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RESEARCH ARTICLE

Investigation of Connectedness Effects in the Euro Region: The Case of the Real Estate Prices Index

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ABSTRACT

Shocks occurring in the housing market among countries using the common currency in the European Union also cause fluctuations in real estate market prices. Therefore, the analysis of the spread and mutual influence of price fluctuations in the real estate market on the economies of countries becomes essential in the implementation of macroeconomic and common monetary policies. In terms of the social and economic impact of the housing market, this information has become the most important source for understanding countries' investment preferences and price dynamics. Consequently, what initially begins as country-specific shocks in housing markets often evolves into a structure in which these shocks affect housing markets in other countries. Within this framework, the primary objective of this study is to present findings regarding the estimation of parameters related to the interconnectedness of shocks occurring in the housing markets of countries using the single currency of the European Union with other countries' housing markets.Otherwise, it explores the macroeconomic impacts of countries' housing markets in the Eurozone due to the mutual interdependence among these countries.The main findings obtained from the study indicate that shocks in the left tail (τ = 0.05) and right tail (τ = 0.95) have a greater impact on connectivity than shocks obtained from median predictions. This demonstrates that relying solely on median-based predictors is not appropriate for examining return transmissions associated with extreme positive/negative events. This is because shocks in the housing market propagate more strongly in the right and left tails than in the median.

Keywords: European Union, Housing Market Shocks, Interconnectedness, Quantile İnterconnectedness Approach, Eurozone house price index
JEL Clasification: G51, H31, E27, F15, E00

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1. Introduction

Interest rates, as an economic variable that discounts the future values of asset prices to the present in an economy, play a decisive role in intertemporal asset prices. Therefore, when interest rates decrease, a valuation emerges today based on the potential future values of assets. This situation is the most significant factor in increasing housing demand in the current period. In practise, the fundamental relationship underlying the decrease in financing costs and the subsequent increase in housing demand due to lower interest rates is present. One of the key determining variables is the income level of the decision-making unit undertaking borrowing. The expectation that the future income stream may be higher in return for the investment in the asset within the framework of the current income levels of the decision units is also stated in economic theory as a second determinant for the purchase in question. In general, the real channel of the monetary transmission mechanism operates within this framework.

A change in the interest rate leads households to purchase real estate through mortgage loans as a housing or wealth element. Consequently, it affects the value of real estate, particularly housing. This is because a low interest rate by reducing financing costs, increases housing demand while also tending to raise housing prices. An increase in the interest rate decreases house prices as it increases financing costs and reduces aggregate demand. The effect of interest rate changes on household housing demand and the alteration of housing preferences also reveal the presence of asymmetric pricing flexibility in housing markets (Tsai and Chen, 2009; Fan, 2022), which contributes to volatility in housing prices and causes macroeconomic cyclical fluctuations (Demary, 2010). Based on the insights derived from Tsai and Chen (2009), Fan (2022), and Demary (2010), Tsai (2013) established that the impact of interest rates on housing demand depends on their effect on household income, thereby demonstrating the effectiveness of monetary policy on the real estate market (Tsai, 2013).

At the core of household borrowing lies the objective to finance the adverse effects of changes in consumption expenditures resulting from fluctuations in income or to maintain the consumption level within a given time frame (Taşdöken and Kahyaoğlu, 2022). This situation leads households to utilise housing as collateral for credit, increasing their indebtedness in the short term while smoothing consumption over the long term. In other words, the high value of the house makes it easier for households to use collateral loans and also creates a substitution effect on their savings, acting as a different channel through which the value of the house is transferred to consumption expenditures over different periods.Consequently, the wealth effect arising from changes in housing value has been demonstrated to move in tandem with consumption expenditure patterns (Ortalo-Magné and Sven, 2006; Lustig and Nieuwerburgh, 2010).

The decrease in the value of housing and the unexpected and persistent nature of this price change lead to alterations in household borrowing and spending capacities in housing investments. This situation, by causing a decline in the value of credit collateral, triggers changes in savings preferences, increases consumption sensitivity to income, and reduces consumption expenditures. This interplay, contingent on the permanence of changes in the stock size and value of housing wealth, influences households' economic decisions and preferences (Skinner, 1989; Muellbauer and Murphy, 1990; Engelhard, 1994; Case et al., 2005). In other words, within the framework of life-cycle income theory, any change in the value of households' housing, in other words, any change in the total present value of lifetime wealth, will lead to a wealth effect due to changes in households' current and future borrowing preferences, consumption expenditures, and savings decisions.

Household expenditures for the purchase of a dwelling are considered investment expenditures within the total expenditure composition.Therefore, the consequences of changes in these expenditures lead to a real connexion between housing markets and macroeconomic factors through their influence on financial markets (Cochrane, 2005). From this perspective, developments in the housing market find out the "feedback" effect of housing, which is the main product of this market, or more broadly defined as real estate, through its forward and backward linkages with numerous production sectors in the economy, both in real and financial terms (Fratzscher, 2007; Goodhart and Hofmann, 2008; Holinski and Vermeulen, 2009; Attanasio et al., 2009). Particularly, the financialization of housing, with its financing source relying on asset-backed securities (e.g., mortgages), affects the financial soundness of financial institutions through the collateral value of housing.

One of the most significant consequences of the global crisis of 2008-2009 was that the financialization of the housing markets was a source of crisis on a global scale. As indicated, these housing markets have gained paramount importance as a key indicator for national economies (Gupta and Hartley, 2013; Bandt et al., 2010; Claessens et al., 2011). Hence, it can be stated that investigating the interaction between the countries where housing markets are located and the degree of relationship, which is the measure of this interaction, is essential information for the analysis of macroeconomic balances, especially for Eurozone countries that implement a common monetary policy.

The high correlation and interconnectedness among housing markets change one market to spread more rapidly to other markets. This is because, as the link between housing markets and macroeconomic variables strengthens, housing markets across countries become more interconnected and exhibit similar characteristics. Therefore, considering the indicators of the pricing process of financial assets as the determinant effect of information transmission, a common piece of information or policy change has an impact on market expectations (Harvey and Huang, 1991; Ederington and Lee, 1993). In this respect, the mentioned effects of households on housing demand may also be the main reason for the volatility in the markets.

The utilisation of a common currency among Eurozone countries and the increasing degree of economic integration in Europe have concurrently led to higher interconnectedness among financial institutions, housing markets, and macroeconomic variables (Bandt et al., 2010; Yunus and Swanson, 2012; Tsai, 2018). Therefore, high interconnectedness across countries also increases the magnitude and severity of the spillover effect of shocks from one country to another when economic changes occur. In this context, with the growing mutual dependence among housing markets in these countries, fluctuations in housing prices in one country can easily spread to other countries. Therefore, because an economic change in housing markets has a direct impact on GDP, macroeconomic variables, and household decisions both within the country and in other countries, the change can trigger a global crisis. Thus, it can be categorised as a potential crisis risk within financial markets. Hence, evaluating the macroeconomic consequences of fluctuations in housing markets is of essential significance from a global standpoint.

To examine changes in the housing market and the resulting transmissions, this study focuses on the interconnectedness among countries using the Eurozone house price index. The second section of the study reviews the relevant literature of applied research. In the third section, data, econometric methods, and empirical findings are presented. The fourth section interprets the results of the analysis.

2. Literature Review of Applied Studies

We use the method proposed by Diebold and Yilmaz (2014), which uses variance decomposition of the forecast error of vector-lagged distributed (VAR) approaches to measure the link between the time series representing the variables. The literature features a growing body of work applying this approach to various hypotheses and datasets. Using the new approaches developed within the framework of Diebold and Ylmaz (2009, 2012, 2014), studies in the literature on housing markets have yielded different findings. These findings are supported by Vansteenkiste and Hiebert (2011), who show that there are restricted house price spillovers in the Eurozone (Belgium, Germany, Ireland, Spain, France, Italy and the Netherlands). Lee and Lee (2018) investigated volatility interconnectedness between housing markets in the G7 region. Volatility interconnectedness significantly fluctuated over time and exhibited an unprecedented jump during the global crisis, as indicated by the interconnectedness index values. In Antonakakis et al. (2018), the network topology of Areal property yields in the United Kingdom were examined. The transmission of inter-regional property yield shocks is a significant source of regional property yield fluctuations.

