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A Regional Decomposition of US Housing Prices and Volume: Market Dynamics and Economic Diversification Opportunities

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Abstract

In this study we employ a TVP-VAR model in order to investigate dynamic connectedness of housing prices and sales volume across four US regional housing markets; namely, Midwest, Northeast, South, as well as, West, for the period between January 1990 and March 2019. Furthermore, utilizing an insightful decomposition of the results, we provide a thorough investigation of the underlying dynamics. Overall, results indicate that during turbulent economic periods, it is sales volume shocks that drive developments in the US housing market, rather than shocks in housing prices. In addition, we find that the South is rather a persistent net transmitter of both prices and volume housing market shocks, while the Northeast, a net receiver. On the whole, all four markets assume both roles over time. Results are important for policy makers and regulators aiming to alleviate the negative ramifications of an overheated housing market. In addition, given that over time, the four markets behave differently in connection with their short run shock-transmission capacity, results are also suggestive that there is potential for economic (i.e., rather than strictly geographical) portfolio diversification.

Keywords: US regional housing markets; Housing prices; Transaction volume; TVP-VAR, Dynamic connectedness; Dynamic connectedness decomposition

JEL codes: C32; G10; G20

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1 Introduction

Investigating housing market conditions has gained much prominence over time, especially in the years that followed the Global Financial Crisis (GFC). To a certain extent, the housing market (i) is closely related to developments in the business cycle (Leamer, 2007), (ii) provides a channel for monetary policy (Mishkin, 2007), as well as (iii), lies at the epicenter of research in relation to asset bubbles (Shiller, 2014). In this regard, a thorough investigation of the factors that fashion developments within the housing market, not only facilitates our understanding of the broader economy, but also, contributes to effective policy decision making. In light of this rather versatile role of housing markets in economic developments, this study provides new evidence on housing market dynamics, in connection with four US regional housing markets; that is, Midwest, Northeast, South, as well as, West, for the period between January 1990 and March 2019. More importantly, this study considers two different metrics of housing market conditions (i.e., both housing prices and transactions volume) and further investigates their respective interaction in order to provide both policy recommendations and portfolio diversification insights.

Starting with the consideration of the interaction between different spatial units, existing literature has shown keen interest in identifying common trends or sources of influence across separate geographical regions. In point of fact, research in this field is being conducted at different levels of disaggregation (i.e., country-level, regional-level, city-level, etc.) and typically, the overriding objective is to identify potential strong correlations between the housing prices (i.e., the most popular metric of housing market conditions) of different spatial units. In short, authors in this area purport to identify the underlying transmission mechanism (i.e., the ripple effect) that determines housing market developments and interrelations within a given geographical space. Recent examples of relevant studies that analyse the ripple effect include, among others, Miao et al. (2011); Barros et al. (2012); Payne (2012); Yunus and Swanson (2013); Brady (2014); Kallberg et al. (2014); Chiang and Tsai (2016); Füss and Zietz (2016); Pijnenburg (2017), as well as, Antonakakis et al. (2018). All aforementioned studies provide useful insights in connection with the respective interrelations. What is more, it should be stressed early on that, there is strong evidence that integration across different geographical areas intensified after 2005; that is, immediately before the 2006 prices peak and the subsequent collapse of the market.

Turning to the interaction between housing prices and transactions (i.e., sales) volume, it should

be noted that, although most studies in the field predicate their analysis merely upon one metric of housing market conditions (i.e., housing prices), there is also a rather scarce, strand of the housing market literature that further considers the interaction between housing prices and sales (i.e., transactions) volume. The rationale underpinning this choice of study, is closely related to well established research that focuses on the relationship between prices and volume in financial markets (see, inter alia, Bessembinder and Seguin, 1993; Campbell et al., 1993; Chen et al., 2001; Statman et al., 2006). Arguably, the recent financialization of the housing market has clearly paved the path for analyses of this persuasion.

Within the territory of this relatively scarce strand of the literature, Shi et al. (2010) conduct a study using urban area data on New Zealand and provide evidence that causality between the two metrics is rather evident in the long run, while, the direction of the causality is from the volume towards price. What is more, Oikarinen (2012) making use of data for Finland provides empirical support to the argument that demand shocks are followed by a much more immediate response from sales volume, compared to that from prices. In addition, De Wit et al. (2013) investigate the relationship between prices and volume for the Netherlands showing that shocks in the mortgage rate will have an immediate impact on volume and a rather gradual impact on price. Finally, authors such as Tsai (2014) and Cook and Watson (2018) investigate this nexus for the UK housing market. More particularly, Tsai (2014) underscores that the long run relationship between the two metrics is rather constant, while Cook and Watson (2018) emphasize the volatility-reduction properties of transaction volume.

