Economic Modelling 29 (2012) 1820–1829

Contents lists available at SciVerse ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Real estate markets and the macroeconomy: A dynamic coherence framework

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ARTICLE INFO

Article history:
Accepted 25 May 2012
Available online xxxx

JEL classification:
C22
E4
G1
R3

Keywords:
Real estate markets
Macroeconomic factors
Dynamic coherence
Evolutionary co-spectral analysis

ABSTRACT

This paper analyzes the dynamic interactions between real estate markets, in the US and the UK and their macroeconomic environments. We apply a new approach based on a dynamic coherence function (DCF) to study these interactions bringing together different real estate markets (the securitized market, the commercial market and the residential market). The results suggest that there is a common trend that drives the different real estate markets in the UK and the US, particularly in the long run, since they have a similar shape of the DCF. We also find that, in the US, wealth and housing expenditure channels are very conductive during real estate crises. However, in the UK, only the wealth effect is significant as a transmission channel during real estate market downturns. In addition, real estate markets in the UK and the US react differently to institutional shocks. This brings some insights on the conduct of monetary policy in order to avoid disturbances in real estate markets.

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1. Introduction

The recent global economic downturn, attributed to the subprime crisis in the US with rapid worldwide contagion particularly in the housing sector, has attracted the attention of academics, policy makers, and economic agents at large. The magnitude of economic instability caused by the real estate sector highlighted the need to study the relationship between real estate and monetary policy to identify shocks that drive recessions. This issue is one of major concerns for central banks especially due to the role of housing as collateral. Since the 1990s, central banks have succeeded in their objective of price stability by means of inflation targeting policy but they failed to prevent asset prices bubbles and having negative real effects. Therefore, the recent emergence of boom-bust cycles in house prices, which was followed by a significant contraction in the real economy is very concerning to policy makers (Iacoviello and Neri, 2010; Reinhart and Rogoff, 2008).

One of the most important characteristics of asset prices is their quick reaction to news. According to Rigobon and Sack (2004) and Bernanke and Kuttner (2005), asset prices react quickly to monetary policy announcements. They are not only considered as a source of disturbance but also as a shock transmission channel (Mishkin, 2007). It is, thus crucial for central banks to analyze thoroughly the effects of monetary policy on asset prices in general, and on real estate in particular. However, the existing literature has focused mainly on the housing sector and its concomitant interaction with the economy (Ahearne et al., 2005; Bjørnland and Jacobsen, 2010; Iacoviello, 2005; Iacoviello and Neri, 2010; Vargas-Silva, 2008). The main reason is that houses are commonly used as collateral for loans, so that a large portion of financial assets could be affected by housing values. In contrast, this paper provides an analysis of different real estate sectors and their linkages within the macroeconomic environment.

This study analyzes interactions between real estate markets in the UK and the US and their relative macroeconomic environments. Our analysis differs from previous studies in two ways. Firstly, we compare a small and a large economy that have different practices in the real estate markets[1] in order to see the degree of the convergence or divergence these two countries have with their economies. Secondly, this study brings together different real estate markets, the securitized market, the commercial market and the residential market. We do this because real estate indices are constructed differently. Thus, the sensitivity to macroeconomic factors might vary across the different real estate markets. Therefore, we can have a

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[1] For instance, mortgages in the UK are mainly based on short term interest rates. However, most of mortgages in the US are based on long term interest rates (Borio, 1995).

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doi:10.1016/j.econmod.2012.05.034

better understanding of transmission mechanisms between real estate markets and the macroeconomic environment and take the relevant actions when shocks hit one of the markets.

Moreover, this paper contains some empirical contributions. We use a dynamic coherence function (DCF), developed by Ftiti (2010). It is based on the theory of evolutionary co-spectral analysis proposed by Priestley and Tong (1973). This is the first time that this methodology is used in the literature to measure the degree of interaction (co-movement) between real estate markets and macroeconomic variables. The DCF approach has many advantages. Firstly, it takes into account the dynamic dependence between time series. Secondly, this measure is useful for non-stationary series. Thus, we do not need any prior treatment of stationarity for the data. So, it allows us not to lose any information related to the real estate data that require already some processing of smoothing, appraisal and aggregation.

The rest of the paper is organized as follows. Section 2 reviews the related literature on the linkages between real estate markets and macroeconomy. Section 3 explains the methodology and presents the data used in the study. Section 4 provides the empirical results. Finally, Section 5 concludes.

2. Related literature

Real estate crises can have major consequences on the economy. Many studies found that collapses in house prices are at the heart of many financial crises (Iacoviello and Neri, 2010; Leamer, 2007; Reinhart and Rogoff, 2008). Thus the booms and busts in real estate markets have been an issue of concern for policy makers. In fact, central banks and the International Monetary Fund (IMF) studied the impact that monetary policy has on the residential sector. For instance, Mishkin (2007) discusses the role of housing in the monetary transmission mechanism and the implications that this role can have for the conduct of monetary policy. Despite the important role of housing for monetary policy, he does not agree with emphasizing the role of house prices within monetary policy, given that central banks cannot easily identify housing bubbles. He suggests that monetary policy should take into account house prices only to the extent that they have predictable effects on inflation and employment. But this is peculiar to the US as a large economy where real estate bubbles are regional. This makes targeting real estate prices a harder task to achieve. This idea is supported by Allen and Carletti (2010) in a theoretical model of real estate bubbles. They suggest that interest rates can be used as an instrument to prevent these bubbles, but only in small homogeneous economies, not in large ones. For instance, Sweden as a small economy, takes into account the housing prices or real estate prices in the implementation of monetary policy. The Swedish central bank considers real estate prices when it makes a real interest rate decision by adjusting monetary policy to face a rapid increase in house prices (Ingves, 2007). Consequently, we have chosen both a large economy (US) and a smaller economy (UK) to study the degree of co-movements between real estate markets and the macroeconomy in order to find some conclusions about the effectiveness of targeting real estate prices in two differently sized economies.

Numerous studies have attempted to explain the linkages that real estate markets have with the macroeconomy using different tools. On the one hand, some authors use theoretical models to study these linkages. Indeed, in their study of business cycles, Ahearne et al. (2005) find through their analysis that housing prices show co-movements with the macroeconomic environment and that house price booms are preceded by loose monetary policy. Iacoviello (2005) and Iacoviello and Neri (2010) find a strong linkage between economic activity and the residential market in the US by means of Dynamic Stochastic General Equilibrium Models (DSGE) to study this relationship.

A different strand of the literature studies the relationship between real estate markets and the macroeconomy using empirical models, among them the vector autoregressive models (VAR). In their study of the links between the housing sector and the macroeconomy, Bjørnland and Jacobsen (2010) use a structural VAR to study the interaction between real house prices in Norway, Sweden and the UK and their relative macroeconomic characteristics. They find that unexpected changes in interest rates have an immediate effect on house prices and that the role of housing increases considerably when the interest rate and the house prices react at the same time. This highlights its role as a monetary transmission channel.