According to the findings of the three studies, it is concluded that price volatility is more strongly correlated with price level. However, it was found that geographic proximity plays a role in the heightened interconnectedness due to price levels. Hwang and Suh (2019) investigated the regional housing market interconnectedness among 25 districts in Seoul. The study's outcome reveals that the effect of interconnectedness varies across the entire country after the global crisis. Lee and Lee (2019) identified the housing market in Seoul, South Korea, as the most influential market, with findings indicating that other metropolitan cities only impress neighbouring areas. Zhang and Fan (2019), in their study on housing prices across 70 major cities in China, found that the highest level of interconnectedness within a city group was as high as 85%. In addition, the authors obtained results that support prior research in the literature through their study. In the study by Tsai and Lin (2019), housing price indices of 20 major cities across the United States are utilised. The housing markets on the western coast are the most influential, and this influence is affected by the spatial distribution of the high-interest mortgage crisis. Lee and Lee (2020) examined the interconnectedness of housing prices in China, Japan, and South Korea. The main finding is that interconnectedness precautions increased during the global financial crisis and changed throughout the business cycle. However, international connexions among the three Asian housing markets were found to be quite weak. This demonstrates that economic relationships between countries within the same spatial region are influenced by non-economic variables or factors. For regions exhibiting tendencies towards economic integration, it can be anticipated that the propagation of changes in asset prices may be transmitted through specific regions. Gabauer et al. (2020), who investigated the dynamic connexions of random shocks among 50 US states and the District of Columbia in terms of housing prices, concluded that the propagation of regional random shocks moves from southern states to western states and from the Midwest states to the Northeast states.

Diebold and Ylmaz (2014) developed the interconnectedness approach using the Vector Autoregression (VAR) framework to measure the linkage between different markets or macroeconomic variables.Formun Üstü Considering the studies conducted in the literature on housing markets using the approaches developed within the framework of this methodology, the interconnectedness effect in housing markets increases due to the increase in financial and macroeconomic interconnectedness across countries or regions. The lack of an analysis of the countries using a common currency in the studies conducted in the literature can be considered as a study that provides empirical information. This is because, due to the use of a common currency, interdependence between these countries and the correlation between their markets are expected to be high (Nzama et al., 2022) . In other words, the effect of the preference for housing as an asset in household portfolios on the tendency to integrate spatially and the spillovers of the consequences of macroeconomic policies will be analysed. Hence, investigating the macroeconomic impacts of countries' housing markets is crucial. In this context, housing markets have a significant effect on the macroeconomic structure and transmission mechanism in financial markets, both as indicators of household wealth and as an important part of the financial structure.

3. Data and Methodology

In this section, the dataset used in the study and the econometric methodology are discussed.

3.1. Data Set

In this study, analyses are conducted using the quantile interconnectedness approach developed by Chatziantoniou et al. (2021), based on the Diebold and Ylmaz studies, employing the housing price index data of 12 Eurozone countries for the period between Q1 2006 and Q4 2021. The housing price index data for the Eurozone were obtained from the European Central Bank. Because of the incomplete nature of housing price index data for some Eurozone countries, they are not included in the study. Therefore, the study focuses on 12 Eurozone countries: Belgium, Germany, Estonia, Ireland, Spain, France, Cyprus, Latvia, Lithuania, Malta, Slovakia, and Finland. The housing price index data for these countries are organised as return series in the analysis. The analysis was performed using the R econometric package programme.

Using the Diebold and Ylmaz (2014) method, the impact of housing market interconnectedness has been studied by considering regions or cities on a country basis. In this context, our study differs from the studies in the literature by first investigating the interconnectedness structures in the Eurozone countries using the common currency and the impact of their values, which can be defined as a source of asymmetric effects, defined as time-varying right and left tail effects, on the markets. This research is the first to explore the effect on changes occurring in the median, left, and right tails of the housing market return series for the 12 Eurozone countries. Second, this is the first study to examine quantile VAR-based return transmissions between Eurozone housing price index data and housing markets.

The main aim of this study is to reveal the magnitude of the effect on spillovers, which emerge as country-specific housing market shocks, on the housing markets of other countries and to reveal housing market mobility across countries in the Eurozone. Second, it investigates which countries exert the most influence on the housing market and probes the implications of changes in the housing market from these countries to others. Third, the research aims to identify systematic risks by forecasting correlations among housing markets concerning the research topic. Fourth, it explores the macroeconomic impacts of countries' housing markets in the Eurozone due to mutual interdependence among these countries. Fifth, it delves into the integration of housing markets within the Prozone.

3.2. Econometric Methodology

In this section of the study, the quantile connectedness approach and the Elliot, Rothenberg, Stock's Point Optimum (ERS,1996) Test will be discussed.

3.2.1. Quantile Connectedness Approach

In the traditional least squares method, when making linear predictions, the condition of unrelatedness between changing variance, error terms, and the previous value of the period under consideration is necessary. In particular, when the distributions of the series or data representing the variables used in the estimation have fat tails or outliers, the parameters of these estimation methods lose their effectiveness. To address this issue, Koenker and Bassett (1978) developed the quantile method, which reduces the impact of these tail effects on the efficiency of parameters by using left or right tail and median values. Combining the approach of Koenker and Bassett (1978) with the method developed by Diebold and Ylmaz (2012), the connectivity method was advanced in this framework. With this method, the effect of structural shocks within the network on the volatility of every variable within that network is demonstrated using the variance decomposition of the prediction error. In this method, findings are obtained that give the relationship between the tails at the endpoints of the distribution according to the criteria determined in the range of 0.05–0.95. In the prediction stage of this approach, the characteristics of data representing median ($\tau = 0.50$), left tail ($\tau = 0.05$), and right tail ($\tau = 0.95$) variables were considered (Ando et al., 2022). Thus, this approach provides a more valid and efficient parameter estimator than traditional methods for explaining the effects of shocks to the economy, such as epidemics and crises. These effective parameter values, which are indicators of the degree of interconnectedness, also provide information on the direction and time-varying effects of these shocks within the system.

Based on the studies by Diebold and Ylmaz, the quantile VAR (QVAR) method developed by Chatziantoniou et al. (2022, 2021) integrates the quantile connectivity method with the frequency connectivity method for calculating connectivity evaluation in terms of time, frequency, and quantiles. This is because the original QVAR connectivity method does not consider the effect between frequencies, the frequency connectivity method is sensitive to outliers, and does not consider the effect between quantiles. Hence, this method allows identification of the time-frequency dynamics in both the left and right tails of the distribution and thus provides information on the impact of the left and right tails on the distribution (Chatziantoniou et al., 2022, p. 4). In this context, the quantile connectivity method analyzes whether the powerful co-movement between variables depends on the strength of the shock, considering both extreme positive structural shocks (namely higher quantile values) and extreme negative structural shocks (namely lower quantile values).

Quantile vector autoregression QVAR(p) is estimated using the equation shown in equation 1 to calculate the connectedness metrics.

$$x_t = \mu_t(\tau) + \varphi_1 x_{t-1} + \varphi_2(\tau)x_{t-2} + \ldots + \varphi_p(\tau)x_{t-p} + u_t(\tau) \quad (1)$$

The parameters x_t ve x_{t-i} (i=1,2,...,i) given in Equation 1 represent N×1 dimensional vectors of endogenous variables, where the parameter τ represents the quantile value within [0,1], p denotes the lag length of the QVAR model, $\mu_t(\tau)$ parameter represents the N×1 dimensional conditional mean vector, $\varphi_j(\tau)$ parameter represents the N×N dimensional QVAR coefficient matrix, and $u_t(\tau)$ parameter represents the N×1 dimensional error vector with the variance-covariance matrix Σ(τ). The Wold theorem (Equation 2) is used to transform the QVAR(p) equation into the vector moving average representation QVMA(∞) to express the quantile vector.

$$x_t = \mu(\tau) + \sum_{j=1}^{p} \varphi_j(\tau)x_{t-j} + u_t(\tau) = \mu(\tau) + \sum_{i=0}^{\infty} \gamma_i(\tau)u_{t-i} \quad (2)$$

The Generalised Forecast Error Variance Decomposition (GFEVD) is calculated to forecast the connectivity approach. The values obtained from the GFEVD calculation are interpreted as the effect of a shock in series j on the forecast error variance share for series i. The GFEVD calculation is presented in Equations 3 and 4 below.

$$\theta_{ij}(H) = \frac{\left(\Sigma(\tau)_{jj}^{-1}\right)\sum_{h=0}^{H}\left((\gamma_h\Sigma(\tau))_{ij}\right)^2}{\sum_{h=0}^{H}\left(\gamma_h(\tau)\gamma_h'\right)_{ii}} \quad (3)$$

$$\tilde{\theta}_{ij}(H) = \frac{\theta_{ij}(H)}{\sum_{k=1}^{N}\theta_{ij}(H)} \quad (4)$$

Since the sum of the rows in Equation 4, given by $\tilde{\theta}_{ij}(H)$), is not equal to one, normalisation is required based on the row sum, resulting in the parameter θ_{ij}.