With reference to the US market which is also the focal point of the present study, one of the most interesting academic articles concerning both metrics of US housing market conditions, is that of Clayton et al. (2010), who – predicating upon a vector autoregressive (VAR) framework and a large sample of US Metropolitan Statistical Areas (MSAs) for the period 1990 to 2002 – provide empirical evidence that, both metrics are affected by developments in the labor, the stock, as well as, the mortgage market, while the extent of that influence is also a function of the degree of elasticity of supply within each specific geographical area. Furthermore, Clayton et al. (2010) show that for the period under investigation there appears to be both positive correlation between the two metrics and bidirectional Granger causality (pointing out that prices cause short run asymmetric effects and that volume has a short run effect only in markets characterized by inelastic supply). More recently, Tsai (2018) applies the Diebold and Yılmaz (2014) framework to find that there is negative

correlation between the two metrics; while, Tsai (2019) utilizing a Granger causality framework, shows that there is a lead-lag relationship between the two metrics only during turbulent periods.

Apart from exogenous shocks that can be reflected upon the responses from both housing market metrics, other efforts aiming to further investigate the lead-lag relationship between the two involve monetary policy decision making and speculation. The influence of monetary policy on the housing market has been particularly underscored by Leamer (2015) who argues that monetary policy is indeed a key determinant of housing market developments and that the housing boom that ended in 2005 was in fact the result of the (unfitting) accommodative monetary policy that followed the business downturn of 2000-01, expediting housing supply that would have otherwise been spread more evenly across time.

Speculation in the housing market has been mainly investigated from a theoretical point of view. For instance, DeFusco et al. (2017) concentrate on the speculative character of transactions volume. More particularly, DeFusco et al. (2017) provide a theoretical model of the US housing market and suggest that large-scale fluctuations in transactions volume can be conducive to price bubbles, emphasizing the role of short-term investors. DeFusco et al. (2017) also argue in favor of a lead-lag relationship between volume and prices, whereupon volume fluctuations typically lead changes in prices. It should be noted that, the presence of speculation in the housing market during housing market expansions that results in increased levels of transactions, has also been reported in the theoretical work of Burnside et al. (2016).

In retrospect, this study considers two different metrics of US housing market conditions; that is, housing prices and sales (or transactions) volume. We then utilize monthly data on four US regional housing markets; namely, Midwest, Northeast, South, as well as, West, for the period between January 1990 and March 2019. The contribution of the study is twofold. First, this is the first study to investigate housing market conditions, captured by price and volume, that utilises a decomposed, region-specific, time-varying parameters (TVP) framework. Second, we thoroughly investigate the interaction of both metrics over time and across regions and reach valuable conclusions for both policy makers and risk managers.

As far as the method is concerned, the TVP framework substantially improves the standard rolling-window approach to spillover analysis (i.e., in the spirit of Diebold and Yılmaz (2014)), since there is there is no loss of observations, no need to arbitrarily set the rolling-window size, and the results are not sensitive to outliers. Monte Carlo simulations given by Antonakakis and Gabauer

(2017) provide further evidence regarding the added value of the particular approach. In turn, we employ the connectedness decomposition methodology introduced by Gabauer and Gupta (2018). The adoption of this particular approach offers further insights in the dynamics of both, across regions (i.e., single-metric analysis) and across metrics (i.e., cross-metrics analysis). Considering policy makers and risk managers, our approach allows for attaining a better understanding (i) of the specific conditions that are conducive to a lead-lag relation between the two metrics and (ii) of the extent of integration across regions (that may not necessarily by adjoined).

Main findings show that the lead-lag relationship between price and volume depends on the broader economic conditions. That is, during turbulent economic periods, sales volume drives developments in the US housing market, while, housing prices drive sales during more tranquil periods. Considering the second issue, results are suggestive of the fact that the South appears to be a persistent net transmitter of both prices and volume housing market shocks, while the Northeast, a net receiver. However, all four regions may eventually assume any of the two roles depending on the time interval, signifying that linkages are neither merely constrained between adjoining geographical areas, nor time-invariant. Our findings are relevant for policy makers and regulators, as well as, risk managers investigating potential portfolio diversification opportunities.

The remainder of the paper is organized as follows. In Section 2, we present the data and the adopted empirical method. Then, in Section 3, we present the findings of the study and discuss the relevant market and policy implications. Finally, Section 4 concludes the study.

2 Data and Methodology

2.1 Data

Our dataset consists of monthly sales volumes and average prices of single-family and condos sold across the four US regional housing markets, namely, Midwest, Northeast, South, and, West, over the period from January, 1989 to March, 2019, retrieved from datastream. To generate stationary and seasonally adjusted time-series, all raw variables (Figure 1) are converted to annual percentage changes (Figure 2) by, $y_{it} = \frac{x_{it} - x_{it-12}}{x_{it-12}}$. The summary statistics in Table 1 indicate that the price in the West, South, Midwest and the volume in the South is significantly negatively skewed and that all variables, except for the Western volume, are significantly platykurtic and not normally distributed. Additionally, the ERS unit-root test (Elliott et al., 1996) shows that all returns are stationary at least on the 10% significance level while the weighted portmanteau statistics (Fisher and Gallagher, 2012) point out that all returns significantly inherent ARCH errors.