McCue and Kling (1994) study the US securitized market by modeling the filtered equity Real Estate Investment Trusts (REITs) by an unrestricted VAR. They suggest that 60% of the variation in real estate prices is explained by the macroeconomy. It is thus the nominal short term interest rate variable that explains the majority of real estate price movement, while the output and the investment variables explain less of the variations in real estate markets.

Also, by using a VAR model on filtered real estate returns, property returns series and a range of economic and financial factors, Brooks and Tsolacos (2001) find that unexpected inflation and the interest rate term spread have explanatory powers for the UK property market.

The recent study of Bredin et al. (2011) deals with the impact of the unexpected component of monetary policy, proxied by futures market. By using a structural VAR, they confirm that REITs respond negatively to interest rate surprises, which confirms the sensitivity of real estate to monetary policy. Ewing and Payne (2005) employ generalized impulse response on the total returns of US equity REITs, finding that a shock in economic growth, in inflation and in monetary policy cause a fall in expected REIT returns. However unexpected default risk premia of REITs are positively linked to future REIT returns.

Another branch of empirical studies uses the Vector Error Correction Model (VECM). Following the study of Bjørnland and Jacobsen (2010), Schätz and Sebastian (2009) restrict their study to the property markets in the UK and Germany. They apply a VECM only on appraisal-based property indices. They find that the long term equilibrium in the real estate sectors of both economies is determined by the same macroeconomic factors: consumer prices, government bonds and the unemployment rate. There is a positive linkage between the property markets and the consumer prices as well as government bonds. In addition, their analysis shows a significant role of the labor market appearing in both economies through a negative linkage between property markets and the unemployment rates. Furthermore, Hoesli et al. (2008), apply a VECM to general equity, and small capitalization stock returns in the UK and the US to see their interaction with a range of macroeconomic variables with an emphasis on the role of real estate as inflation hedge. They find that when both real and monetary variables are included, asset returns are positively linked in the long run to anticipated inflation but not to unexpected shocks in inflation. They suggest also that the results can be driven by appraisal effects particularly in the UK market.

Another part of the literature study the links between the real estate sector and the macroeconomy using factor models. For instance, in an FVAR framework, Gupta et al. (2010) find that real house price growth in South Africa responds negatively to positive monetary shocks. The response of housing prices does, however, depend on its market segmentation.

Ling and Naranjo (1997) study the sensitivity of commercial real estate returns in the US to a range of macroeconomic risk factors using a Multifactor Asset Pricing Model (MAP). Their main result is that commercial real estate returns are influenced by the term structure of interest rates and unexpected inflation, the growth rate in real per capita consumption and the real Treasury Bill rate.

In addition, Bredin et al. (2007) provided evidence of the response of REIT returns and their volatility to unexpected changes in monetary policy in a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) framework.

Previous studies suffer from some drawbacks. Firstly, the focus in previous work was mainly, either on the residential sector, or the

securitized market or the commercial market separately, but the different markets have rarely been studied jointly. Thus, no comparative analysis between commercial, residential and securitized real estate markets and their interactions with the economy has been undertaken under the co-spectral analysis. Secondly, the presence of nonlinearity in the degree of dependence between series has not been considered. The latter, however, is crucial to avoid biased results. Thirdly, they do not distinguish between dynamic short run and dynamic long run dependence to assess interactions and their nature between the real estate sector and the wider economy. It is important to understand the dynamic evolution of the real estate markets vis-à-vis the macroeconomic environment in order to adjust the policy makers' decisions to avoid disturbances. In this paper, we propose a new empirical methodology to overcome all these drawbacks.

3. Methodology and data

This paper focuses on analyzing the degree and the horizon of the interaction between real estate markets and the macroeconomic environment in the UK and the US. In contrast to the previous literature which focuses mainly on residential markets, this work deals separately with the relationship between the direct real estate market, the indirect real estate market and the monetary environment. This investigation on the magnitude of the impact of the macroeconomic environment on the different real estate markets is important for two reasons. Firstly, it is crucial in the interest of portfolio diversification to know to what degree there is such a dependence. Secondly, it is also important to analyze the economic implications for public policy. In this work, the degree of dependence between real estate markets and the macroeconomy is investigated through the dynamic measure developed by Ftiti (2010)[2] which consists of a dynamic coherence function. We use this measure to take into account the nonlinearity in the transmission mechanisms.[3] Besides the aim of bringing together three different real estate markets to study, our empirical approach differs from the previous literature. Firstly, we use a dynamic coherence function to tease out the change over time of the correlation pattern. Secondly, our approach decomposes the dynamic interaction into two horizons (long run and short run). This characteristic[4] is useful for the portfolio diversification and transmission mechanism literature. Moreover, it limits the bias that derives from the assumptions necessary for the VAR models. Thirdly, using this technique, we do not need any prior treatment of stationarity on data. So, it avoids any loss of information on scarce real estate data.

In this section, we present the empirical framework. The subsections below present an overview of the frequency approach of the evolutionary co-spectral analysis.

3.1. Dynamic coherence function (DCF)

To study the dependence between series, the most popular tool is the time approach. It provides the instantaneous dependence between two series and describes their pattern over time. However, it suffers from some drawbacks. Indeed, it does not assess whether coherence between series increases or not over time. This limit is solved by spectral analysis which detects changes in synchronization processes in different frequencies. This additional information allows us to understand the nature of dependence between series (long run: low frequency, short run: high frequency) which will be useful to assess their reactions to shocks.[5] Moreover, it does not define the duration of the correlation between bivariate processes. In addition this limit is solved by the spectral analysis framework and in our study we investigate the nature of the dependence between real estate markets and macroeconomic variables.

There are many reasons for applying a frequency approach to the study of the dependence and the interaction between real estate markets and the macroeconomic environment. Firstly, this approach does not depend on any particular detrending technique which avoids the possibility of a misspecification. Secondly, it allows us to determine a coherence function useful for non-stationary series. Thirdly, the approach identifies the nature of the dependence between series. In other words, it is a short, a medium or a long run dependence. This distinction is important when the linkages between real estate markets and the macroeconomic environment are studied.

To analyze a bivariate process in the frequency approach, Priestley and Tong (1973) suggest the use of evolutionary co-spectral analysis to study the co-movement process between two non-stationary series. Following this theory, Ftiti (2010) developed a DCF suitable for non-stationary processes. The choice of DCF to analyze the dependence between the real estate markets and the macroeconomy is motivated by the fact that we do not need any treatment concerning the stationarity of the series. In that case, the DCF proposed by Ftiti (2010) allows us to assess the nature and the degree of dependence (short run or long-run dependence) between the different real estate markets and the macroeconomic variables. This identification is important for policy makers to adjust their decisions to the economic conditions. Also, it is useful to know such linkages to identify the transmission mechanisms between real estate markets and the macroeconomic environment.

