattern and trend through time and across regions.

We employ monthly data for the period from 1992 to 2018, covering all regions of New Zealand. Data are collected from the Real Estate Institute of New Zealand (REINZ), accounting for more than 80% of total residential sales and includes detached houses and apartments. Due to data availability, this paper is one of few studies using monthly data that is high-frequency data to explore the house prices ripple effect. It significantly increases the degree of freedom and more helpful to illustrate the connectedness across housing markets.

The empirical findings advise the presence of connectedness in the New Zealand housing market. For the first approach examining the connectedness between local and national housing markets, the national housing market appears to be an important source of housing fluctuation in regional housing markets (Tsai, 2015). Core regions, namely Auckland, Wellington, and Canterbury shows the highest connectedness with the national housing market. Notably, Auckland and Otago are two regions having positive net connectedness (on average), indicating their contribution to the variation of the nationwide growth rate of house prices. In terms of the second approach regarding inter-region connectedness, overlapping with Qiao (2016), we found a stronger ripple effect amongst the Upper North regions. Auckland acts as the top contributor since the price movement of Auckland housing market, by some means, can be used to predict house prices in its adjacent regions of Waikato and Bay of Plenty. When it comes to the Lower North and the South Island regions, the innovation starting from Wellington and Otago before rippling out to the other regions within their groups. On the other
hand, Bay of Plenty, Southland, and Northland are the dominant receivers of shock over time. Moreover, the financial and economic downturn may also play a significant role as housing connectedness across regions tends to be more intensive during the negative shock events. The pattern of overall connectedness after the crisis changes across regions. It reveals the significant gap in housing price across regions in the Upper North while for the rest, the symmetric change is observed. For the last finding, a closer observation at connectedness across regions unveils that rather than always be a net transmitter (net recipient) of shock, any region can play its role as a shock net receiver (net transmitter). The interchangeable roles, therefore, is dependent on time span and events (Antonakakis et al., 2018).

Deserving attention, our study will be of strong benefit to both investors and policymakers. Understanding the connectedness in the growth rate of house prices across regions clearly assists investors to diversify their risk and get the optimal property portfolio. Likely, the acknowledgment of leading region for the ripple effect assists policymakers in preventing the housing bubble and stabilizing economic growth. The presence of a ripple effect, in addition, suggests a unified housing policy rather than different and local policies for individual regions.

The remainder of this paper is proceeded as follows. Section 2 is to add an explanation for empirical methodology. Section 3 focuses on the data and provide descriptive statistics. In section 4, we perform a static analysis in which we calculate “average” total and directional connectedness. Then, a dynamic connectedness is estimated by using a rolling sample. Finally, the paper is summarized with the main conclusion in Section 5.

2 Methodology

To detect the connectedness of house price growth across housing markets, literature has applied several types of methodologies. Prior studies on the long-term correlation of housing markets have selected cointegration or unit root tests to scrutinize the convergence (Holmes & Grimes, 2008; Meen, 1999; Tsai, 2014). Engle and Granger or Johansen test of co-integration is the second common approach focusing on studying the connectedness (Blake & Gharleghi, 2017; Teye et al., 2017; Tsai, 2015). Lately, extensive studies used vector autoregression model (Tsai, 2018; Vansteenkiste & Hiebert, 2011; L. Zhang et al., 2017).

This paper follows closely to the methodology of generalized VAR framework employed by Diebold and Yilmaz (2012). Having measurements to disclose the connectedness
matter, the method can be utilized for discovering the connectedness in the housing markets. It allows assessing both total and directional connectedness on the growth rate of house prices in static and dynamic structures, then, disclosing the ripple effect’s existence and pattern across time. Importantly, it is more preferable to Diebold and Yilmaz (2009)’s methodology of the simple VAR framework on account of its ability to measure the connectedness that is invariant to the order of variables.

