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DOUBLE TROUBLE: TIME-VARYING CONNECTEDNESS BETWEEN STOCK AND HOUSING MARKETS

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Abstract. Joint new records in the stock and housing markets are now gradually becoming a focal point of controversy in Taiwan. Based on the local heterogeneity of real estate assets, this study proposes setting up a two-market transmission mechanism between the stock and city-level housing markets to fully reply to this question. The estimation results using the Diebold-Yilmaz spillover method offer some critical information: the fact that the overheated housing market is precisely caused by the Taiwan stock market, which serves as evidence of the wealth effect. As far as the housing network is concerned, it is interesting to note that housing prices in Taipei as the source city spill out from near to far: New Taipei, Taichung and ultimately Kaohsiung. All these things make it clear that the authorities pay special attention to the status of the stock market as well as to inter-city differences in terms of housing spillovers.

Keywords: stock and housing markets, systemic risk, Diebold-Yilmaz method.

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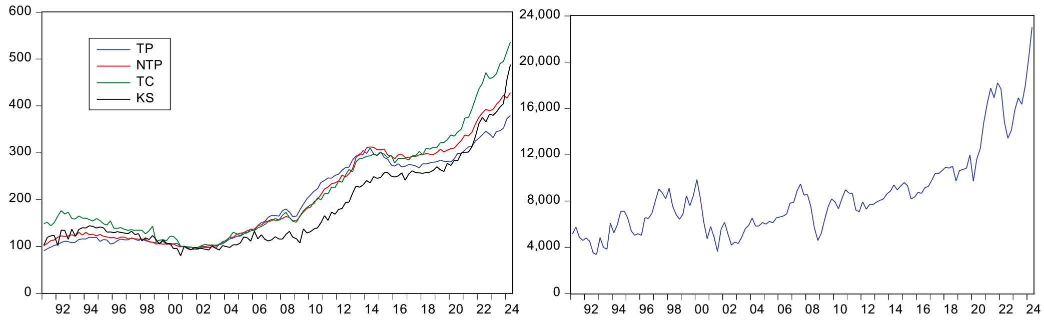
1. Introduction

Following the outbreak of the global financial crisis (GFC) in 2008, it was eventually recognized that financial systems are vulnerable to housing market downturns (Reinhart & Rogoff, 2008; Blanchard et al., 2010; Jordà et al., 2015; Agnello et al., 2018; Brunnermeier et al., 2020; Chiang & Chen, 2025; Chen et al., 2025). On the other hand, due to huge discrepancies between housing and other financial commodities (i.e., stocks) in terms of their characteristics, increasing numbers of institutional investors would like to consider real estate assets as another essential component of their portfolios owing to their ability to reduce risk and stabilize cash flows (De Wit, 2010; Gallo & Zhang, 2010; Yavas & Yildirim, 2011). As a consequence, stock and housing assets are now both generally regarded as the most important ingredients of a financial portfolio (Oikarinen, 2010), and so the connectedness between the stock and housing markets deserves explicit emphasis. In particular, we see two separate directions for their interaction. In real estate research, a considerable number of housing studies have been devoted to the interrelationships among local housing markets excluding the possibilities of other financial markets like the stock market (Lee et al., 2016; Gholipour & Lean, 2017; Tsai & Chiang, 2019; Chen et al., 2024). By contrast, past financial research has almost exclusively concentrated on the national housing market in relation to the stock market and has neglected the local heterogeneity that characterizes real estate properties.[1] To fill this gap, the purpose of this paper is to probe more deeply into the interaction between the stock market and city-level housing markets.

More recently, a surging tide of capital inflows and outflows caused by unconventional and even unlimited monetary policies, especially following the COVID-19 pandemic, has ignited an investment frenzy worldwide. Taiwan is a particularly notable case, with its stock price (SP) and city-level housing price (HP) having both reached new highs as shown in Figure 1. We believe that fully understanding the interactions between the two markets is extremely critical to finding the right way to resolve these two market frenzies that are concurrently taking place right now.

To fairly evaluate their relationship, we can find two main estimation methods: the Granger causality test and the variance decomposition approach that is based on the Diebold-Yilmaz (DY) method (Diebold & Yilmaz, 2009, 2012). Compared to the Granger causality test where the lead-lag relationship only encompasses these two markets

[1] It is well documented that the housing market is the most notable example of regional heterogeneity (Fratantoni & Schuh, 2003), and so we are devoting more attention to four local markets that are connected to Taiwan's stock market.



Note: The right and left diagrams represent the stock price and housing prices for four urban areas including Taipei (TP), New Taipei (NTP), Taichung (TC) and Kaohsiung (KS), respectively.

Figure 1. Stock and housing markets (1991–2024Q2) in Taiwan

(Sim & Chang, 2006; Billio et al., 2012; Ding et al., 2014; Shi et al., 2017; Hurn et al., 2022; Chiang & Chen, 2022), we have decided to adopt the DY method that has three advantages as follows. First, there are ten results of causality behind five variables, namely, one stock price associated with four local housing prices, so that it is very hard to judge and explain such complicated relations, whereas the DY method can be used to directly collect the "system-wide" directions between a specific market and the entire system under a single vector autoregressive (VAR) model (Diebold & Yilmaz, 2014). Second, the DY method is the first attempt to quantify the size of the spillovers and to identify the source of the spillovers. Third, the DY method can help us to scrutinize the evolving procedure for spillovers under rolling window calculations. To sum up, these benefits can offer a key to understanding the full process of the interrelationships between regional housing markets and the stock market.