To our knowledge, this is the first study which uses spectral analysis to study the degree of dependence between different real estate indices and a range of macroeconomic variables. Usually, the spectral framework is used to analyze the synchronization between business cycles and the interdependence between international markets. For instance, Zhao et al. (2005) propose a dynamic coherence function based on the Short Time Fourier Transform. This measure is based on an autoregressive moving average (ARMA) model, which is not suitable to capture nonlinear characteristics of time series. Croux et al. (2001) offer new measures to study the coherence between business cycles in the US and in Europe. These functions are based on the average weights of coherence which are appropriate only for stationary processes. Wilson and Okunev (1999) used the spectral framework to study the co-cycles between REITs and stock markets in the UK, the US and Australia. According to this literature, our methodology is more appropriate. It contributes to the literature by suggesting a dynamic coherence function without looking at the stationary state of series, or any upstream treatment. After an overview of the evolutionary spectral analysis, we present the estimation techniques of the DCF.

3.2. Estimation of the DCF

The theory of the evolutionary spectrum of Priestley and Tong (1973) is concerned with the non-stationary process that is defined as follows:

$$X_t = \int_{-\pi}^{+\pi} A_{t,X} e^{iwt} dZ(w). \quad (1)$$

Where, for each w, the sequence $A_t(w)$ is time dependent and has a generalized Fourier transform whose modulus has an absolute maximum at the origin $dZ(w)$ and is an orthogonal process in $[-\pi,\pi]$,

[2] The dynamic measure consists of a dynamic coherence function which measures a dynamic co-movement of bivariate process based on the theory of evolutionary co-spectral analysis proposed by Priestley and Tong (1973).

[3] Our objective is to take into account nonlinear interaction between real estate markets and the macroeconomic environment.

[4] The nature of dependence between series: a long run dependence or short run dependence.

[5] Frequency domain defines correlation between two components as coherence interpreted as the squared linear correlation coefficient for each frequency of the spectra of two series.

Table 1
Descriptive statistics.

United Kingdom										
	Growth.rate	Inf.rate	LIBOR(6m)	10y.gov.B.Yield	Employment.G	M3	IPD	Halifax	REIT	–
Mean	0.547	2.835	3.584	3.656	0.159	77.966	430.620	360.994	3101.868	–
Median	0.656	2.396	3.610	3.727	0.275	67.244	367.740	309.217	2780.466	–
Max	2.197	8.051	9.307	6.901	3.175	155.786	897.985	617.820	7727.344	–
Min	−2.255	0.610	−4.423	−0.925	−3529	30.919	168.939	229.270	1376.097	–
Std. Dev.	0.700	1.734	2.683	1.795	1.363	36.371	211.564	122.024	1218.132	–
Skewness	−1.538	1.238	−0.720	−0.5995	−0.557	0.759	0.602	0.649	1.783	
Kurtosis	6.891	3.895	4.055	2.795	3.854	2.330	2.115	1.954	6.1786	–
United States										
	Growth.rate	Inf.rate	LIBOR(6m)	10y.gov.B.Yield	Employment.G	M3	NCREIF	SP/CS	REIT	MIT
Mean	0.632	2.872	1.604	2.813	−0.120	87.268	287.143	124.009	955.901	379.748
Median	0.685	2.828	2.028	3.102	0.125	80.654	247.253	115.819	886.881	331.555
Max	1.951	6.038	4.871	5.242	1.633	125.212	541.484	186.964	1938.844	805.361
Min	−2.301	−1.637	−3.269	−1.243	−4.448	69.376	160.253	100.369	344.122	173.948
Std. Dev.	0.657	1.256	1.938	1.406	1.207	16.686	120.633	24.732	351.645	189.637
Skewness	−1.405	−0.446	−0.459	−0.577	−1.690	0.676	0.692	1.2262	0.812	0.711
Kurtosis	7.408	4.666	2.254	2.838	6.480	2.081	2.072	3.312	3.252	2.165

Notes: M3 = money supply M3. IPD = Investment Property Databank index (UK commercial market). Halifax = Halifax price index (UK residential market). REIT = Real Estate Investment Trust index (UK securitized market). NCREIF = National Council of Real Estate Investment Fiduciaries (US commercial market). SP/CS = Standard and Poor's Case Shiller National Price Index (US residential market). MIT = Massachusetts Institute of Technology index, it is a transactions-based index. Macroeconomic data derived from Datastream.

with $E[dZ(w)]=0$[6] and $E[|dZ(w)|^2]=d\mu(w)$, where $\mu(w)$ is a measure. The evolutionary spectral density of the process $X(t)$ is defined by $h_t(w)$ as follows:[7]

$$h_t(w)=\frac{dH_t(w)}{dw},-\pi<w<\pi. \tag{2}$$

Where $dH_t(w)=|A_t(w)|^2 d\mu(w)$. The instantaneous variance of $X(t)$ is given by:

$$\sigma^2=\operatorname{var}(x_t)=\int_{-\pi}^{+\pi}h_t(w)d(w). \tag{3}$$

In the case of a bivariate process $\{X(t),Y(t)\}$, each component has an evolutionary spectral density function like Eq. (2). Their time varying cross-spectrum is defined by $H_{t,XY}$.

$$H_{tXY}=h_{t,XY}\left(w_j,t\right)\exp\left\{i\theta_{XY}\left(w_j,t\right)\right\}. \tag{4}$$

The dynamic coherence function is defined as follows:

$$Coh_{t,XY}(w)=\frac{\left|\hat{h}_{t,XY}(w)\right|}{\left\{\hat{h}_{t,XX}(w)\hat{h}_{t,YY}(w)\right\}^{1/2}}. \tag{5}$$

3.3. Data

Real quarterly data from the first quarter of 1987 until the third quarter of 2011 are used.[8] Note that for the evolutionary spectral estimation necessity, we lose ten observations at the beginning and at the end. So, for all variables, we have 80 observations. The table below summarizes the descriptive statistics (Table 1).

3.3.1. Real estate data

There are different types of real estate performance or valuation indicators.[9] Real estate data are scarce and have some issues. However, the data have been used by researchers. For the private real estate sector, we are using appraisal-based indices[10]: The Investment Property Databank (IPD) index for the UK and the National Council of Real Estate Investment Fiduciaries (NCREIF) index for the US. The main issue with these data sets is that they are smoothed, aggregated and influenced by appraiser behavior, and this may minimize the magnitude changes in returns (Geltner, 1991; Geltner, 1993). For the indirect sector,[11] a REIT index (the international property share index of Datastream) is chosen for both the UK and the US; these indices are used to model real estate securities. The advantages of these data are that they have high frequencies and they are transactions-based indices. Nevertheless, they can also contain the price changes of the direct market.

For the residential market, we have chosen the Halifax price index for the UK and Standard and Poor's Case Shiller National Price Index for the US. Both are transactions-based indices and they are the most frequently used indices for the residential sector for the two countries.

