University of Pretoria
Department of Economics Working Paper Series

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Working Paper: 2021-02
January 2021

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Uncertainty and Predictability of Real Housing Returns in the United Kingdom: A Regional Analysis

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Abstract: The predictability of uncertainty for real housing returns in the United Kingdom is examined using regional data covering twelve (12) regions namely East Midlands, East of England, London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands, Yorkshire and the Humber. We utilize both housing policy uncertainty (HPU) and economic policy uncertainty (EPU) data while we render analyses for three data samples – full sample and two sub-samples covering the periods before and after the emergence of global financial crisis (GFC). Relying on a predictive model that accounts for the salient characteristics of the data, we find a negative relationship between HPU and real housing returns, on the average, regardless of the region analysed. Also, the model that accounts for HPU outperforms the benchmark model that ignores it while controlling for relevant covariates further improves the forecast performance. Additional analyses involving the EPU measure depict lower predictive contents for house price movements relative to the HPU measure and therefore using sector-specific uncertainty measure is crucial for more precise forecasts of real housing returns.

JEL Codes: C32, C53, R31
Keywords: Real Housing Returns, Economic Policy Uncertainty, United Kingdom, Predictability, Forecast Evaluation

1. Introduction

In the wake of the global financial crisis, which, as pointed out by Leamer (2007, 2015), had its roots in the turmoil surrounding the housing market of the United States (US), before engulfing the world economy (Hirata et al., 2013), a burgeoning number of studies (see for example, Antonakakis et al., 2015, 2016; El Montasser et al., 2016; Su et al., 2016; André et al., 2017; Christou et al., 2017, 2019; Aye, 2018; Chow et al., 2018; Christidou and Fountas, 2018; Aye et al., 2019; Aye and Gupta, 2019; Choudhry, 2020; Nguyen Thanh et al., 2020; Strobel et al., 2020; Gupta et al., forthcoming) have highlighted the effect of uncertainty on international house price movements.

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These studies outline multiple channels through which uncertainty can affect the housing market: First, increased uncertainty about the demand for housing or the cost of financing can cause developers to postpone new construction, thus reducing supply, due to concerns surrounding the irreversibility of investment decisions. Second, increased uncertainty about future employment, income and wealth might cause households to postpone the home-buying decision, and instead increase precautionary savings. Third, when uncertainty about employment and income raises the probability of default on the mortgage, lenders might reduce or deny mortgages to risker borrowers. Taken together, these decisions in response to uncertainty can cause a decline in demand and prices in the housing markets, unless demand for other assets is more sensitive to uncertainty. Fourth, given that the user cost of housing is equal to the sum of the depreciation rate of the dwelling, g the maintenance and repair costs as a fraction of the current value, the marginal income tax rate, the nominal interest rate, the property tax rate, and the expected nominal housing price inflation rate, the last component is likely to be influenced by uncertainty surrounding any determinant of housing price, including income, interest and tax rates, and housing market regulations, among others. Therefore, it is not surprising to expect an empirical link between uncertainty and housing returns, and as depicted by the above-mentioned works, the effect is generally negative, with uncertainty being characterized as an adverse demand shock.

While these studies are of tremendous importance in deducing the uncertainty-housing returns link empirically, these primarily being in-sample analyses (barring André et al., (2017), Christou et al., (2017), Gupta et al., (forthcoming), which forecasts aggregate and state-level housing returns of the US, and that of a panel of Organisation for Economic Co-operation and Development (OECD) countries based on aggregate uncertainty), is to some degree of limited value to policymakers and investors looking to make real-time decisions, for which they require out-of-sample forecasts. Furthermore, in-sample predictability does not guarantee out-of-sample forecasting gains, and at the same time, the best evaluation of predictors and econometric frameworks is obtained from out-of-sample, rather than in-sample exercises (Campbell & Thompson, 2008). In light of this, the objective of our current study is to analyse the role of uncertainty, and in particular the same associated with the housing market, in forecasting real housing returns of the overall and 12 regions of the United Kingdom (UK), after controlling for other standard macroeconomic and financial predictors, as well as aggregate economic uncertainty. The decision to choose the UK, is primarily driven by the availability of recent data on housing

policy uncertainty (HPU) in the public domain.[1] Besides, our sample period primarily focusses on 1998Q1 to 2019Q2 (with an extended analysis also delving into 1983Q1 to 2019Q2), which not only includes several business cycles, the global financial and European sovereign debt crises, but also (the recently concluded) Brexit process, and hence studying the role of uncertainty in forecasting housing returns of the UK, which has been shown to be a leading indicator historically for the country (Plakandaras et al., 2020), is an interesting case study on its own. This is because, the Brexit process could potentially affect the UK housing market by reducing foreign investment in the housing market and deferred buying leading to heightened housing market and overall uncertainty.

Thus, we offer the following contributions to the literature associated with uncertainty and house price movements. First, we utilize quarterly data for twelve of UK's regions, over and above the overall housing returns. Our choice of regional data helps to circumvent any possible aggregation bias and therefore avoid any generalization issues about the relationship under consideration, especially given the well-established heterogeneity across the regions (Ashworth and Parker, 1997; Cameron et al., 2006; Hamnett 2009). Second, we distinctly accommodate housing policy uncertainty (HPU) in the predictive model of UK house price movements contrary to the practice in the literature which limits the uncertainty proxy to economic (aggregate) policy uncertainty (EPU) (examples of such studies include Antonakakis et al., 2015; El Montasser et al., 2016; Su et al. 2016; André et al, 2017; Aye et al., 2018; Chow et al., 2018; Christidou and Fountas, 2018; Huang et al., 2018; Aye et al., 2019; Christou et al., 2019; Choudhr, 2020; Gupta et al., forthcoming).[2] Consequently, the predictive contents of both sector-specific and overall policy uncertainties for house price movements in the UK are distinctly examined. We consider three predictive models of real housing returns that account for HPU: a single predictive model with HPU being the only predictor; an extended predictive model that controls for important macroeconomic and financial predictors of real housing returns in addition to HPU; and a predictive model that accounts for any probable asymmetric effect of HPU on real housing returns, with the role of such asymmetries stressed by Bahmani-Oskooee and Maki-Nayeri (2019), while

[1] Nguyen Thanh et al., (2020) has also developed a real estate-based uncertainty index for the US, but that data only runs till 2017, and is no longer updated.

[2] For instance, Leahy and Whited (1996) argue that any test of the relationship between investment and uncertainty must distinguish between the effects of industry-wide and firm-specific shocks. Similarly, Choi and Loungani (2015) show that, despite the high correlation between the aggregate and sector-specific uncertainty measures (see also Bloom, 2009), they have distinct impacts on unemployment.

relating uncertainty and investment decisions due to the possibility of both positive and negative effects. These variants of HPU-based model offer robust results that enable us make some generalizations about the predictability of HPU. Third, we use both recent and long data samples as well as sub-samples that account for the role of global financial crisis owing to its adverse effects on the housing market. Fourth, we utilise both the housing policy uncertainty and overall economic policy uncertainty in order to check if the outcome will be sensitive to the coverage of uncertainty. And finally, we consider multiple out-of-sample forecast horizons and the outcomes are compared with a benchmark model that ignores the role of HPU in the predictive model of real housing returns.

Our empirical analyses rely on a technique that accounts for the inherent statistical features of the variables of interest (see Westerlund and Narayan (2012, 2015) for technical details).[3] To the best of our knowledge. This is the first paper to forecast aggregate and regional real housing returns based on sector-specific and aggregate measures of economic uncertainty. At this stage, we must emphasize that our paper can be considered to be an out-of-sample extension of the work of Choudhry (2020). The author of this paper empirically investigated the effect of the economic policy related uncertainty on house prices across 10 different geographical regions of England and Wales, based on the Autoregressive Distributed Lag (ARDL) bounds cointegration test. Results showed a stable long-run relationship (cointegration) between house prices and its determinants (including economic policy uncertainty) in nine of the regions, and more importantly, uncertainty was found to have negative effect on house prices both in the short- and long-runs.

Our results show that on the average, there exists an inverse relationship between HPU and real housing returns for all the regions examined in the United Kingdom. We equally find that the model that accounts for HPU outperforms the benchmark model that ignores it. We also demonstrate the role of other important determinants of real housing returns and sound a note of caution as regards accounting for the role of asymmetry in the HPU data. Finally, we are able to establish that sector-specific uncertainty measure (HPU) contains higher predictive contents for house price movements than the aggregate economic policy uncertainty measure.

[3] Several studies have employed this methodology to analyze return predictability although not from the perspective of housing return predictability (see for example, Narayan and Gupta (2015), Narayan et al., (2018), Salisu et al., (2019a,b,c,d,e)).

Following this introduction, the rest of this paper is structured as follows. Section 2 captures the adopted methodology. Section 3 presents the issues surrounding the data. Empirical analyses and results are provided in section 4, followed by section 5 which concludes the paper.