Finally, the stock-housing mechanism can be traced back to two main strands of economic theory. First, the most popular theory in terms of the relationship between the two markets is the wealth effect, which argues that, due to the huge capital gains from the stock market, wealthier investors would like to spend more on housing commodities and hence this pushes up housing prices. In our opinion, the dominance of the wealth effect theory actually has its roots in the characteristics of the stock market: its highly liquid cash flows and the forward-looking expectations of investors (Chodorow-Reich et al., 2021). Thus, over the past several decades, the literature has overwhelmingly favored the "wealth effect" theory. Kapopoulos and Siokis (2005) used a causality test to prove the one-way direction from the stock market to the housing market in Greece. Kiohos et al. (2017) employed a cointegration system to show that the wealth effects are dominant in the UK and Germany. Liow et al. (2019) applied wavelet analysis and found that there are stronger wealth effects from the stock to housing markets in the U.S. Chen and Chiang (2022) cited a time-varying causality test to show that wealth effects from G7 countries are found in Canada, the U.S., Italy and Japan. Lin and Stankov (2025) strongly recommended the evidence of wealth effects in an international context. Second, the credit-price effect states that once housing price appreciation leads to a rise in collateral values and credit ratings, households or firms have a greater capacity to expand their investment, which causes stock prices to end up higher than expected. After the GFC in particular, the credit-price effect attracted more interest from scholars, for example, Lin and Lin (2011), and Tsai (2015).

To sum up, the wealth effect emphasizes the leading role played by the stock market in the housing market in terms of running "from the stock to the housing market", while the credit-price effect suggests the alternative way running "from the housing to the stock market". More specifically, Lin and Lin (2011) found that the credit-price effect gives a better account of the relationship between the two markets in Taiwan. Differing from Lin and Lin (2011) by using national data regarding stock and housing prices, our estimation results once again recognize this relationship between regional housing prices and the national stock price using more up-to-date data through applying the DY method. The results make it clear that the wealth effect is exactly identified. Moreover, the spillovers are diffused first from the Taiwan stock market, to the housing market of Taipei city as the economic center, then to the surrounding New Taipei city, followed by Taichung city and finally the farthest city, Kaohsiung city, in that order.

As long as the exact relationship is determined, the authorities can follow their lead-lag relationship to execute more efficient strategies to avoid overall financial vulnerability. Taking the wealth effect as an example, since stock market booms serve as a stimulus for rises in housing prices, it is imperative for the Taiwan government to first monitor the ups and downs of the stock market in order to quell any subsequent housing market mania that would lead to financial instability.

The contribution of this paper is five-fold. First, this is the first attempt to use the DY method to explore the dynamic relations between local housing markets and the stock market. Second, as in past studies, we confirm that the wealth effect from the stock to the housing markets is the main reason for the exuberance in the two markets. Third, the levels of the ripple effects rely on the distance from Taipei city as the source city. Fourth, based on the frequency domain, it is clear that the portfolio diversification between the stock and housing markets is feasible only in the short run. Finally, higher spillovers in a bearish stock market support the general finding that psychological spillovers mainly stem from bad news. The above-mentioned contributions provide useful policy implications when dealing with overheated financial markets.

The remainder of this paper is organized as follows. Section 2 describes our data as well as our estimation method. Section 3 analyzes the estimation results. Section 4 details our robustness checks. Our conclusions are presented in the final section.

2. Data and estimation methodology

2.1. Data source

Housing price indices for the four major cities since 1991 are obtained from the Sinyi real estate development company. Moreover, these indices are calculated in accordance with existing and second-hand housing transactions and have been widely used in past academic research (Chien, 2010; Chen et al., 2011; Chiang & Chen, 2023). In particular, based on the geographic distribution, New Taipei surrounds Taipei, which is the core of Taiwan's economy, and is located in the northern region, whereas Taichung and Kaohsiung are located in the central and southern regions, respectively. As far as the stock price index is concerned, the closing prices on the final transaction date are obtained every quarter from the Taiwan Economic Journal (TEJ) in order to match the low-frequency housing data. All quarterly data during the 1991–2024Q2 period are further transformed into return data by first-differenced natural logarithms to meet the stationarity requirement in the VAR model. Finally, by using the rolling window (60 quarters, 15 years) calculation, we can trace the spillovers across the housing and stock markets during the 2006–2024Q2 period with 75 estimated spillovers.

2.2. Estimation model

A generalized VAR (GVAR) is proposed to solve the variable ordering problem. Our model with X, including the stock return (SPR) and four city-level housing returns (HPR) and p lags is shown as in Equation (1), where all return variables must be stable.[2]

$$X_t = \sum_{k=1}^{p} A_k X_{t-k} + \varepsilon_t, \varepsilon_t \sim (0, \Sigma), \tag{1}$$

where ε is a random error with a zero mean and covariance matrix, Σ, and A_k.

According to the variance decomposition account under this GVAR model, cross-variance shares (φ_{ij}) is defined by the size of explanatory ability of city j on city i. More importantly, Diebold and Yilmaz (2009, 2012) expanded to infer that higher (lower) φ_{ij} can be analogous to strong (weak) spillovers from city j to i. If their argument is valid, φ_{ij} becomes the first indicator to quantify the spillovers. Besides, the normalization of Equation (2) can be operated by $\tilde{\varphi}_{ij}$ to sum up to 1 as in Equation (3).

$$\varphi_{ij} = \frac{\Sigma_{jj}^{-1} \sum_{h=0}^{H} [(A_h \Sigma)_{ij}]^2}{\sum_{h=0}^{H} (A_h \Sigma A_h^{'})_{ii}}; \tag{2}$$

$$\tilde{\varphi}_{ij} = \frac{\varphi_{ij}}{\sum_{j=1}^{5} \varphi_{ij}}. \tag{3}$$

Since cross-variance shares are proxies of spillovers, we provide a spillover table as in Table 1, where quantifying spillovers via $\tilde{\varphi}_{ij}$ contributes to some meaningful spillover indices, including total, directional, and net indicators to further elaborate on interactive behaviors in various aspects.

The first spillover index is constructed by the total spillover index (TS), as in Equation (4):

$$TS(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{5} \tilde{\varphi}_{ij}(H)}{5} = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{5} \tilde{\varphi}_{ji}(H)}{5}. \tag{4}$$

This index is used to calculate the average value based on the sum of all possible spillovers (cross-variance shares) divided by the number of markets. Thus TS is a spillover index based on all variables that is an indicator of systemic risk across the stock and local housing markets (Diebold & Yilmaz, 2014).