2.2 Methodology

The time-varying relationships are estimated via the TVP-VAR algorithm a la Antonakakis and Gabauer (2017). This procedure allows the parameters of the VAR model to vary over time with the help of a multivariate Kalman filter. Furthermore, two multivariate exponentially weighted moving average models allow the error variance and the parameter variance to vary over time, giving the model more flexibility. Finally, the Kalman gain makes the model resilient to outliers, which makes this algorithm a nice fit for this application. According to the Bayesian information criterion the TVP-VAR model should have one lag and hence can be written as follows,

$$\boldsymbol{y}_t = \boldsymbol{\Phi}_t \boldsymbol{y}_{t-1} + \boldsymbol{e}_t \qquad \boldsymbol{e}_t | \boldsymbol{F}_{t-1} \sim N(\boldsymbol{0}, \boldsymbol{\Sigma}_t) \qquad (1)$$

$$vec(\mathbf{\Phi}_t) = vec(\mathbf{\Phi}_{t-1}) + \boldsymbol{\zeta}_t \qquad \qquad \boldsymbol{\zeta}_t | \boldsymbol{F}_{t-1} \sim N(\mathbf{0}, \boldsymbol{\Xi}_t)$$
(2)

where F_{t-1} represents all information available up to t-1, y_t and e_t represent $m \times 1$ dimensional vectors and Φ_t and Σ_t are $m \times m$ dimensional matrices. In addition, ζ_t and $vec(\Phi_t)$ are $m^2 \times 1$ dimensional vectors and Ξ_t is an $m^2 \times m^2$ dimensional matrix¹.

The time-varying parameters and time-varying error variances are the basic ingredients for the generalized impulse response functions (GIRF), and generalized forecast error variance decompositions (GFEVD) – developed by Koop et al. (1996) and Pesaran and Shin (1998) – on which the connectedness approach (Diebold and Yılmaz, 2014) rests. Hence, we first need to convert the TVP-VAR into its TVP-VMA representation via the Wold representation theorem, $\boldsymbol{z}_t = \sum_{i=1}^p \boldsymbol{\Phi}_{it} \boldsymbol{z}_{t-i} + \boldsymbol{e}_t = \sum_{j=1}^\infty \boldsymbol{\Lambda}_{jt} \boldsymbol{e}_{t-j} + \boldsymbol{e}_t.$

The GIRFs ($\Psi_{ij,t}(K)$), opposed to the standard IRFs, do not assume a structure of the errors, which is in favour of our analysis. This approach represents the difference of the dynamics of all variables j whether variable i is shocked or not (thus it measures the impact of a shock in i).

¹For details to the Kalman filter algorithm interested reader are referred to Antonakakis and Gabauer (2017)

Mathematically, this can be formalised by,

$$GIRF_t(K, \sqrt{\Sigma_{jj,t}}, \boldsymbol{F}_{t-1}) = E(\boldsymbol{y}_{t+K} | \boldsymbol{\epsilon}_{j,t} = \sqrt{\Sigma_{jj,t}}, \boldsymbol{F}_{t-1}) - E(\boldsymbol{y}_{t+J} | \boldsymbol{F}_{t-1})$$
(3)

$$\Psi_{j,t}(K) = \sum_{j,t}^{-\frac{1}{2}} \Lambda_{K,t} \Sigma_t \epsilon_{j,t}$$
(4)

Subsequently, the GFEVD $(\psi_{ij,t}(K))$ illustrates the contribution of all variables on the forecast error variance of variable *i* (hence, how much, in percent, one variable influences the forecast error variance of another variable). This can be defined as follows,

$$\psi_{ij,t}(K) = \frac{\sum_{t=1}^{K-1} \Psi_{ij,t}^2}{\sum_{j=1}^m \sum_{t=1}^{K-1} \Psi_{ij,t}^2} \qquad \sum_{j=1}^m \psi_{ij,t}(K) = 1 \qquad \sum_{i,j=1}^m \psi_{ij,t}(K) = m.$$
(5)

Afterwards, we can calculate how much variable i is influenced by others and how much variable i influences all the others, and finally, if variable i is influencing others more than being influenced by them. This is done in three steps.

In the first step, we want to know by how much all the other variables influence variable i. Therefore, the shares of the error variance of variable i caused by all other variables j is summed up. If the effect of variable i on its future value would be taken under consideration as well, the value would be 100%. Hence, the influence of all the others on variable i has to be strictly below 100%. The influence of all others on variable i is called the *total directional connectedness FROM* all others and can be computed by,

$$\Gamma_{i \leftarrow j,t}(K) = \frac{\sum_{j=1, i \neq j}^{m} \psi_{ij,t}(K)}{\sum_{i=1}^{m} \psi_{ij,t}(K)} * 100$$
(6)

In the second step, we reverse our interested and want to know the influence variable i has on all the others j. This is done by accumulating the effects variable i has on every other variables' forecast error variance. As opposed to the first step, this value can be above 100%. This measure is called the *total directional connectedness TO all others*, and can be computed by,

$$\Gamma_{i \to j,t}(K) = \frac{\sum_{j=1, i \neq j}^{m} \psi_{ji,t}(K)}{\sum_{j=1}^{m} \psi_{ji,t}(K)} * 100$$
(7)

Finally, in the third step, we deduct equation (7) from (6) to attain the NET total directional

connectedness. This measure determines whether the influence of variable i on others is greater than the influence of others on variable i:

$$\Gamma_{i,t}(K) = \Gamma_{i \to j,t}(K) - \Gamma_{i \leftarrow j,t}(K) \tag{8}$$

A positive (negative) value illustrates that variable i is driving the others more (less) than being driven by them.

