House price dynamics and business cycle turning point detection.*

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Abstract

In this paper, we attempt to analyse whether house price developments can be informative with regards to predicting business cycle turning points. Employing a time-varying transition probability Markov switching framework, we provide empirical evidence that house price growth may prove a useful leading indicator for turning point detection. In focusing on three countries, the US, UK and Spain we furthermore provide evidence that although potentially informative from an overall perspective in business cycle modelling, the significance of signals contained in house prices may not be symmetric across the identified high growth and low growth states. In addition, we suggest a possible range of values for house price deflation which may trigger a recession the following period.

JEL Classification: C11,C32,G15,R31,E32

Keywords: Business cycles, leading indicators, housing, Markov switching

1 Introduction

The economic crisis that erupted in 2008 was triggered by the bursting of the US housing price bubble. This adverse shock had repercussions internationally, the result of which was a global recession comparable in scale to the Great Depression. The large impact on real economies, especially the loss in output has renewed policy makers' interest regarding the question of the sensitivity of GDP to unfavorable house price developments. Therefore, understanding the relationship between housing markets and the business cycles is becoming increasingly intertwined with macroeconomic

*The opinions expressed are not necessarily those of the Banque de France or the Eurosystem. We are grateful to Frédérique Bec, Claude Lopez, Laurent Ferrara, Olivier de Bandt and Jean-Pierre Villetelle for helpful suggestions and comments. All errors are our own.

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policy formulation. Depending on the phase of the business cycle an economy moving through, policy measures may either be preemptive, i.e. maintaining economic stability and avoiding collapses into recessions; or those aimed at pulling an economy out of recession.

Indeed, historically housing market downturns have usually proceeded in tandem with long lasting recessions. Policy makers attempt to derive signals contained in housing market dynamics to inform on the future direction of the economy. The inherent belief being that there is predictive value of doing so. In this vein, there is now a vast amount of empirical literature considering the relationship between features of the housing markets and GDP growth cycles. Leamer (2007) goes as far as advocating that for the US, housing *is* the business cycle. This he owes to his findings that developments in the housing sector actually lead economic activity.[1] Similar evidence highlighting the leading nature of housing market cycles with respect to business cycles have been put forth by Álvarez et al. (2009) for the Euro area, Ferrara and Vigna (2009) for France and most recently by Álvarez and Cabrero (2010) for Spain.[2]

More generally, monitoring of asset price fluctuations is of great importance for central banks with regards to formulation and assessment of monetary policy.[3] A major debate currently is the manner in which monetary policy should respond to these fluctuations given the belief that extreme deviations of asset prices from fundamentals to the pose a risk for future instability; see for example, Bordo and Jeanne (2002), Borio and Lowe (2002) and Cecchetti et al. (2000). Amongst the set of asset prices, house prices are perhaps the most scrutinized and subject to regular assessment owing to the major role played by the housing sector in overall economic output. The housing market's role in the transmission of monetary policy has been considered *inter alia* by Iacovello (2005), Miskin (2007) and Muellbauer and Murphy (2008).

In view of its rapidly growing importance for monetary authorities, our aim in this paper will broadly be on investigating the role house prices could potentially play in modelling the business cycle and assessing predictive ability of house price fluctuations. More specifically, we attempt understand the influence house price developments (real house price growth) may have in shifting an economy between high growth (expansion) and low growth (recession) states; in addition to gauging its influence on the dynamics of the economy within states. This we consider to be an relevant issue since it is reasonable to expect that signals contained in house prices

[1]Leamer (2007) claims that eight out of ten US post-war recessions have been preceded by substantial problems in housing and consumer durables. He also proposes a monetary policy based on features of the housing sector such as housing starts as opposed to output gap.

[2]These studies consider the cyclical features of a variety of housing market indicators such as housing starts, housing permits and amount of residential investement.

[3]Issues regarding housing market dynamics and macroeconomic policy have been also been addessed by, for example, Vargas-Silva (2007), Muellbauer and Murphy (2008) and Goodhart and Hofmann (2008).

may not be symmetric over the course of a business cycle.[4] Therefore, understanding the way in which information encapsulated in house prices influences business cycle dynamics at the different states of the business cycle is essential in order to formulate appropriate policy corresponding to the different states. To this end we would essentially proceed to jointly model the cyclical feature real GDP growth as a function of real house price growth.

The econometric methodology employed in this paper is new relative with those used thus far in the empirical literature investigating the housing-business cycle relationship. The seminal work of Hamilton (1989, 1990) models the business cycle using a Markov switching autoregressive framework and imposes fixed transition probabilities (FTP) governing the move between business cycle states, i.e. expansion (high growth) and recession (low growth) of real GDP. We adopt a variant of this approach which was put forth by Filardo (1994) which allows for time-varying transition probabilities (TVTP) in a Markov switching autoregressive model. The transition probabilities are modelled as functions of certain conditioning variables, which could be economic or financial variables conjectured to be leading indicators useful for informing on business cycle turning points. In contrast to the FTP setting the transition probabilities are allowed to vary before, during and after a turning point given movements in the conditioning variables. This aspect of TVTP models is attractive in describing business cycle asymmetries and aiding the prediction of a switch in state brought about by movements in potential 'leading indicators' (in our case real house price growth).[5] From our perspective, the benefit of employing the TVTP methodology is that whilst modelling the interaction of house price dynamics and business cycle in unified setting it allows the flexibility to investigate possibly asymmetric relationships between the two at different states of the business cycle. Furthermore, the structure provided is attractive in studying the potential risk of falling into a recession given a collapse in house price; for instance.