By returning to a specific market, we can introduce the directional spillover (DS_i) index for market i "from" other markets as in Equation (5) by $DS_{i.}$ via the row sum and the directional spillover index for market i "to" other markets as in Equation (6) by $DS_{.i}(H)$ via the column sum to find out more about the direction of the spillovers between a specific market and other markets.

$$DS_{i.}(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{5} \tilde{\varphi}_{ij}(H)}{\sum_{i,j=1}^{5} \tilde{\varphi}_{ij}(H)} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{5} \tilde{\varphi}_{ij}(H)}{5}; \tag{5}$$

$$DS_{.i}(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{5} \tilde{\varphi}_{ji}(H)}{\sum_{i,j=1}^{5} \tilde{\varphi}_{ji}(H)} = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{5} \tilde{\varphi}_{ji}(H)}{5}. \tag{6}$$

Moreover, a net spillover index (NS_i) can be used to determine the final position of a market in relation to other markets, as in Equation (7) by Equation (6) minus Equation (5). A positive (negative) net spillover index indicates that this market is a provider (receiver), compared to other markets.

$$NS_i(H) = DS_{.i}(H) - DS_{i.}(H). \tag{7}$$

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[2] Based on the ADF unit root tests, all returns are stable due to the rejection of the null hypothesis. All results are available from the authors upon request.

Table 1. A spillover table

	SPR	HPR_{TP}	HPR_{NTP}	HPR_{TC}	HPR_{KS}	Contribution **from** others
SPR	$\tilde{\varphi}_{11}$	$\tilde{\varphi}_{12}$	$\tilde{\varphi}_{13}$	$\tilde{\varphi}_{14}$	$\tilde{\varphi}_{15}$	$\sum_{j=2}^{5}\tilde{\varphi}_{1j}/5$
HPR_{TP}	$\tilde{\varphi}_{21}$	$\tilde{\varphi}_{22}$	$\tilde{\varphi}_{23}$	$\tilde{\varphi}_{24}$	$\tilde{\varphi}_{25}$	$\sum_{j=2}^{5}\tilde{\varphi}_{2j}/5$
HPR_{NTP}	$\tilde{\varphi}_{31}$	$\tilde{\varphi}_{32}$	$\tilde{\varphi}_{33}$	$\tilde{\varphi}_{34}$	$\tilde{\varphi}_{35}$	$\sum_{j=2}^{5}\tilde{\varphi}_{3j}/5$
HPR_{TC}	$\tilde{\varphi}_{41}$	$\tilde{\varphi}_{42}$	$\tilde{\varphi}_{43}$	$\tilde{\varphi}_{44}$	$\tilde{\varphi}_{45}$	$\sum_{j=2}^{5}\tilde{\varphi}_{4j}/5$
HPR_{KS}	$\tilde{\varphi}_{51}$	$\tilde{\varphi}_{52}$	$\tilde{\varphi}_{53}$	$\tilde{\varphi}_{54}$	$\tilde{\varphi}_{55}$	$\sum_{j=2}^{5}\tilde{\varphi}_{5j}/5$
Contribution **to** others	$\sum_{j=1, j\neq 1}^{5}\tilde{\varphi}_{j1}/5$	$\sum_{j=1, j\neq 1}^{5}\tilde{\varphi}_{j2}/5$	$\sum_{j=1, j\neq 1}^{5}\tilde{\varphi}_{j3}/5$	$\sum_{j=1, j\neq 1}^{5}\tilde{\varphi}_{j4}/5$	$\sum_{j=1, j\neq 1}^{5}\tilde{\varphi}_{j5}/5$	$\sum_{i,j=1, i\neq j}^{5}\tilde{\varphi}_{ij}/5=\sum_{i,j=1, i\neq j}^{5}\tilde{\varphi}_{ji}/5$

However, if we only wish to evaluate the net spillovers between two specific markets, for example, market i and market j, another index, namely, a "net pairwise" spillover index (SP_{ij}) is presented as in Equation (8) by extracting two cross-variance shares, $\tilde{\varphi}_{ij}(H)$ and $\tilde{\varphi}_{ji}(H)$, from Table 1. A positive (negative) value tells us that the former (latter) is a provider of spillovers to the latter (former).

$$SP_{ij}(H)=\left[\frac{\tilde{\varphi}_{ji}(H)-\tilde{\varphi}_{ij}(H)}{5}\right]. \quad (8)$$

3. Empirical results

3.1. Static analysis

According to the FPE, AIC, SC and HQ criteria, a lag equal to 1 is determined by using the full sample (1991–2024Q2), which is applied to create a static spillover table as shown in Table 2, where the total spillover index is 28.5%.

Table 2. A static spillover table

	SPR	HPR_{TP}	HPR_{NTP}	HPR_{TC}	HPR_{KS}	"From" others
SPR	91.5	3.6	1.5	0.6	2.9	8.5
HPR_{TP}	6.7	62.1	24.8	6.4	0	37.9
HPR_{NTP}	5.3	24.1	58.4	11	1.3	41.6
HPR_{TC}	3.9	12.6	15.2	67.1	1.1	32.9
HPR_{KS}	1.7	5.2	8.7	6	78.4	21.6
"To" others	17.6	45.4	50.2	24	5.3	28.50%
Net spillovers	9.1	7.5	8.6	–8.9	–16.3	

Moreover, when comparing "To" and "From" spillovers, it is obvious that the stock market as well as two housing markets in Taipei and New Taipei are classified as information transmitters due to their positive net values, while Taichung and Kaohsiung with their negative net values are both classified as the receivers.

3.2. Dynamic analysis

A financial market is always characterized by a high degree of volatility as shown in Figure 1, and so a single estimation result using traditional time-series econometrics is apparently insufficient (Diebold & Yilmaz, 2012). We thus follow the rolling-window approach to calculate the dynamic spillover indices from Equations (4)–(8), respectively.