Moreover, even if one variable is a net transmitter, it does not mean that it dominates each of the other variables in the network. It only means that it dominates the others on average. Hence, we are interested in a more granular, bidirectional measure to see for which variables, variable i is a transmitter and for which a receiver. This is of main interest since it gives us further insights in the underlying dynamics of the network the net total directional connectedness measure would have masked. Thus, the net pairwise directional connectedness (NPDC) can be calculated as follows,

$$NPDC_{ij}(K) = \left(\frac{\psi_{jit}(K) - \psi_{ijt}(K)}{m}\right) * 100.$$

The total connectedness index (TCI) serves as a measure of network interconnectedness. Since the original TCI varies between [0, (k - 1)/k] and is therefore difficult to interpret Gabauer and Gupta (2018) proposes a standardized TCI measure which varies between [0, 100] and hence improves the interpretability. This measure can be calculated as follows,

$$\Gamma_t(K) = \frac{\sum_{i,j=1, i \neq j}^m \psi_{ij,t}(K)}{m-1} * 100.$$
(9)

Afterwards, the decomposed connectedness approach of Gabauer and Gupta (2018), rewrites the connectedness table as follows,

$$\boldsymbol{\psi}(K) = [\boldsymbol{\psi}]_{ij,t}(K) = \begin{bmatrix} \boldsymbol{\Gamma}_{11} & \boldsymbol{\Gamma}_{12} & \dots & \boldsymbol{\Gamma}_{1k} \\ \boldsymbol{\Gamma}_{21} & \boldsymbol{\Gamma}_{22} & \dots & \boldsymbol{\Gamma}_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ \boldsymbol{\Gamma}_{k1} & \boldsymbol{\Gamma}_{k2} & \dots & \boldsymbol{\Gamma}_{kk} \end{bmatrix}$$

where Γ_{ii} includes the internal spillovers of country *i* and Γ_{ij} represents the spillovers between

country *i* and *j*. Second, for computing internal and external connectedness, we have to set $diag(\Gamma_{ii,nn}) = 0$ and compute,

$$TO_{ij} = \sum_{n=1}^{k} \Gamma_{ij,nm}$$

$$FROM_{ij} = \sum_{m=1}^{k} \Gamma_{ji,nm}$$

$$NET_{ij} = TO_{ij} - FROM_{ij}$$

$$EX_{ij} = \sum_{n=1}^{k} \sum_{m=1}^{k} \Gamma_{ij,nm} - \sum_{n=1}^{k} \sum_{m=1}^{k} \Gamma_{ji,nm}$$

where TO_{ij} , $FROM_{ij}$ and NET_{ij} are corresponding to the previous interpretation but on the metric-level and EX_{ij} is the net external total connectedness.

3 Empirical Results and Discussion

3.1 Average and Dynamic Network Connectedness

We begin our analysis by presenting average dynamic results on total connectedness. In particular, Table 2 illustrates results that pertain to both metrics of housing market conditions. We note that the TCI for housing price connectedness (i.e., price-on-price) is equal to 23.8 implying that there is moderate interrelation of housing prices across the four US regions. Results are somewhat similar in connection with the sales volume connectedness (i.e., volume-on-volume) whereupon, the respective TCI is equal to 27.4. Finally, considering the cross-metrics TCI (i.e., price-on-volume and vice versa), this is equal to 22.6. Although individually, these values imply somewhat modest interrelation across variables, aggregating the values suggests that total connectedness captured within this specific framework of analysis amounts to 73.8, which is a rather considerable rate. The latter, practically implies that 73.8% of the forecast error variance in the system (network) can be attributed to the interrelation across the variables that make up the system in the first place.

[Insert Table 2 about here]

Nonetheless, it should be noted that these average values are not expected to hold for the entire timespan of the analysis; the reason being that, both housing prices and sales volume are not independent of economic developments. In this respect, we should also investigate how total connectedness across these variables evolves over time. Subsequently, Figure 3, illustrates the dynamic results of our study.

[Insert Figure 3 about here]

Notably, total connectedness within the network remains at relatively high levels; that is, between 60 and 85, especially towards the end of our sample. This appreciation of total connectedness over time is also evident when we consider total connectedness that excludes cross-metrics results (i.e., white dashed-line). Furthermore, note that the area from the white dashed-line upwards reflects exactly this cross-metrics connectedness which also increases with time. Nevertheless, the most interesting finding that is evidenced in Figure 3 relates to the evolution of both price-on-price and volume-on-volume connectedness, respectively. To be more specific, following the GFC we note that price-on-price connectedness (i.e., grey dotted-line) loses its standing as the main driver of total connectedness in the network; a role, which is immediately assumed by volume-on-volume connectedness (i.e., white dotted-line). Apparently, similar results can be reported also for the period engulfing the savings and loan crisis in the US (i.e., late 1980s to early 1990s). These results indicate that during recessions, sales volume becomes a rather critical variable reflecting developments in the housing market.