For the US commercial market, we are using a transactions-based index (MIT index) and an appraisal-based index (NCREIF index) to see if the appraisal has a significant impact on measuring the linkage between the real estate market and the macroeconomic environment.

3.3.2. Macroeconomic data

The macroeconomic variables are chosen based on previous literature, which has identified the importance and the significance of real economic activity, inflation and interest rates as fundamentals and explanatory variables for the real estate markets (Baffoe-Bonnie, 1998; Bjørnland and Jacobsen, 2010; Bredin et al., 2011; Brooks and Tsolacos, 2001; Hoesli and MacGregor, 2000; Ling and Naranjo,

[6] This condition implies that $E(X_t)=0$.
[7] For more details see Appendix A.
[8] The transactions-based index (MIT index) for the US is only available in quarterly frequency and 1987 is the date of availability of the IPD index.
[9] See Chapter 4 of Hoesli and MacGregor (2000) for an overview of the property indices.
[10] They are constructed according to a sample of properties, the value of the properties is estimated on a regular basis because they are not sold during each considered period. If the index is quarterly, the property is evaluated every quarter.
[11] The returns are obtained indirectly by the purchase of shares of companies which own properties.

1997; McCue and Kling, 1994; Schätz and Sebastian, 2009). We are using a 10 year government bond yields as a proxy for the long term interest rate, the 3 month LIBOR for the short term interest rate, money supply M3, the growth rate, the employment growth rate and inflation rate.

The choice of the macroeconomic variables is related to these variables in the conduct of monetary policy and to the economic conditions. In fact, real GDP growth is an indicator of the state of the economy that may affect the property and equity stocks. The employment growth is a good indicator for the economic conditions and consumer behavior. The long term interest rate has an impact on property and equity through mortgages and the present value of future expected cash flows. The short term interest rate is a proxy for short term monetary decisions and short term loans. The inflation rate is a key instrument for monetary policy and it is an important component for investors' choices and expectations. Money supply affects the real estate markets through its impact on the overall economy. It may have a positive effect on investments into property on one side but may affect negatively the property share price by the inflation expectation and uncertainty.

4. Empirical results

Before presenting the results, let us remind ourselves of the methodology applied. Our analysis consists of measuring the degree of interaction between real estate market and the economy. The major contribution of the study is that we consider three different real estate markets in purpose to investigate their different linkages with the macroeconomy. We use co-spectral analysis in order to reveal the existence of a link between real estate markets and the macroeconomic environment. The coherence function allows us to identify the nature of the relationship and the convergence in each country besides analyzing the degree of synchronization between the US and the UK in terms of the co-movements of their real estate markets with their macroeconomic environment.[12]

In this analysis, we focus on two frequencies for each bivariate process. The first one reflects the long run (detected in frequency $\frac{\Pi}{20}$ equivalent to 10 years) and the second one reflects the short run (detected in frequency $\frac{19\Pi}{20}$ equivalent to two quarters).[13] We have chosen these two frequencies in order to assess whether the long run and short run linkages are different or similar while considering a comparison between a large economy (US) and smaller one (UK).

In Figs. 1 and 2, we observe that the degree of co-movement between the different real estate indices and the overall macroeconomic variables is high in the early 1990s and in 2007 in the UK and the US, periods of turmoil. In fact, in the early 1990s, the US economy was hit by the savings and loan crisis that was mainly caused by the Tax Reform Act of 1986, which limited the tax deductions for losses related to the real estate investment, while the UK experienced a burst of the residential and the property bubble concomitant with the European exchange rate mechanism (ERM) crisis that worsened the economic conditions.

Moreover, the securitized market seems to have the most different features in its levels of coherence in the long and short runs. In fact, the REIT index exhibits higher co-movements levels with macroeconomic variables in both cases (UK and US). However, the residential and the commercial markets show the same dependence pattern with macroeconomic variables. This is because REITs behave more like stocks, which make them more volatile than the other real estate indices.

We turn now to the difference in the degree of interaction between a large economy (US) and a smaller one (UK) as shown in Figs. 1 and 2.

According to Fig. 1 (1.2), there is a divergence in the long run dynamic interaction of real estate markets and the short term interest rate between the UK and the US since 2000. The DCF is higher in the US than in the UK. Since 2000, the three real estate indices in US are more dependent on short term interest rates than those in the UK. However, this divergence vanishes in the short run (Fig. 2 (2.2)) but the DCF in the US has higher levels. This difference in the nature of the relationship (long run–short run) gives more accurate information concerning the interest rate as a monetary transmission channel for real estate markets. Our result, contrary to Allen and Carletti (2010), shows that the short term interest rate has a significant level of dependence on the US real estate markets and is an instrument that we should take into account when trying to prevent real estate bubbles.

Concerning the long and the short run coherence between the real estate markets and the long term interest rates in the two countries, they are shown in Figs. 1 (1.4) and 2 (2.4) respectively. The interaction between the long term interest rate and the three real estate indices for both the US and the UK has a similar shape in the long run (Fig. 1 (1.4)). However, it is different in the short run (Fig. 2 (2.4)). In this instance, only the REIT indices are correlated with the long term interest rate. Indeed, the dependence between the REIT index and the long term interest rates is higher for the US than for the UK. The coherence levels of the rest of the indices and the long term interest rate in the short run are not important since their magnitude is less than 0.5.[14]

Figs. 1 (1.3) and 2 (2.3) show the degree of dynamic interaction between the real estate market indices and the inflation rate respectively in the long and short runs. The level of this interaction is similar between the UK and the US in the long-run (Fig. 1 (1.3)) in the early 1990s. However, this pattern diverges between the UK and the US starting from the onset of the subprime crisis, when there was an upward trend for both cases. However, for the case of the US they reach a higher level of dependence between real estate markets and the inflation rate from 2007. Nevertheless, this dependence is low in the case of UK (lower than 0.5). In the short run (Fig. 2 (2.3)), there is no significant interaction between real estate indices and inflation rate for both cases (UK and US) except in the beginning of the 1990s. This greater sensitivity of the real estate markets and the inflation rate in the US compared to the UK is due to the objectives that each country has in the conduct of its monetary policy. In fact, the UK has inflation targeting as its main monetary policy objective. The US, on the other hand, has a threefold objective: inflation, economic growth and employment, which can explain the more important dependence between the inflation and the real estate markets.

Concerning the DCF between the real estate markets and money supply, Fig. 2 (2.1) shows that in the short run, the DCF has a high level of coherence between the money supply and the real estate markets in 1990 in both the UK and the US. In the US, the short run DCF between the real estate markets and the money supply started to rise from 2000 until 2007 showing slightly greater levels of coherence in the short run than the long run (Fig. 2 (2.1)).

The high level of the DCF in the UK between the real estate markets and the money supply and the inflation rate in 1990 and then the fall in the early 1990s is explained by the ERM crisis that forced the UK to withdraw the pound sterling from the European monetary

[12] This interaction is measured by the dynamic coherence function developed by Ftiti (2010). The estimation of the coherence function was performed according to a code that we have developed with MATLAB software.