First of all, we cite total spillovers across the stock and housing markets to evaluate the degree of systemic risk as shown in Figure 2. There is considerable evidence of a highly volatile pattern of spillovers to prove the importance of time-varying econometrics. Besides, it is clear that

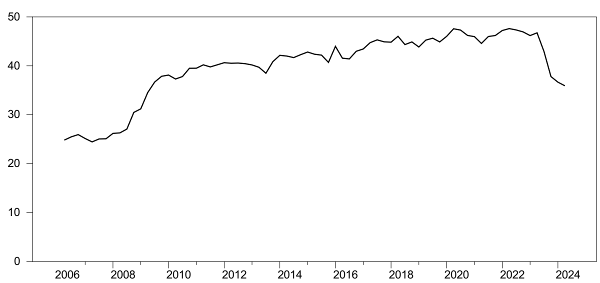

Figure 2. Total spillovers across housing and stock markets

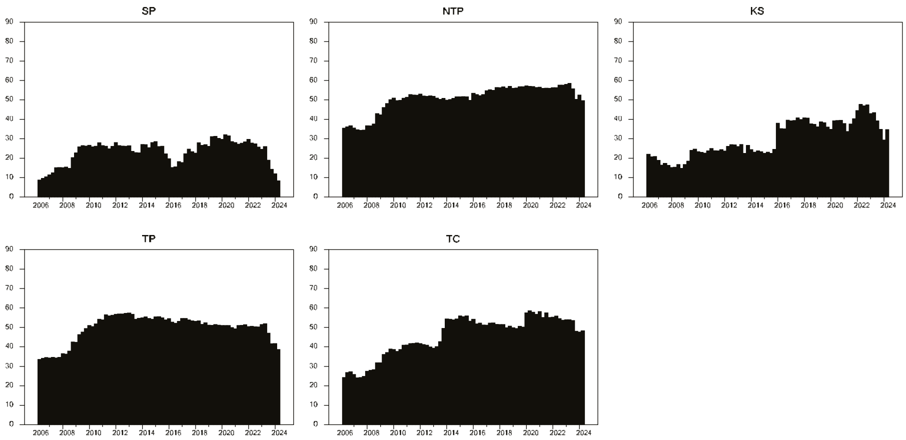

Figure 3. Directional spillovers (from)

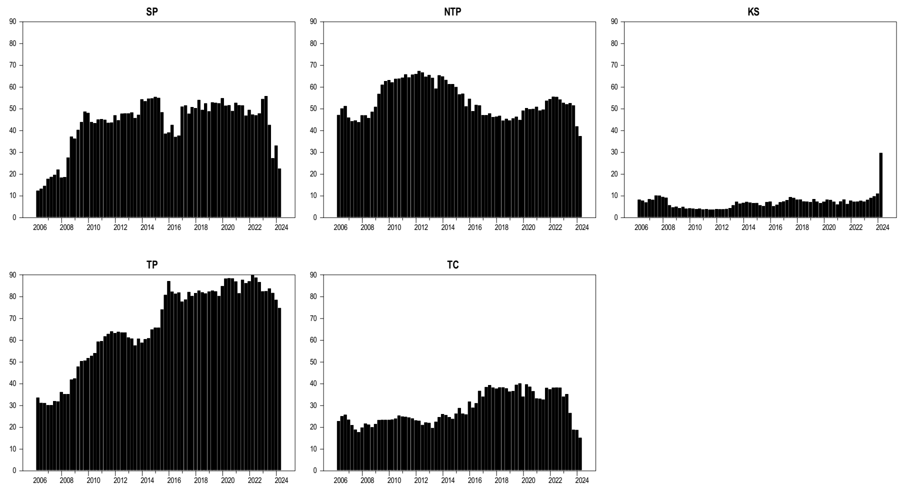

Figure 4. Directional spillovers (to)

systemic risk remains at a high level after the 2008 GFC and this consequence is a warning signal for the authorities.

By returning to individual stock and housing markets, we can employ directional spillovers "From" and "To" others, as seen in Figures 3 and 4, respectively. Figure 3 reveals that the stock market is seldom affected by local housing markets, while local housing markets are found to have been greatly affected by the stock market and other housing markets following the 2008 GFC. According to the directional spillovers "To", the stock market and the two housing markets in Taipei and New Taipei all display significant spillovers to other markets. By contrast, Taichung and especially Kaohsiung both reveal only negligible spillovers to other markets.

To ascertain the final role of the stock and housing markets, the net spillovers are represented by a positive (negative) value, which is regarded as an information transmitter (receiver). In Figure 5, first and foremost, the positive net spillovers in the stock market indicate that the stock market has stronger spillovers to the overall housing market and this result serves as evidence of the wealth effect from the stock to the housing markets in the case of Taiwan. Second, Taipei's housing market is another example with positive net spillovers to other markets, while the two housing markets in Taichung and Kaohsiung are clearly information receivers due to their negative values. More specifically, New Taipei's housing market has played a mixed role from being a transmitter to a receiver in terms of spillovers since 2016. Based on the above, according to the order of net spillovers from Taipei, New Taipei, Taichung to Kaohsiung, we argue that housing spillovers may be centralized from Taipei.

However, one may notice that directional and net spillovers are calculated based on a specific market versus other markets and this often leads to obscure conclusions. For example, a positive value of net spillovers from the stock market only informs us that there are spillovers from the stock market to the overall housing market. However, this is still unavailable in the case of the stock market to any specific housing market.

To more concretely evaluate the relative position between two specific markets, we must appeal to net pairwise spillovers as shown in Figure 6 with ten combinations, where a positive (negative) value implies that there is a net spillover from the former (latter) to the latter (former).