We shall restrict ourselves for the purpose of this analysis to three countries, namely the United States, United Kingdom (henceforth referred to as US and UK respectively) and Spain. The choice of these countries can be motivated as follows. The most recent episode of recession was evidently rooted in the bursting of the US housing market bubble as we witnessed the unraveling of the Sub-Prime Crisis 2008/2009 (see Reinhart and Rogoff, 2008). Following the US other countries also found themselves in a situation of housing market collapse. In terms of international economic influence, UK and Spain are the most prominent countries amongst those,

[4] A key aspect within the context of business cycle research is modelling the asymmetric nature of the business cycle; which is a widely documented, stylized fact in the economics literature. The transitions between periods of high and low growth are marked by differing sharpness of turning points, expansions appear to be more persistent than contractions and their duration varies across time. For a more technical overview regarding the features of business cycle asymmetries see Sichel (1993), McQueen and Thorley (1993) and Clements and Krolzig (2003).

[5] TVTP models have been used in a variety of other contexts; e.g. Gray (1996) considers interest rate dynamics and Deibold et al. (1994) and Engel and Hakkio (1994) study exchange rates.

also in terms of severity of recession faced (see Jannsen, 2009). Additionally, given that this analysis is not just confined to period covering the most recent recession, we feel the choice of countries provides an interesting variety with regards to GDP dynamics. The UK is thought, for the most part, to be sandwiched in terms of synchronization between the European and US business cycles whereas Spain is typically considered a reference country for the Euro area business cycle.

The plan of this paper is as follows. Section 2 presents the methodology and describes the data. Section 3 provides estimates and interpretation. Section 4 considers some predictions regarding house price "bubble " bursting and Section 5 concludes.

2 Methodology

We are interested in examining the cyclical features of real GDP growth, y_t, $t = 1, ..., T$. Allowing for state-dependent means the prototypical TVTP probability Markov switching model, provided in Filardo (1994) can be described as below (see also Filardo and Gordon,1998 and Layton and Smith, 2007);

$$\begin{aligned} y_t &= \mu^0 + \Phi(L)(y_{t-1} - \mu^{S_{t-1}}) + \epsilon_t \text{ in state 0} \\ &= \mu^1 + \Phi(L)(y_{t-1} - \mu^{S_{t-1}}) + \epsilon_t \text{ in state 1} \end{aligned} \quad (1)$$

Here $\Phi(L) = \delta_1 + \delta_2 L + ... + \delta_d L^{d-1}$ is a lag polynomial, $\epsilon_t \backsim IIDN(0, \sigma^2)$, and $S_t \in \{0, 1\}$; thus the state-dependent mean $\mu^{S_t} = \mu^0 + \mu^1 S_t$. The state variable S_t is governed by a hidden 2-state Markov-chain with transition probability matrix, $P(S_t = s_t | S_{t-1} = s_{t-1}, \mathbf{h_t})$

$$= \mathbf{\Pi} = \begin{bmatrix} p(\mathbf{h_t}) & 1 - p(\mathbf{h_t}) \\ 1 - q(\mathbf{h_t}) & q(\mathbf{h_t}) \end{bmatrix}, \quad (2)$$

where $\mathbf{h_t} = \{h_t, h_{t-1}, ...\}$ is the history of the conditioning (leading indicator) variable(s) conjectured to be informative with regards to detecting of business cycle turning points. The choice of functional form of $q(\bullet)$ and $p(\bullet)$ is typically probit or logistic type. For the purpose of this analysis we shall deal with the latter, thus the relevant logisitic function will take the form,

$$p(\mathbf{h}_t) = \frac{\exp(\theta_{p0} + \Sigma_{m=1}^{M_1} \theta_{pm} h_{t-m})}{1 + \exp(\theta_{p0} + \Sigma_{m=1}^{M} \theta_{pm} h_{t-m})},$$

and similarly,

$$q(\mathbf{h}_t) = \frac{\exp(\theta_{q0} + \Sigma_{m=1}^{M_2} \theta_{qm} h_{t-m})}{1 + \exp(\theta_{q0} + \Sigma_{m=1}^{M_2} \theta_{qm} h_{t-m})}.$$

The model can be cast as a conditional-joint density $g(\bullet)$ written as,

$$\begin{aligned} g(y_t | y_{t-1}, ..., y_{t-d}, \mathbf{h_t}) = \textstyle\sum_{s_t=0}^{1} ... \sum_{s_{t-d}=0}^{1} \widehat{g}(y_t | S_t = s_t, ..., S_{t-d} = s_{t-d}, y_{t-1}, ..., y_{t-d}) \\ \times P(S_t = s_t | S_{t-1} = s_{t-1}, \mathbf{h_t}) \\ \times P(S_{t-1} = s_{t-1}, ..., S_{t-d} = s_{t-d} | y_{t-1}, ..., y_{t-d}, \mathbf{h_{t-1}}), \end{aligned} \quad (3)$$

and correspondingly the log-likelihood is given by,

$$L(\theta) = \sum_{t=1}^{T} \ln[g(y_t|y_{t-1}, ..., y_{t-d}, \mathbf{h_t}; \boldsymbol{\theta})]. \quad (4)$$