Suppose there is the covariance stationary N-variance vector autoregressive lag of p - VAR(p) as follows:

\[ x_t = \sum_{i=1}^{p} \varphi_i x_{t-i} + \varepsilon_t \]  

Where: \( x_t \) is a vector of house price growth; \( t \) is for time, especially, and \( \varepsilon_t \sim (0, \Sigma) \) is the vector of the disturbances distributed independently and identically. It is, in fact, troublesome to read the estimated coefficients because of the complexity of variable’s interaction and the variables are generally over parameterized (Yang et al., 2018). Thus, to understand the dynamic of the system, moving average form of the above model is used and calculated as:

\[ x_t = \sum_{i=0}^{\infty} A_i \varepsilon_{t-1} \]  

With \( A_i \) is N x N matrices following the rule: 
\[ A_i = \varphi_1 A_{i-1} + \varphi_2 A_{i-2} + \varphi_3 A_{i-3} + \cdots + \varphi_n A_{i-p} \] and for \( i<0, A_i = 0 \).

To understand the dynamics of the system, moving average coefficient is worth noticing. From there, we find variance decomposition, disclosing the contribution of each variable to other variables, in percentage. In other words, it is to measure the portion of the H step-ahead error variance in forecasting \( x_i \) that is due to shocks to \( x_j \),with \( i \neq j \) for each i. Notably, the result from variance decomposition appears to be responsive to the order of variables in the system. Utilizing the generalized VAR framework which first proposed by of Koop, Pesaran, and Potter (1996) and Pesaran and Shin (1998), Diebold and Yilmaz (2012)’s methodology can correct the issue. In particular, as denoted \( \theta^H_{ij} \) - H-step-ahead forecast error variance for \( H=1,2,\ldots \), is measured as follows:
\[
\theta_{ij}^\varnothing(H) = \frac{\sigma_{ij}^{-1} \sum_{h=0}^{H-1} (e'_h A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e'_h A_h \Sigma A_h e_h)}
\]

(3)

Where:
- \( \Sigma \) is the variance matrix for the error vector \( \varepsilon \),
- \( \sigma_{jj} \) is the \( j \)th equation’s standard deviation of the error term
- \( e_i \) is the selection vector, which is equal to 1 for the \( i \)th element and 0 for the others.

Since the total variance decomposition in each row is different than 1, it is advisable to normalize each entry given the need of calculating the connectedness index.

\[
C_{i\leftarrow j}(H) = \frac{\tilde{\theta}_{ij}^\varnothing(H)}{\sum_{j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)}
\]

(4)

\( \tilde{\theta}_{ij}^\varnothing(H) \) shows the pairwise directional connectedness from market \( j \) to market \( i \). For simplification, it is denoted as \( C_{i\leftarrow j}(H) \). The total variance decomposition of each row or across a particular housing market should be equal to 1 after normalization: \( \sum_{j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H) = 1 \) and \( \sum_{i,j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H) = N \).

Especially, for our paper’s aim, a key for understanding the connectedness is to look at total connectedness value. Using the error variance decomposition, total connectedness (TC) is constructed as:

\[
TC(H) = \frac{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)} \times 100 = \frac{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)}{N \times 100}
\]

(5)

The index, thus, indicates the impact of connectedness across regional housing markets on the total forecast error variance. The next interesting step is to find the direction of the ripple effect to discover which regions are transmitting shock to others and which are receiving shock from others. Concerning directional connectedness from all other regions \( j \) to region \( i \), it is:

\[
DC_{i\leftarrow j}(H) = \frac{\sum_{j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)} \times 100 = \frac{\sum_{j=1}^{N} \tilde{\theta}_{ij}^\varnothing(H)}{N \times 100}
\]

(6)

Correspondingly, the directional connectedness transmitted by market \( i \) to all other markets \( j \), is calculated as:
After having directional connectedness, net total direction connectedness, then, address the question of whether regions are net transmitters or receivers of shocks on housing markets when the value is positive or negative, correspondingly. Net total connectedness from region $i$ to all other regions $j$ is found as the difference between the total directional connectedness from market $i$ transmitted to other markets and the total directional connectedness to market $i$ received from other markets:

$$NC_i(H) = C_{i\rightarrow} - C_{i\leftarrow}$$  \hspace{1cm} (8)

To conclude, for a closer look into specific region housing markets, we are occasionally interested to analyse the net pairwise directional connectedness between 2 regions $i$ and $j$. It is obtained by the following:

$$PC_{ij} = C_{j\rightarrow} - C_{i\leftarrow} = \left( \frac{\tilde{\theta}_{ji}^g(H)}{\sum_{k=1}^{N} \tilde{\theta}_{ik}^g(H)} - \frac{\tilde{\theta}_{ij}^g(H)}{\sum_{k=1}^{N} \tilde{\theta}_{jk}^g(H)} \right) \times 100$$

$$= \left( \frac{\tilde{\theta}_{ji}^g(H) - \tilde{\theta}_{ij}^g(H)}{N} \right) \times 100$$  \hspace{1cm} (9)

Thus, the value gives us details about how much each region affects another specific region.