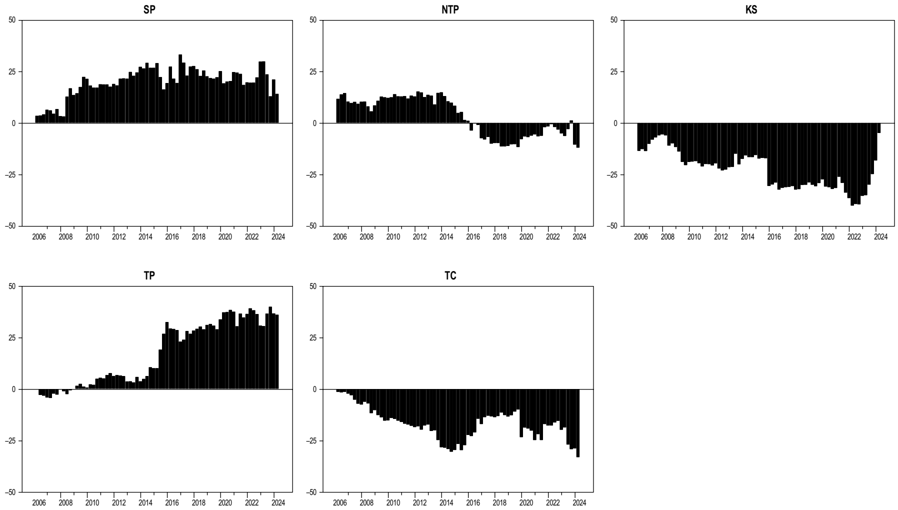

Figure 5. Net spillovers across housing and stock markets

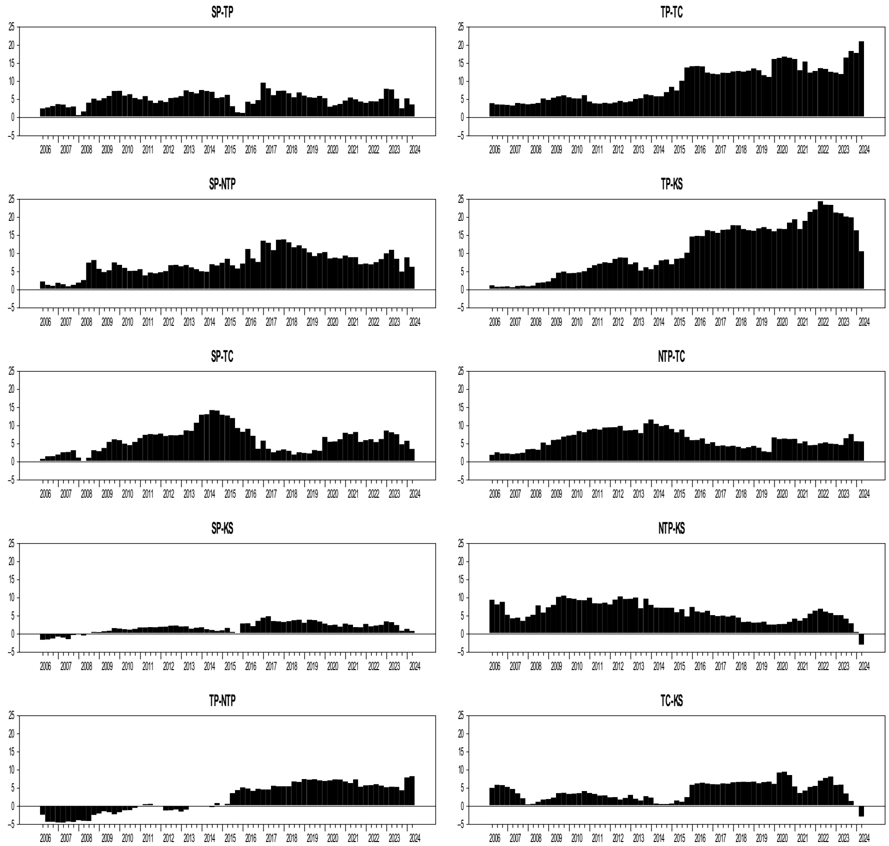

Figure 6. Net pairwise spillovers

First, based on the top four sub-graphs on the left, almost positive net pairwise spillovers between the stock market and any local housing market again prove the existence of the wealth effect. In other words, spillovers from the stock market to the overall housing market (Figure 5) or any specific local housing market (Figure 6) completely support the wealth effect. Second, based on the last sub-graph on the left and top two sub-graphs on the right, we can see the relative positions of Taipei's housing market in relation to the other three local housing markets. After 2014, positive values of net pairwise spillovers in Taipei reveal that housing spillovers only stem from Taipei. Third, compared to the spillovers between New Taipei and Taichung (NTP-TC) or between New Taipei and Kaohsiung (NTP-KS), positive values in New Taipei demonstrate that the direction of the spillovers is from

New Taipei city to these two cities. Finally, the remaining spillovers represented by (TC-KS) determine the relative position between Taichung and Kaohsiung. Positive values signify that the direction of the spillovers is from Taichung to Kaohsiung.

It may be concluded, from what has been said above, that housing spillovers are transferred from the northern region (Taipei and then New Taipei) to the central region (Taichung) and ultimately to the southern region (Kaohsiung). In other words, as far as the housing market is concerned, Taipei is the core and source of the housing diffusion mechanism: from Taipei to New Taipei, Taichung and Kaohsiung in that order. In fact, the most important economic center as the source city for housing spillovers is very popular in some international cases, for example, London as the capital city in the UK (MacDonald & Taylor, 1993; Alexander & Barrow, 1994), Helsinki as the core city in the Finnish economy (Oikarinen, 2006) and Seoul as the capital city in Korea (Lee & Lee, 2019).

4. Robustness checks and other applications

In this section, we implement several possible robustness checks. First of all, it is well known that there are different spillovers based on different forecast horizons, and so we calculate the spillover index for forecast horizons varying from 8 to 12 and 16 quarters. Secondly, the concept of frequency domain can be integrated into the DY method to show the difference in connectedness between the short- and long-run dynamics to further decide on the validity of portfolio diversification. Finally, we apply asymmetric connectedness (Barunik et al., 2017) to investigate what is different when faced with bearish and bullish stock markets. All of these tasks can provide additional information about the robustness checks with regard to the interrelationship between the stock and housing markets in Taiwan.

4.1. DY spillovers over different horizons

Although the selection of the forecast horizon is arbitrary, there are different patterns of spillovers using different horizons. To check for the sensitivity of the results to the choice of the forecast horizon (Diebold & Yilmaz, 2012; Zhang & Fan, 2019), we apply three forecast horizons of 8, 12 and 16 quarters as shown in Figure 7. From the results, it is easy to find that the difference in total spillovers among the different window sizes is very small, which proves that total spillovers are not sensitive to the choice of the forecast horizons.