3.2 Directional Network Connectedness

Continuing the analysis on total connectedness, we turn our attention to directional interrelations. Figure 4 (i.e., 'TO' all others) and Figure 5 (i.e., 'FROM' all others) illustrate directional connectedness across the four regions of our study both in terms of housing prices and sales volume. These figures further incorporate the effect of each housing market metric on the other. Starting with the first panel on the left-hand side column of Figure 4, the grey line corresponds to the degree of connectedness transmitted, over time, from housing prices in the West to housing prices in all other regions. In turn, the remaining panels of this column, have reference to the same transmission of connectedness considering the South, the Midwest, and the Northeast, respectively. What is more, the area from the grey line upwards, in all panels of the left-hand side column, reflects the impact of price on volume. Note that this particular area diminishes over time and especially, after the GFC; which is suggestive of the fact that, following the GFC the influence of price on volume also diminishes. Especially for the West and the Northeast regions this effect almost entirely dissolves towards the end of our sample.

[Insert Figures 4 and 5 about here]

By contrast, if we concentrate on the right-hand side column of Figure 4, then, the grey line corresponds to the degree of connectedness transmitted, over time, from sales volume in the West to sales volume in all other regions. Clearly, this increases after the GFC. As previously, the remaining panels of this column, have reference to the same transmission of connectedness considering the South, the Midwest, and the Northeast, respectively. Furthermore, the area from the grey line upwards, in all panels of the right-hand side column, reflects the impact of volume on price. Note that this particular area expands over time and especially, after the GFC; which is suggestive of the fact that, following the GFC the influence of volume on price becomes stronger. The latter is rather evident in all four regions of our study.

Figure 5, is merely the mirror image of Figure 4. In this regard, the left-hand side panels show that after the GFC the impact of volume on price substantially increases; whereas, the right-hand side panels of Figure 5 call attention to the fact that after the GFC, the impact of price on volume substantially diminishes.

On a final note, regarding both Figures 4 and 5, we note that the impact of volume on price is also very pronounced during the beginning of our sample; that is, during the period of the savings and loan crisis in the US.

3.3 Net Network Connectedness

Another interesting decomposition of connectedness results, is given by Figure 6. This figure illustrates net directional connectedness (i.e., the difference between what each region transmits 'TO' all others and what it receives 'FROM' all others), considering again both housing prices and sales volume. Positive values indicate that, overall, a region is a net transmitter of shocks, while, negative values, indicate that, overall, a region is a net receiver of shocks. The grey line indicates what would be the standing of each region on this analysis if only one of the metrics was considered. To be more explicit, the grey line on the left-hand side panels of Figure 6 distinguishes regions between net transmitters and net receivers on the basis of housing prices shocks; whereas, the grey line on the right-hand side panels of Figure 6 distinguishes regions on the basis of sales volume shocks. Following on from this initial distinction, the black area shows what the complete standing of each region would be, if we also included sales volume shocks on the left-hand side panels and price shocks on the right-hand side panels.

[Insert Figure 6 about here]

Note that incorporating the additional shocks, lead to the following results (i.e., in connection with the period following the GFC): (i) Both South and Midwest stand as net receivers of shocks from the whole system; that is, despite the fact that both regions initially appear to transmit prices shocks to other regions, (ii) Northeast receives more from the network than it would otherwise do, (iii) West, which initially stands as a net receiver of volume shocks from others, turns into a net transmitter of shocks. Overall, results presented in Figure 6 corroborate previously reported findings that following the GFC, sales volume becomes a critical variable that drives connectedness in the housing market. Once more, the above analysis also holds considering the period of the savings and loan crisis in the US.

3.4 Net Pairwise Connectedness

Next, in order to extend our dynamic analysis and uncover connectedness between specific regions, we turn to net pairwise spillovers. These are given by Figure 7 (i.e., price-on-price and volume-on-volume pairwise connectedness) and Figure 8 (i.e., price-on-volume pairwise connectedness). For the sake of brevity, we will merely identify the common patterns that are evidenced on both of these Figures with the period immediately after the onset of the GFC being our primary concern. We start with Figure 7. First, as far as housing prices are concerned, we note that following the beginning of the GFC (i) West is a net recipient of price shocks from both the South and the Midwest; however, it transmits to the Northeast, (ii) South is a net transmitter to all other regions, (iii) Midwest transmits to Northeast and to the West; however it receives from the South, while (iv), Northeast receives from all other regions.