### 3 Data and descriptive statistics

We undertake the empirical analysis using monthly regional house indices collected from the Real Estate Institute of New Zealand (REINZ). The data accounts for more than 80% of the total house and apartment sales in New Zealand. The effective sample begins in Jan 1992 and ends in March 2018.

Our data comprises 10 New Zealand regions, namely Auckland (AUK), Bay of Plenty (BOP), Canterbury (CAN), Manawatu-Wanganui (MWT), Marlborough/Nelson/Tasman/West Coast (MNTW), Otago (OTA), Southland (STL), Taranaki (TKI), Waikato (WKO), and Wellington (WGN). Marlborough/Nelson/Tasman/West Coast regions are merged into single indices due to the relatively small number of sales that occur in the singular regions on a monthly basis.
Zhang and Fan (2018) stated the explanation role of information transmission mechanism in housing’s connectedness. Indeed, information for housing markets appears to be more costly in comparison to that in other capital markets. It is easier for housing buyers to collect housing information for the adjacent regions to make a purchasing decision, leading to the ripple effect to these regions (Blake & Gharleghi, 2017). Fig.1 represents the geographical distribution of 10 New Zealand regions. Importantly, based on geographic proximity, we classified New Zealand regions into 3 groups, which are: The Upper North, the Lower North, and the South Island.

The Upper North group:
- Auckland region
- Bay of Plenty region
- Waikato region

The Lower North group:
- Manawatu-Wanganui region
- Taranaki region
- Wellington region

The South Island group:
- Canterbury region
- Marlborough/Nelson/Tasman/West Coast region
- Otago region
- Southland region

Figure 1 Map of New Zealand

In the tradition of a large body of literature, our main variables for running the connectedness test is a monthly growth rate of housing price). It is calculated by taking the difference of the natural logarithm of the property price index between time \( t \) and time \( t-1 \).

Descriptive statistics were calculated for all variables used in the study. Table 1 provides a snapshot of the national and regional house price growth in New Zealand. Generally, the rate of growth in house prices for all New Zealand is positive, ranging from 0.38% to 0.64%. Indeed, Auckland recorded the highest monthly growth of 0.64% on average, follows closely by Otago (0.54%) and Bay of Plenty (0.53%). In contrast, the lowest rate of growth in
house prices at 0.38% per month is found in Manawatu-Wanganui region. Regarding the standard deviation, it reveals the volatility of house price growth across time. The fact is that small regions, such as Southland and Taranaki appear to have the highest volatility in house price growth.