4.2. Short- and long-run spillovers based on the frequency domain

While the DY method involves tracing out a time trend in housing spillovers, Barunik and Krehlik (2018) employed a spectral representation to set up a frequency version of dynamic spillovers to analyze and compare short- and long-run spillover behaviors.

In this paper, we select 1–2 quarters as the short run and over 2 quarters as the long run in Taiwan from Figure 8. It is found that there are very low spillovers under the short-run dynamics, while there are relatively higher spillovers over the long-run dynamics. Following this by the concept of portfolio theory, low (high) spillovers among various markets are found to have a good (bad) capacity for risk diversification. There is plenty of evidence to show that portfolio diversification strategies are effective only in the short run, rather than in the long run. This result is similar to that of Chen and Chiang (2020) in the case of China.

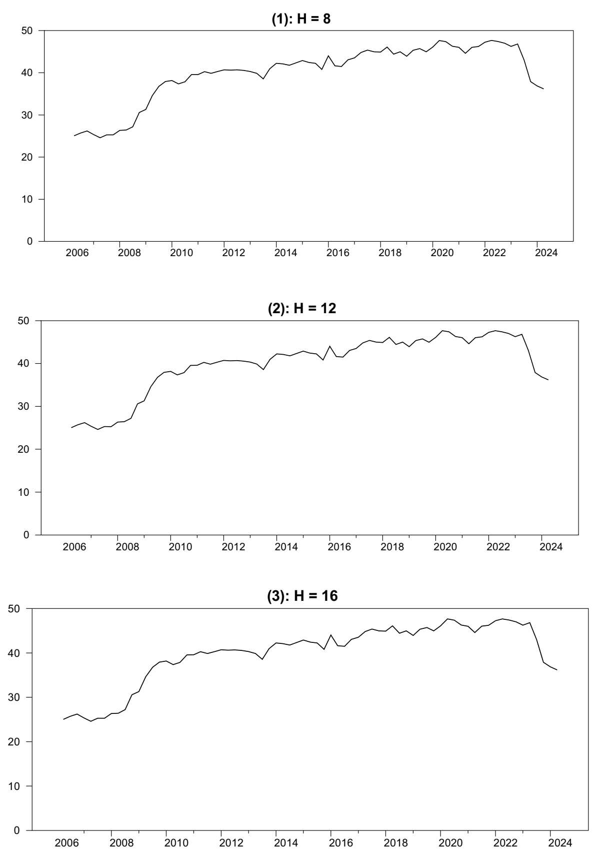

Figure 7. Robustness check: Different forecast horizons

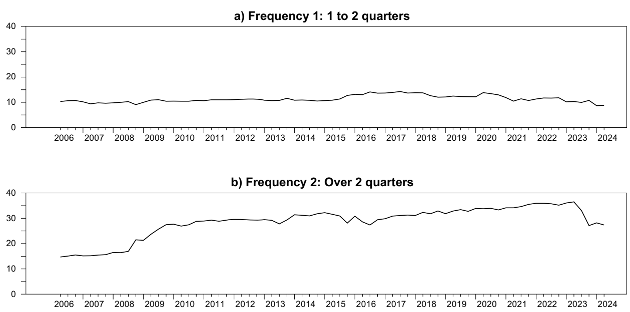

Figure 8. Total spillovers of the frequency domain

4.3. Time-varying spillovers between bullish and bearish markets

To evaluate the differences in spillovers in bullish and bearish markets, two advanced approaches can be considered. One is the quantile version of spillovers (Ando et al., 2022; Foglia et al., 2022) and the other is referred to as asymmetric spillovers (Barunik et al., 2017; Chiang et al., 2022). The former involves adopting different quantiles from low to high in order to account for bearish and bullish markets, respectively. Moreover, the latter approach has to do with setting up an augmented VAR model to cover different states using dummy variables. In fact, a quantile VAR model requires much more data to be divided into various quantiles over time. However, the number of our quarter-based data observations is very limited. Thus, we have decided to adopt asymmetric spillovers to explore the differences in spillovers in bearish and bullish markets by using two dummy variables: $D^1\left(D^2\right)$ is defined by the bearish (bullish) market when negative (positive) market returns last for at least two consecutive quarters. Our new VAR model using a new vector: $Z_t = X_t \times D_t^h = \left(SPR_t^+, HPR_{TP,t}^+, HPR_{NTP,t}^+, HPR_{TC,t}^+ HPR_{KS,t}^+; SPR_t^-, HPR_{TP,t}^-, HPR_{NTP,t}^-, HPR_{TC,t}^-, HPR_{KS,t}^-\right)$ is adopted with ten variables, and not five variables. This is an interesting case of total spillovers over time as in Figure 9, which well illustrates that higher spillovers prevail in a bearish market due to the fears of suffering a loss, while spillovers in a bullish market are lower.

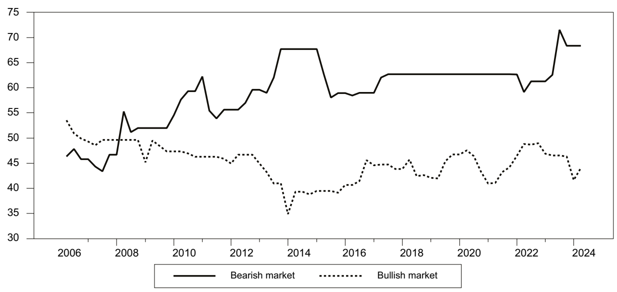

Figure 9. Total spillovers in bullish and bearish markets

5. Conclusions and policy implications

In this paper, we extend spillovers from local housing markets to the national stock market to account for the twin peaks of the stock and housing markets in Taiwan using the time-varying DY spillover method. There is evidence to magnify the unparalleled status of the stock market in relation to four local housing markets. The "wealth effect" result suggests that the top priority of the authorities is to set up a warning system for irrational behavior in the stock market, which further spills over in the housing markets resulting in exorbitant housing prices.