With normalisation applied to the equations, $\sum_{i=1}^{N} \tilde{\theta}_{ij}(H) = 1$ and $\sum_{j=1}^{N} \sum_{i=1}^{N} \tilde{\theta}_{ij}(H) = N$ equations are obtained. In this context, the sum of each row is equal to unity, representing how a shock in the series affects the series itself and all other j series. with these equations, other connectedness values are calculated. In this framework, The (overall) total directional connectedness TO is defined as the extent to which a shock in series i is transmitted to all other series j (see Equation 5).

$$TO_i(H) = \sum_{i=1}^{N} \widetilde{\emptyset}_{ji}(H) \; i \neq j \tag{5}$$

The (overall) total directional connectedness *FROM* measures how much of the shocks in all other j series are received by the i series (See Equation 6).

$$FROM_i(H) = \sum_{i=1}^{N} \widetilde{\emptyset}_{ij}(H) \;\; i \neq j \tag{6}$$

The (overall) NET total directional connectedness represents the difference between the (General) total directional connectivity (TO) and the (General) total directional connectivity(FROM), expressed as the net impact that series i has on the predetermined network (See Equation 7). When series i influences all other series and is considered a net transmitter of shocks. However, when , series i is influenced by other series and is considered to be a net receiver of shocks.

$$NET_i(H) = TO_i(H) - FROM_i(H) \tag{7}$$

The (General) Total Connectivity Index (TCI), which measures the degree of interconnectivity within the network, is calculated using Equation 8.

$$TCI(H) = N^{-1} \sum_{i=1}^{N} TO_i\,(H) = N^{-1} \sum_{i=1}^{N} FROM_i\,(H) \tag{8}$$

The TCI value indicates the mean impact of a shock in one series on the other series. In this context, when the TCI value is very high, market risk increases. Conversely, when the TCI value is low, market risk decreases (Chatziantoniou et al., 2022:4)we propose a novel quantile frequency connectedness approach that enables the investigation of propagation mechanisms by virtue of quantile and frequency. This approach allows for the analysis of connectedness measures considering either different frequencies for a given quantile or different quantiles for a given frequency. We investigate dynamic integration and return transmission among a set of four well-established environmental financial indices, namely the S&P Green Bond Index, MSCI Global Environment, Dow Jones Sustainability Index World, and S&P Global Clean Energy over the period from November 28th, 2008 to January 12th, 2022. S&P Green Bond Index and S&P Global Clean Energy appear to be both short-term and long-term net receivers of shocks while MSCI Global Environment and Dow Jones Sustainability Index World are both short-term and long-term transmitters of shocks. We also find that total connectedness indices (TCIs).

3.2.2. Elliot, Rothenberg, Stock'un Nokta Optimum (ERS,1996) Test

The ERS (1996) test provides more reliable results when the series has an unknown mean and linear trend. The equation for the ERS (1996) test is shown below.

$$P_T = \frac{SSR(\bar{\alpha}) - \bar{\alpha}\, SSR(1)}{f_0} \tag{9}$$

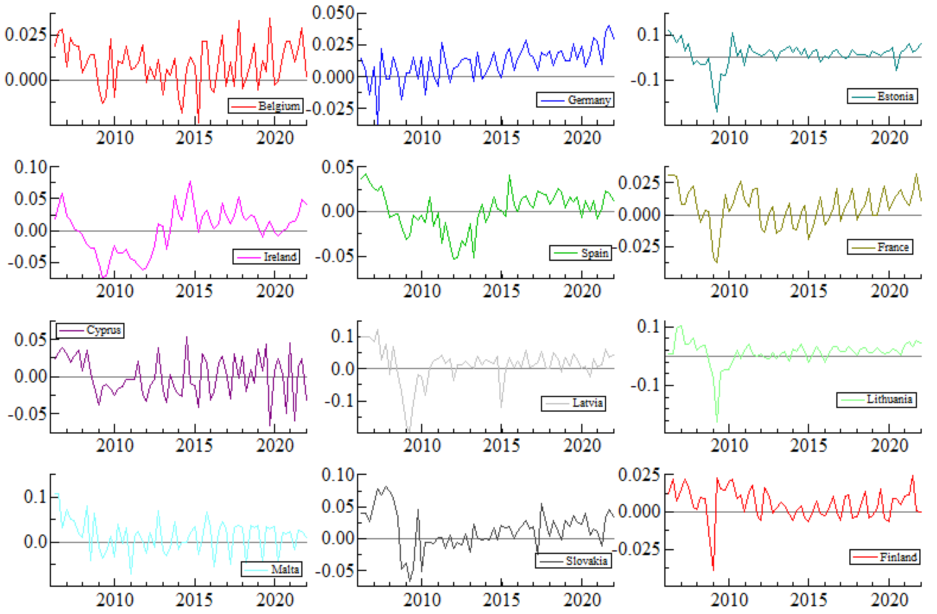
The parameter $\bar{\alpha}$ given in Equation 9 is calculated as $\bar{\alpha} = 1 + \frac{\bar{c}}{T}$. The $\bar{c}$ parameter is chosen to maximise the power of the test, and its values are determined through Monte Carlo experiments. According to the results obtained from the Monte Carlo experiments, when the econometric model includes a constant, $\bar{c} = 7$ is taken as. However, when the econometric model includes both a constant and a trend, $\bar{c} = 13{,}5$ is taken as. The SSR given in Equation 9 is the sum of the squared residuals. In addition, the parameter f_0 is an estimator of the residual spectrum at zero frequency and can be obtained using estimators based on the sum of covariances. In the ERS test, the null hypothesis is expressed as "there is a unit root.'(Çağlayan & Saçaklı, 2006:125-126).

3. Empirical Findings

In this study, we use the quantile mean connectivity approach to estimate the network and impact of the distribution of positive and negative shocks on the housing market associated with the median, right tail, and left tail of the distribution of positive and negative shocks. This study aims to estimate the connectivity network and the effects of both positive and negative shocks that are effective on the housing market using the Quantile Autoregressive Vector (QVAR) approach. Specifically, the distribution of shocks associated with median, right tail, and left tail values is examined to forecast the connectivity network and its effect on shocks in the housing market. In the initial phase of the study, descriptive statistics for the data were obtained, as presented in Figure 1. Pre-tests for descriptive statistics of all series are provided in Table 1, and the correlation matrix illustrating the relationship between variables is presented in Table 2.

The analysis of whether the series has a normal distribution is conducted through the Skewness, Kurtosis, and Jarque-Bera (JB) tests provided in Table 1, which presents the basic statistical values. In these analyses, in the Kurtosis test, a coefficient greater than 3 indicates that the series has heavier tails, whereas a coefficient less than 3 demonstrates a distribution with thinner tails. The Skewness test examines the skewness of the distribution based on whether the coefficient is different from zero and positive; a positive skewness indicates a right-skewed distribution. When the skewness coefficient for the series is negative, it signifies a left-skewed distribution. A skewness coefficient of zero demonstrates a normal distribution for the series. The ERS test is employed for unit root analysis of the series. This test was developed with the aim of enhancing the power of the Dickey–Fuller test. It is particularly acknowledged to be more robust than other tests, even when time series have components with unknown mean and linear trend. In this study, this test was employed against the assumption that the time series representing variables defined as returns have an unknown mean and linear trend (Çağlayan & Saçaklı, 2006:125). The Ljung-Box (Q(20)) test was used to assess the autocorrelation of the return series.