2. Methodology

In a bid to forecast housing price returns of the different regions in the United Kingdom, we construct a predictive model that accounts for the inherent statistical features (such as endogeneity, conditional heteroscedasticity and persistence) that typically characterize high frequency time series data (see Westerlund and Narayan (2012, 2015) hereafter referred to as WN). The WN-type model was designed to circumvent parameter proliferation by isolating predictor(s) in the estimation and predictability analyses, a major attraction of the model. In essence, the technique helps to limit the predictability analyses to the predictor(s) of interest, while it also simultaneously resolves any inherent bias (see Westerlund and Narayan (2012, 2015) for the theoretical expositions; and also Narayan and Gupta (2015), Narayan et al., (2018), Salisu et al., (2019a,b,c,d,e) among others for recent applications). Our model is therefore a distributed lag model that incorporates the observed statistical features within a single model framework. It does not include an autoregressive part since the model is often used for return series which are typically stationary and therefore allowing for additional lags may increase redundancy and by implication introduce bias in the estimation process.

We briefly highlight the estimation process as follows. First, we test for the presence of conditional heteroscedasticity, endogeneity and persistence, to be adequately guided while making a choice on the predictive model (Bannigidadmath and Narayan 2015; Narayan and Gupta, 2015; Phan et al., 2015; Narayan et al., 2016, 2018; Devpura et al., 2018; Salisu et al., 2018, 2019a,b,c,d,e; among others). Second, a distributed lag model, with one period lag and a first difference of the predictor that accounts for persistence, is specified. Third, the comprising variables of our model are pre-weighted with the inverse of the standard deviation of the residuals $\left(1/\hat{\sigma}_{\varepsilon}\right)$ that is obtained from an autoregressive conditional heteroscedastic (ARCH) structure - $\hat{\sigma}^2_{\varepsilon,t} = \varpi + \sum_{j=1}^{q} \hat{\varepsilon}^2_{t-j}$, to exploit the additional information of the conditional heteroscedasticity effect and improve predictability. We specify three different variants of the model for HPU (and also replicate the same for EPU): the first relates housing returns with HPU $\left(hpu\right)$ (see equation

1); the second incorporates some control variables ($rgdp$, fsi and $intr$) to extend the first model construct (see equation 2), while the last incorporates positively and negatively decomposed partial sums of the economic policy uncertainty, to ascertain asymmetry effect (see equation 3).

$$r_t = \alpha + \beta_1 hpu_{t-1} + \beta_2 \Delta hpu_t + \varepsilon_t \tag{1}$$

$$\begin{aligned} r_t = \alpha &+ \beta_1 hpu_{t-1} + \beta_2 \Delta hpu_t + \beta_3 rgdp_{t-1} + \beta_4 \Delta rgdp_t \\ &+ \beta_5 fsi_{t-1} + \beta_6 \Delta fsi_t + \beta_7 intr_{t-1} + \beta_8 \Delta intr_t + \varepsilon_t \end{aligned} \tag{2}$$

$$r_t = \alpha + \beta_1 hpu_{t-1}^{(+)} + \beta_2 \Delta hpu_t^{(+)} + \beta_3 hpu_{t-1}^{(-)} + \beta_4 \Delta hpu_t^{(-)} + \varepsilon_t \tag{3}$$

where $r_t = \ln\left(P_t / P_{t-1}\right)$ measures the returns on housing prices - P_t at time t; α is the intercept; the subscript - $t-1$ for the predictor and control variables indicates the one period lag of the variable of interest; $\beta_i's$ are the slope parameters associated with the variables in the model; while ε_t is the error term. The differenced terms (Δepu_t, $\Delta rgdp_t$, Δfsi_t and $\Delta intr_t$) correct for plausible endogeneity bias that may result from the correlation between each of the variables and the residual $\left(\varepsilon_t\right)$, as well as plausible unit root in the predictors.

On the asymmetry effect, the hpu_t is decomposed into positive and negative partial sums, respectively defined as $hpu_t^{(+)} = \sum_{t=1}^{T} \Delta hpu_t^{(+)} = \sum_{t=1}^{T} \max\left(\Delta hpu_t, 0\right)$ and $hpu_t^{(-)} = \sum_{t=1}^{T} \Delta hpu_t^{(-)} = \sum_{t=1}^{T} \min\left(\Delta hpu_t, 0\right)$ (see also, Narayan and Gupta (2015); Salisu et al., (2019a,b,c,d,e, 2020)). In all cases, we examine the statistical significance of the one period lag of the predictor variables of interest, under the null hypothesis of no predictability using the conventional t-test statistic. As previously espoused, we expect a priori the relationship between housing returns and economic policy uncertainty to be negative.

We estimate the regression models in a rolling- rather than a fixed-window, to forecast regional housing returns. We consider a historical average model that regresses regional housing returns on constant only, as a benchmark model; and compare the model fitness and forecast errors of our predictive model with those of the benchmark historical average model using the conventional likelihood ratio [LR] test and relative RMSE, respectively. The LR-test is often used

to ascertain the goodness of fit of nested contending models using their estimated log-likelihood functions. The test statistic is given by

$$LR-test=-2\ log_e\left(\frac{L_{HA\ model}\left(\hat{\theta}\right)}{L_{WN-Type\ DL\ model}\left(\hat{\theta}\right)}\right) \tag{4}$$

where the numerator and the denominator correspond to the likelihood of the historical average (restricted) and the WN-Type DL (unrestricted) models, respectively. The test statistic is approximates a Chi-Squared random variable, with the difference in the number of parameters from both contending models as the number of degrees of freedom. The null hypothesis asserts preference of the restricted (historical average) model, such that a rejection of the null would indicate that the unrestricted (WN-Type DL) model is preferred. Also, on the basis of forecast errors, the relative RMSE is obtained as the ratio of the RMSE of the unrestricted model to the restricted model. Given that smaller RMSE are indicative of better forecast performance, we expect the relative RMSE value to be less than one for our WN-type DL model to be preferred over the benchmark historical average model. Relative RMSE values greater than one indicates preference in favour of the historical average model; while relative RMSE value 1 indicates no difference between the forecast errors of the contending models.

We also formally compare our predictive model with the benchmark historical average model, using Clark and West [CW] (2007) statistic. CW, which is a pairwise comparison test that is suited for nested models, tests the statistical significance of the difference between the forecast errors of a pair of contending models. The CW estimation equation is given in (5):

$$\hat{f}_{t+h}=\left(r_{t+h}-\hat{r}_{1t,t+h}\right)^2-\left[\left(r_{t+h}-\hat{r}_{2t,t+h}\right)^2-\left(\hat{r}_{1t,t+h}-\hat{r}_{2t,t+h}\right)^2\right] \tag{5}$$

where h is the forecast period; $\left(r_{t+h}-\hat{r}_{1t,t+h}\right)^2$ and $\left(r_{t+h}-\hat{r}_{2t,t+h}\right)^2$ are respectively the squared residuals from the historical average (restricted) and our distributed lag predictive (unrestricted) models; while $\left(\hat{r}_{1t,t+h}-\hat{r}_{2t,t+h}\right)^2$ is a CW test incorporated term - adjusted squared residual, that serve as a corrective measure for the noise associated with the forecasts of the larger model. Furthermore, $\hat{f}_{t+h}$ is defined as $MSE_1-\left(MSE_2-adj.\right)$, where $MSE_1=P^{-1}\sum\left(r_{t+h}-\hat{r}_{1t,t+h}\right)^2$, $MSE_2=P^{-1}\sum\left(r_{t+h}-\hat{r}_{2t,t+h}\right)^2$, $adj.=P^{-1}\sum\left(\hat{r}_{1t,t+h}-\hat{r}_{2t,t+h}\right)^2$ and P is the number of averaged

forecasts. We subsequently regress $\hat{f}_{t+h}$ on a constant and adjudge the equality, or otherwise, of the forecast errors of the paired contending models using the t-statistic of the estimated constant. Significance of the t-statistic would imply that the unrestricted model outperforms the restricted model.

3. Data Issues

We employed quarterly frequency data on UK regional housing returns, housing related economic policy uncertainty (HPU), regional and overall real output growth, financial stress index (FSI), mortgage rate and aggregate economic policy uncertainty (EPU), spanning a period between 1998Q1 and 2019Q2, based on data availability. Although, HPU data is available from 1982, however, the overall EPU data only begins from 1998. Thus, for the purpose of comparing the results of the two EPU proxies, we use data covering 1998Q1 to 2019Q2. Nonetheless, we also perform additional analysis using a long range data of the HPU from 1982Q1 to 2019Q2. Total seasonally-adjusted house prices for each region and the overall UK were obtained from Land Registry data of the Office for National Statistics. The nominal house price is deflated by the seasonally-adjusted overall Consumer Price Index of the UK, with the latter derived from the Main Economic Database of the OECD. We work with log-returns of the real house price. Our data cover twelve regions in the UK namely East Midlands, East of England, London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands, Yorkshire and the Humber.

The study aims to ascertain the predictability of housing returns using housing related uncertainty. We also considered model without and with control variables. In this regard, the mortgage rate data comes from the Bank of England, while the FSI is derived from the Statistical Data Warehouse of the European Central Bank. The index includes six market-based financial stress measures that capture returns and (realized) volatility of three financial market segments, i.e., equity, bond and foreign exchange. In addition, when aggregating the sub-indices, the FSI takes the co-movement across market segments into account. For further details, the reader is referred to Duprey et al., (2017). The measure for economic (gross value added) growth of the regions is obtained from the nowcasting project of Koop et al., (2020) associated with the

Economic Statistics of the Centre of Excellence,[4] while that for the overall UK is from the Main Indicators database of the OECD. In the paper, Koop et al., (2020) develop a mixed frequency Vector Autoregressive (MF-VAR) model and use it to produce estimates of quarterly regional output growth. Temporal and cross-sectional restrictions are imposed in the model to ensure that the quarterly regional estimates are consistent with the annual regional observations and the observed quarterly UK totals. Koop et al., (2020) use a machine learning method based on the hierarchical Dirichlet-Laplace prior to ensure optimal shrinkage and parsimony in the over-parameterised MF-VAR.