[13] The horizon of the study is calculated as follows: $\frac{2\pi}{\lambda}$, where λ is the studied frequency. For instance, the studied frequency $\frac{\Pi}{20}$ defines the horizon of $\frac{2\pi}{\frac{\Pi}{20}}$ quarters = 40 quarters = 10 years.

[14] No exact empirical standards have been set for the significant degree of correlation. Some papers such as Priestley and Tong (1973), Croux et al. (2001), and Hallett and Richter (2011) consider that correlations higher than 0.35 are high. Others like Moneta and Rüffer (2009), Girardin (2004), and Lee (2003) benchmarks range from 0.31 to 0.50. In this paper, we set as benchmark a DCF coefficient equal to 0.50.

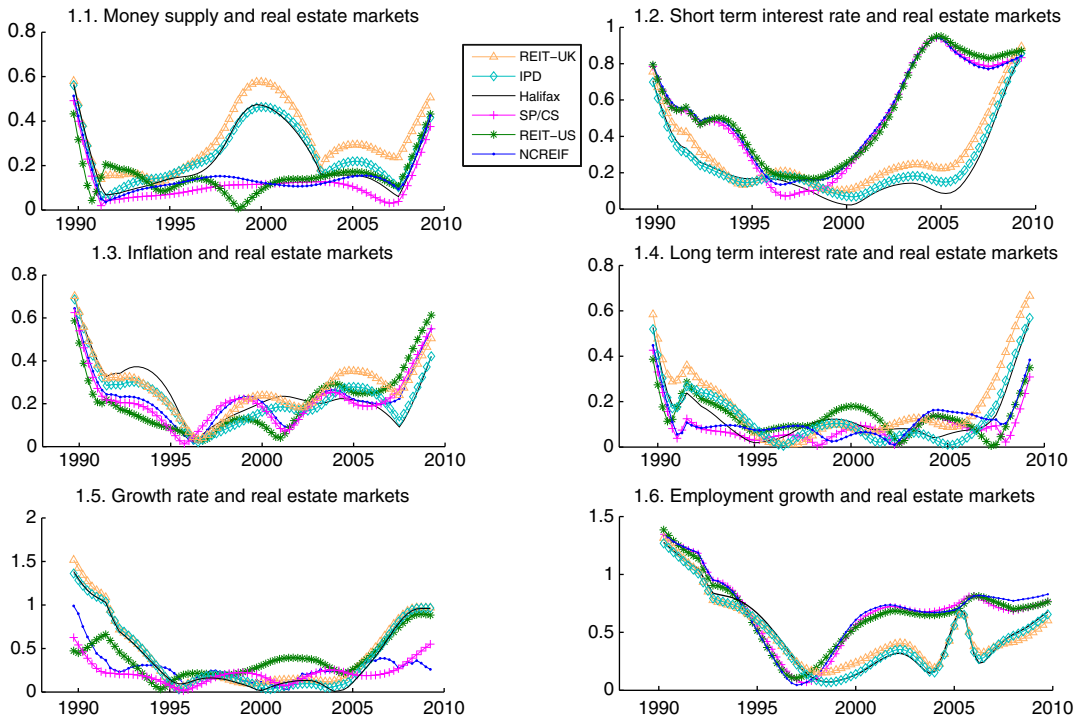

Fig. 1. Long run DCF between real estate markets and macroeconomic variables in the UK and the US.

system (EMS). Hence the inflation targeting framework emerges in the aftermath of the sterling's exit from the ERM in September 1992. And the low level of the DCF with the inflation in 1997 (approximately 0) is due to the change in the institutional structure of monetary policy. Indeed, in 1997, the monetary policy committee (MPC) was created to set the interest rates and inflation target and to thus take up the role previously played by the HM treasury in order to be more independent from political interference and enhance the credibility of interest rate decisions.

The low level of the DCF between the US real estate markets, the short term interest rate and the inflation rate at the end of 1995 can be justified by the fact that in 1994, the Federal Open Market Committee (FOMC) was planning to tighten monetary policy with the aim to improve its transparency, so that the public could better understand its objectives. In fact, in 1995, it started to make its announcements clearer by explicitly declaring its short term objectives concerning open market operations. This implies that real estate markets in the UK and the US are sensitive to the institutional shocks in the long

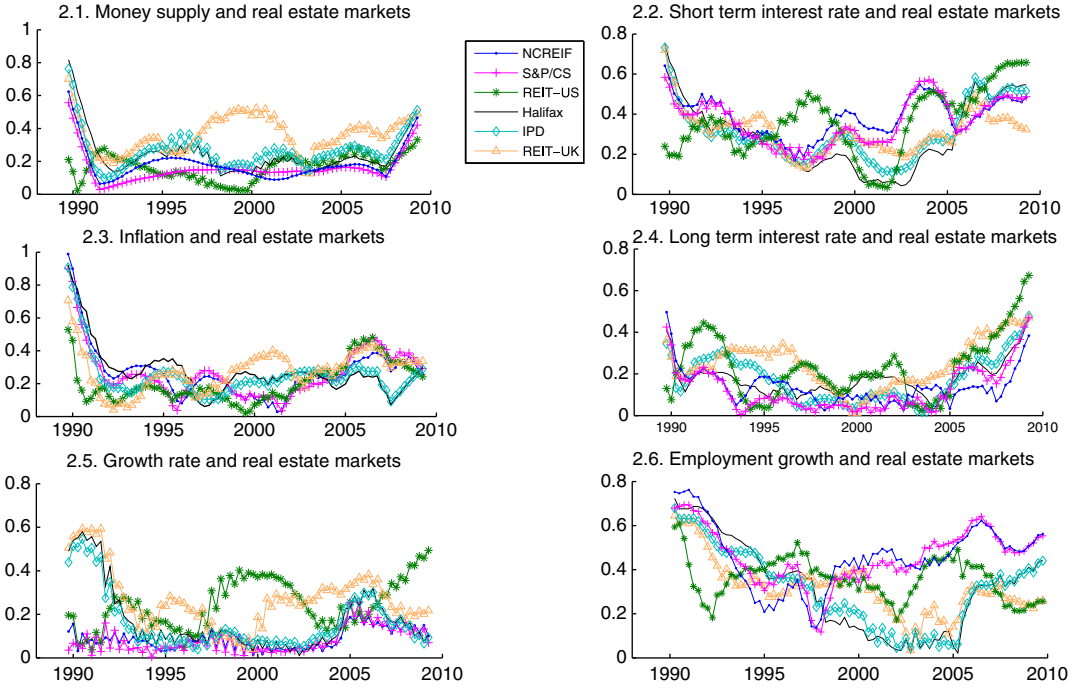

Fig. 2. Short run DCF between real estate markets and macroeconomic variables in the UK and the US.

run. Indeed, real estate markets in the two countries respond by a decrease in the DCF with the inflation and the money supply in the UK and by a decrease in the DCF with the inflation and the short term interest rate for the US.