Figure 1: Housing Market Return Series



Note: This study was prepared by the authors using the econometrics software package, with data obtained from the European Central Bank.

The changing returns of all calculated series for each country are shown in Figure 1. As seen in the figure, the time-varying return series exhibits volatility trends across different time periods in all markets.

According to the basic statistics (Table 1), the average return series of the entire housing market in all countries is positive. Moreover, housing prices in Belgium, Germany, Estonia, Ireland, France, Lithuania, Malta, Slovakia, and Finland are statistically significant and coefficients positive, and these return series have a positive mean. Belgium (0.009), Germany (0.011), Estonia (0.014), Lithuania (0.011), Malta (0.014), and Slovakia (0.013) are the countries with the highest average returns. Skewness is negative in all markets except Malta. In this respect, the recurring values of countries with close returns are generally larger than the overall average. Kurtosis is greater than three in Estonia, Lithuania, Latvia, and Finland's housing markets. When examining Jarque-Bera (JB) statistics at a 5% significance level, the

Table 1: Descriptive Statistics

	"Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Lithuania	Latvia	Malta	Slovakia	Finland
Mean	0,009***	0,011***	0,014**	0,002	0,001	0,006***	0,000	0,011**	0,012	0,014***	0,013***	0,006***
Prob	0,000	0,000	0,048	0,697	0,603	0,002	0,907	0,038	0,102	0,004	0,001	0,000
Variance	0,000***	0,000***	0,003***	0,001***	0,000***	0,000***	0,001***	0,002***	0,003***	0,001***	0,001***	0,000***
Skewness	-0,195	-0,754**	-1,964***	-0,288	-0,643**	-0,570*	-0,156	-2,666***	-1,504***	0,008	-0,105	-0,922***
Prob	0,489	0,013	0,000	0,310	0,031	0,053	0,580	0,000	0,000	0,979	0,708	0,003
Ex. Kurtosis	-0,393	1,670**	7,460***	-0,465	0,132	0,601	-0,689	13,752***	3,733***	-0,125	0,338	3,317***
Prob	0,642	0,022	0,000	0,512	0,540	0,201	0,174	0,000	0,001	0,886	0,352	0,001
JB	0,817	13,494***	189,545***	1,463	4,453	4,434	1,526	580,126***	61,292***	0,042	0,422	38,399***
Prob	0,665	0,001	0,000	0,481	0,108	0,109	0,466	0,000	0,000	0,979	0,810	0,000
ERS	-1,413	-1,945*	-1,272	-1,980**	-1,334	-2,040**	-1,687*	-3,155***	-1,644*	-0,161	-2,346**	-2,694***
Prob	0,164	0,057	0,209	0,053	0,188	0,046	0,097	0,003	0,106	0,873	0,023	0,009
Q(20)	41,814***	37,886***	43,786***	135,332***	99,547***	56,435***	12,779	46,853***	59,758***	29,923***	43,357***	32,665***
Prob	0,000	0,000	0,000	0,000	0,000	0,000	0,248	0,000	0,000	0,000	0,000	0,000
	34,415***	16,784*	11,824	33,192***	28,646***	18,591**	8,049	3,896	26,850***	12,417	109,691***	16,579*
Prob	0,000	0,064	0,324	0,000	0,000	0,031	0,720	0,987	0,001	0,275	0,000	0,069

Note: The symbols *, **, and *** shown in Table 1 indicate statistical significance at the levels of 10%, 5%, and 1%, respectively.

null hypothesis indicating the normal distribution of return series for Germany, Estonia, Lithuania, Latvia, and Finland is rejected. Therefore, it can be inferred that the return series of these countries' housing markets are not normally distributed. For countries other than those mentioned, the normality null hypothesis cannot be rejected, indicating that the return series for these countries is normally distributed.

The variance value indicates whether the variability of housing market returns in one country explains the variability of returns in another country more weakly or strongly. This situation also reflects the impact of variability dispersion based on the interconnectivity between the two markets. In general, although the variance values are significant, their explanatory power is different.

When examining the ERS[1] values, it is observed that despite using the series of returns for all countries, the housing price series of Belgium, Estonia, Spain, and Malta are not statistically significant. In this context, the non-significant results for these countries' housing market return series indicate the presence of unit roots and demonstrate that shocks still have an effect on their housing markets. Therefore, shocks in these countries' housing markets have a persistent impact. Regarding the autocorrelation of the return series, the results of the Ljung-Box (Q(20)) test reject the null hypothesis of no autocorrelation in all countries except Cyprus. , When considering a lag of 20 periods, it provides information suggesting that variability in the variance is persistent. The probability values for Lithuania, Estonia, Cyprus, and Malta are statistically insignificant. For countries other than these, considering the probability values implies that shocks within the system have a statistically persistent trend, depending on the lag value. In other words, this finding indicates that there is information about volatility having a certain duration effect on the system.

To determine the degree and direction of the relationship among the housing markets of countries, Kendall's rank correlation analysis is employed. This analysis is fundamentally used for the correlation analysis of non-normally distributed variables. The findings obtained from this analysis are presented in Table 2.

[1] For more information see. Elliott et al. (1996)

Table 2: Estimated Kendall's rank correlation coefficients

Kendall	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Lithuania	Latvia	Malta	Slovakia	Finland
Belgium	1,000	-0,028	0,196**	0,202**	0,276***	0,564***	0,204**	0,236***	0,208**	0,322***	0,232***	0,079
Germany	-0,028	1,000	0,093	0,169**	0,225***	0,080	0,144	0,211**	0,112	0,054	0,104	0,052
Estonia	0,196**	0,093	1,000	0,260***	0,185**	0,236***	0,101	0,249***	0,346***	0,210**	0,141	0,113
Ireland	0,202**	0,169**	0,260***	1,000	0,448***	0,179**	0,202**	0,297***	0,263***	0,278***	0,216**	-0,177**
Spain	0,276***	0,225***	0,185**	0,448***	1,000	0,344***	0,268***	0,361***	0,341***	0,191**	0,363***	0,127
France	0,564***	0,080	0,236***	0,179**	0,344***	1,000	0,217**	0,263***	0,274***	0,262***	0,243***	0,147
Cyprus	0,204**	0,144	0,101	0,202**	0,268***	0,217**	1,000	0,349***	0,259***	0,330***	0,343***	0,163
Lithuania	0,236***	0,211**	0,249***	0,297***	0,361***	0,263***	0,349***	1,000	0,408***	0,068	0,402***	0,107
Latvia	0,208**	0,112	0,346***	0,263***	0,341***	0,274***	0,259***	0,408***	1,000	0,205**	0,373***	0,192**
Malta	0,322***	0,054	0,210**	0,278***	0,191**	0,262***	0,330***	0,068	0,205**	1,000	0,229***	0,014
Slovakia	0,232***	0,104	0,141	0,216**	0,363***	0,243***	0,343***	0,402***	0,373***	0,229***	1,000	0,099
Finland	0,079	0,052	0,113	-0,177**	0,127	0,147	0,163	0,107	0,192**	0,014	0,099	1,000

Note: The symbols *, **, and *** shown in Table 2 indicate statistical significance at the levels of 10%, 5%, and 1%, respectively.

According to Table 2, some countries have positively correlated return series, whereas others have negatively correlated series. Overall, there is a correlation between these countries. In general, there is a statistically significant correlation between these countries. The correlation relationships in the markets of Belgium-France, Spain-Ireland, and Latvia-Lithuania are observed to be stronger compared to Belgium-Germany and Ireland-Finland markets among these countries.In this context, the correlation between housing markets suggests, first, that housing, as an indicator of wealth, is a risky asset and the possibility of hedging against the risk of changes in different markets is reduced, and second, that housing prices tend to spread. Third, the low correlation between the markets of some countries also indicates that country-specific factors such as demographics and tax systems have an impact on the markets of these countries. Fourth, the integration relationship between markets is also low.