Here $\boldsymbol{\theta}$ denotes the parameter vector. $g(y_t|y_{t-1}, ..., y_{t-d}, \mathbf{h_t})$ makes explicit the link between the conditioning variables contained in $\mathbf{h_t}$ with regards to how they feature in the inferential procedure for a Markov switching model for series y_t via the transition probabilities. Estimation is carried out via maximum likelihood (ML) methods adapted for mixtures of normals. This is naturally facilitated given the structure of the model as in (1) and (2) and functional form for the transition probabilities (3) such that $q(\mathbf{h_t}), p(\mathbf{h_t}) \longrightarrow (0, 1)$ guarantees a well-defined log-likelihood function.

The ML approach has advantages over competing estimation strategies for TVTP models. Notwithstanding its computational ease it may be preferable over estimation via EM algorithm put forth by Diebold, Lee and Weinbach (1994) where it is generally difficult to implement the maximization step in the presence of AR dynamics. On the other hand Filardo and Gordon (1998) work with a Gibbs sampling approach which may be feasible in the context of this variety of model. Although a tractable approach, in practice we may require very tight priors for estimation, an aspect which we perceive as being perhaps more difficult to justify for purposes of a cross country-type analysis (see also Albert and Chib, 1992).

Indeed if there is no statistically meaningful information with regards to evolution of the state of the economy contained in $\mathbf{h_t}$, then the specification tends to a fixed transition probability (FTP) model (see Hamilton, 1989); more specifically, when the restrictions on coefficients corresponding to the conditioning variables $\theta_{pi} = \theta_{qi} = 0$ for $i \neq 0$ are upheld. Formally, under the null of non time-varying transition probabilities the likelihood ratio test statistic is given by,

$$\Xi = 2 \times [L(\boldsymbol{\theta}) - L_R(\boldsymbol{\theta})] \backsim \chi^2_{(M_1+M_2),\alpha} \quad (5)$$

where $L_R(\boldsymbol{\theta})$ is the restricted log-likelihood, $M_1 + M_2$ are the number of restrictions on the test at significance level of α. This can be perceived as a test of the informativeness of the economic indicator variables in modelling and/or predicting business cycle turning points. Furthermore, the likelihood ratio test can also be implemented in order to choose between alternative lag specifications for the conditioning variable, i.e. to test if there is significant information contained in additional lags.

In regards to being able to invoke classical likelihood theory, Kiefer (1978) demonstrated that in the case of an i.i.d. switching model the solution to the likelihood equations yields estimators which are consistent, asymptotically efficient and normal. Furthermore the inverse of the negative of the Hessian at the estimate is consistent estimator of the asymptotic variance-covariance matrix of parameter values. Under the assumption that functions of the restrictions are twice differentiable around the true parameters and the gradient of the function is of full rank in the neighbourhood

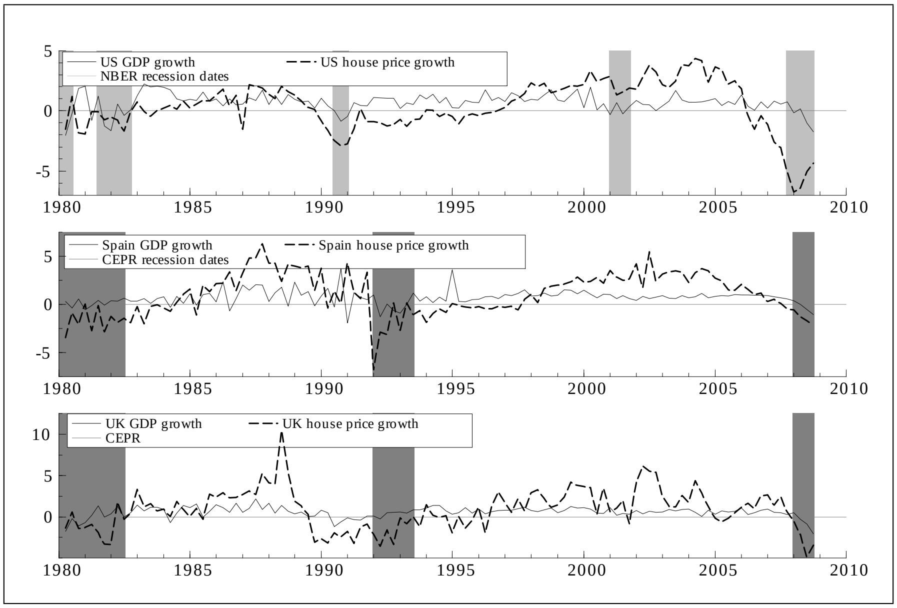

Figure 1: *Quarterly real GDP growth and quarterly real house price growth over the period 1980 (Q2) to 2008 (Q4). Shaded areas depict NBER or CEPR recession dates.*

of the true parameters, standard likelihood ratio tests of restrictions are valid. This rank condition can be violated due to the presence of a single data point representing a single regime. In such case we may attain a singularity in the likelihood; i.e. the variance may be zero, thus not fall within the permitted parameter space, yielding an unbounded likelihood and inconsistent parameter estimates. One particular way of circumventing this possibility is to model the variance to be constant across regimes; this is what was proposed in Hamilton (1989), followed in Filardo (1994) and what we shall maintain for the purpose of this analysis.[6]

2.1 Data

We employ quarterly real GDP growth rate (%) for the US, UK and Spain for the period 1980 (Q2) to 2008 (Q4).[7] Our economic indicator/conditioning variable $\mathbf{h_t}$ is quarterly real house price growth rate (%) for all the aforementioned countries over the same time span.[8]We use data on house prices was constructed by de Bandt, Barhoumi

[6]This assumption may not be inconsistent with the quarterly frequency of data we employ in this analysis. We refer the reader to Kiefer (1980), Phillips (1991) and Caudill and Acharya (1998) for further discussion about suggestions to deal with this issue.