As shown in Fig. 1 (1.5), the long run DCF between the real estate markets and economic growth in the UK and the US was high in 1990 then fell and stayed at a low level until 2005 when it started to rise again to reach a high level of approximately 0.8 in 2007. This is for all the real estate markets except the securitized market. In fact, in the UK and the US, all the real estate markets have the same shape of the DCF with the growth rate in the long run. However, in the short run, there is more divergence of the REIT market from the residential and the commercial market in the two countries (see Fig. 2 (2.5)). Indeed, in the UK, the DCF between the REIT index and the economic growth fell in the 1990s and reached a low value in 2000, started to rise again in the early 2000s before falling once more preceding and during the subprime crises. On the other hand, in the US, the DCF had a low level in the early 1990s and started to rise from 1997 before falling again in 2001 and then rising in 2005. The long and the short run DCF between the real estate markets and economic growth in the US were low in 1995 even if in this period, there was a bull market generated by the technology expansion before falling in 2000, a period known as the dotcom boom-bust. Furthermore, in the US, the DCF between real estate markets and economic growth is not very dynamic in the short run except for the securitized market. These results suggest that the real estate markets in the US are more independent from the general economic conditions than in the UK, where the real estate markets seem to be more sensitive to them. But the short run DCF with economic growth in the US and the long run DCF with the short term interest rate started to increase in 2005, suggesting that the US real estate markets are more sensitive to what drives the economic conditions. Indeed, in 2005, the economy was driven purely by a combination of government and monetary stimulus, while in 1995 the bull market was driven by organic economic growth.

The employment growth rate in the UK and the US is characterized by a remarkable decline between 1990 and 1993 and between 2008 and the last quarter of 2009. However, the fall is more important in the UK than in the US. On the other hand, the DCF between the real estate markets and employment growth in the UK and the US is more important in the long run than in the short run (Figs. 1 (1.6) and 2 (2.6)). This is consistent with the results of Schätz and Sebastian (2009) and deviates from the finding of Liang and McIntosh (1998), who detect only a short term linkage between property markets and employment growth. The important level of co-movements in the long run between employment growth and real estate prices reflects the adjustment process between the supply and the demand in the real estate markets.

In addition, the US has higher co-movements with the employment growth than the UK in the short run and in the long run. This confirms our result that the real estate markets in the US are more sensitive to what drives the economic growth. Moreover, these higher levels of dependence reflect the importance of the employment variable in the conduct of the monetary policy since it is one of the three objectives of the monetary policy in the US. When employment growth rises, the levels of the DCF are weak in both countries. And when employment growth falls, the levels of the DCF between the real estate markets and the employment growth increase. This implies that in periods of economic downturn, the co-movements between real estate markets and employment growth are more important. This is related to the fact that employment growth is an indicator for the economic conditions. A decreasing employment growth affects negatively the purchasing power and the consumption that is reflected directly in the economic growth. In addition, it is a key indicator of future building activity where construction determines supply (Smith and Tesarek, 1991) and employment growth determines demand. A low employment rate means thus a low demand for office space which decreases rent levels. This implies that declining employment rate contributes to the decrease of rental growth which is reflected in property valuation. Therefore a low employment growth contributes to a decrease of property prices.

Preceding the subprime crises, the DCF between the real estate markets and the long term interest rate in the UK and the US was not very high while the DCF with the short term interest rate was high in the case of the US preceding the crisis and started to decrease during 2007. However for the UK the DCF was low before the last turmoil but started to rise in 2005. And for this last crisis, in the UK, the long and short runs had the same level of DCF, while in the US the long run was more important. This gives some indications about the characteristics of the subprime crisis in the US, proving that the sensitivity to the short term interest rate during this crisis was more important than to the long term interest rate since mortgage loans are based on variable rates.

Let us now turn to the comparison between the degree of dependence between the appraisal-based index (NCREIF) and the transactions-based index published by the MIT for Real Estate in the US (Fig. 3). The transactions-based index provides a more precise picture about what happens in the market (Fisher et al., 2007). The two indices have broadly the same level of coherence with almost all the macroeconomic variables except with economic growth. Our results match the results of Hoesli et al. (2008). The transactions-based index MIT, shows more significant correlation with economic growth in the long run particularly starting from 2005. This confirms the interpretation that US real estate markets are sensitive to what drives the economic conditions, since commercial real estate markets are found to be sensitive to economic growth.

5. Conclusion

Due to the lack of consensus in the literature regarding the linkage between direct and indirect real estate markets and the macroeconomy, this paper further investigates the dynamic interaction between the direct and indirect real estate markets in the UK and the US and their relative macroeconomic environments. It contributes to the literature by evaluating the long and short run relationships between two of the largest and most developed direct and indirect real estate markets and the macroeconomy.

The following conclusions can be drawn from the present study. First, a comparison of the real estate markets' co-movements with the macroeconomic variables in the UK and the US reveals a degree of synchronization of the UK and the US in their linkages with their macroeconomic environment. In fact, there is some synchronization between the UK and the US real estate markets in their long run co-movements with the long term interest rate, inflation and employment growth. Besides, the higher levels of the DCF of the employment growth in the long run comparing to the short run in both the UK and the US, determines the horizon of the adjustment between the supply and the demand in the real estate markets.

On the other hand, there is some desynchronization between the two countries in the long and short run coherence functions of their real estate markets and economic growth, the money supply and the short term interest rate. The divergence that exists is more significant in the short run and more pronounced in the securitized market since it is the most volatile market and its volatility is higher in the short run. However, the global trend of the different indices converges in the long run even if their construction methodology is different. As a result, we conclude that there is a common trend that drives all the real estate markets, particularly in the long run, since they have similar shape of the DCF. Nevertheless, the returns of the different real estate markets are still different.

Moreover, our results allow us to draw a clearer picture of the transmission mechanisms between real estate markets and monetary policy in the UK and the US during crises. We conclude that in the US, wealth and housing expenditure channels are very conductive during real estate crises. However, for the UK only the wealth effect is significant as a transmission channel during real estate market downturns.