[Insert Figure 7 about here]

In turn, as regards sales volume, we observe that during the period of interest (i) West receives volume shocks from all other regions, (ii) South transmits to all other regions, (iii) Midwest transmits to the West and to Northeast, while (iv), Northeast transmits only to the West. With reference to Figure 8, initially we focus on cross-metrics shocks within the same region. In particular, we note that for the period under investigation (i) volume is a net transmitter of shocks on price in all four regions of our sample. It would be instructive at this point to note that this result also holds for the period of the savings and loan crisis, while at the same time, it appears to be diametrically opposite during the relative tranquil period immediately before the unfolding of the GFC. These results provide additional support to the realization that during relatively turbulent periods, volume becomes instrumental in reflecting housing market developments.

[Insert Figure 8 about here]

Evidently, when we consider interregional price-on-volume (or vice versa) connectedness, results remain identical to those mentioned above throughout our sample period. It follows that, during turbulent periods it is more likely the volume that drives developments in the housing market and not housing prices.

3.5 Discussion and Implications

Before drawing any inferences from our analysis so far, we provide an intuitive summary of the findings in order to facilitate discussion. This is given by Figures 9 and 10. In particular, the black area on Figure 9 represents the net outcome associated with the position of each metric. What is also evident in Figure 9, is the three distinct time intervals that make up our sample period (i.e., early sample observations correspond to the turbulent period of the savings and loan crisis, then we have a relatively tranquil period which is later interrupted by the collapse of the Lehman brothers; that is, the outset of the GFC). Notably, volume is a net transmitter during the more turbulent periods, whereas price acts as a net transmitter only during the years that preceded the GFC. Besides, the omnipotence of the South as a net transmitter of shocks (i.e., both housing prices and sales volume) is also depicted on Figure 10 (i.e. black-shaded area).

[Insert Figure 9 about here]

[Insert Figure 10 about here]

In retrospect, main findings of the study indicate that, during turbulent economic periods, volume shocks are instrumental in that they drive developments in the US housing market. What is more, the South appears to be a persistent net transmitter of housing market shocks while the Northeast rather stands as a net receiver of housing market shocks (i.e., considering both metrics). As we explain below, these results strongly corroborate arguments put forward by existing literature.

At first, as far as the relationship between price and volume is concerned, Learner (2015) investigating US housing market developments over time, maintains that the housing market (i) is the strongest indicator of looming economic recessions and (ii) is primarily subject to volume cycles. In particular, Learner (2015) stresses that, in periods of growth, sales volume and prices typically move in the same direction (i.e., positively); however, at times of recession (i.e., when volume declines considerably), it takes longer for prices to adjust due to certain shortfalls of the price discovery process (although, admittedly, during the GFC, prices responded much sooner, mainly due to banks' willingness to resell properties associated with non-performing loans at relatively low prices). Besides, Mian et al. (2015) provide evidence that between 2007 and 2009 the increased number of foreclosures and the fire sales that followed led to a sharp drop in housing prices. Furthermore, DeFusco et al. (2017), show that there is an explicit lead-lag relationship between volume and prices cycles and that volume can actually play a speculative role in the housing market. More particularly, DeFusco et al. (2017) explain that speculative buyers increase transactions' volume, providing positive feedback on future prices and this in turn is conducive to housing bubbles. In this respect, weak lending criteria (e.g., interest-only mortgage loans) might aggravate the situation, while appropriate transaction taxes aiming to deter speculative activity (e.g., when the burden falls on the seller) might actually be imperative. Along these lines, Burnside et al. (2016) explain that during market hikes (e.g., the period until 2005) potential buyers with rather speculative motives typically enter the housing market, rendering the selling of existing properties much easier and increasing the number of transactions in the market. In this regard, Burnside et al. (2016) further document that housing market booms are characterized by large volumes of transactions, while the reverse is also true. In light of the above, the respective findings of our study are quite relevant to this particular strand of the literature that investigates housing prices and volume transactions spillovers during boom and bust periods. What is more, our findings are also relevant to policy makers who should rather concentrate on volume dynamics in order to act preemptively with regard to housing market overheating.

Turning to interregional connectedness, the main finding of our study is that the Northeast is a main net receiver of both price and volume shocks, while the South is a main net transmitter of both, particularly after the GFC. On general principles, we maintain that, irrespective of whether a shock to the system is associated with prices or sales volume, these results should be seen through the prism of the degree of integration across US regions. Although, existing relevant literature has adopted a variety of different delineations of borders across US regions, as well as, different levels of data disaggregation, we may still draw very useful conclusions in connection with the results of our study. To begin with, Yunus and Swanson (2013) adopt a similar framework of analysis and show that there is short-run bi-directional Granger causality across all four regions, which further supports their argument that integration is rather becoming stronger with time. However, they cannot report any major drivers (i.e., specific regions) of regional housing market developments for the whole period 1975-2010. These authors also provide evidence that interregional income variables are also gradually converging. Besides, as mentioned earlier in this study, Zhu et al. (2013) put forward the argument that linkages across geographical regions should not be restricted to connectedness across adjoining spatial units, but rather, they should also include connectedness predicating upon similar economic conditions. Yunus and Swanson (2013) further posit that when we consider the longer run, integration across US regions rather intensified after 2005, a result which is also in line with Miles (2015) who argues that the period 2001-05 is more likely a period of market segmentation. What is more, Miles (2015) provides evidence that the three most integrated regions in the US are East North Central (i.e., part of Midwest), East South Central (i.e., part of South) and South Atlantic (i.e., also part of South). By contrast, according to Miles (2015) New England (i.e., a key constituent of Northeast) appears to be rather segmented. This practically implies that it is more likely for highly integrated areas to coordinate with trends in key macroeconomic variables (e.g., income and labour), than it is for segmented areas. At a more disaggregated level, Cohen and Zabel (2018) emphasize that aside from income, it is employment – and hence, population mobility across different spatial units – that also results in housing market shocks which are later diffused to other areas. Along a similar vein, Füss and Zietz (2016) argue that a combination of solid population growth within some specific area, or, constrained supply of housing and low interest rates could result in housing prices shocks. It should therefore come as no surprise that the South, which has steadily experienced the largest population growth in the past few years (US Census Bureau, 2018^2) is a key driver of developments in the US housing market. Note also that, at the same time, the Northeast has the smallest share of population growth in the US (US Census