This study aims to analyse the quantile connectivity relationship among countries' housing markets by considering median ($\tau = 0.50$), left tail ($\tau = 0.05$), and right tail ($\tau = 0.95$) values for prediction. The findings obtained from the prediction are presented in Tables 3, 4, and 5, which represent median total connectivity estimates (Refer to the appendices for Tables 4 and Table 5). In this study, using the mentioned quantile values, connectivity relationships at the extreme points of the distribution are estimated, providing detailed information about shocks that affect the economy.

When looking at the median average connectivity table(See alsoTable 3), it is observed that Belgium's housing market variance explains 52.68% of its own variance. Belgium's housing market has the highest connectivity impact on Latvia (6.02%) and Slovakia (6.79%) housing markets, whereas the highest connectivity impact on Belgium's housing market comes from Latvia (6.11%) and Slovakia (6.63%) housing markets. In other words, Belgium's housing market not only influences the markets of Latvia and Slovakia but is also influenced by these markets in return. Therefore, there is a mutual interaction among these country markets. While the connectivity impact of other countries on Belgium's housing markets is 47.32%, Belgium's impact on other countries' housing markets is 45.79%.

Table 3: Median Average Connectivity Estimated (τ = 0,5)

	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	52,68	3,99	4,21	2,49	3,72	3,89	2,99	6,02	4,10	4,13	6,79	4,98	47,32
Germany	3,78	48,77	3,57	2,71	3,37	4,86	11,18	2,85	3,67	5,74	4,85	4,64	51,23
Estonia	4,27	3,98	52,34	4,11	4,92	2,31	6,24	3,61	3,92	3,47	9,45	1,39	47,66
Ireland	2,83	3,09	4,65	53,27	4,95	4,77	5,20	1,77	4,03	4,34	8,30	2,78	46,73
Spain	3,36	3,49	4,46	4,43	48,19	8,06	4,04	3,37	7,64	4,30	2,57	6,08	51,81
France	3,68	4,91	2,02	4,33	8,00	44,40	2,09	3,60	4,91	5,25	3,25	13,57	55,60
Cyprus	2,66	11,28	5,69	4,20	3,75	2,49	50,55	6,07	4,33	3,01	4,27	1,70	49,45
Latvia	6,11	2,99	3,39	1,67	3,36	4,24	5,90	50,65	5,58	5,33	6,51	4,27	49,35
Lithuania	3,64	3,74	3,72	3,45	7,62	4,91	4,47	5,31	50,67	5,15	1,65	5,66	49,33
Malta	3,79	6,15	3,53	4,34	4,42	5,46	3,10	5,00	5,10	50,29	3,06	5,75	49,71
Slovakia	6,63	4,68	9,20	7,40	2,63	3,22	4,23	6,25	1,44	2,88	47,65	3,80	52,35
Finland	5,04	4,87	1,25	2,55	5,92	13,69	1,68	4,04	5,29	5,58	3,71	46,37	53,63
TO	45,79	53,18	45,70	41,68	52,66	57,90	51,13	47,90	50,01	49,18	54,42	54,62	604,18
Inc. Own	98,47	101,94	98,04	94,94	100,86	102,30	101,68	98,54	100,68	99,48	102,07	100,99	cTCI/TCI
NET	-1,53	1,94	-1,96	-5,06	0,86	2,30	1,68	-1,46	0,68	-0,52	2,07	0,99	54,93/50,35
NPT	4,00	10,00	2,00	1,00	5,00	9,00	6,00	4,00	5,00	3,00	9,00	8,00	

When we look at the interconnectedness values of the other countries in the table and their effects on other markets, we see that these effects are different in each country, firstly because the population mobility that emerged as a result of the Russian-Ukrainian war affected the labour markets and the migration receiving/receiving countries changed. Second, differing tax policies in countries have led households to respond differently to housing purchases and sales. Third, an increase in inflation rates leads to a widening gap between house prices and rental rates, thereby increasing the demand effect on housing markets, resulting in different housing demand across countries. Fourth, different socio-cultural factors across countries impact households' housing purchase/sale decisions. Therefore, these aforementioned factors are fundamental causes of heterogeneity among Eurozone housing markets.

When looking at the TO values in the table for the median(See alsoTable 3), it indicates the spread effect of a change from one country's market to another country's markets. The highest spread effects are observed in the markets of Germany (%53.18), France (%57.90), Slovakia (%54.42), and Finland (%54.62), while the lowest spread effects originate in Belgium (%45.79), Estonia (%45.70), and Ireland (%41.68) markets. Notably, Germany's strong economic structure within the Prozone, its low impact of monetary policy shocks on household decisions (Demary, 2010), and the use of a common currency have amplified Germany's influence on other housing markets. Therefore, we can conclude that these markets have the most influence on the Eurozone housing market.

When examining the FROM values(See alsoTable 3), they indicate the impact of a change taken by one country's market from another country's market. Consequently, the countries most significantly affected by other country markets are France (%55.60), Slovakia (%52.35), and Finland (%53.63), while the least affected countries are Belgium (%47.32), Ireland (%46.73), and Estonia (%47.66). Considering the results obtained, both the countries that have an effect of other country markets and the countries where other country markets have an impact are the same. Therefore, the fact that these countries are not only affected by other markets but also affect other markets suggests that both the impact of monetary policy are the same in these countries, i.e., households react similarly to changes in interest rates, and housing markets have similar characteristics. Moreover, a slow or high degree of interconnectedness between these markets may cause a change in one market to disappear without spreading to other markets or to spread very quickly.

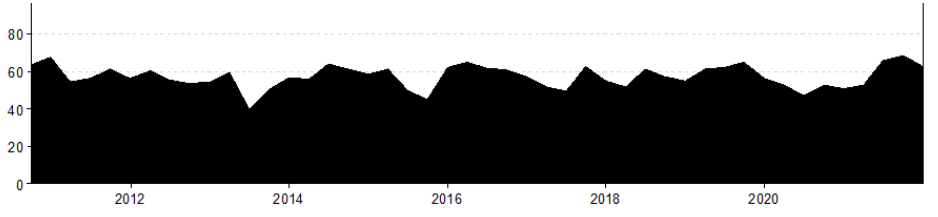
The net spread value reveals the difference between the information/shock transmitted from one country's housing markets to another country's housing markets and the information/shock received. A positive value indicates that the country plays the role of a net transmitter, whereas a negative value indicates that the country acts as a net receiver. In this context, countries such as Germany, Spain, France, Cyprus, Lithuania, Slovakia, France, and Finland being net shock transmitters to other markets implies their significant influence on those markets. In addition, Belgium, Estonia, Ireland, Latvia, and Malta are influenced by changes occurring in other countries' markets. In particular, shocks in the housing markets of France and Slovakia have the highest effect on other markets. This is due to the presence of a contractual savings system (Bauspar) that facilitates mortgage lending in Slovakia, coupled with low transaction costs and high liquidity in the housing market. This situation makes Slovakia's housing market conducive to facilitating arbitrage transactions among other country markets.

When examining the NPT values in the table(See also Table 3), it illustrates the shocks occurring in a country's market. Observing the shock cycles of countries throughout the considered period reveals that these cycles are distinct for each country, with the most shocks observed in the markets of Germany, Cyprus, France, Slovakia, and Finland. This situation demonstrates that shocks originating from a country capable of influencing global factors are not transmitted to all countries worldwide, but only to certain countries. In other words, macroeconomic similarities across markets also impact the propagation of shocks, as they lead to similarities in the housing market cycles of the Prozone. Furthermore, among the findings is that fiscal policies might have negative effects on housing markets in some countries, while being supportive for others. Therefore, the different responses of housing markets to monetary and fiscal policies indicate, first, an asymmetric relationship between markets and, second, heterogeneous characteristics. As a result, it emphasises the need to consider the asymmetry of housing price changes in European Central Bank policies.