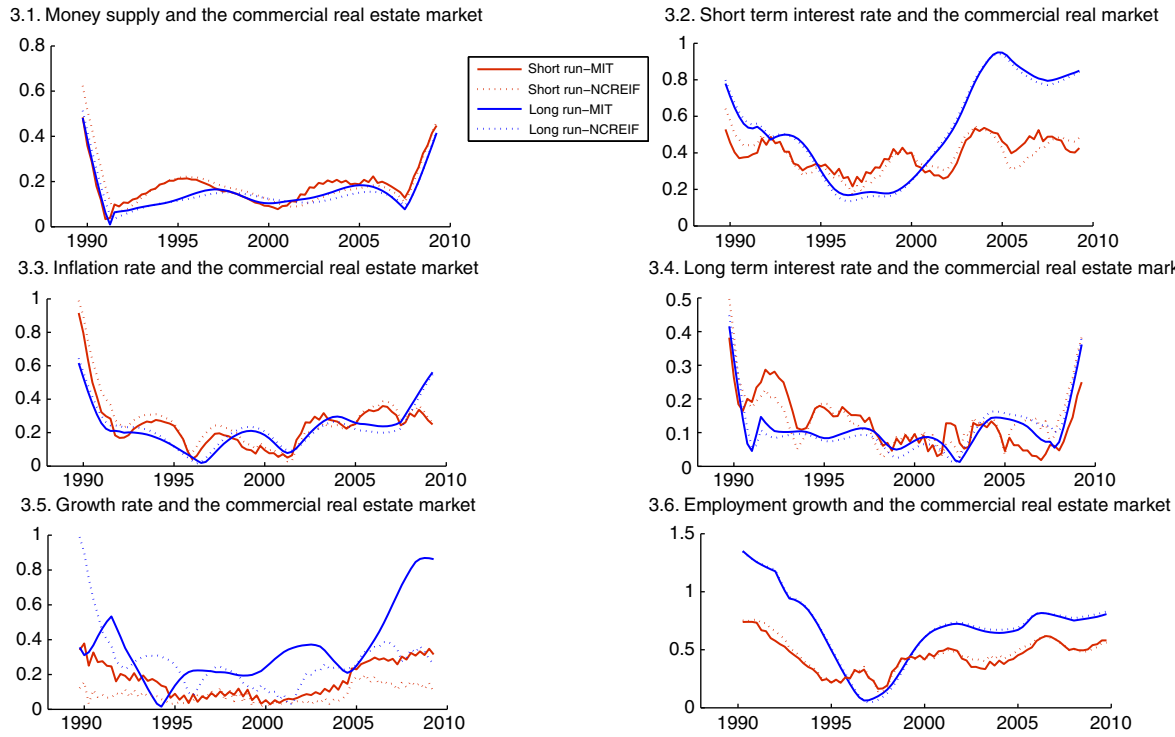

Fig. 3. Short and long run DCFs between MIT, NCREIF and macroeconomic variables.

In fact, real estate prices are considered as one of the channels of asset prices through which monetary policy affects the economy. This is achieved through their effects on the aggregate demand by means of household wealth effect and direct effect on housing expenditure (Mishkin, 2001). Our results allow us to evaluate the intensity of these effects.

Regarding the wealth channel, the real income is a driver for the real estate prices. In fact, a decreasing employment growth affects negatively the real income which decreases the purchasing power and housing affordability, this means that house price to income ratio decreases. Therefore, less spending on the housing market will be expected. On the other hand, a decreasing employment growth will generate a lower real income which reduces the accumulated household's wealth. This lowers the value of collateral and then the access for mortgages loans is reduced. Our results show that this channel had an important role in the US during recessions as the savings and loans crisis in the early 1990s and the subprime crisis in 2007, since the DCF in the US has high levels during these two crises.

In the UK, the wealth channel is also important. However, the transmission mechanism is based on economic growth rather than employment growth since the DCF shows more important levels between the real estate markets and economic growth in the UK than in the US.

The other strong channel between real estate markets and the macroeconomy is the direct effect on housing expenditure. It can be evaluated according to the high levels of the DCF in the US between real estate markets and short term interest rate during the crisis. In fact, the low interest rate that preceded the subprime crisis contributed to lower the cost of financing housing and then increases their prices. Then it becomes more profitable to build housing which increases the housing expenditure.

In addition, real estate markets in the UK and the US react differently to institutional shocks that support transparency and independence of the monetary authorities.[15] In fact, real estate markets in the UK respond by a decrease in the DCF with the inflation and money supply. In the US, we observe a decrease in the DCF with inflation and the short term interest rate. This means that in order to reduce the effects of the aforementioned macroeconomic variables for each country, the monetary authorities should improve its transparency. This decision affects the expectations of the investors and the households that will be reflected on the real estate prices. However, this can be only a short term policy.

These findings provide some insights for future research on the linkage between the direct and the indirect real estate markets and its impact on the monetary policy. Moreover, it would be interesting to conduct a regional analysis for the US real estate markets to investigate their different responses to the macroeconomic environment.

Appendix A. Evolutionary co-spectral theory: Estimation

According to Priestley (1965), a non-stationary discrete[16] process or a continuous[17] process can be written as Eq. (1). Priestley and Tong (1973) extend the theory of the evolutionary spectral analysis of Priestley (1965, 1966) to the case of a bivariate non-stationary process. In this appendix, we present this theory.

Consider, for example, a bivariate discrete parameter process $\{X(t), Y(t)\}$, in which each component is an oscillatory process. Each component can be written as follows:

$$X_t = \int_{-\infty}^{+\infty} A_{t,X}(w_1) e^{iwt} dZ_X(w_1). \quad (.1)$$

$$Y_t = \int_{-\infty}^{+\infty} A_{t,Y}(w_2) e^{iwt} dZ_Y(w_2). \quad (.2)$$

where

$$E[dZ_X(w_1)dZ_X^*(w_2)] = E[dZ_Y(w_1)dZ_Y^*(w_2)] = [dZ_X(w_1)dZ_Y^*(w_2)] = 0$$

[15] In 1997, the MPC was created in the UK and in 1995, the FOMC in the US started to declare its short term objectives.

[16] A discrete process corresponds to a process of which the value of T is countable. Indeed, a time series is considered as a discrete process.

[17] A continuous process is a process used to describe the physical signal.

for $w_1 = w_2$

$$E\left[|dZ_X(w_1)|^2\right] = d\mu_{XX}(w_1) \qquad E\left[|dZ_Y(w_1)|^2\right] = d\mu_{YY}(w_1)$$

and, $E[dZ_X(w_1)dZ_Y(w_1)] = d\mu_{XY}(w_1)$ with, [.] denoting the conjugate function of [.].

Let, F_X, F_Y denote respectively the families of oscillatory functions as: $\{\phi_{t,X}(w_1) \equiv A_{t,X}(w_1)e^{iwt}\}$, $\{\phi_{t,Y}(w_1) \equiv A_{t,Y}(w_1)e^{iwt}\}$. Priestley and Tong (1973) define the evolutionary power cross-spectrum at time t with respect to the families F_X, F_Y, $dH_{t,XY}$ by

$$dH_{t,XY} = A_{t,X}A^*_{t,Y}d\mu_{XY}(w). \tag{.3}$$

Further, if $\{X(t), Y(t)\}$ is a bivariate stationary process, so that F_X and F_Y may be chosen to be the family of complex exponentials, namely $F_x \equiv F_Y \equiv \{e^{iwt}\}$, $dH_{t,XY}(w)$ reduced to the classical definition of the cross-spectrum. Thus, for each t, we may write

$$dH_{t,XY} = E\left[A_{t,X}dZ_X(w)A^*_{t,Y}dZ^*_Y(w)\right]. \tag{.4}$$

Priestley and Tong (1973) extend the above relation to the case of a non-stationary bivariate process where the amplitudes are time-dependent; correspondingly, the cross-spectrum is also time-dependent. Clearly, $dH_{t,XY}$ is complex-valued, and, by virtue of the Cauchy–Schwarz equality, we have immediately that

$$|dH_{t,XY}|^2 \le dH_{t,XX}dH_{t,YY} : \forall t, w. \tag{.5}$$

If the measure $\mu_{XY}(w)$ is absolutely continuous with respect to the Lebesgue measure, we may write, for each t:

$$dH_{t,XY} = h_{t,XY}(w)dw \tag{.6}$$

and $h_{t,XY}(w)dw$ may then be termed the evolutionary cross-spectral density function.