**Table 1 Descriptive statistics of house price growth, 1992 Jan – 2018 Mar**

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean</th>
<th>Max</th>
<th>Min</th>
<th>Std. Dev.</th>
<th>ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand Aggregate level</td>
<td>0.55</td>
<td>5.64</td>
<td>-3.55</td>
<td>1.04</td>
<td>-4.57**</td>
</tr>
<tr>
<td>New Zealand exclude Auckland</td>
<td>0.49</td>
<td>3.29</td>
<td>-2.82</td>
<td>0.97</td>
<td>-3.97**</td>
</tr>
<tr>
<td>Auckland</td>
<td>0.64</td>
<td>8.69</td>
<td>-6.03</td>
<td>1.63</td>
<td>-10.81**</td>
</tr>
<tr>
<td>Bay of Plenty</td>
<td>0.53</td>
<td>5.09</td>
<td>-4.95</td>
<td>1.89</td>
<td>-4.28**</td>
</tr>
<tr>
<td>Canterbury</td>
<td>0.46</td>
<td>7.27</td>
<td>-5.37</td>
<td>1.74</td>
<td>-4.58**</td>
</tr>
<tr>
<td>Manawatu-Wanganui</td>
<td>0.38</td>
<td>7.33</td>
<td>-5.56</td>
<td>2.00</td>
<td>-3.85**</td>
</tr>
<tr>
<td>Marlborough/Nelson/Tasman/West Coast</td>
<td>0.47</td>
<td>9.73</td>
<td>-9.49</td>
<td>2.84</td>
<td>-27.23**</td>
</tr>
<tr>
<td>Otago</td>
<td>0.54</td>
<td>12.18</td>
<td>-8.18</td>
<td>2.97</td>
<td>-25.19**</td>
</tr>
<tr>
<td>Southland</td>
<td>0.44</td>
<td>15.05</td>
<td>-20.00</td>
<td>4.01</td>
<td>-18.38**</td>
</tr>
<tr>
<td>Taranaki</td>
<td>0.47</td>
<td>10.60</td>
<td>-11.03</td>
<td>3.16</td>
<td>-26.12**</td>
</tr>
<tr>
<td>Waikato</td>
<td>0.50</td>
<td>6.34</td>
<td>-5.20</td>
<td>2.12</td>
<td>-8.57**</td>
</tr>
<tr>
<td>Wellington</td>
<td>0.51</td>
<td>5.27</td>
<td>-4.16</td>
<td>1.49</td>
<td>-4.34**</td>
</tr>
</tbody>
</table>

Notes: The sample period is from Jan 1992 to Mar 2018. House price growth is calculated as the difference of natural logarithm of house price indices. Min and Max are and Minimal and maximal growth rate of housing prices. Std.Dev stands for standard deviation. Jarque-Bera is the test for normality. An Augmented Dickey-Fuller test for the unit root is denoted as ADF. *, ** indicates the significance level of 5% and 1%, respectively. The ADF tests confirm that house price growth is stationary.

4 Empirical results

For empirical result session, we run two strands of analysis. The first strand is to analysis connectedness of house price growth between the local and the nationwide housing markets. Then, the second strand illustrates the connectedness amongst regions in three different regional groups, comprising the Upper North, the Lower North, and the South Island.

4.1 Connectedness between individual regional and nationwide housing markets

Running the first part of the empirical study, we evaluate the connectedness between the individual region and the nationwide housing markets. For the static connectedness; a predictive horizon of 6 months is used. The optimal lag length for running the VAR model is selected by criterion at 5% significance level, which includes FPE (final prediction error); AIC (Akaike information criterion); SIC (Schwarz information criterion), and HQ (Hannan–Quinn information criterion). The maximum lag length is chosen at 12 (12 months).
Table 2 describes the transmission mechanism between the regional and overall New Zealand housing markets. Firstly, in terms of net directional connectedness, value higher than zero suggests that the regional housing market is the source of shock to the national housing market. On the other hand, when the net spillover is lower than the zero, the national housing market stimulates change in the local housing markets.

Table 2 Connectedness of house price growth between individual regional and New Zealand housing markets

<table>
<thead>
<tr>
<th></th>
<th>AUK</th>
<th>BOP</th>
<th>CAN</th>
<th>MWT</th>
<th>MNTW</th>
<th>OTA</th>
<th>STL</th>
<th>TKI</th>
<th>WKO</th>
<th>WGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net connectedness</td>
<td>0.00</td>
<td>-3.65</td>
<td>-0.12</td>
<td>-1.07</td>
<td>1.69</td>
<td>1.35</td>
<td>-6.5</td>
<td>0.64</td>
<td>-0.13</td>
<td>-0.94</td>
</tr>
<tr>
<td>Total Connectedness</td>
<td>43.28</td>
<td>16.26</td>
<td>19.86</td>
<td>7.25</td>
<td>7.05</td>
<td>9.92</td>
<td>6.60</td>
<td>5.82</td>
<td>15.54</td>
<td>15.92</td>
</tr>
</tbody>
</table>

Notes: AUK, BOP, CAN, GIS.HKB, MWT, MBH.NSN.TAS.WTC, NTL, OTA, STL, TKI, WKO, and WGN are Auckland, Bay of Plenty, Canterbury, Canterbury, Gisborne/Hawkes Bay, Manawatu-Wanganui, Marlborough/Nelson/Tasman/West Coast, Northland, Otago, Southland, Taranaki, Waikato, and Wellington, respectively. The row of “Net connectedness” is the difference between directional connectedness “To” the national housing market and directional connectedness “From” the national housing market. The positive value indicates that the regional housing markets are shock transmitters while the negative value means that the regional housing market are shock receivers. The optimal lag length for the VAR model is selected by FPE (final prediction error); AIC (Akaike information criterion); SIC (Schwarz information criterion), and HQ (Hannan–Quinn information criterion) at 5% significance level. The predictive horizon is 6 months.