Considering the left tail (τ = 0.05) and right tail (τ = 0.95) values, connectivity values for all housing markets have been predicted (See alsoTable 3and Table 4). In this estimation, the distinction between extreme negative shocks and extreme positive shocks, namely shocks that have an impact on the series, allows us to differentiate between the right and left tails of quantile connectivity. In this context, the estimated average connectivity values for different quantile values are presented in Tables 4 and 5, and these tables are presented in the appendices. When examining the findings within this framework, it becomes evident that the spread in both the right and left tails exceeds the median spread. In other words, while the median total connectivity value is 50.35%, the total connectivity index in the left tail (τ = 0.05) is 53.49% and that in the right tail (τ = 0.95) is 53.55%. This result is consistent with the finding that spillover effects defined as "bubble" have the same proportion of price changes as periods defined as stable (Hu, 2022). That is, the observed connectedness values in the tails are both different from and higher than the median value. First, the fact that the right and left tails are higher than the median is an indication of the reason why the spread is asymmetric in both directions. Second, for these countries, the relationships in the right and left tails are stronger. In other words, it signifies that these markets are highly interrelated during events or crises. Consequently, extreme negative/positive shocks have a significant influence on the connectivity system (Bouri et al., 2021)

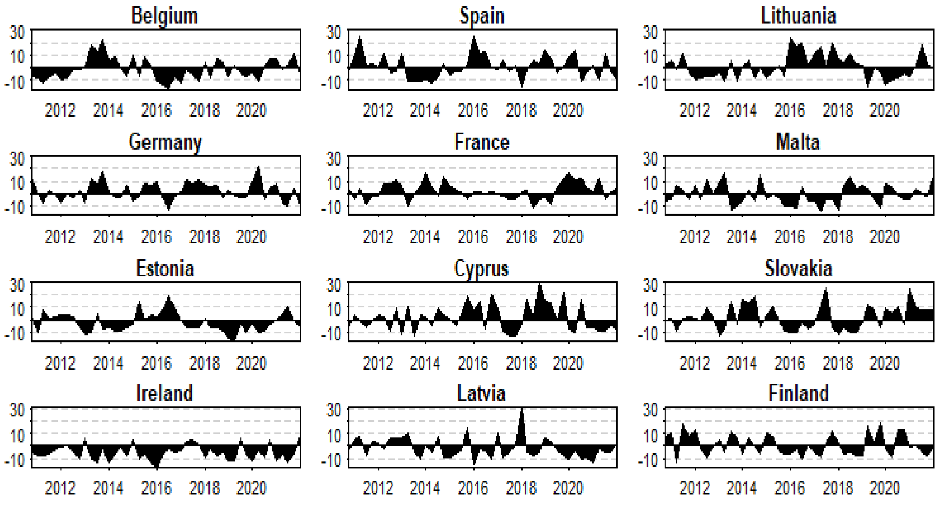
Because certain countries primarily act as net recipients or net transmitters of spread effects in both the right and left tails, the net spread patterns are mixed. Therefore, in the housing market connectivity system, during significant events and crises, the diffusion patterns in the left and right tails are different from the diffusion patterns in the median. Within this framework, the rates at which shocks spread and influence markets vary across different quantile values for countries. These results imply that shocks have a strong effect on the return-spillover system and that the net receivers and transmitters of shock spillovers also change. Hence, when considering the obtained results, it becomes evident that the quantile-VAR approach is more appropriate than the average-VAR approach. In other words, the Quantile VAR approach provides more detailed information regarding the connectivity of shocks within the system.

Figure 2: Dynamic Total Connectivity Estimated



According to the findings obtained from the Dynamic Total Connectivity Estimate using the Quantile VAR approach (See also Figure 2), the median dynamic total connectivity illustrates specific events occurring in certain years and their impact on housing market return series. When observing the TCI (namely the shaded black area), it becomes evident that the housing price market is significantly tied to events (approximately between 60% to 70%) and displays substantial fluctuations over time. In other words, the housing market is greatly influenced Fby factors such as crises, policy decisions, and pandemics. However, these influences do not lead to abrupt changes in the housing market. Considering the time period analysed, it can be said that the housing market crisis that started in the US in the period before 2012, the economic effects of the Covid19 pandemic that affected all countries globally, the increase in uncertainty about the future in the preferences and decisions of households, the high inflation rate all over the world in 2021, and uncertainty shocks also had an impact on the housing market.

Figure 3: Net Total Direct Connectivity Estimated



According to Net Total Direct Connectivity Estimated(See also Figure 3), depicts the general directional connectedness across all countries based on median values (represented by the shaded black region). In addition, a shaded area indicates the net shock transmitter country when it falls into positive values, whereas negative values correspond to net recipient countries. Furthermore, over time, any country's housing market can exhibit both scenarios (namely net transmitter or net recipient). When considering the estimated net total direct connectivity, in 2020, Lithuania, Belgium, Ireland, Malta, and Latvia received shocks from the housing markets of other countries, while Slovakia and France transmitted shocks to the markets of other countries. In each country, in different periods, markets respond low to shocks, whereas in other years, they respond high. Taking these findings into consideration, it can be concluded that all countries alternately act as shock receivers and transmitters at different periods. Hence, for different quantile values, the status of any market as a net taker or net giver changes over time. In this context, net return spreads change over time in all markets. However, no evidence has been found indicating that this variation arises due to geographical proximity in the connectedness effects among markets.

The static connectedness analysis fails to capture changes in the propagation effects of the housing market across all countries over time. In this context, the quantile-based average connectedness estimation demonstrates dynamically changing propagation effects in the housing markets at the median, right tail, and left tail values. In other words, to capture the time variability of the conditional distribution not only at the median but also in the return spreads at the right and left tails, an estimation based on VAR methodology is performed (Chatziantoniou et al., 2022). Within this framework, the obtained predictive results are presented in Figure 4.

Figure 4: Overall Dynamic Total Connectivity over Time and Quantile Values

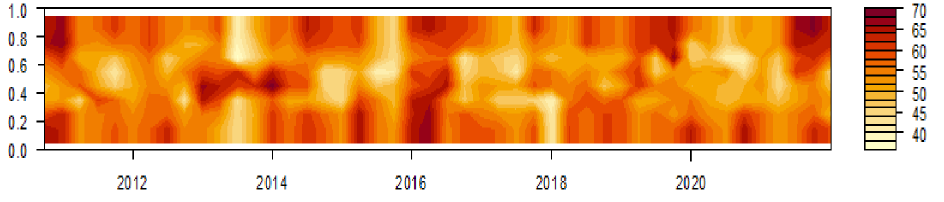


Figure 4 illustrates the overall dynamic total connectedness forecast for all countries included in the analysis. According to the findings of the analysis, darker colours in the figure correspond to higher levels of connectedness. Connectedness is very strong for both very negative housing market changes (below 40%) and positive changes (above 70%). Therefore, there exists a high degree of connectedness between the housing markets of these countries. In these countries, the connectedness effect increased in the years before 2012, 2016, 2018, and 2021.

Figure 7 in the Appendix shows that Germany, France, Finland, and Cyprus have the highest degree of connectedness when the dynamic total degree of connectedness for each country is considered. In other words, a shock in the housing market of these countries exerts an influential effect on the housing markets of other countries because of their elevated degrees of connectedness. Additionally, Belgium, except for the year 2015, Ireland in the period prior to 2016 and post-2020, Malta between 2016 and 2020, Estonia before 2015, and

Latvia in the periods of 2016-2017 and post-2020 act as net recipients of shocks. This implies that a shock occurring in the housing markets of other countries affects these countries' housing markets during the specified years. Therefore, considering the findings from the analysis, the findings from the estimation of overall dynamic aggregate connectedness over time and quantile values support the other findings and provide a more detailed picture of connectedness over time for each country.

4. Conclusion

This study enables us to research the interconnectedness of interaction among housing markets in Eurozone countries within the framework of the quantile VAR model, considering median(τ = 0.50) values in the right tail (τ = 0.95) and left tail (τ = 0.05). Based on the information explained earlier in this study, the interconnectedness between the markets of these countries should be considered as a new channel for both the cause and propagation of new macroeconomic shocks. In other words, shocks in the right and left tails have a greater effect on connectivity than shocks obtained from the median prediction. This situation demonstrates that relying solely on median-based predictors is not appropriate for examining the spread of returns associated with extreme positive/negative events.