A.1. Estimation of the dynamic evolutionary co-spectral density function

The evolutionary cross-spectral density function estimation, which we develop here, is proposed by Ftiti (2010). In this paper, we present only the case of discrete process.[18]

Let a non-stationary discrete bivariate process $\{X(t), Y(t)\}$ have the Gramer representation for each $-\pi \prec w \prec +\pi$

$X_t = \int_{-\pi}^{+\pi} A_{t,X}e^{iwt}dZ_X(w)$ et $Y_t = \int_{-\pi}^{+\pi} A_{t,Y}e^{iwt}dZ_Y(w)$

with

$$\begin{aligned} E[dZ_X(w_1)dZ^*_X(w_2)] &= E[dZ_Y(w_1)dZ^*_Y(w_2)] \\ &= [dZ_X(w_1)dZ^*_Y(w_2)] = 0 \end{aligned}$$

for $w_1 = w_2$

$$E\left[|dZ_X(w_1)|^2\right] = d\mu_{XX}(w_1) \qquad E\left[|dZ_Y(w_1)|^2\right] = d\mu_{YY}(w_1)$$

and, $E[dZ_X(w_1)dZ_Y(w_1)] = d\mu_{XY}(w_1)$.

By virtue of the Cauchy–Schwarz inequality, we can write that:

$|dH_{t,XY}|^2 \le dH_{t,XX}dH_{t,YY}$: for all t and w

and, $dH_{t,XY} = h_{t,XY}(w)dw$

where $h_{t,XY}$ may then be termed the evolutionary cross-spectral density function.

[18] For more details to the case of continuous process, please look Ftiti (2010), page 470–472.

The estimation of the evolutionary cross-spectral density function needs two filters. For the discrete univariate process, Priestley (1966) gives two relevant windows. These are relevant filters and they are tested by several researchers such as Ahamada (2002), Ahamada and Ben Aïssa (2004), Essaadi and Ftiti (2008) and Ftiti (2010). For the discrete bivariate process, Priestley and Tong (1973) adopt the same choice that:

$$g_u = \begin{cases} 1/\left(2\sqrt{h\pi}\right) & if\ |u| \le h \\ 0 & if\ |u| > h. \end{cases} \tag{.7}$$

Let

$$w_v = \begin{cases} 1/T' & if\ |v| \le T'/2 \\ 0 & if\ |v| > T'/2 \end{cases}. \tag{.8}$$

Then, Ftiti (2010) presents the estimation of the evolutionary cross-spectral density function as follows:

$$\hat{h}_{t,XY} = \sum_{v \in Z} w_{T'}(v)U_X(w, t-v)U_Y(w, t-v) \tag{.9}$$

with,

$$U_X(t, w) = \sum_{u \in Z} g(u)X(t-u)e^{iw(t-u)}du \tag{.10}$$

$$U_Y(t, w) = \sum_{u \in Z} g(u)Y(t-u)e^{iw(t-u)}du. \tag{.11}$$

In this paper, we take $h = 7$ and $T' = 20$. We make the same choice[19] as Artis et al. (1992), Priestley (1996), Ahamada (2002), Ahamada and Ben Aïssa (2004) and Essaadi and Ftiti (2008).

According to Priestley (1988), if we have $E\left(\hat{h}(w)\right) \approx h_t(w)$, $var\left(\hat{h}(w)\right)$ decreases when T' increases $\forall (t_1, t_2), \forall (w_1, w_2), cov\left(\hat{h}_{t1}(w_1), \hat{h}_{t1}(w_2)\right) = 0$, if at least one of the conditions (i) or (ii)[20] is satisfied.

A.2. Estimation of dynamic coherence function

According to Priestley and Tong (1973), the evolutionary cross-spectral density function may be written as:

$$h_{t,XY} = C_{t,XY} - iQ_{t,XY}(w) \tag{.12}$$

$$\begin{aligned} C_{t,XY}(w) &= R\left\{h_{XY}\left(w_j, t\right)\right\} \\ Q_{t,XY}(w) &= Im\{h_{XY}(w, t)\} \end{aligned} \tag{.13}$$

and the real-valued functions $C_{t,XY}(w)$ and $Q_{t,XY}(w)$ termed the evolutionary co-spectrum and the evolutionary quadrature spectrum, respectively. If the measures $\mu_{XX}(w)$ and $\mu_{YY}(w)$ are absolutely continuous, Priestley and Tong (1973) similarly define the evolutionary auto-spectral density functions, $h_{XX}(w_j, t)$, $h_{YY}(w_j, t)$.[21] The coherence function is defined by the following expression:

$$C_{t,XY}(w) = \frac{|h_{t,XY}(w)|}{\left\{h_{t,XX}(w)h_{t,YY}(w)\right\}^{1/2}} \tag{.14}$$

[19] This choice of values is justified by the fact that they respect the conditions (i) and (ii).

[20] $(i)|t_1 - t_2| > T', (ii)|w_1 \pm w_2| \ge \frac{\Pi}{h}$.

[21] For more details see Essaadi and Ftiti (2008).

$$= \frac{|E[dZ_Y(w)dZ^*(w)]|}{\left\{E|dZ_X(w)|^2 \quad E|dZ_Y(w)|^2\right\}^{1/2}}. \qquad (.15)$$

Priestley and Tong (1973) interpret $C_{t,XY}(w)$ as the modulus of the correlation coefficient between $dZ_X(w)$, $dZ_Y(w)$ or, more generally, as a measure of the linear relationship between corresponding components at frequency w in the processes $\{Y(t)\}$ and $\{X(t)\}$.

The estimation of the dynamic varying coherence function is based on the estimation of the dynamic cross-spectral density function between two processes $\{Y(t)\}$ and $\{X(t)\}$ (proposed by Ftiti (2010) and presented above, Eq. (.9)) and the estimation of the auto-spectral density function of each process. So, the estimation dynamic coherence can be written as follows:

$$\hat{C}_{t,XY}(w) = \frac{\left|\hat{h}_{t,XY}(w)\right|}{\left\{\hat{h}_{t,XX}(w)\hat{h}_{t,YY}(w)\right\}^{1/2}}. \qquad (.16)$$

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