Consistent with Tsai (2014)’s conclusion, our results find that most regions exhibit negative net connectedness. The nationwide housing market, hence, is demonstrated as the force yielding a change in the growth rate of house prices in most New Zealand regions. Furthermore, we acknowledge the case of Auckland and Otago where the positive value of net connectedness is recorded. In other words, presenting the pattern of the ripple effect in New Zealand, house prices alteration tends to originate from Auckland and Otago before rippling out to other regions. Not only confirms a potential leading impact of these regions to the entire country’s housing market in general, this finding also suggests Auckland and Otago’ ripple effect to other nearby regions in particular. Such inter-regional connectedness will be tested further in the next session.

Secondly, by averaging the total direction connectedness, the total connectedness is given. The figure gives an idea about how strong the connectedness between the national and the regional house price growth is. Generally, we observe that the connectedness is quantitatively more pronounced in New Zealand core regions of Auckland, Canterbury, and Wellington (43.28%, 19.86%, and 15.92% respectively). Specifically, the rate of house price
growth in Auckland is proved to have the strongest linkage with the overall New Zealand house price growth.

Regarding the cases of Marlborough/Nelson/Tasman/West Coast and Taranaki, their net connectedness is found positive but this contradictory results may be explained by the high volatility in these regions’ house price growth. In fact, lack of connectedness with the national housing market. Taranaki and Marlborough/Nelson/Tasman/West Coast have extremely low corresponding values of total connectedness with the national housing market, at merely 5.82% and 7.05%.

4.2 Connectedness across housing markets within three regional groups

4.2.1 Static connectedness

Having discussed the issue of connectedness between the regional and the national housing markets, the next part of our empirical analysis addresses ways of inter-region connectedness in the case of three different regional groups, including The Upper North regions, The Lower North regions, and the South regions.

Table 3 illustrates the connectedness across regions within three regional groups of New Zealand. In fact, the total connectedness index varies greatly across groups. The Upper North housing markets present the highest connectedness at approximately 18%. It indicates that on average, 18% of the forecast error variance in regional house price growth is due to the connectedness across regions. Indeed, the Upper North group is well known as the most powerful economic regions in New Zealand and contributes big proportion to the country’s GDP. Such robust collaboration in economy amongst regions in the Upper North groups (Auckland, Bay of Plenty, and Waikato), accordingly, is one of the determinants driving the strong connectedness in their housing markets (D. Zhang & Fan, 2018). On the other hand, the other two regional groups, namely the Lower North and the South Island, witness the relatively lower index, approximately at 10%. Such finding, accordingly, is consistent with the conclusion of Qiao (2016), proving that the ripple effect is much stronger when it came to Auckland and it appears to restrict to the North Island, rather than spilling to far distance regions.
Table 3 Connectedness of house price growth across regions in The Upper North, the Lower North, and the South Island of New Zealand

A. Group 1: The Upper North regions

<table>
<thead>
<tr>
<th></th>
<th>Auckland</th>
<th>Bay of Plenty</th>
<th>Waikato</th>
<th>FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>86.46</td>
<td>5.53</td>
<td>8.02</td>
<td>13.54</td>
</tr>
<tr>
<td>Bay of Plenty</td>
<td>8.52</td>
<td>78.75</td>
<td>12.73</td>
<td>21.25</td>
</tr>
<tr>
<td>Waikato</td>
<td>9.19</td>
<td>8.59</td>
<td>82.22</td>
<td>17.78</td>
</tr>
<tr>
<td>TO</td>
<td>17.72</td>
<td>14.12</td>
<td>20.75</td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>4.17</td>
<td>-7.13</td>
<td>2.96</td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td></td>
<td></td>
<td></td>
<td>17.52</td>
</tr>
</tbody>
</table>