Turning now to the main predictor of uncertainty related to the housing market. We gather the quarterly housing economic policy uncertainty (HPU) series from the United Kingdom Housing Observatory.[5] The HPU index is constructed by Yusupova et al., (2020) using the methodology suggested by Baker et al., (2016). The HPU is an index of search results from five large newspapers in the UK: The Guardian, The Independent, The Times, Financial Times and Daily Mail. In particular, the authors use LexisNexis digital archives of these newspapers to obtain a quarterly count of articles that contain the following three terms: 'uncertainty' or 'uncertain'; 'housing' or 'house prices' or 'real estate'; and one of the following: 'policy', 'regulation', 'Bank of England, 'mortgage', 'interest rate', 'stamp-duty', 'tax', 'bubble' or 'buy-to-let' (including variants like 'uncertainties', 'housing market' or 'regulatory'). To meet the search criteria an article must contain terms in all three categories. The resulting series of search counts is then scaled by the total number of articles in the given newspaper and in the given quarter. Finally, to obtain the HPU index, Yusupova et al., (2020) average across the five newspapers by quarter and normalise the index to a mean of 100. As far as the overall EPU of the UK is concerned, we utilize the index of Baker et al., (2016), which is based on the number of news articles containing the terms uncertain or uncertainty, economic or economy, as well as policy relevant terms: 'policy', 'tax', 'spending', 'regulation', 'Bank of England', 'budget', and 'deficit'.[6]

The statistical summary, as well as preliminary analyses of the variables to be used in this study are presented in Table 1. The intuition is to understand the data characteristics, so as to be

[4] See: https://www.escoe.ac.uk/regionalnowcasting/.
[5] https://uk.housing-observatory.com/dashboard.html.
[6] The data is downloadable from: http://policyuncertainty.com/uk_monthly.html.

guided in the choice of model to be adopted. An appropriate model would be one that accounts for most of the observed salient data features.

Regional real housing returns are found to range between 0.728 and 1.453, which corresponds to Northern Ireland and London; with Northern Ireland housing returns over time having the highest deviation from the estimated mean, while others in the range of 2.165 and 2.610. The regional housing returns are partly negatively (positively) skewed, while all the regions' real housing returns are found to be leptokurtic. While most of the regions' real housing returns showed the presence of ARCH effect and/or autocorrelation up to the 10^{th} lag, North West and Yorkshire and the Humber do not show any evidence of ARCH effect and/or autocorrelation at the highest specified lag. However, there are evidence of high persistence in all but Scotland that exhibited persistence of about 0.5. On the other hand, the average real output growth for the twelve regions and the aggregate is observed to range between 1.578 and 3.364, corresponding to North East and London, respectively; with the least and highest dispersions found in South West and London, respectively. Output growth is negatively skewed and leptokurtic (exhibiting excess kurtosis values greater than 3) in all the regions except in the North East. We also find evidence of ARCH effect, autocorrelation and higher order autocorrelation, as well as high level of persistence in the output growth series. While the predictor variables (housing related economic policy uncertainty and UK aggregate economic policy uncertainty) only showed evidence of persistence, the other control variables showed evidence of ARCH, autocorrelation as well as persistence (see Table 1).

Few evidences of endogeneity were found in the cases of UK aggregate economic policy uncertainty, regional output growth and mortgage rate (see results in Table 2). Given these data characteristics, it is pertinent to adopt a model that capture most, if not all, of the observed salient features; and to this effect, the WN-type distributed lag model that accounts for conditional heteroscedasticity as well as persistence is employed.

Table 1: Summary Statistics and Preliminary Analysis

	Mean	Std. Dev.	Skewness	Kurtosis	$ARCH\,(1)$	$ARCH\,(5)$	$ARCH\,(10)$	$Q(1)$	$Q(5)$	$Q(10)$	$Q^2(1)$	$Q^2(5)$	$Q^2(10)$	Persistence
Real Housing Returns														
East Midlands	1.165	2.361	-0.182	5.130	0.105	8.410	16.990*	0.149	5.39	9.11	0.11	12.560***	20.008***	0.850***
East of England	1.330	2.349	-0.826	5.706	2.081	11.046*	12.695	5.336**	17.791***	26.392***	2.17	14.925**	16.562*	0.844***
London	1.453	2.424	-0.715	4.852	0.104	3.007	7.051	1.346	13.822**	19.264**	0.109	2.872	6.884	0.780***
North East	0.854	2.610	0.492	5.093	0.001	2.820	4.403	4.254**	12.656**	17.883*	0.001	3.557	6.503	0.746***
North West	1.076	2.350	0.101	4.442	0.118	4.722	13.982	0.043	3.746	6.539	0.123	5.606	14.346	0.852***
Northern Ireland	0.728	4.459	-0.184	3.796	22.580***	33.959***	34.333***	2.267	15.377***	17.948*	23.238***	57.642***	57.956***	0.607***
Scotland	0.966	2.609	0.039	3.292	4.139**	7.346	11.618	0.391	2.629	15.452	4.317*	6.008	11.62	0.499***
South East	1.231	2.355	-0.874	5.540	1.158	16.595***	21.729**	4.100**	18.059***	23.602***	1.209	21.212***	26.118***	0.806***
South West	1.225	2.388	-0.556	5.054	0.075	9.252*	11.193	2.577	12.559**	19.133**	0.079	10.193*	11.868	0.838***
Wales	1.068	2.386	0.290	4.357	0.463	8.068	13.182	3.438	15.029	17.355*	0.482	8.803	15.423	0.821***
West Midlands	1.096	2.213	-0.385	5.029	0.001	10.957*	14.299	0.216	6.414	10.856	0.001	13.417**	19.123**	0.840***
Yorkshire and the Humber	1.062	2.411	0.187	4.731	2.520	4.453	6.179	0.596	6.902	8.991	2.623	4.961	6.249	0.825***
Aggregate	1.083	2.165	-0.744	5.652	7.549***	10.629*	10.729	0.094	11.019*	13.645	7.888***	13.318**	16.062*	0.730***
Output Growth														
East Midlands	1.638	1.601	-2.274	9.909	39.722***	64.840***	62.525***	52.351***	93.330***	102.330***	41.574***	85.962***	88.347***	0.909***
East of England	2.065	1.940	-1.669	6.611	32.211***	48.550***	47.761***	49.849***	122.520***	166.440***	33.681***	45.801***	48.205***	0.925***
London	3.364	2.768	-1.176	5.929	42.853***	49.663***	51.156***	51.938***	110.390***	131.780***	44.779***	74.907***	79.111***	0.910***
North East	1.578	2.040	0.244	2.985	25.987***	35.504***	34.481***	49.082***	85.383***	93.054***	27.006***	42.885***	43.666***	0.955***
North West	2.046	1.628	-0.752	3.333	24.302***	39.290***	48.664***	49.716***	100.840***	108.640***	25.112***	38.313***	52.348***	0.938***
Northern Ireland	1.661	2.315	-0.674	3.356	8.343***	20.701***	26.084***	32.518***	47.295***	53.642***	8.679***	21.894***	25.800***	0.945***
Scotland	1.885	1.629	-1.201	5.386	15.544***	27.618***	28.173***	35.785***	88.728***	107.500***	16.247***	27.749***	28.743***	0.880***
South East	2.023	1.726	-1.175	5.910	40.836***	63.079***	62.598***	51.247***	150.060***	204.010***	42.631***	77.097***	81.425***	0.871***
South West	1.745	1.583	-0.989	5.044	22.251***	34.272***	37.323***	40.491***	114.860***	154.130***	22.933***	51.170***	60.446***	0.877***
Wales	1.644	2.015	-1.584	7.133	32.094***	35.639***	39.553***	41.651***	77.647***	83.278***	33.438***	41.308***	58.562***	0.901***
West Midlands	1.740	1.976	-2.835	11.852	42.749***	64.648***	62.033***	52.437***	101.770***	115.180***	44.722***	87.494***	90.851***	0.911***
Yorkshire and the Humber	1.694	2.033	-1.223	4.863	0.367	17.471***	20.692**	20.103***	34.377***	45.894***	0.383	21.877***	28.277***	0.946***
Aggregate	1.986	1.845	-2.485	10.596	36.975***	45.973***	44.268***	31.800***	79.177***	94.644***	38.656***	57.821***	59.945***	0.897***
Main Predictor and Other Control Variables														
Housing EPU	4.600	0.545	-0.090	2.285	2.446	3.784	5.324	0.148	3.27	9.024	2.491	3.856	5.903	0.845***
UK Aggregate EPU	4.673	0.490	-0.042	2.559	1.081	4.656	8.785	0.108	1.371	10.043	1.121	5.094	13.848	0.823***
Financial Stress Index	0.125	0.095	2.078	7.437	2.152	9.460*	11.842	0.007	5.142	7.741	2.252	13.910**	16.200*	0.824***
Mortgage Rate	4.535	1.688	0.375	2.188	0.205	0.200	0.411	18.009***	23.446***	26.859***	0.214	0.238	0.308	0.963***

Note: ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively. ARCH effect, autocorrelation and higher autocorrelation is tested at lags 1, 5 and 10, under the null hypothesis of no presence of the corresponding statistical feature; with significance (non-significance) indicating the presence (absence) of the corresponding statistical features. In the case of persistence test, the null hypothesis asserts the absence of persistence; such that a rejection of the null will indicate the plausibility of the presence of unit root in the series.