For the housing network itself, it is clear that Taipei as the economic center in Taiwan serves as the source city in other cities. This Taipei-centric result is consistent with Taiwan's studies (Lee et al., 2014; Chiang & Chen, 2023) as well as some international cases, as mentioned in Section 3.2. Based on the above, the central bank and local government in Taiwan must attach more importance to the status of Taipei's housing market to prevent the high prices in Taipei from being diffused to other cities resulting in an overall overheated housing market.

Besides, by considering the portfolios across the stock and housing assets, it is suggested that a good portfolio should be built based on a combination of the stock market and Kaohsiung's housing market due to the lowest correlation (via the smallest spillovers). However, the frequency spillover analysis informs us that this may be an efficient portfolio strategy in the short run, not the long run. Finally, the bearish-bullish spillover analysis warns us that psychologic spillovers in a bearish market are particularly noteworthy.

Finally, we need to mention our data limitations, especially the low-frequency housing prices versus high-frequency stock prices. For the sake of consistency, we are forced to adjust the stock prices from a daily to a quarterly basis. However, this adjustment cannot but result in missing a lot of critical information behind the stock market. To sum up, our study can provide valuable policy implications using a time-varying spillover method when the housing and stock markets are overheated.

References

Agnello, L., Castro, V., & Sousa, R. M. (2018). Economic activity, credit market conditions, and the housing market. *Macroeconomic Dynamics*, *22*(7), 1769–1789. https://doi.org/10.1017/S1365100516000869

Alexander, C., & Barrow, M. (1994). Seasonality and cointegration of regional house prices in the UK. *Urban Studies*, *31*(10), 1667–1689. https://doi.org/10.1080/00420989420081571

Ando, T., Greenwood-Nimmo, M., & Shin, Y. (2022). Quantile connectedness: Modelling tail behavior in the topology of financial networks. *Management Science*, *68*(4), 2401–2431. https://doi.org/10.1287/mnsc.2021.3984

Barunik, J., & Krehlik, T. (2018). Measuring the frequency dynamics of financial connectedness and systemic risk. *Journal of Financial Econometrics*, *16*(2), 271–296. https://doi.org/10.1093/jjfinec/nby001

Barunik, J., Kocenda, E., & Vacha, L. (2017). Asymmetric volatility connectedness on the forex market. *Journal of International Money and Finance*, *77*, 39–56. https://doi.org/10.1016/j.jimonfin.2017.06.003

Billio, M., Getmansky, M., Lo, A. W., & Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk in the finance and insurance sectors. *Journal of Financial Economics*, *104*(3), 535–559. https://doi.org/10.1016/j.jfineco.2011.12.010

Blanchard, O., Dell'Ariccia, G., & Mauro, P. (2010). Rethinking macroeconomic policy. *Journal of Money*, *Credit and Banking*, *42*(s1), 199–215. https://doi.org/10.1111/j.1538-4616.2010.00334.x

Brunnermeier, M., Rother, S., & Schnabel, I. (2020). Asset price bubbles and systemic risk. *Review of Financial Studies*, *33*(9), 4272–4317. https://doi.org/10.1093/rfs/hhaa011

Chen, C., & Chiang, S. (2020). Time-varying spillovers among first-tier housing markets in China. *Urban Studies*, *57*(4), 844–864. https://doi.org/10.1177/0042098019841580

Chen, C., & Chiang, S. (2022). Portfolio diversification possibilities between the stock and housing markets in G7 countries: Evidence from the time-varying Granger causality. *Finance Research Letters*, *49*, Article 103124. https://doi.org/10.1016/j.frl.2022.103124

Chen, C., Hui, E. C. M., & Chiang, S. (2024). Inter-city housing spillovers and monetary policy in China. *Cities*, *152*, Article 105158. https://doi.org/10.1016/j.cities.2024.105158

Chen, C., Hui, E. C. M., & Chiang, S. (2025). Unveiling systemic risk in China's housing market between first- and second-tier cities. *Habitat International*, *163*, Article 103488. https://doi.org/10.1016/j.habitatint.2025.103488

Chen, P., Chien, M., & Lee, C. (2011). Dynamic modeling of regional house price diffusion in Taiwan. *Journal of Housing Economics*, *20*(4), 315–332. https://doi.org/10.1016/j.jhe.2011.09.002

Chiang, S., & Chen, C. (2022). From systematic to systemic risk among G7 members: Do the stock or real estate markets matter? *Journal of International Financial Markets*, *Institutions* & *Money*, *79*, Article 101594. https://doi.org/10.1016/j.intfin.2022.101594

Chiang, S., & Chen, C. (2023). Macroprudential policy and the real estate market: Effectiveness and repercussions. *Journal of Asian Economics*, *88*, Article 101652. https://doi.org/10.1016/j.asieco.2023.101652

Chiang, S., & Chen, C. (2025). Exploring macroeconomic determinants of housing bubbles: New evidence from dynamic panel probit models. *Atlantic Economic Review*, *53*(1–2), 3–17. https://doi.org/10.1007/s11293-025-09820-8

Chiang, S., Hui, E. C. M., & Chen, C. (2022). Asymmetric housing information diffusions in China: An investor perspective. *Urban Studies*, *59*(10), 2036–2052. https://doi.org/10.1177/00420980211026555

Chien, M. (2010). Structural breaks and the convergence of regional house prices. *Journal of Real Estate Finance and Economics*, *40*(1), 77–88. https://doi.org/10.1007/s11146-008-9138-y

Chodorow-Reich, G., Nenov, O. T., & Simsek, A. (2021). Stock market wealth and the real economy: A local labor market approach. *American Economic Review*, *111*(5), 1613–1657. https://doi.org/10.1257/aer.20200208

De Wit, I. (2010). International diversification strategies for direct real estate. *Journal of Real Estate Finance and Economics*, *41*(4), 433–457. https://doi.org/10.1007/s11146-009-9173-3

Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *Economic Journal*, *119*(534), 158–171. https://doi.org/10.1111/j.1468-0297.2008.02208.x

Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, *28*(1), 57–66. https://doi.org/10.1016/j.ijforecast.2011.02.006