B. Group 2: The Lower North regions

<table>
<thead>
<tr>
<th></th>
<th>Manawatu-Wanganui</th>
<th>Taranaki</th>
<th>Wellington</th>
<th>FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manawatu-Wanganui</td>
<td>86.44</td>
<td>6.35</td>
<td>7.21</td>
<td>13.56</td>
</tr>
<tr>
<td>Taranaki</td>
<td>2.54</td>
<td>93.08</td>
<td>4.38</td>
<td>6.92</td>
</tr>
<tr>
<td>Wellington</td>
<td>5.10</td>
<td>5.84</td>
<td>89.05</td>
<td>10.95</td>
</tr>
<tr>
<td>TO</td>
<td>7.64</td>
<td>12.19</td>
<td>11.59</td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>-5.92</td>
<td>5.28</td>
<td>0.65</td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td></td>
<td></td>
<td></td>
<td>10.48</td>
</tr>
</tbody>
</table>

C. Group 3: The South Island regions

<table>
<thead>
<tr>
<th></th>
<th>Canterbury</th>
<th>MNTW</th>
<th>Otago</th>
<th>Southland</th>
<th>FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canterbury</td>
<td>90.22</td>
<td>2.28</td>
<td>5.95</td>
<td>1.55</td>
<td>9.78</td>
</tr>
<tr>
<td>MNTW</td>
<td>1.42</td>
<td>85.06</td>
<td>7.72</td>
<td>5.80</td>
<td>14.94</td>
</tr>
<tr>
<td>Otago</td>
<td>4.33</td>
<td>1.97</td>
<td>91.58</td>
<td>2.12</td>
<td>8.42</td>
</tr>
<tr>
<td>Southland</td>
<td>3.56</td>
<td>2.28</td>
<td>4.13</td>
<td>90.03</td>
<td>9.97</td>
</tr>
<tr>
<td>TO</td>
<td>9.31</td>
<td>6.52</td>
<td>17.80</td>
<td>9.48</td>
<td></td>
</tr>
<tr>
<td>NET</td>
<td>-0.47</td>
<td>-8.42</td>
<td>9.38</td>
<td>-0.49</td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10.78</td>
</tr>
</tbody>
</table>

Notes: The $ij$th entry represents the pairwise directional connectedness. It indicates the estimated contribution to the forecast error variance of house price growth that market i received from the innovation of market j. The “FROM” column is the sum of pairwise directional from others, measuring the proportion of shocks received from other housing markets in the total variance of the forecast error for each region. Likewise, the row of “TO” is the sum of directional to others. The bottom row of “NET” is the difference subtracting “FROM” from “TO”. The total connectedness (TC) is at the right end corner. The optimal lag length for the VAR model is selected by FPE (final prediction error); AIC (Akaike information criterion); SIC (Schwarz information criterion), and HQ (Hannan–Quinn information criterion) at 5% significance level. The predictive horizon is 6 months.

On the question of the connectedness in the Upper North regions, the figure (Panel A) provides strong evidence of a ripple effect as Auckland housing growth can be used for discovering price growth in other adjacent housing markets, such as Waikato and Bay of Plenty. Auckland, as shown in the table, is the top contributor by having a positive net connectedness of 4.17. In contrast, Bay of Plenty records a negative net total directional connectedness, revealing its position as a shock receiver. In the same way, in the Lower North
regions (Panel B), the change in the central housing market of Wellington results in a variation of its adjacent regions’ housing markets, especially to Manawatu-Wanganui. The positive net connectedness recorded in Taranaki, however, is due to its high volatility in house price growth rather than showing its impact on other regions. Noticeably, as regards the South Island (Panel C), Canterbury is the biggest and most populated region, yet the finding points out that it takes little responsibility for the variation in the house price growth in the South. It is the fact that the devastating 6.3 magnitude earthquake in 2011 had its impact on Canterbury region. The region’s infrastructure and houses were damaged seriously after the earthquake, and there were more people leaving the regions rather than arriving. Consequently, Canterbury currently plays the dominant role as the net recipient rather than the net transmitter of shock. On the other hand, Otago region, including Queenstown and Dunedin, has been found as the most expensive housing market after Auckland. The housing demand has surpassed the supply, causing people looking for houses in other adjoining regions. These factors, therefore, play a role in explaining the positive net connectedness in Otago and define its ability to shape its surrounding regional house price growth. On the other hand, Southland and Marlborough/Nelson/Tasman/West Coast are perceived as the shock receiver when observing the negative and lowest net connectedness.