Table 2: Endogeneity Results

	HPU	EPU	Real Output Growth	Financial Stress Index	Mortgage Rate
East Midlands	0.0010	-0.0070	0.0052	-0.0633	0.0089
East of England	0.0045	0.0001	0.0060*	-0.0659	0.0122
London	0.0005	-0.0004	0.0034	-0.0508	0.0151*
North East	-0.0082	-0.0203**	0.0098**	-0.0664	0.0125
North West	-0.0034	-0.0130	0.0089**	-0.0649	0.0150*
Northern Ireland	-0.0099	-0.0237	0.0008	-0.1099	0.0483***
Scotland	-0.0060	-0.0243***	0.0016	-0.0357	0.0183*
South East	0.0022	0.0019	0.0032	-0.0620	0.0154*
South West	0.0000	-0.0057	0.0057*	-0.0681	0.0118
Wales	-0.0027	-0.0123	0.0076***	-0.0518	0.0147*
West Midlands	0.0001	-0.0060	0.0040	-0.0664	0.0110
Yorkshire and the Humber	-0.0035	-0.0136	0.0077**	-0.0773	0.0151*
Aggregate	-0.0052	-0.0048	1.1387***	-0.0674	0.0189**

Note: HPU = Housing Policy Uncertainty; EPU = Economic Policy Uncertainty; ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively. Significant estimates would imply that the corresponding predictor variables listed on each column exhibit some form of endogeneity bias, such that the variable is correlated with the model residual.

4. Empirical Results

4.1 Main Results

Following from the observed data characteristics, we adopted the WN-type distributed lag model that accounts for conditional heteroscedasticity and persistence within a single model framework, to ascertain the predictive capacity of housing policy uncertainty for housing returns in twelve UK regions as well as the aggregate housing returns. We considered three different constructs of the WN-type distributed lag model: First, is a model with no included control variables that is estimated to ascertain the predictability of regional housing returns using only HPU as the predictor; second, the initial model is extended to include some control variables (regional output growth, financial stress index and mortgage rate), in a bid to ascertain if their inclusion would improve forecast performance; and third, a model construct that incorporates both positively and negatively decomposed partial sums of the uncertainty measures, to view plausible impact of asymmetry effect on the predictability of housing returns. The estimation process is conducted with respect to each of the twelve regions in the UK, as well as the aggregated data, under three different sub-sample intervals: Full sample (1998Q1 – 2019Q2), Pre-GFC sample (1998Q1 – 2007Q4) and Post-GFC sample (2008Q1 – 2019Q2). While the HPU measure is considered for the main estimation (see results in Tables 3 - 6), we consider the aggregate EPU as additional analysis for robustness purpose (see results in Tables 7 - 10). Furthermore, in addition to the in-sample evaluation of the model performance(s), we also evaluate the models' out-of-sample forecast performance for three different forecasts horizons as previously explained.

Table 3: Predictability of housing policy uncertainty (HPU) for housing returns

	Without Control	With Control	Asymmetry Effect	
			Positive	Negative
Full Sample				
East Midlands	-1.594*** [0.065]	-1.817*** [0.111]	0.101 [0.137]	0.236 [0.160]
East of England	-0.998*** [0.123]	-1.992*** [0.108]	-1.094*** [0.156]	-0.837*** [0.169]
London	-1.605*** [0.043]	-4.048*** [0.178]	-2.020*** [0.065]	-2.054*** [0.096]
North East	-0.661*** [0.069]	-1.140*** [0.174]	-0.105*** [0.022]	0.095*** [0.027]
North West	-0.250*** [0.073]	-0.392** [0.178]	0.323** [0.126]	0.550*** [0.137]
Northern Ireland	-2.036*** [0.173]	-1.781*** [0.143]	0.138 [0.157]	0.670*** [0.161]
Scotland	-1.702*** [0.082]	-2.020*** [0.399]	-1.313*** [0.102]	-1.197*** [0.113]
South East	-0.999*** [0.054]	-2.735*** [0.238]	-1.853*** [0.071]	-2.019*** [0.081]
South West	-2.145*** [0.070]	-2.244*** [0.258]	-0.186 [0.148]	0.169 [0.171]
Wales	-0.934*** [0.099]	-0.998*** [0.119]	-0.537* [0.269]	-0.374 [0.323]
West Midlands	-0.307*** [0.061]	-0.898*** [0.281]	0.156 [0.092]	0.537*** [0.098]
Yorkshire and the Humber	-0.318*** [0.060]	-0.711*** [0.132]	0.443 [0.267]	0.698** [0.304]
Aggregate	-1.425*** [0.079]	-2.719*** [0.215]	-1.565*** [0.099]	-1.546*** [0.106]
Pre-GFC Sample (1998Q1 – 2007Q4)				
East Midlands	2.582*** [0.117]	0.349 [0.300]	3.440*** [0.265]	4.591*** [0.287]
East of England	-1.437*** [0.068]	-2.509 [1.551]	0.249 [0.142]	1.379*** [0.101]
London	-1.805*** [0.243]	-6.729*** [0.493]	-1.429** [0.601]	-0.621 [0.673]
North East	4.288*** [0.241]	-1.073* [0.589]	3.776*** [0.468]	4.469*** [0.420]
North West	2.670*** [0.089]	2.169*** [0.193]	1.927*** [0.559]	2.243*** [0.554]
Northern Ireland	0.157 [0.149]	1.149 [2.035]	-4.541*** [0.491]	-5.078*** [0.617]
Scotland	1.552*** [0.403]	-0.635 [1.225]	0.760* [0.404]	0.194 [0.539]
South East	-0.833*** [0.184]	0.801* [0.373]	-0.226 [0.162]	0.971*** [0.142]
South West	-0.245 [0.471]	-2.024** [0.696]	0.373* [0.190]	1.382*** [0.157]
Wales	3.122*** [0.221]	0.863** [0.319]	3.757*** [0.499]	4.320*** [0.670]
West Midlands	1.731*** [0.135]	0.595 [0.523]	2.584*** [0.514]	3.046*** [0.512]
Yorkshire and the Humber	0.481*** [0.147]	-0.385** [0.129]	3.038*** [0.075]	3.587*** [0.087]
Aggregate	-0.647* [0.336]	-2.373** [1.025]	-1.685*** [0.207]	-1.716*** [0.131]
Post-GFC Sample (2008Q1 – 2019Q2)				
East Midlands	-0.157** [0.062]	-1.449*** [0.203]	-0.300*** [0.041]	-0.977*** [0.075]
East of England	-0.428*** [0.095]	-2.891*** [0.200]	-1.140*** [0.183]	-2.728*** [0.236]
London	-3.142*** [0.200]	-4.620*** [0.464]	-3.527*** [0.062]	-3.856*** [0.102]
North East	-0.497*** [0.143]	-1.452*** [0.158]	-0.808*** [0.062]	-1.470*** [0.094]
North West	0.241** [0.079]	-1.938*** [0.153]	-0.782*** [0.185]	-1.544*** [0.212]
Northern Ireland	-0.148* [0.076]	-2.012*** [0.174]	-2.953*** [0.508]	-4.960*** [0.469]
Scotland	0.122*** [0.027]	-1.241*** [0.127]	-0.261*** [0.080]	-0.795*** [0.133]
South East	-1.656*** [0.189]	-3.311*** [0.325]	-1.883*** [0.316]	-3.400*** [0.546]
South West	-0.431** [0.151]	-2.162*** [0.550]	-0.948*** [0.124]	-1.697*** [0.132]
Wales	0.348*** [0.067]	-1.043*** [0.265]	-0.485*** [0.086]	-1.043*** [0.135]
West Midlands	0.419*** [0.117]	-0.509** [0.195]	0.044 [0.225]	-0.385 [0.294]
Yorkshire and the Humber	0.332** [0.130]	-1.389*** [0.331]	-0.799*** [0.038]	-1.449*** [0.100]
Aggregate	-0.510*** [0.161]	-1.658*** [0.064]	-0.919*** [0.222]	-2.199*** [0.411]

Note: The reported estimates are the slope coefficients and the corresponding standard error in square brackets associated with the one period lag of HPU-based models. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates a stance of predictability with respect to our HPU-based model is confirmed; otherwise, it's a case of no predictability.

On the in-sample predictability, Table 3 presents the estimated coefficients of one period lag of HPU, under the three specified sample intervals – Full sample (top panel), Pre-GFC sample (middle panel) and Post-GFC (bottom panel); and under three different constructs of the WN-type distributed lag models (without control variables, with control variables and with the incorporation of positively and negatively decomposed partial sums of HPU). Under the full sample interval, we find the nexus between housing returns and HPU to be negative and statistically significant. This stance is consistent across all the regions as well as in the case of the aggregated housing data. The

magnitude of the negative impact of HPU on housing returns is further increased and still statistically significant when control variables are included in the HPU-based model. With respect to the third model construct, there appears to be some similarities between the estimated coefficients associated with the positively and negatively decomposed HPU, across the UK regions and which is suggestive of little or no difference between the decomposed partial sums. Imperatively, while the inclusion of control variables may seem to have some supportive influence on the predictive capability of HPU, accounting for asymmetry effect may not matter. The observed negative relationship aligns with our a priori expectation that low housing returns are associated with high risks. Our confirmation of a significant predictive capacity of HPU aligns with the extant studies that also find overall uncertainty to be a good predictor for real housing returns (see, Choudhry (2020) in particular as it deals with regional UK data).