[7]Source: OECD.

[8]In what follows house prices will always be taken to mean real house prices unless stated otherwise.

and Bruneau (2010). Housing markets across countries can be difficult to compare. Indeed, house price indices themselves are generally available with a substantial delay but moreover, given heterogeneity in the structure of markets there is evidently a lack of harmonized indices across countries. In view of this one should acknowledge, however, the compilation of data on house prices that has been undertaken by the BIS, the OECD and one underway by Eurostat. de Bandt et al. (2010) partially rely on data obtained from these institutions which they found to be consistent with the data assembled by the OECD for the period starting in 1980. Hence we focus on the period 1980 onwards for which data on house prices can be considered most reliable.

	US	UK	Spain
Mean	0.365	0.928	1.011
Standard deviation	2.081	2.452	2.237
Maximum	4.372	10.40	6.321
Minimum	-6.721	-5.001	-6.803

Table 1: *Descriptive statistics for quarterly real house price growth series; period 1980 (Q2) to 2008 (Q4).*

The real data series were constructed by deflating by the country-specific consumer price index based at 2005 prices. All series are seasonally adjusted. For comparison we also utilize the NBER and CEPR recession dates. The data are illustrated in Figure 1. Visual inspection reveals some evidence that the declining trend in house price growth has been witnessed prior to a downturn in GDP growth. Figure 2 illustrates some distributional aspects of house price growth across the three countries and how the series have tended to evolve over the span. The cascade effect of the 2008/2009 US housing market collapse is evident with the downturn in Spain and the UK housing markets following approximately the same time. The histograms suggest that the data are indeed unimodal following a seemingly normal distribution. Some descriptive statistics for house price growth are provided in Table 1. These suggest that Spain has the highest mean growth rate over the period followed closely by the UK and then US whereas the sample standard deviations appear roughly similar.[9]

3 Estimates and interpretation

We now describe briefly some notation before proceeding to the results. We consider a 2-state Markov switching autoregressive model for GDP growth in which one state is intended to capture the recession periods. In the terminology of Filardo (1994) we refer to this as a "low growth" state. This should, *a priori*, correspond to the

[9] Sample skewness measures reveal that the data on US and Spain is negatively skewed with values of -0.77 and -0.26 respectively whereas postively skewed in the case of UK, i.e. 0.34.

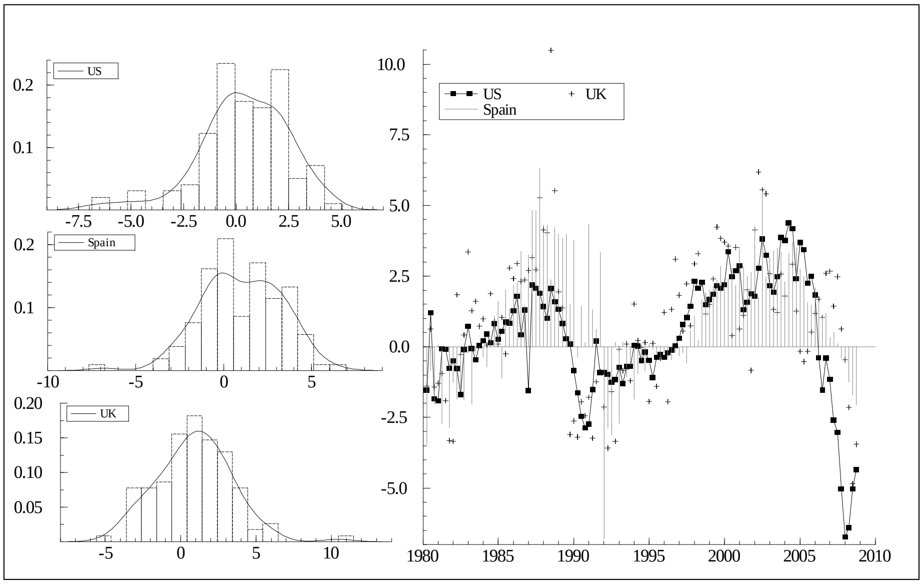

Figure 2: *Left: Histograms and kernel density estimates of real house price growth. Right: Comparison of real house price growth across countries; period 1980 (Q2) to 2008 (Q4).*