²https://www.census.gov [accessed by, 9 April, 2019]

Bureau, 2018). It is also worth mentioning that according to the US Census Bureau (2018) sales volume in the South in recent years is comparably bigger than corresponding sales in other regions. It follows that, investigating employment growth and population mobility, as well as, sales patterns in various States could shed additional light to the results presented in this study.

On a final note, given that according to our results the housing market of the Northeast appears to be a net receiver of shocks from other regions in the short run, we maintain that particular emphasis should be given to the fact that the State of New York is a major financial center and an integral part of the international residential market (see Holly et al., 2010, 2011). In this regard, we would expect – at least in the short run, New York to receive feedback from many sources; that is, both domestic and foreign, before determining the prices for its markets. Overall, these findings are highly relevant to the specific strand of the literature that investigates spillovers and linkages across housing markets of US regions. More importantly, we show that, although in recent years integration across US regions has been intensified, there may still be opportunities for portfolio diversification on the basis of economic (i.e., rather than strictly geographical) similarities and differences across specific regions, a finding which is further supported by the transmission dynamics of each region that change over time.

4 Concluding Remarks

Investigating housing market conditions is crucial given the role of this market in the business cycle. In this study, we employ two different metrics of US housing market conditions; namely, housing prices and housing sales volume. In addition, we consider monthly data on four geographical regions; that is, Midwest, Northeast, South, as well as, West, for the period between January 1990 and March 2019. In turn, we utilize a novel TVP-VAR approach to capture the dynamic connectedness both across regions (i.e., single-metric analysis) and across metrics (i.e., cross-metrics analysis). Furthermore, both the specific framework of analysis (i.e., two different metrics and four regions) and the adopted method allow for a thorough itemization and illustration of the relevant findings (i.e., results are also presented on the basis of a cross-regional / cross-metrics decomposition approach) which facilitates our better understanding of the dynamics of this particular network.

Main findings indicate that, especially during turbulent economic periods, sales volume drives developments in the US housing market. By contrast, housing prices drive sales during more tranquil periods. On top of that, we provide evidence that for most of the period under investigation, the South appears to be a persistent net transmitter of both prices and volume housing market shocks, while the Northeast, a net receiver. However, results are also indicative of the fact that all four regions may assume any of the two roles over time.

Considering the nexus between prices and volume, in line with relevant literature, we maintain that sales volume is most likely the barometer of housing market conditions. From this point of view, during an economic downturn, both fire sales and speculative sales (i.e., increased supply of dwellings) will eventually result in a considerable drop in housing prices. By contrast, during relatively tranquil times of steady growth, supply of dwellings is rather ordinary and thus prices that predicate upon healthy economic conditions shape housing sales. These findings are particularly useful to policy makers as they provide support to the argument that appropriate measures (e.g., a tax on sales) are necessary in order to alleviate the negative impact of housing sales volume, particularly during turbulent economic times.

Turning to connectedness across the four US regions, in line with existing literature, we provide evidence that integration across regions has been intensified over the years. That is, we note that all regions affect each other to some extent. Although, this finding could be suggestive of fewer opportunities for portfolio diversification, we should not lose sight of the fact that, for specific time intervals, certain regions act as net transmitters, while others as net receivers of housing prices or sales volume (or both) shocks. We strongly believe that the standing of each region over time greatly depends not only on the broader macroeconomic conditions, but also, on specific developments within each region, with population mobility associated with employment, perhaps being the most important one. In this regard, irrespective of geographical diversification, risk management should further concentrate on the particular economic conditions within each US region in order to identify unique characteristics that result in a region acting as a transmitter or a receiver of the relevant housing market shocks.