The high interdependence of financial systems in the Eurozone leads to higher risks and volatility in the markets. Particularly, with financial institutions in these countries being overseen by the European Central Bank when considering median, left-tail, and right-tail values, it can be argued that both markets and household behaviours react differently to shocks. Therefore, it can be inferred that the varying sensitivities of financial institutions to common shocks, along with the diverse social, economic, and cultural differences in the markets, contribute to the differentiation in household behaviours and preferences.

The fact that the behaviour of households is different for each country under market conditions also implies that their expectations are also different. This is because news related to housing prices can lead households to adjust their expectations about housing prices in other countries. Therefore, despite homogeneous financial markets across countries, there are highly heterogeneous house price spillovers at the country level. This phenomenon also reveals that even with the implementation of the same monetary policies, household decisions have heterogeneous effects on housing markets at the country level. The effects on housing markets are different, given the general trend of monetary union towards increased linkages in trade, financial markets, and general economic conditions. More generally, the effect of financing costs on house prices has been growing over time. In this context, changes in long-term interest rates increase the borrowing costs of households and thus impact housing markets, indicating that monetary policy is also effective in these markets. Therefore, changes in interest rates cause intertemporal preferences of households and liquidity constraints to affect macroeconomic variables through the housing market.

While housing is perceived as a stable long-term investment and a reliable hedge against inflation for households, evidence indicates that during significant events and crises, there is a stronger interdependence among markets compared with normal periods. Therefore, it can be inferred that households are more sensitive to information dissemination during abnormal periods, and markets respond rapidly to this sensitivity. Therefore, we can say that households' sensitivity to information diffusion is also higher than in abnormal periods and that markets react quickly to this sensitivity. In this context, the high impact of both internal and external factors on housing markets increases market volatility. Therefore, it is important for policymakers to take measures to reduce external shocks and the size of spillovers.

The high volatility of housing prices for households can lead to perceptions of housing as a risky investment asset. In this framework, households' perception of housing as a risky asset will affect their consumption and investment decisions. Therefore, this necessitates a detailed analysis of the housing markets for them to be considered a reliable investment instrument. Hence, the varying effects of shocks at different quantile levels indicate that when households are forming their housing portfolios, they should consider not only the median value but also the values in the left and right tails. Economic uncertainty and unexpected events directly or indirectly affect housing market interdependence, and this impact varies across different quantile values. Considering the sector's backward and forward linkages and the macroeconomic effects of new investments to be made, the impact of macroeconomic policies will be asymmetric for the studied countries. In this context, policies addressing issues such as inflation and unemployment should consider the relationships between these housing markets.

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APPENDICES

Table 4: Average Commitment Estimated (τ = 0.05)

	Belgium	Germany	Estonia	Iceland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	53,78	1,84	0,96	4,60	4,27	2,58	6,21	5,18	3,84	5,64	7,67	3,44	46,22
Germany	1,40	41,54	3,44	2,48	4,47	3,51	13,20	4,25	6,26	8,01	5,63	5,79	58,46
Estonia	0,96	4,07	51,24	5,65	2,73	5,07	3,85	6,34	4,48	7,84	5,61	2,16	48,76
Iceland	4,06	2,64	5,31	44,81	5,10	7,32	7,06	4,46	3,98	3,87	9,17	2,23	55,19
Spain	3,94	4,56	2,39	4,82	50,20	9,16	3,82	4,79	1,86	3,25	2,66	8,55	49,80
France	1,96	3,27	4,69	6,69	8,12	40,59	4,14	7,55	4,57	1,82	4,68	11,92	59,41
Cyprus	4,94	12,62	3,38	6,41	3,25	4,12	39,19	4,74	7,02	4,00	6,37	3,94	60,81
Latvia	4,30	3,81	6,57	4,43	4,84	8,23	4,71	45,26	6,87	1,82	5,28	3,87	54,74
Lithuania	3,13	6,62	4,26	3,96	1,48	4,91	8,13	7,13	47,90	1,53	4,12	6,82	52,10
Malta	5,79	8,93	7,46	4,14	3,24	2,06	4,87	2,07	1,84	52,73	5,20	1,67	47,27
Slovakia	7,31	5,65	5,49	8,43	2,65	4,48	6,87	5,20	3,53	4,90	44,05	1,45	55,95
Finland	3,01	6,43	2,07	1,92	7,91	13,16	4,32	3,69	7,60	1,68	1,40	46,80	53,20
TO	40,81	60,43	46,02	53,54	48,06	64,61	67,18	55,41	51,84	44,37	57,81	51,82	641,92
Inc. Own	94,59	101,97	97,26	98,35	98,26	105,19	106,38	100,68	99,74	97,10	101,86	98,62	cTCI/TCI
NET	-5,41	1,97	-2,74	-1,65	-1,74	5,19	6,38	0,68	-0,26	-2,90	1,86	-1,38	58,36/53,49
NPT	2,00	8,00	1,00	3,00	4,00	9,00	10,00	6,00	6,00	3,00	8,00	6,00	

Table 5: Average Commitment Estimated (τ = 0.95)

	Belgium	Germany	Estonia	Ireland	Spain	France	Cyprus	Latvia	Lithuania	Malta	Slovakia	Finland	FROM
Belgium	52,54	2,50	1,15	4,84	4,15	3,46	5,88	3,04	3,13	6,20	8,14	4,98	47,46
Germany	1,9	41,58	3,49	2,77	3,60	2,77	15,52	2,97	7,46	7,82	5,27	4,87	58,42
Estonia	1,22	4,36	56,54	5,72	3,42	6,41	3,24	2,50	4,72	4,44	4,72	2,70	43,46
Ireland	4,51	2,87	5,62	46,77	6,19	5,66	6,85	3,49	1,55	6,27	7,75	2,48	53,23
Spain	3,74	3,14	3,16	6,21	47,21	10,99	2,80	3,36	0,99	3,52	4,14	10,75	52,79
France	2,79	2,71	5,27	5,55	10,32	40,88	3,42	5,06	4,40	2,05	4,53	13,03	59,12
Cyprus	4,33	14,45	2,64	6,06	2,35	3,21	39,54	4,41	6,67	6,00	6,62	3,71	60,46
Latvia	2,97	3,03	2,41	4,14	3,81	6,37	4,72	52,90	8,52	2,62	4,10	4,42	47,10
Lithuania	2,67	8,80	4,31	1,96	1,16	4,70	8,25	7,26	48,55	1,56	2,92	7,87	51,45
Malta	6,44	8,98	3,82	6,41	3,66	2,49	7,18	2,96	1,86	51,35	3,32	1,52	48,65
Slovakia	7,83	5,92	4,64	6,85	4,07	4,66	8,03	3,76	2,51	3,20	47,54	0,99	52,46
Finland	4,24	5,54	2,12	2,32	10,15	13,29	4,32	3,69	7,67	1,66	1,01	44,00	56,00
TO	42,64	62,29	38,63	52,82	52,88	64,00	70,21	42,49	49,48	45,32	52,52	57,32	630,61
Inc. Own	95,18	103,88	95,17	99,59	100,09	104,88	109,75	95,39	98,02	96,67	100,06	101,31	cTCI/TCI
NET	-4,82	3,88	-4,83	-0,41	0,09	4,88	9,75	-4,61	-1,98	-3,33	0,06	1,31	57,33/52,55
NPT	2,00	8,00	0,00	6,00	6,00	10,00	11,00	3,00	4,00	2,00	8,00	6,00	

Figure 5: Net Total Direct Connectivity Estimated (τ = 0.05)