### 4.2.2 Dynamic connectedness

The preceding part of static connectedness gives an explanation about the “average” connectedness across housing markets. Yet, it keeps silence to the details of the connectedness through time. It is the fact that the significant impact of certain events on the connectedness is undeniable (Diebold & Yilmaz, 2012). Therefore, the following is on account of the dynamic connectedness for a more comprehensive picture, which employs a rolling estimation window of 96 months (8 years). Fig 2 describes the dynamics of the total connectedness across New Zealand housing markets.

At a glance, what is striking in this figure is the significant growth of the total connectedness during the period of financial crisis. Great Recession of 2008-2012 is a good illustration for the substantial impact of negative economic events into the connectedness in housing markets. Financial crisis can give rise to the connectedness in New Zealand housing markets since it was believed to associate with high-interest rates and sinking house prices in New Zealand. Thereby, during the 4-year period from 2008 to 2012, the value of total

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connectedness hit an unprecedented record. During the active phase, the connectedness figure steeply rose to nearly 48% while it was around 25% - 35% during the calm phase. Such variation in housing connectedness during the economic downturn was owed to the risk diffusion effect (Tsai, 2014; Tsai (2015). Overall, these cases support the view that crisis and recession played a vital role in bringing about the connectedness in the housing markets.

Figure 2 Rolling total connectedness of house price growth across New Zealand regions and across regions in three regional groups

Notes: The predictive horizon for the underlying variance decomposition (H) is 6 months and the rolling estimation window (W) is 96 months (8 years).

Again, strong connectedness amongst regions in the Upper North is demonstrated by the higher rolling total connectedness across time, in comparison with the others. Despite this, different patterns of connectedness can be seen across groups after 2012. In place of the Upper North regions, the total connectedness sharply dropped from the top of 35% to around 15%. The result advises the potential asymmetric change in housing prices in Auckland, which is likely to produce a substantial difference in housing price growth between Auckland and other regions after the crisis. By contrast, unlike the Upper North regions’ pattern, the Lower North regions and the South Island regions after the financial crisis experienced a gradual decrease
in the total connectedness. Therefore, it illustrated a symmetrical change in these regions’ housing growth.

A. Group 1: The Upper North regions

B. Group 2: The Lower North regions

C. Group 3: The South Island regions

Figure 3 Rolling net connectedness of house price growth across regions in The Upper North regions, the Lower North regions, and the South Island in New Zealand

Notes: The predictive horizon for the underlying variance decomposition (H) is 6 months and the rolling estimation window (W) is 96 months (8 years).

A more detailed account of net connectedness across regions is given in the Fig 3, corresponding to the difference between the “Directional from” and “Directional to” connectedness. As stated by D. Zhang and Fan (2018), rather than playing one role, any region could be shock transmitter and receiver interchangeable depending on the time period of study. In the same way, net connectedness in New Zealand regions fluctuated widely from years to years and the role as a net receiver and net transmitter of shock is not fixed for any region. Take
Wellington as an example, its house price growth had a negative net connectedness during the period from 2002 to 2006 before continuously increasing. It has started to record positive value since 2011 and remains a significantly high level of net connectedness in recent years.

Overall, what stands out is the dominance of positive net spillover in the central regions, including Auckland, Wellington, and Otago. These urban regions are proved to be the most influential regions in their corresponding regional groups as their net connectedness figures stayed positive throughout most of the time. On the other hand, small regions, such as Bay of Plenty, Manawatu-Wanganui, and Marlborough/Nelson/Tasman/West Coast are classified as the dominant receivers of shock since the net connectedness appears to remain negative over the studied period.