The stance is however different under the Pre- and Post-GFC sample periods, especially when model without control variables is considered. However, the results for the model with control variables under the Post-GFC sample period align reasonably well with the results under the full sample period, and further confirms our a priori expectation of a significantly negative relationship. The results in the Pre-GFC sample period are mixed, with high risk – low returns and high risks – high returns relationship, and more of the latter being observed. Again, there appears to be great similarities in the estimated coefficients associated with the decomposed partial sums. However, across the sample periods and under the model constructs, the negative relationship between housing returns and HPU is quite evident.

On the model fitness, based on the likelihoods of the contending models, we find statistically significant likelihood ratio statistics across the UK regions and the aggregated data (see results in Table 4). The results emanate from the fact that maximization of the likelihood function is higher in our HPU-based predictive model than the historical average model. This is indicative of the goodness of fit of our predictive model for UK regions' housing returns and by extension, HPU data is said to contain predictive contents for housing returns. The result is consistent across model constructs and sample periods. One striking feature here is the improvement in the model fitness when control variables are introduced. This is indicative of the additional significant information the inclusion of control variables provides. Evidently, with respect to model fitness, HPU-based predictive models fit the data better than the benchmark model.

Table 4: Likelihood Ratio test for HPU-based models relative to the benchmark model

	Without Control Variables			With Control Variables			Asymmetry Effect Incorporated		
	Restricted	**Unrestricted**	**LR-Test**	**Restricted**	**Unrestricted**	**LR-Test**	**Restricted**	**Unrestricted**	**LR-Test**
				Full Sample					
East Midlands	-17.314	39.655	113.938***	-63.445	52.366	231.623***	-28.653	8.713	74.732***
East of England	-30.424	-5.861	49.127***	55.689	137.306	163.235***	-59.637	8.075	135.424***
London	-21.597	45.439	134.072***	-59.892	53.837	227.458***	-55.458	32.124	175.164***
North East	-18.868	5.407	48.551***	-62.738	14.432	154.340***	-25.852	43.886	139.475***
North West	22.350	28.593	12.486***	7.86744	112.2999	208.865***	-21.646	18.373	80.038***
Northern Ireland	-51.716	-23.629	56.175***	-2.058	87.205	178.525***	31.71308	82.649	101.872***
Scotland	-27.723	5.976	67.399***	-66.427	88.218	309.290***	182.302	222.058	79.512***
South East	-36.336	20.629	113.931***	1.935	100.781	197.692***	-47.088	-2.510	89.155***
South West	-70.014	-10.811	118.407***	-64.464	105.525	339.978***	-41.334	42.553	167.775***
Wales	-13.430	13.353	53.567***	-18.975	60.713	159.375***	56.486	93.747	74.522***
West Midlands	20.612	42.701	44.177***	140.094	226.623	173.060***	-13.171	21.252	68.847***
Yorkshire and the Humber	-7.800	1.916	19.433***	-27.682	16.032	87.428***	84.158	117.440	66.564***
Aggregate	-20.513	19.733	80.492***	3.036	63.046	120.019***	-23.540	15.202	77.485***
				Pre-GFC Sample					
East Midlands	-13.195	0.600	27.589***	-22.815	21.683	88.996***	-17.541	8.387	51.855***
East of England	-13.138	19.315	64.905***	-19.495	21.194	81.377***	-35.556	2.666	76.444***
London	-24.254	-12.843	22.823***	8.528	96.637	176.218***	-30.943	8.033	77.953***
North East	-5.106	17.520	45.252***	-34.854	4.819	79.346***	34.627	51.031	32.808***
North West	-21.842	5.413	54.510***	-16.037	15.676	63.426***	-23.003	0.903	47.811***
Northern Ireland	26.374	28.733	4.718*	-12.959	61.484	148.886***	-24.607	-10.517	28.180***
Scotland	11.582	35.415	47.666***	-28.404	36.297	129.402***	-33.603	-13.793	39.619***
South East	-6.126	27.639	67.529***	-20.853	39.541	120.789***	-25.780	11.238	74.037***
South West	-2.677	9.631	24.617***	-36.879	-6.003	61.753***	-19.293	26.076	90.739***
Wales	15.159	59.213	88.108***	-24.971	7.601	65.146***	-36.043	-1.399	69.288***
West Midlands	-12.703	4.733	34.871***	-4.779	37.013	83.583***	-4.994	18.484	46.955***
Yorkshire and the Humber	122.089	137.477	30.777***	-16.064	49.970	132.068***	-6.269	69.467	151.473***
Aggregate	-15.0722	-13.3985	3.347403	-19.297	6.667	51.927***	34.65906	54.83481	40.351***
				Post-GFC Sample					
East Midlands	13.642	17.187	7.090**	-24.886	26.490	102.751***	48.899	83.182	68.565***
East of England	17.395	33.858	32.926***	-21.283	58.749	160.063***	-16.551	14.565	62.232***
London	-30.019	-9.570	40.897***	5.184	55.084	99.802***	-37.536	21.235	117.542***
North East	-5.472	3.489	17.922***	-29.841	20.515	100.713***	-11.520	18.951	60.943***
North West	6.036	14.586	17.099***	-28.628	30.783	118.821***	-23.755	11.208	69.925***
Northern Ireland	4.104	6.576	4.945*	0.854	57.381	113.054***	-30.680	16.165	93.691***
Scotland	16.947	23.069	12.243***	-41.561	4.405	91.932***	-18.619	-4.309	28.620***
South East	-20.579	-4.225	32.708***	-51.806	9.334	122.281***	-29.241	-4.287	49.908***
South West	9.664	12.719	6.109**	13.043	58.340	90.594***	-11.136	16.216	54.705***
Wales	5.725	8.351	5.253*	-25.071	39.324	128.791***	-11.302	12.347	47.298***
West Midlands	-5.271	11.680	33.901***	-35.007	19.469	108.951***	-12.777	7.807	41.170***
Yorkshire and the Humber	6.427	7.868	2.883	-18.751	15.304	68.110***	45.414	83.323	75.818***
Aggregate	8.916	14.432	11.032***	0.000	62.891	125.783***	-3.575	18.668	44.485***

Note: The reported estimates are the log likelihood of the restricted (historical average) and the unrestricted (HPU-based) models, as well as the likelihood ratio test statistics, which is based on the Chi-Square statistics. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU data, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates preference of the HPU-based model over the restricted benchmark model; otherwise, the latter is preferred over the former.