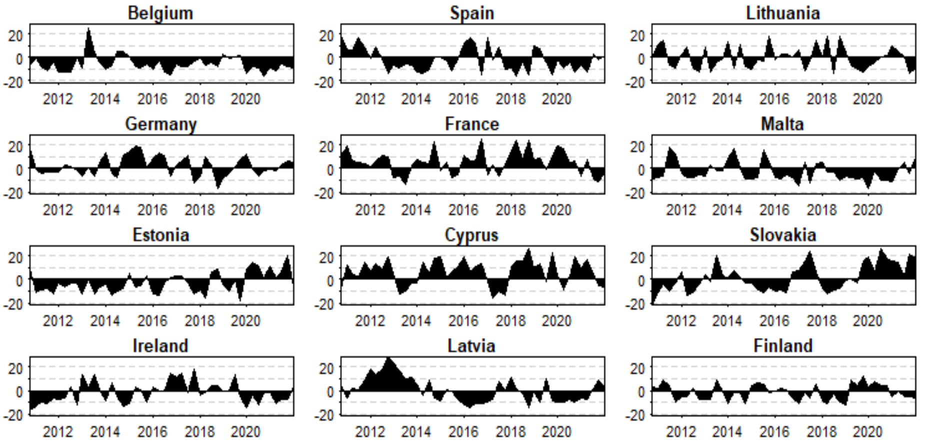


Figure 6: Net Total Direct Connectivity Estimated (τ = 0.95)

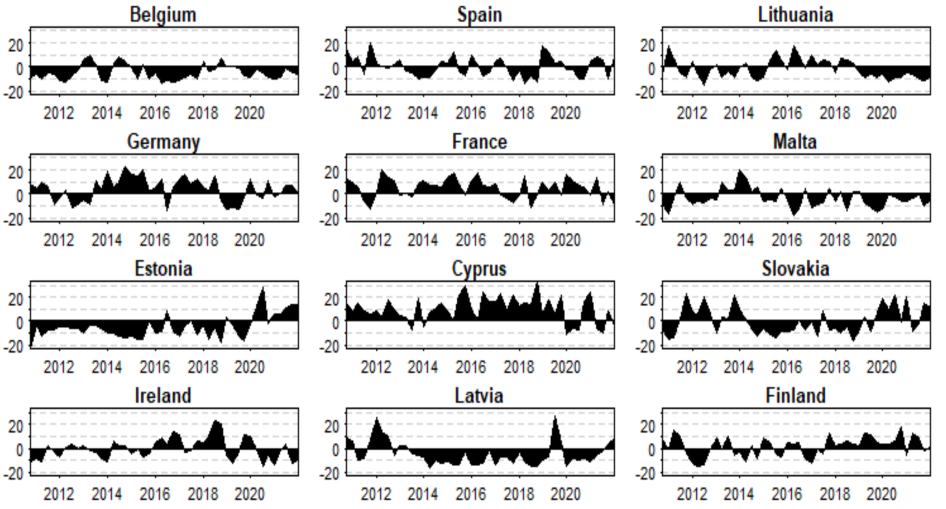
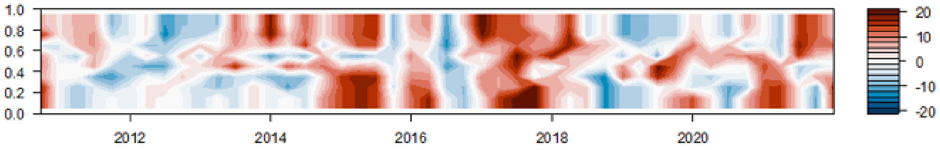
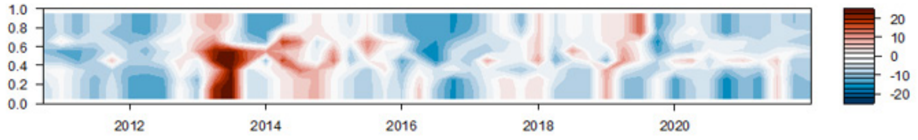


Figure 7: Overall Dynamic Total Connectivity by Country by Time and Quantile

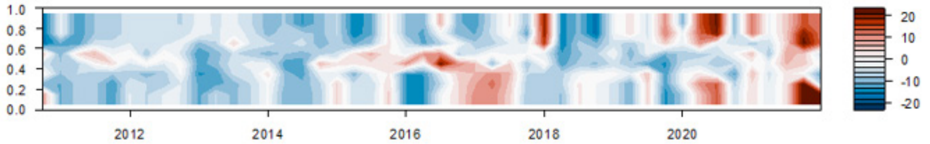
Germany



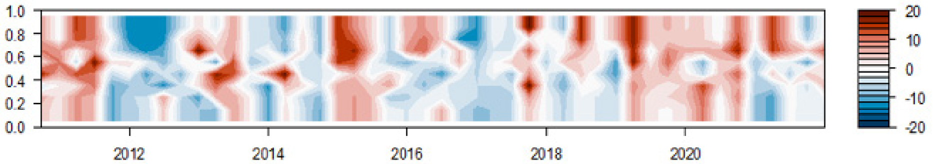
Belgium



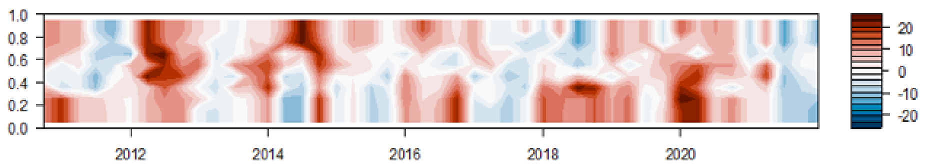
Estonia



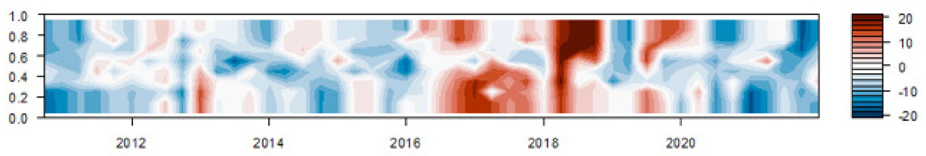
Finland



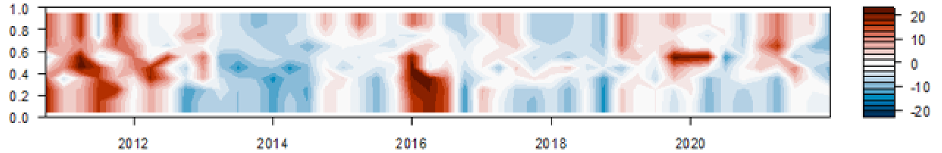
France



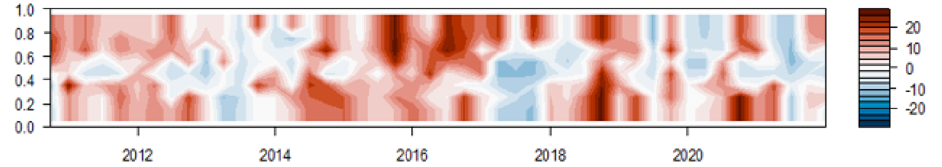
Ireland



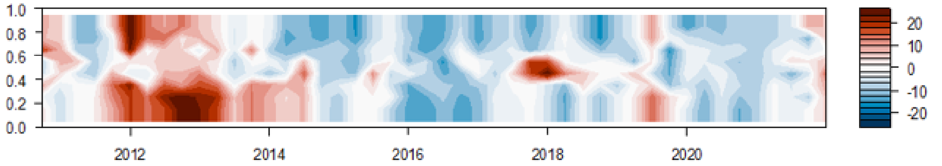
Spain



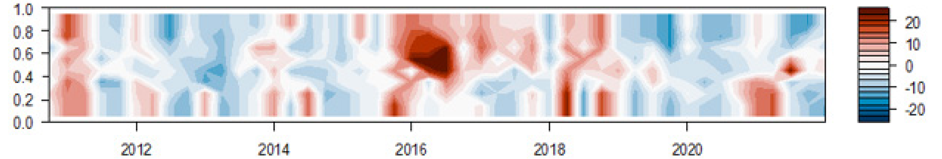
Cyprus



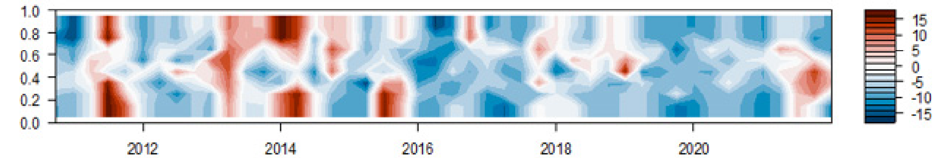
Latvian



Lithuania



Malta



Slovakia