4.2.3 Auckland’s halo effect

Having the largest share of total New Zealand’s population, Auckland is the country largest urban region. Auckland ‘halo effect’, therefore, has attracted media attention. It is the fact that there are more and more Aucklanders spreading to nearby regions to buy houses. It has triggered a powerful ripple effect, most notably to its nearby regions. We move on now to have a closer look into how innovation from Auckland prompting house price adjustment in each of their neighboring regions. Net pairwise connectedness, thus, is to address the concern.

![Graphs showing net pairwise connectedness in the Upper North regions](image)

**Figure 4 Rolling net pairwise connectedness in the Upper North regions**

Notes: The predictive horizon for the underlying variance decomposition (H) is 6 months and the rolling estimation window (W) is 96 months (8 years).

The rolling net pairwise connectedness in the Upper North regions clearly demonstrate the significance role of Auckland housing market in explaining the change in housing markets of Waikato and Bay of Plenty. Except for the period of 2012-2015, Auckland housing market is proved to be the source of Bay of Plenty house price growth’s variation. For the case of
Auckland and Waikato, the net pairwise connectedness started at the positive value from the beginning of time span but then remained negative since 2012. It, accordingly, indicates the increasing leading impact of Auckland to Waikato.

As proposed by Meen (1999), there are two reasons explaining why Auckland housing market becomes dominant to other outlying regions. First, it is due to migration. In fact, people who find expensive houses in one region will have a tendency to move to neighboring regions to find more affordable ones. This kind of movement will gradually increase the house prices of geographically close regions, prompting the ripple effect. Auckland has the highest rate of immigration most of the time, which stresses the already constrained housing supply (Statistics New Zealand, 2015). In the same period, the house price median rose by nearly 26% (Real Estate Institute of New Zealand, 2015). The deterioration of housing affordability in Auckland shifts housing demand to regions where house buyers can afford\(^4\), which includes Bay of Plenty and Waikato. Equity transfer is the second factor. Due to increasing house prices in Auckland, Auckland’s house owners found themselves richer, originating stronger capacity to buy additional houses in neighboring regions\(^5\). As a result, investors and house purchaser’ strong purchasing power has contributed to the increase of housing prices in the nearby regions.

5 Conclusion

For decades, the topic of connectedness in the housing market has attracted literature’s attention in different countries. Our paper comprehensively studies the ripple effect in the context of New Zealand, using the approach proposed by Diebold and Yilmaz (2012). A comprehensive measurement and explanation for the connectedness are provided by looking at both static and dynamic connectedness across time and regions.

Broadly translated, instead of the fact that the magnitude of housing connectedness in New Zealand is relatively low, the empirical results demonstrate its existence with some revealing patterns. Our first empirical finding ties well with previous studies, which highlights the vital role of the national housing market in explaining the forecast error variance of house price growth in most local housing markets. In addition, the magnitude of connectedness between the regional and the national housing markets is reported much stronger in central

\(^4\)https://www.nzherald.co.nz/property/news/article.cfm?c_id=8&objectid=11531211

\(^5\)https://www.noted.co.nz/money/property/auckland-s-halo-effect-in-new-zealands-property-market/
regions of Auckland, Wellington, and Canterbury. On the other hand, small regions of Southland and Manawatu-Wanganui found comparatively weak connectedness with the nationwide housing market. Interestingly, when New Zealand regions are segmented into three regional groups based on their geographic location, the ripple effect on average is found much stronger in the Upper North groups in comparison with that in the others. It reflects the robust economy connection amongst regions of the Upper North.

Our findings are also in line with prior studies showing that the matter of time and extreme events can alter the role of any region between the net transmitter and net receivers of shock. Nevertheless, Auckland, Wellington, and Otago can be concluded as the top transmitters of shock in the Upper North, the Lower North, and the South regions, respectively. What is more, we add evidence to the literature the dependence of connectedness in housing markets on extreme economic and financial events. Recession or crisis can draw a noticeable increase in connectedness across regional house price growth. Furthermore, the Upper North group differs from the other two in term of the pattern of total connectedness post-crisis. It reveals the significant gap in the rate of house price growth across regions in the Upper North (between Auckland and its outlying regions) while for the rest, the symmetric change is observed.

This paper provides a good starting point for discussion of ripple effect in respect to New Zealand background. Further work, should address the driving force of the house price growth’s connectedness. In addition, using a sale volume of houses rather than house prices might prove an important area for future research.
References