case of a statistically significant negative value of μ_0. We label the second state as a "high growth " in which the mean growth rate of GDP is positive and this should be captured by the finding of a statistically positive coefficient $\mu_1 + \mu_0$. The TVTP parameters $\{\theta_{p_0}, \theta_{p_1}, \theta_{p_2}\}$ and $\{\theta_{q_0}, \theta_{q_2}, \theta_{q_2}\}$ govern the dynamics of to the transition probabilities $p(\mathbf{h_t})$ (low growth state) and $q(\mathbf{h_t})$ (high growth state) respectively. In what follows we shall comment on models with one and two lags for the conditioning variable, i.e. $\mathbf{h_t} = \{h_{t-1}\}$.[10] Moreover, the transition probabilities in (2) imply the following;

$$\begin{cases} p(\mathbf{h_t}) & \text{:low growth state at } t \mid \text{low growth state at } t-1, \mathbf{h_t}. \\ q(\mathbf{h_t}) & \text{:high growth state at } t \mid \text{high growth state at } t-1, \mathbf{h_t}. \\ 1-p(\mathbf{h_t}) & \text{:high growth state at } t \mid \text{low growth state at } t-1, \mathbf{h_t}. \\ 1-q(\mathbf{h_t}) & \text{:low growth state at } t \mid \text{high growth state at } t-1, \mathbf{h_t}. \end{cases} \tag{6}$$

Indeed, any movements in the transition probabilities will be brought about by variation in the house price growth. We also examine whether the estimated TVTP models significantly improves over a corresponding (nested) FTP model by conducting a likelihood ratio test under the null of non time-varying transition probabilities described in the previous section. This is essentially in order to gauge the impact of

[10] For the given analysis we found all lags above two quarters not to be statistically significant and thus not informative about forthcoming turning points in the business cycle. We considered specifications with up to and including five lags for house price growth.

the loss of information provided by the house price variable in modelling the business cycle. Finally, we test for the presence of autocorrelation in the expected residuals as a test for the statistical specification of our models. Furthermore in order to ascertain the economic validity of the models we set a benchmark by which we require the estimated TVTP models to adequately correspond to the NBER or CEPR recession dates.[11] The model estimates are provided in Table 2 below.[12]

3.1 The case of the US

We shall now proceed to comment upon the estimated results for the individual countries. Columns (1) through (3) in Table 2 list the estimates for the TVTP model and for the FTP model with respectively one and two lags for the house price growth. We find significantly negative μ_0 and positive $\mu_1 + \mu_0$ estimates which correspond to the assertion of distinct low growth and high growth regimes. The results of the likelihood ratio test suggests that we can reject (albeit marginally) the null of non-time varying transition probabilities. This provides evidence that the TVTP model is preferred over the FTP; but more specifically that there is useful informational content contained within the house price growth to inform upon business cycle turning points. This is evident from Figure 4 in the Appendix which indicates that the TVTP model not only adequately captures the NBER recession chronology, but more strikingly (given the span considered and frequency of data used) detects NBER turning points remarkably better than the nested FTP specification.

[11] We are aware that the CEPR is representative of the Euro area aggregate business cycle; but is the nearest option available with regards to a chronology of Spanish and UK recession dates.

[12] All the models incorporate autoregressive coefficients ($\delta_i,\ i = 1, ..., d$) which are not state-dependent. The choice for the lags is one that satisfies the mispecification test on the expected residuals. Basically, the expected residuals are constructed as the weighted average of residuals in each state (low-growth and high-growth); i.e. weighted by the posterior probabilities of being in one state or the other. In the results that follow, we compute the Ljung-Box statistic to test for the presence of autocorrelation in the residuals up to the fourth-order.

	United States			United Kingdom			Spain		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Parameter	FTP	$\{h_{t-1}\}$	$\{h_{t-1}, h_{t-2}\}$	FTP	$\{h_{t-1}\}$	$\{h_{t-1}, h_{t-2}\}$	FTP	$\{h_{t-1}\}$	$\{h_{t-1}, h_{t-2}\}$
μ_0	-0.55	-0.55	-0.57	-1.38	-0.87	-0.839	0.954	-0.206	-1.05
	(-3.23)	(-2.93)	(-3.80)	(-3.97)	(-4.13)	(-4.16)	(14.14)	(-0.88)	(-4.45)
$\mu_1 + \mu_0$	0.76	0.747	0.758	0.789	0.836	0.84	0.181	0.929	0.85
	(13.73)	(13.26)	(13.12)	(10.23)	(11.82)	(11.86)	(1.47)	(14.43)	(17.09)
θ_{p_0}	1.571	3.346	-0.818	0.308	-1.44	-2.69	3.24	-1.32	4.66
	(1.739)	(1.27)	(-0.92)	(0.26)	(-1.02)	(-0.86)	(5.14)	(-0.87)	(1.22)
θ_{p_1}		-0.561	-0.481		-0.806	-4.42		-1.32	2.382
		(0.639)	(-0.849)		(-1.29)	(-1.08)		(-1.44)	(1.24)
θ_{p_2}			-0.793			2.90			0.06
			(-1.20)			(1.01)			(0.08)
θ_{q_0}	3.678	5.486	3.41	3.502	3.97	3.89	2.72	2.05	6.54
	(5.11)	(5.63)	(4.02)	(5.78)	(4.02)	(4.19)	(3.15)	(2.03)	(2.13)
θ_{q_1}		1.327	0.456		1.246	1.02		1.625	3.33
		(2.674)	(1.176)		(2.43)	(1.51)		(1.88)	(1.68)
θ_{q_2}			0.155			0.313			0.53
			(0.784)			(0.42)			(0.25)
Ξ		4.49	5.57		10.25	12.53		12.74	9.84
p-value		0.07	0.233		0.006	0.014		0.0047	0.04
Ξ_1			2.28			0.88			90.0
p-value			0.319			0.65			0.00
Diagnostics-Autocorrelation tests on expected residuals									
One lag	1.651	0.851	0.331	4.001	2.764	2.68	0.113	0.113	0.769
p-value	0.198	0.356	0.564	0.045	0.09	0.10	0.736	0.736	0.38
Four lags	8.298	7.06	5.73	7.368	7.78	6.74	5.931	5.93	9.05
p-value	0.081	0.132	0.219	0.11	0.09	0.15	0.204	0.204	0.06