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	P_{WEST}	P_{SOUTH}	$P_{MIDWEST}$	$P_{NORTHEAST}$	Q_{WEST}	Q_{SOUTH}	$Q_{MIDWEST}$	$Q_{NORTHEAST}$
Mean	0.038	0.034	0.037	0.03	0.022	0.03	0.023	0.024
Variance	0.006	0.002	0.002	0.003	0.017	0.013	0.015	0.022
Skewness	-1.252 * * *	-0.900***	-1.381 * * *	0.098	-0.108	-0.371 * * *	-0.170	-0.052
	(0.000)	(0.000)	(0.000)	(0.450)	(0.409)	(0.006)	(0.195)	(0.688)
Kurtosis	2.741 * * *	1.246 * * *	2.699 * * *	0.581 * *	0.252	0.934 * * *	1.163 * * *	1.578 * * *
	(0.000)	(0.001)	(0.000)	(0.048)	(0.287)	(0.006)	(0.001)	(0.000)
$_{\rm JB}$	195.790 * * *	68.127 * * *	211.918 * * *	5.355*	1.562	20.226***	20.847 * * *	35.556***
	(0.000)	(0.000)	(0.000)	(0.069)	(0.458)	(0.000)	(0.000)	(0.000)
ERS	-2.735 * * *	-2.504 * *	-1.683 *	-2.598 * * *	-4.501 * * *	-3.624 * * *	-4.153 * * *	-3.716 * * *
	(0.007)	(0.013)	(0.093)	(0.010)	(0.000)	(0.000)	(0.000)	(0.000)
$Q^2(20)$	659.966***	444.486***	284.017 * * *	1180.954 * * *	248.116 * * *	260.865***	209.168***	483.183***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Table 1: Summary statistics

Note: JB stands for the normality test introduced by Jarque and Bera (1980), ERS represents the unit-root test of Elliott et al. (1996) and Q^2 is the weighted Ljung-Box statistics provided by Fisher and Gallagher (2012). *p < 0.1; **p < 0.05; ***p < 0.01

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 Table 2: Connectedness table

	P_{WEST}	P_{SOUTH}	$P_{MIDWEST}$	$P_{NORTHEAST}$	Q_{WEST}	Q_{SOUTH}	$Q_{MIDWEST}$	$Q_{NORTHEAST}$	$FROM_i$	FROM
P_{WEST}	33.5	17.7	14.0	12.0	3.8	6.1	5.9	6.9	43.8	66.5
P_{SOUTH}	14.4	34.1	16.0	12.2	5.3	6.3	5.4	6.4	42.6	65.9
$P_{MIDWEST}$	10.4	14.9	41.1	10.4	4.4	6.2	5.6	6.9	35.8	58.9
$P_{NORTHEAST}$	15.7	17.2	11.4	34.9	5.0	5.5	5.8	4.5	44.3	65.1
Q_{WEST}	1.7	6.1	4.2	5.0	38.6	19.7	16.6	8.1	44.5	61.4
Q_{SOUTH}	1.6	5.3	5.8	4.6	19.7	30.5	21.2	11.3	52.2	69.5
$Q_{MIDWEST}$	1.9	4.5	5.1	5.6	15.9	21.1	31.5	14.5	51.5	68.5
$Q_{NORTHEAST}$	3.6	4.7	5.3	3.9	10.8	14.6	18.2	39.0	43.6	61.0
TO_i	40.4	49.9	41.5	34.6	46.4	55.4	56.0	34.0	TCI_P :	23.8
NET_i	-3.3	7.3	5.7	-9.7	1.9	3.2	4.5	-9.6	TCI_Q :	27.4
ТО	49.2	70.4	61.9	53.6	64.8	79.5	78.8	58.7	TCI_X :	22.6
NET	-17.3	4.6	3.0	-11.5	3.4	9.9	10.2	-2.3	TCI:	73.8

Notes: Values reported are variance decompositions for estimated TVP-VAR models. Variance decompositions are based on 10-step-ahead forecasts. In both periods, a lag length of order 1 was selected by the Bayesian information criterion.





Figure 2: US Housing Price Returns



Figure 3: Dynamic Total Connectedness



Notes: The dark grey shaded area illustrates the TCI with external spillovers, while the white (grey) line illustrates the internal TCI based on prices (volumes) and blue line the TCI without external spillovers



Notes: Black shaded areas illustrate the connectedness with external spillovers.



Notes: Black shaded areas illustrate the connectedness with external spillovers whereas the grey lines represent the internal spillovers.



Figure 6: NET Directional Connectedness

Notes: Black shaded areas illustrate the connectedness with external spillovers whereas the grey lines represent the internal spillovers.



Notes: Black shaded areas illustrate the connectedness with external spillovers whereas the grey lines represent the internal spillovers.

Figure 8: Net external pairwise total directional connectedness NET P_{WEST} – V_{WEST} NET PWEST - VSOUTH NET P_{WEST} – V_{MIDWEST}



Notes: Black shaded areas illustrate the connectedness with external spillovers whereas the grey lines represent the internal spillovers.



Notes: The light-grey shaded area illustrates dynamic external connectedness from volume to price, the dark-grey shaded area shows dynamic external connectedness from price to volume and the black area represents net external connectedness from price to volume.



Notes: The light-grey shaded area illustrates dynamic external connectedness from region i to region j, the dark-grey shaded area shows dynamic external connectedness from region j to region i and the black area represents net external connectedness from region i to region j.