Diebold, F. X., & Yilmaz, K. (2014). On the network topology of variance decompositions: Measuring the connectedness of financial firms. *Journal of Econometrics*, *182*(1), 119–134. https://doi.org/10.1016/j.jeconom.2014.04.012

Ding, H., Chong, T. T., & Park, S. Y. (2014). Nonlinear dependence between stock and real estate markets in China. *Economics Letters*, *124*(3), 526–529. https://doi.org/10.1016/j.econlet.2014.05.035

Foglia, M., Addi, A., Wang, G., & Angelini, E. (2022). Bearish vs. Bullish risk network: A Eurozone financial system analysis. *Journal of International Financial Markets*, *Institutions* & *Money*, *77*, Article 101522. https://doi.org/10.1016/j.intfin.2022.101522

Fratantoni, M., & Schuh, S. (2003). Monetary policy, housing and heterogeneous regional markets. *Journal of Money*, *Credit and Banking*, *35*(4), 557–589. https://doi.org/10.1353/mcb.2003.0029

Gallo, J. G., & Zhang, Y. (2010). Global property market diversification. *Journal of Real Estate Finance* & *Economics*, *41*(4), 458–485. https://doi.org/10.1007/s11146-009-9178-y

Gholipour, H. F., & Lean, H. H. (2017). Ripple effect in regional housing and land markets in Iran: Implications for portfolio diversification. *International Journal of Strategic Property Management*, *21*(4), 331–345. https://doi.org/10.3846/1648715X.2016.1272010

Hurn, S., Shi, S., & Wang, B. (2022). Housing networks and driving forces. *Journal of Banking and Finance*, *134*, Article 106318. https://doi.org/10.1016/j.jbankfin.2021.106318

Jordà, Ò., Schularick, M., & Taylor, A. M. (2015). Betting the house. *Journal of International Economics*, *96*(Suppl. 1), S2–S18. https://doi.org/10.1016/j.jinteco.2014.12.011

Kapopoulos, P., & Siokis, F. (2005). Stock and real estate prices in Greece: Wealth versus credit-price effect. *Applied Economics Letters*, *11*(2), 741–744. https://doi.org/10.1080/1350485042000307107

Kiohos, A., Babalos, V., & Koulakiotis, A. (2017). Wealth effect revisited: Novel evidence on long term co-memories between real estate and stock markets. *Finance Research Letters*, *20*, 217–222. https://doi.org/10.1016/j.frl.2016.10.002

Lee, C., Lee, C., & Chiang, S. (2016). Ripple effect and regional house prices dynamics in China. *International Journal of Strategic Property Management*, *20*, 397–408. https://doi.org/10.3846/1648715X.2015.1124148

Lee, H. S., & Lee, W. S. (2019). Cross-regional connectedness in the Korean housing market. *Journal of Housing Economics*, *46*, Article 101654. https://doi.org/10.1016/j.jhe.2019.101654

Lee, M.-T., Lee, M.-L., & Lin, S. (2014). Trend properties, cointegration and the diffusion of presale house prices in Taiwan: Can Taipei's house prices ripple out? *Habitat International*, *44*, 432–441. https://doi.org/10.1016/j.habitatint.2014.09.003

Lin, P.-T., & Stankov, I. (2025). Dynamic between housing and stock markets: International evidence over 1870 to 2015. *Journal of Real Estate Research*, 1–17. https://doi.org/10.1080/08965803.2024.2442226

Lin, T., & Lin, Z. (2011). Are stock and real estate markets integrated? An empirical study of six Asian economies. *Pacific-Basin Financial Journal*, *19*(5), 571–585. https://doi.org/10.1016/j.pacfin.2011.05.001

Liow, K. H., Huang, Y., & Song, J. (2019). Relationship between the United States housing and stock markets: Some evidence from wavelet analysis. *North American Journal of Economics and Finance*, *50*, Article 101033. https://doi.org/10.1016/j.najef.2019.101033

MacDonald, R., & Taylor, M. (1993). Regional house prices in Britain: Long-run relationships and short-run dynamics. *Scottish Journal of Political Economy*, *40*(1), 43–55. https://doi.org/10.1111/j.1467-9485.1993.tb00636.x

Oikarinen, E. (2006). The diffusion of housing price movements from centre to surrounding areas. *Journal of Housing Research*, *15*(1), 3–28. https://doi.org/10.1080/10835547.2004.12091958

Oikarinen, E. (2010). Foreign ownership of stocks and long-run interdependence between national housing and stock markets—Evidence from Finnish data. *The Journal of Real Estate Finance and Economics*, *41*(4), 486–509. https://doi.org/10.1007/s11146-009-9175-1

Reinhart, C. M., & Rogoff, K. S. (2008). Is the 2007 US sub-prime financial crisis so different? An international historical comparison. *American Economic Review*, *98*(2), 339–344. https://doi.org/10.1257/aer.98.2.339

Shi, G., Liu, X., & Zhang, X. (2017). Time-varying causality between stock and housing markets in China. *Finance Research Letters*, *22*, 227–232. https://doi.org/10.1016/j.frl.2017.06.003

Sim, S., & Chang, B. (2006). Stock and real estate markets in Korea. *Journal of Economic Research*, *11*, 103–126.

Tsai, I. (2015). Dynamic information transfer in the United States housing and stock markets. *North American Journal of Economics and Finance*, *34*, 215–230. https://doi.org/10.1016/j.najef.2015.09.012

Tsai, I., & Chiang, S. (2019). Exuberance and spillovers in housing markets: Evidence from first- and second-tier cities in China. *Regional Science and Urban Economics*, *77*, 75–86. https://doi.org/10.1016/j.regsciurbeco.2019.02.005

Yavas, A., & Yildirim, Y. (2011). Price discovery in real estate markets: A dynamic analysis. *Journal of Real Estate Finance and Economics*, *42*(1), 1–29. https://doi.org/10.1007/s11146-009-9172-4

Zhang, D. F., & Fan, G. (2019). Regional spillovers and rising connectedness in China's urban housing prices. *Regional Studies*, *53*(6), 861–873. https://doi.org/10.1080/00343404.2018.1490011