Table 2: *Parameter estimates for FTP and TVTP models. The t-statistics are given in the paranthesis ( ). Ξ : Likelihood ratio test statistic under the null of non time varying transition probabilities. Ξ_1 : Likelihood ratio test statistic comparing between one lag and two lag specifications for the conditioning variable in the TVTP model. Significance level α for likelihood ratio tests is 5%.*

In column (2) the TVTP coefficients θ_{p_1} and θ_{q_1} have opposite signs which imply the transition probabilities will also move in opposite direction given variations in $\{h_{t-1}\}$ or $\{h_{t-1,}h_{t-2}\}$. A negative sign of θ_{p_1} indicates that a higher growth rate of housing prices reduces the probability that the economy will evolve in the following quarter to a low growth state. Conversely, the positive sign of θ_{q_1} means that an increase in house prices increases the probability of a high growth state for the economy next quarter. This accords with the intuition and is still true when we consider two lags for the house price growth.

Indeed, none of the estimated coefficients θ_{p_1}, $\theta_{q_1}, \theta_{p_2}$ and θ_{q_2} in column (3) are statistically significant. Moreover, the likelihood ratio statistic Ξ_1 in choosing between the one lag and two lag specifications indicates that there is no significant information contained at lag two for the conditioning variable. As a consequence it is suggested that the house price growth can be considered as a leading indicator of the US business cycle at one quarter only.

However, one important feature is the relative importance of the information conveyed by the housing variable for the high growth and low growth states. As is evident from column (2), the coefficient θ_{p_1} is not statistically significant, while θ_{q_1} is significant. We suggest that this can be viewed as evidence that developments in the US real house prices are relatively uninformative regarding the transitional dynamics of the economy during a low growth state and/or shifting from a low growth to a high growth state.

3.2 UK and Spain

The interpretations of the estimated coefficients are similar to the case of the US. The TVTP models detects two regimes in the business cycles with opposite signs for the means μ_0 and $\mu_1 + \mu_0$. Regarding the likelihood ratio tests, the TVTP incorporating information contained in lagged house price growth outperforms the FTP model. As in the case of the US, specifications with one lag for house price growth are supported by the data for the case of the UK whereas in the case of Spain there is evidence of significant information contained in the two lag specification. We ruled out the two lag specification for Spain on grounds of economic observation. It was found that the relevant smooth probabilities with one lag specification corresponded relatively better to the CEPR recession dates with the smooth probabilities generated for the latter we found to be unjustifiably spiky. The models for both countries detect adequately the CEPR recession periods; see Figures 5 and 6 in the Appendix.

Moreover, similar to the case of the US we again find evidence of an asymmetric significance of the information conveyed by house price developments on the states of business cycle for these two countries. Fluctuations in the house prices are not informative of the changes observed in the states of low growth of the business cycle. This is evident from the estimates in column (5) for the UK and column (8) for Spain; the coefficient θ_{p_1} is negative but not statistically significant whereas θ_{q_1} is positive and significant for both countries.

Lastly, autocorrelation diagnostic tests reveal that the specifications chosen also generate well-behaved expected residuals in the case of all three countries.

3.2.1 Similarity across countries

It is found from the analysis thus far that there is a similarity across the three countries considered with regards to asymmetric significance of information contained in house prices conveyed at two states of the business cycle. We find evidence of statistical significance of parameters constituting $q(\mathbf{h_t})$ but not those constituting $p(\mathbf{h_t})$. [13]It appears that house price growth has a discernible effect on the dynamics of the economy in the high growth state; evidence of its effect in a low growth state is less compelling.

4 If the bubble bursts?

Given the unprecedented scale of house price booms in recent years many observers such as the IMF, BIS and OECD have expressed concerns regarding the dangers of subsequent corrections given the view that the prices have overshot levels justified by fundamentals. This can suggestive of the housing market being potentially characterized what may be defined as 'bubble' behaviour (see Miles and Pillonca, 2008 and Muellbauer and Murphy, 2008). Moreover, the prospect that housing markets are not efficient and systematic mispricing may persist has been studied by Stein (1995) and Abraham and Hendershott (1996).[14]

Given the statistically significant parameter estimates of θ_{q0} and θ_{q_1} for the TVTP models when $\mathbf{h_t} = \{h_{t-1}\}$ for the three countries, we attempt to gauge what maximum magnitude of decline of house price growth within one quarter would be required to shift the system into a low growth state the following quarter with near certainty. Figure 3 below traces the transition probability function of shifting from a high growth state to a low growth state next quarter; i.e. $f(\mathbf{H}) = \{1 - q(\mathbf{H}; \theta_{q0}, \theta_{q_1})\}$ where the grid of values for house price growth (%), $\mathbf{H} \in [-9, 10]$. Consistent with intuition, the higher the level of house price growth the lower the probability that the economy will fall into a recession/low growth state the next period. The more interesting feature is the difference rate of decline of this probability profile across the considered countries.