Table 5: Relative RMSE results for the HPU-based models

	Without Control Variables				With Control Variables				Asymmetry Effect			
	In-Sample	Out-of-Sample			In-Sample	Out-of-Sample			In-Sample	Out-of-Sample		
		$h=1$	$h=2$	$h=4$		$h=1$	$h=2$	$h=4$		$h=1$	$h=2$	$h=4$
Full Sample												
East Midlands	0.926	0.926	0.925	0.921	0.911	0.912	0.912	0.910	1.013	1.013	1.013	1.014
East of England	0.920	0.922	0.923	0.922	0.895	0.900	0.904	0.904	0.899	0.899	0.897	0.891
London	0.830	0.832	0.831	0.826	0.730	0.743	0.743	0.734	0.812	0.820	0.822	0.819
North East	0.973	0.972	0.971	0.969	0.811	0.811	0.811	0.810	0.932	0.932	0.931	0.928
North West	0.987	0.988	0.988	0.988	0.776	0.776	0.776	0.774	0.974	0.974	0.974	0.972
Northern Ireland	0.967	0.967	0.967	0.967	0.804	0.804	0.806	0.807	1.073	1.072	1.072	1.072
Scotland	0.985	0.987	0.987	0.986	0.935	0.935	0.934	0.934	0.964	0.964	0.964	0.962
South East	0.902	0.903	0.904	0.903	0.887	0.892	0.894	0.890	0.921	0.926	0.929	0.930
South West	0.832	0.832	0.831	0.825	0.850	0.851	0.851	0.848	0.968	0.967	0.966	0.960
Wales	0.939	0.940	0.939	0.939	0.917	0.917	0.916	0.916	0.922	0.923	0.923	0.922
West Midlands	0.968	0.968	0.968	0.966	1.045	1.046	1.045	1.047	1.038	1.037	1.037	1.033
Yorkshire and the Humber	0.986	0.986	0.986	0.986	0.844	0.844	0.842	0.842	0.965	0.964	0.963	0.962
Aggregate	0.884	0.885	0.885	0.883	0.844	0.847	0.847	0.845	0.921	0.922	0.922	0.919
Pre-GFC Sample												
East Midlands	1.297	1.315	1.371	1.534	0.638	0.638	0.650	0.809	1.048	1.051	1.043	1.110
East of England	0.986	0.987	0.983	0.954	0.916	0.915	0.913	0.996	0.962	0.961	0.960	0.933
London	0.892	0.894	0.903	0.905	0.872	0.868	0.874	1.081	0.813	0.868	0.897	0.956
North East	0.860	0.870	0.912	1.125	0.651	0.664	0.660	0.647	1.056	1.074	1.079	1.234
North West	0.885	0.888	0.926	1.086	1.081	1.085	1.139	1.201	0.947	0.947	0.956	1.040
Northern Ireland	1.008	1.008	1.006	1.011	0.938	0.962	0.964	0.927	1.112	1.069	1.066	1.037
Scotland	1.009	1.007	1.004	1.057	0.871	0.876	0.873	0.885	0.936	0.966	0.962	1.081
South East	0.941	0.941	0.941	0.932	0.947	0.953	0.991	0.999	0.977	0.991	0.999	0.979
South West	1.275	1.315	1.333	1.394	0.884	0.884	0.886	0.881	0.937	0.937	0.929	0.901
Wales	0.885	0.904	0.936	1.148	0.996	1.010	1.021	1.036	0.934	0.938	0.943	1.111
West Midlands	1.067	1.095	1.132	1.289	0.823	0.822	0.817	0.813	0.930	0.925	0.949	1.065
Yorkshire and the Humber	1.074	1.071	1.066	1.043	0.589	0.588	0.587	0.602	0.905	0.901	0.902	0.992
Aggregate	1.044	1.043	1.044	1.029	1.142	1.144	1.141	1.125	1.118	1.128	1.124	1.095
Post-GFC Sample												
East Midlands	1.073	1.072	1.075	1.079	0.633	0.639	0.644	0.659	0.775	0.784	0.797	0.823
East of England	1.068	1.076	1.090	1.098	0.481	0.498	0.507	0.552	0.867	0.916	0.955	1.050
London	0.817	0.835	0.837	0.834	0.612	0.659	0.660	0.679	0.742	0.787	0.792	0.808
North East	1.109	1.109	1.110	1.112	0.768	0.770	0.771	0.775	0.862	0.871	0.870	0.898
North West	1.231	1.231	1.225	1.228	0.563	0.571	0.568	0.569	0.797	0.812	0.817	0.837
Northern Ireland	1.143	1.137	1.126	1.121	0.507	0.504	0.502	0.500	0.578	0.596	0.592	0.609
Scotland	1.069	1.070	1.069	1.067	0.793	0.799	0.801	0.801	0.922	0.933	0.935	0.944
South East	1.015	1.026	1.036	1.040	0.462	0.506	0.540	0.560	0.911	0.966	1.023	1.087
South West	1.071	1.072	1.075	1.083	0.448	0.459	0.466	0.499	0.877	0.893	0.916	0.950
Wales	1.127	1.115	1.111	1.106	0.463	0.460	0.461	0.463	0.827	0.815	0.818	0.819
West Midlands	1.167	1.165	1.165	1.175	0.577	0.580	0.581	0.609	0.959	0.963	0.969	0.994
Yorkshire and the Humber	1.229	1.226	1.228	1.232	0.671	0.671	0.675	0.676	0.803	0.806	0.819	0.825
Aggregate	1.061	1.063	1.064	1.070	0.505	0.519	0.522	0.547	0.842	0.876	0.908	0.972

Note: The values reported are the relative RMSE results that compares the HPU-based models with the benchmark (restricted) model. Hence, we expect values to be less than one for the HPU-based model to be preferred over the benchmark model. Values greater than one lend support to the benchmark model, while a ratio value of one indicates no relative difference between the two competing (nested) models. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU data, as well as their first differences.

On the forecast performance using the relative RMSE (see Table 5), we find all three constructs of HPU-based framework to mostly outperform the benchmark (historical average) model when the full sample period is considered except in the case of East Midlands and Northern Ireland (model with decomposed partial sums of HPU), and Wales (model with control variables and model with decomposed partial sums of HPU). This stance is consistent across the in-sample and the three out-of-sample forecast horizons. The relative RMSE results under the Pre-GFC sample period differ from the stance under the full sample, as there are more cases where the

benchmark model outperforms the HPU-based model, especially when the model with no control variables is considered. The inclusion of control variables is found to improve the forecast performance of our predictive model, in confirmation of the predictability results earlier reported in Table 3. In the Post-GFC sample period, all the HPU-based models, except the model without control variables, consistently out-perform the benchmark model across the UK regions, and the in-sample and out-of-sample forecast horizons. In other words, our proposed HPU-based models predict housing returns more precisely than the benchmark model, especially when the model incorporates relevant control variables. To formally confirm this stance by determining the significance of the out-performance stance, we employ the Clark and West (2007) test, comparing each of the HPU-based constructs with the benchmark model. The stance of outperformance of the former over the latter across the UK regions and forecast horizons observed in Table 5, judging by the reported relative RMSE values, is reaffirmed by the Clark and West test results (see Table 6). The HPU-based models are evidently mostly preferred to the benchmark model, which is not only indicative of the predictive power of HPU and the included control variables but also, the important role that accounting for salient data features plays in predicting housing returns (see also studies on return predictability although not from the perspective of housing return predictability, Bannigidadmath and Narayan (2015), Narayan and Gupta (2015), Phan et al., (2015), Narayan et al., (2016, 2018), Devpura et al., (2018), Salisu et al., (2018, 2019a,b,c,d,e) among others).

Table 6: Clark and West test for HPU-based models relative to the benchmark model

	Without Control Variables			With Control Variables			Asymmetry Effect		
	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$
Full Sample (1998Q1 – 2019Q2)									
East Midlands	1.585*** [0.518]	1.592*** [0.511]	1.631*** [0.500]	2.500** [0.955]	2.473** [0.943]	2.447*** [0.921]	0.552 [0.459]	0.548 [0.453]	0.523 [0.443]
East of England	1.397*** [0.334]	1.374*** [0.330]	1.367*** [0.323]	2.162*** [0.542]	2.114*** [0.538]	2.081*** [0.526]	3.232*** [0.768]	3.218*** [0.759]	3.262*** [0.741]
London	2.550*** [0.539]	2.536*** [0.533]	2.624*** [0.525]	6.456*** [1.458]	6.386*** [1.442]	6.512*** [1.411]	3.546*** [0.770]	3.494*** [0.763]	3.533*** [0.745]
North East	0.656** [0.309]	0.666** [0.305]	0.697** [0.300]	6.001*** [1.311]	5.927*** [1.298]	5.838*** [1.269]	1.389*** [0.202]	1.399*** [0.200]	1.432*** [0.199]
North West	0.351* [0.202]	0.345* [0.200]	0.335* [0.195]	4.003*** [0.950]	3.956*** [0.939]	3.896*** [0.918]	1.044** [0.496]	1.032** [0.490]	1.027** [0.478]
Northern Ireland	4.981*** [1.802]	4.941*** [1.781]	4.822*** [1.741]	14.191*** [2.889]	13.984*** [2.862]	13.744*** [2.799]	2.917 [2.657]	2.883 [2.625]	2.834 [2.562]
Scotland	1.634** [0.782]	1.611** [0.773]	1.591** [0.755]	2.521*** [0.813]	2.501*** [0.803]	2.485*** [0.784]	1.936** [0.763]	1.915** [0.754]	1.903** [0.736]
South East	1.457*** [0.321]	1.440*** [0.318]	1.443*** [0.310]	3.192*** [0.774]	3.138*** [0.766]	3.143*** [0.748]	1.661*** [0.485]	1.621*** [0.481]	1.585*** [0.470]
South West	3.082*** [0.661]	3.064*** [0.654]	3.116*** [0.639]	3.162*** [0.776]	3.130*** [0.767]	3.120*** [0.749]	2.393*** [0.781]	2.383*** [0.772]	2.405*** [0.753]
Wales	1.011*** [0.276]	1.002*** [0.273]	1.001*** [0.267]	1.501*** [0.382]	1.485*** [0.378]	1.472*** [0.369]	1.534*** [0.318]	1.521*** [0.315]	1.511*** [0.308]
West Midlands	0.421*** [0.132]	0.416*** [0.130]	0.428*** [0.127]	0.125 [0.349]	0.124 [0.345]	0.104 [0.337]	1.976** [0.877]	1.954** [0.866]	1.954** [0.846]
Yorkshire and the Humber	0.288*** [0.108]	0.286*** [0.107]	0.280*** [0.104]	3.162*** [0.677]	3.147*** [0.669]	3.087*** [0.654]	1.033** [0.474]	1.037** [0.469]	1.034** [0.457]
Aggregate	1.804*** [0.401]	1.785*** [0.397]	1.778*** [0.388]	4.379*** [1.188]	4.335*** [1.174]	4.268*** [1.147]	1.870*** [0.447]	1.845*** [0.442]	1.839*** [0.431]
Pre-GFC Sample (1998Q1 – 2007Q4)									
East Midlands	1.621 [1.851]	1.077 [1.880]	-0.423 [2.106]	5.914*** [1.258]	5.838*** [1.226]	5.024*** [1.359]	3.759** [1.752]	3.710** [1.703]	2.992* [1.705]
East of England	0.649 [0.428]	0.674 [0.417]	0.930** [0.449]	2.457*** [0.807]	2.461*** [0.785]	1.982** [0.827]	4.047*** [1.086]	4.031*** [1.056]	4.089*** [1.004]
London	1.396** [0.542]	1.331** [0.531]	1.422** [0.535]	4.995*** [1.314]	4.841*** [1.287]	5.220*** [1.388]	3.766*** [1.127]	3.605*** [1.107]	3.614*** [1.089]
North East	4.334*** [1.307]	3.953*** [1.327]	2.340 [1.716]	8.119*** [2.100]	8.311*** [2.052]	8.984*** [2.002]	3.684* [1.885]	3.507* [1.841]	2.040 [2.023]
North West	1.906*** [0.570]	1.674*** [0.601]	0.769 [0.873]	4.476** [1.763]	4.033** [1.771]	3.299* [1.760]	1.146** [0.536]	1.070** [0.526]	0.525 [0.635]
Northern Ireland	0.117 [0.431]	0.170 [0.423]	0.002 [0.431]	4.262 [2.743]	4.101 [2.673]	5.887* [3.109]	4.834 [3.692]	4.764 [3.589]	5.528 [3.522]
Scotland	0.901 [0.625]	0.982 [0.613]	0.424 [0.729]	4.788*** [1.497]	4.753*** [1.457]	4.467*** [1.397]	4.369** [1.632]	4.363*** [1.586]	3.368** [1.661]
South East	0.692** [0.265]	0.679** [0.258]	0.719*** [0.252]	2.470** [0.925]	2.486*** [0.900]	2.766*** [0.876]	4.691*** [1.219]	4.608*** [1.188]	4.694*** [1.131]
South West	1.001 [1.139]	0.845 [1.119]	0.152 [1.166]	3.030*** [0.872]	3.170*** [0.859]	3.196*** [0.818]	3.256*** [0.927]	3.295*** [0.901]	3.447*** [0.866]
Wales	2.633** [0.967]	2.401** [0.969]	0.992 [1.375]	4.674** [1.829]	4.467** [1.791]	4.091** [1.718]	3.046** [1.246]	2.931** [1.216]	1.711 [1.449]
West Midlands	0.875 [0.943]	0.672 [0.940]	-0.295 [1.125]	3.321*** [0.673]	3.512*** [0.681]	3.708*** [0.703]	1.671* [0.881]	1.526* [0.868]	0.898 [0.963]
Yorkshire and the Humber	0.395 [0.650]	0.432 [0.633]	0.587 [0.611]	6.201*** [1.300]	6.149*** [1.265]	6.132*** [1.204]	2.116** [0.842]	2.055** [0.821]	1.437 [0.894]
Aggregate	0.061 [0.268]	0.055 [0.261]	0.120 [0.253]	1.408 [0.964]	1.384 [0.938]	1.336 [0.890]	0.126 [0.376]	0.156 [0.367]	0.319 [0.409]
Post-GFC Sample (2008Q1 – 2019Q2)									
East Midlands	0.232 [0.564]	0.239 [0.551]	0.220 [0.527]	6.004*** [2.155]	5.881*** [2.109]	5.608*** [2.025]	2.430*** [0.751]	2.396*** [0.734]	2.269*** [0.708]
East of England	1.063 [1.278]	1.010 [1.250]	0.906 [1.198]	9.435** [3.582]	9.207** [3.507]	8.686** [3.372]	4.909** [1.898]	4.751** [1.861]	4.210** [1.819]
London	3.704*** [0.997]	3.608*** [0.978]	3.558*** [0.936]	8.605*** [3.116]	8.402*** [3.051]	7.993*** [2.931]	6.476*** [2.214]	6.310*** [2.170]	5.978*** [2.089]
North East	0.348 [0.624]	0.376 [0.611]	0.359 [0.585]	3.209*** [1.061]	3.168*** [1.037]	3.037*** [0.996]	2.328** [1.067]	2.298** [1.043]	2.230** [1.004]
North West	0.095 [0.799]	0.192 [0.787]	0.227 [0.753]	4.770*** [1.595]	4.729*** [1.559]	4.549*** [1.495]	2.373*** [0.565]	2.472*** [0.561]	2.431*** [0.537]
Northern Ireland	0.512 [2.155]	0.853 [2.133]	1.060 [2.044]	18.869*** [5.522]	18.779*** [5.396]	18.167*** [5.176]	15.964*** [4.069]	16.333*** [3.992]	16.130*** [3.820]
Scotland	-0.035 [0.344]	-0.020 [0.336]	0.013 [0.322]	2.830** [1.221]	2.802** [1.193]	2.724** [1.142]	1.006*** [0.371]	1.022*** [0.363]	1.051*** [0.348]
South East	1.604* [0.829]	1.506* [0.815]	1.403* [0.783]	9.522*** [3.384]	9.223*** [3.320]	8.760*** [3.191]	4.808** [1.844]	4.523** [1.824]	4.061** [1.774]
South West	0.426 [0.628]	0.432 [0.613]	0.368 [0.588]	7.936** [2.963]	7.772** [2.899]	7.371** [2.786]	2.405*** [0.740]	2.385*** [0.723]	2.175*** [0.708]
Wales	-0.073 [0.481]	-0.031 [0.472]	0.029 [0.454]	4.497*** [1.539]	4.461*** [1.504]	4.297*** [1.443]	1.737*** [0.432]	1.791*** [0.426]	1.794*** [0.407]
West Midlands	0.008 [0.816]	0.065 [0.799]	0.046 [0.764]	6.246*** [2.018]	6.153*** [1.974]	5.860*** [1.898]	1.272*** [0.395]	1.323*** [0.389]	1.237*** [0.378]
Yorkshire and the Humber	-0.133 [0.751]	-0.116 [0.734]	-0.061 [0.704]	3.749*** [1.257]	3.678*** [1.230]	3.536*** [1.180]	2.059*** [0.685]	2.036*** [0.670]	2.002*** [0.642]
Aggregate	0.390 [0.510]	0.393 [0.498]	0.352 [0.477]	7.438** [2.876]	7.280** [2.814]	6.926** [2.702]	3.636*** [1.258]	3.593*** [1.230]	3.345*** [1.189]

Note: The values reported are the Clark and West results that compares the HPU-based models with the benchmark model. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively. Positive and significant values indicate that the HPU-based model is preferred to the benchmark model. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU, as well as their first differences.

4.2 Additional Results

We consider some additional analyses herein, by way of robustness check on the main estimation results presented in Tables 3 – 6. In the light of the foregoing, we replicate the main analysis for the Economic Policy Uncertainty (EPU) data which is not sector-specific unlike the HPU. The intuition is to ascertain if the coverage of uncertainty measure matters for the predictability and forecast outcomes. We proceed in much the same way as in the main estimation, using three data samples and three variants of the EPU-based framework across the twelve UK regions as well as the aggregated data. The results on predictability, model fitness and forecast performance using relative RMSE and the Clark and West statistics are presented in Tables 7 – 10, respectively. Interestingly, we find the estimated coefficients of the uncertainty measure in the three different constructs to be mostly negative and statistically significant across the UK regions and the aggregated data under the full sample and Post-GFC sample intervals (see results in Table 7). The Pre-GFC sample period has more of positive and statistically significant coefficients, a similitude of the results obtained in the case in the main estimation. This high risk – high returns relationship seems to be associated with period of relative stability (pre-GFC), while the high risk – low returns relationship could be said to be associated with more tensed (Post-GFC and consequently, Full Sample) periods. In other words, in terms of the direction of predictability (see Table 7) and the model fitness of EPU-based models (see results in Table 8), the conclusions are similar to those of the main analysis involving HPU. However, a closer look at the forecast performance of the two uncertainty measures, HPU and EPU (see Tables 5 and 9 respectively) suggests that the sector-specific uncertainty (HPU) measure seems to offer better forecast outcomes than the aggregate uncertainty (EPU) measure. This aligns with our hypothesis on the need to reflect some specific information about the sector in question in the computation of uncertainty measure.

More results, using a longer range of data for HPU from 1982Q1 to 2019Q2, are presented in the appendix (see Tables A1 – A4), and these correspond to the predictability, likelihood ratio test, relative RMSE and the Clark and West statistics. The results are similar to the short range (full) data as virtually all the predictive models outperform the benchmark model judging by the forecast measures. Thus, we confirm again a high risk – low returns relationship, and also, the importance of considering a sample data that includes the post-GFC period.