At a growth rate of between 0% to +2% in house prices, the probability that any of the three economies fall into a recession the following quarter close to zero. Starting from a growth rate of 0% consider a sharp drop in this number within a single quarter, which we consider comparable to "bubble bursting". The model predicts that a drop to, what we term a 'trigger value' of −2%, will increases the probability of the Spanish economy falling into a low growth state (recession) next quarter to near certainty. In comparison we would require a relatively more extreme drop to a trigger

[13]Statistical significance of parameters is assessed with respect to both a 5% critical level (1.96) and 10% (1.65). The results are even more compelling at a 10% critical level. The asymmetric significance results decisively holds. This is more true for the case of Spain where we find somewhat weaker evidence with respect to a 5% significance level; stronger at 10%.

[14]For instance, amongst the forces that have been at work during the recent years leading up to the downturn, housing finance has been incriminated as a major factor causing the misalignment/overvaluation of house prices. This has highlighted the need for reinforcing the supervision and regulatory frameworks in order to discourage risk-taking behaviour; see for example, Igan et al. (2009) and Wagner (2010).

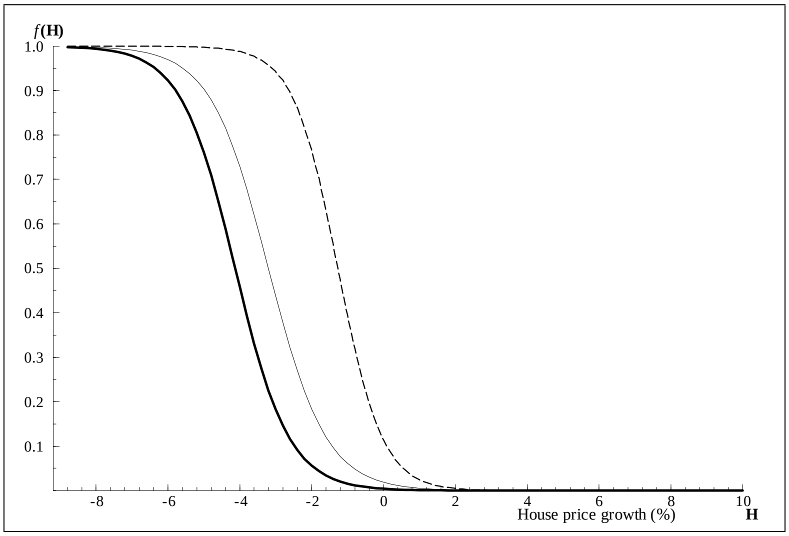

Figure 3: *Transition probability function of the economy of moving from a high growth state to a low growth state. Thick line: US, thin line: UK and dashed line: Spain.* **H**: *House price growth 'trigger value'.*

value of around -7% for the UK and US to be in the region of the same transition probability.

The argument presented in this exercise needs to be tempered by the fact that a drop to the sort of trigger values indicated may generally be spread over multiple periods as opposed to a single quarter with the transition probability accumulating over time. The aim here was to provide an illustration of the sensitivity of each of the three economies to a potential worst case scenario for house prices within a single quarter. In stating this we should also point out these sort of trigger values are not entirely infeasible recalling the descriptive statistics presented in Table 1; where over the span considered the minimum 'outlier' values of house price growth reached were -6.7, -5 and -6.8 for the US, UK and Spain respectively.

5 Conclusion

The analysis in this paper suggests that the house price variable can provide significant informational content in modelling business cycles. Moreover, evidence suggests that the significance of information contained in house price developments is asymmetric across identified high growth and low growth states. It can provide useful information about the dynamics of the economy during a high growth state, and correspondingly allow us to make some claims regarding the probability of transition into a low growth state the following period. In contrast, fluctuations in house prices during a recessionary state may not provide any substantive signal with regards to predicting the state of the economy the following quarter. In other words, a house price collapse may drag the economy down with it, but evidence whether it can pull it back up is less compelling. The tentative policy implication of this is that conditional on being in a recession, it is less clear that any attempt at resurrection of the housing market via stimulus packages, for example, may bring about a recovery. Furthermore, we find that relative to US and UK, a smaller negative growth of house prices in Spain corresponds to a substantially higher risk of falling into the low growth state next quarter.

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Appendix

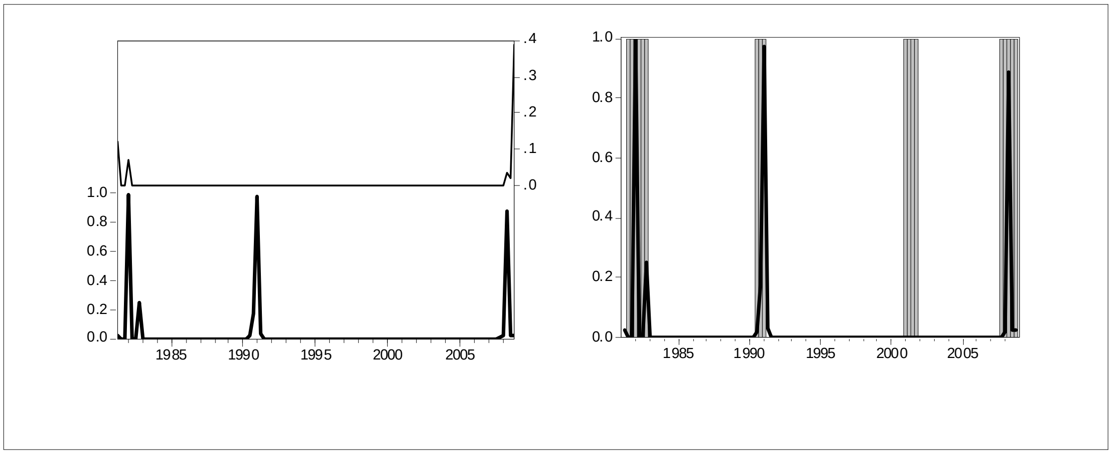

Figure 4: *US. Left panel-Thin line: Smooth probability of low growth state generated by the FTP model. Thick line: Corresponding smooth probability generated by the TVTP model with* $\mathbf{h_t} = \{h_{t-1}\}$*. Right panel: Shaded area depicting NBER recession dates superimposed on the smooth probability of being in low growth state generated by the TVTP model.*

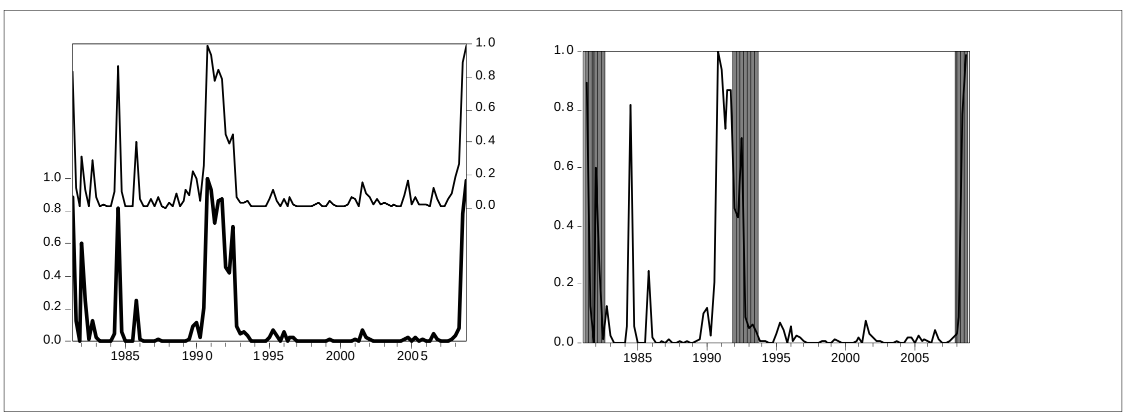

Figure 5: *UK. Left panel-Thin line: Smooth probability of low growth state generated by the FTP model. Thick line: Corresponding smooth probability generated by the TVTP model with* $\mathbf{h_t} = \{h_{t-1}\}$*. Right panel: Shaded area depicting CEPR recession dates superimposed on the smooth probability of being in low growth state generated by the TVTP model.*

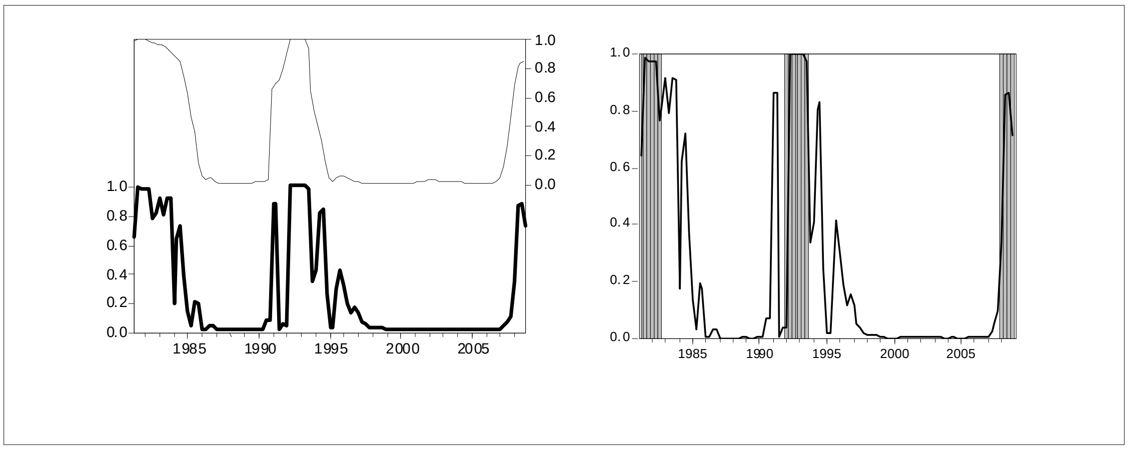

Figure 6: Spain. *Left panel-Thin line: Smooth probability of low growth state generated by the FTP model. Thick line: Corresponding smooth probability generated by the TVTP model with* $\mathbf{h_t} = \{h_{t-1}\}$. *Right panel: Shaded area depicting CEPR recession dates superimposed on the smooth probability of being in low growth state generated by the TVTP model.*