Table 7: Predictability of economic policy uncertainty (EPU) for housing returns

	Without Control	With Control	Asymmetry Effect	
			Positive	Negative
Full Sample (1998Q1 – 2019Q2)				
East Midlands	-0.274*** [0.024]	-0.837*** [0.270]	-0.103 [0.209]	0.024 [0.241]
East of England	-0.302*** [0.082]	-0.369*** [0.125]	-0.438*** [0.136]	-0.418** [0.154]
London	-1.521*** [0.147]	-0.935*** [0.058]	-1.326*** [0.110]	-1.173*** [0.150]
North East	-0.618*** [0.081]	-1.335*** [0.170]	-1.025*** [0.233]	-1.018*** [0.266]
North West	-1.519*** [0.048]	-0.785*** [0.082]	-0.464*** [0.056]	-0.412*** [0.064]
Northern Ireland	-2.108*** [0.102]	-1.051*** [0.222]	-1.663*** [0.047]	-1.674*** [0.081]
Scotland	-2.919*** [0.069]	-2.764*** [0.312]	-2.763*** [0.160]	-2.775*** [0.195]
South East	-0.617*** [0.061]	-0.451*** [0.059]	-0.858*** [0.106]	-0.781*** [0.126]
South West	-0.998*** [0.046]	-0.988*** [0.156]	-0.442*** [0.112]	-0.282** [0.123]
Wales	-0.541*** [0.045]	-0.805*** [0.182]	-0.401*** [0.105]	-0.271* [0.134]
West Midlands	0.003 [0.109]	-0.442*** [0.125]	0.153* [0.076]	0.239*** [0.086]
Yorkshire and the Humber	-1.000*** [0.212]	-1.256*** [0.096]	-0.571* [0.291]	-0.498 [0.317]
Aggregate	-1.164*** [0.031]	-0.698*** [0.095]	-0.861*** [0.072]	-0.749*** [0.079]
Pre-GFC Sample (1998Q1 – 2007Q4)				
East Midlands	2.532*** [0.444]	0.483 [0.286]	3.366*** [0.221]	3.652*** [0.201]
East of England	2.604*** [0.290]	2.838** [1.117]	1.257*** [0.082]	2.132*** [0.125]
London	0.034 [0.146]	2.106*** [0.326]	-0.488** [0.174]	0.000*** [-0.858]
North East	-1.662*** [0.227]	1.129** [0.347]	3.073*** [0.411]	2.724*** [0.413]
North West	-0.553** [0.198]	1.323 [0.786]	1.980*** [0.309]	1.808*** [0.257]
Northern Ireland	-2.111*** [0.074]	2.923*** [0.768]	0.425 [0.473]	-0.564 [0.456]
Scotland	-2.136*** [0.044]	-0.061 [0.846]	-1.548*** [0.388]	-1.946*** [0.424]
South East	1.827*** [0.040]	1.433*** [0.441]	0.673** [0.283]	1.613*** [0.226]
South West	1.922* [0.900]	2.068*** [0.445]	1.380*** [0.313]	2.194*** [0.276]
Wales	-0.348 [0.362]	0.244 [0.286]	1.356*** [0.236]	1.103*** [0.258]
West Midlands	0.993* [0.553]	2.023** [0.581]	1.562*** [0.344]	2.131*** [0.306]
Yorkshire and the Humber	0.836*** [0.252]	0.716 [0.412]	1.393** [0.545]	1.116** [0.473]
Aggregate	0.419* [0.233]	1.215* [0.633]	0.436 [0.593]	1.249** [0.536]
Post-GFC Sample (2008Q1 – 2019Q2)				
East Midlands	0.096 [0.294]	-0.833 [0.500]	-0.417*** [0.109]	-1.086*** [0.102]
East of England	-0.095 [0.134]	-2.184*** [0.203]	-1.469*** [0.064]	-2.580*** [0.086]
London	-2.718*** [0.194]	-5.024*** [0.213]	-3.246*** [0.557]	-3.754*** [0.636]
North East	0.545*** [0.122]	-2.050*** [0.247]	-0.922*** [0.203]	-1.127*** [0.299]
North West	0.338*** [0.037]	-1.280*** [0.279]	-0.567*** [0.114]	-1.323*** [0.169]
Northern Ireland	0.677*** [0.160]	-2.978*** [0.202]	-2.436*** [0.142]	-5.052*** [0.174]
Scotland	0.248*** [0.022]	-1.727*** [0.264]	-0.853*** [0.163]	-1.410*** [0.175]
South East	-1.473*** [0.054]	-2.850*** [0.148]	-1.717*** [0.107]	-2.861*** [0.117]
South West	-0.776*** [0.043]	-2.289*** [0.184]	-0.997*** [0.153]	-1.586*** [0.185]
Wales	0.183*** [0.036]	-0.777*** [0.102]	-0.323 [0.209]	-0.947*** [0.233]
West Midlands	0.462*** [0.111]	-0.691*** [0.157]	-0.188* [0.093]	-0.754*** [0.110]
Yorkshire and the Humber	-0.362*** [0.045]	-1.397*** [0.296]	-0.355*** [0.064]	-0.900*** [0.060]
Aggregate	-0.837*** [0.035]	-1.536*** [0.167]	-1.378*** [0.215]	-2.343*** [0.193]

Note: The reported estimates are the slope coefficients and the corresponding standard error in square brackets associated with the one period lag of EPU-based model. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed EPU data, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates a stance of predictability with respect to the EPU-based model is confirmed; otherwise, it's a case of no predictability

Table 8: Likelihood Ratio test for EPU-based models relative to the benchmark model

	Without Control Variables			With Control Variables			Asymmetry Effect Incorporated		
	Restricted	**Unrestricted**	**LR-Test**	**Restricted**	**Unrestricted**	**LR-Test**	**Restricted**	**Unrestricted**	**LR-Test**
				Full Sample					
East Midlands	18.283	32.113	27.660***	-23.269	8.785	64.110***	-23.016	4.284	54.601***
East of England	19.113	30.441	22.655***	-17.055	45.720	125.550***	-15.949	0.048	31.994***
London	-15.858	3.031	37.780***	-39.389	37.198	153.174***	-27.684	25.468	106.305***
North East	2.069	64.166	124.195***	-23.600	37.758	122.717***	-52.297	29.394	163.383***
North West	-20.338	93.369	227.415***	-34.243	21.913	112.313***	4.376	53.065	97.376***
Northern Ireland	-28.255	15.172	86.854***	-59.100	13.716	145.631***	37.669	110.693	146.047***
Scotland	-27.026	46.668	147.388***	-60.261	23.084	166.690***	-59.330	-5.544	107.573***
South East	-1.208	20.929	44.273***	-2.885	50.910	107.591***	53.320	120.078	133.515***
South West	-38.082	-3.492	69.181***	9.113	109.580	200.934***	-26.722	8.282	70.008***
Wales	7.544	32.044	49.000***	-19.777	9.418	58.390***	-23.901	2.519	52.841***
West Midlands	-1.727	23.352	50.159***	-2.113	22.255	48.736***	-9.461	5.387	29.696***
Yorkshire and the Humber	2.554	17.323	29.538***	-68.760	59.163	255.846***	-25.847	-6.668	38.359***
Aggregate	-24.385	20.527	89.826***	-0.483	39.251	79.469***	-15.957	10.484	52.883***
				Pre-GFC Sample					
East Midlands	-14.466	-6.909	15.116***	-34.029	11.100	90.258***	-24.613	60.886	170.999***
East of England	7.354	17.190	19.672***	23.456	45.228	43.544***	-28.394	3.673	64.133***
London	10.353	13.213	5.719*	13.044	49.919	73.749***	-18.530	5.186	47.432***
North East	39.434	63.104	47.339***	-0.359	47.343	95.404***	-14.120	1.053	30.346***
North West	43.240	48.912	11.344***	-30.864	3.871	69.469***	64.517	76.662	24.291***
Northern Ireland	-15.672	11.670	54.683***	36.790	64.796	56.012***	-43.348	3.632	93.960***
Scotland	-18.192	42.196	120.775***	15.019	28.959	27.880***	-16.033	-2.806	26.454***
South East	7.563	29.370	43.615***	19.271	83.749	128.956***	-15.497	17.974	66.942***
South West	51.347	58.927	15.160***	-25.523	1.331	53.708***	-27.982	-2.640	50.684***
Wales	43.993	46.832	5.677*	-6.692	36.739	86.861***	-19.573	-10.160	18.826***
West Midlands	-9.974	-2.184	15.579***	-20.153	55.048	150.403***	29.738	71.501	83.526***
Yorkshire and the Humber	-13.770	7.475	42.491***	-17.465	50.873	136.675***	47.988	66.674	37.371***
Aggregate	-1.904	0.539	4.887*	84.080	108.506	48.851***	-11.546	17.013	57.117***
				Post-GFC Sample					
East Midlands	18.261	20.159	3.797	-28.923	14.246	86.339***	-29.521	35.591	130.223***
East of England	-10.349	14.900	50.499***	-15.244	46.370	123.229***	86.308	149.078	125.541***
London	-14.394	13.848	56.483***	-18.051	31.540	99.182***	-6.979	24.444	62.847***
North East	1.185	7.136	11.903***	-16.970	54.839	143.619***	-2.552	4.529	14.163***
North West	11.597	35.015	46.836***	28.450	53.380	49.861***	-17.671	9.524	54.389***
Northern Ireland	16.200	28.726	25.052***	-75.909	48.999	249.814***	-39.329	-1.550	75.558***
Scotland	8.986	16.985	15.998***	-4.415	52.219	113.268***	-7.361	12.492	39.708***
South East	-18.806	13.634	64.881***	-25.067	29.805	109.744***	-38.752	16.579	110.662***
South West	3.957	25.715	43.517***	-22.063	71.963	188.053***	-16.014	11.581	55.190***
Wales	4.486	30.610	52.249***	33.981	76.246	84.528***	61.277	99.275	75.996***
West Midlands	3.174	8.096	9.844***	-40.654	23.690	128.687***	1.648	22.496	41.696***
Yorkshire and the Humber	59.478	72.311	25.666***	-20.301	12.206	65.014***	-17.641	16.387	68.056***
Aggregate	-3.639	22.180	51.637***	46.207	96.902	101.391***	-27.343	33.102	120.889***

Note: The reported estimates are the log likelihood of the restricted (historical average) and the unrestricted (EPU-based) models, as well as the likelihood ratio test statistics, which is based on the Chi-Square statistics. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed EPU data, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates preference of the EPU-based model over the restricted benchmark model; otherwise, the latter is preferred over the former.

Table 9: Relative RMSE results for the EPU-based models

	Without Control Variables				With Control Variables				Asymmetry Effect			
	In-Sample	Out-of-Sample			In-Sample	Out-of-Sample			In-Sample	Out-of-Sample		
		$h=1$	$h=2$	$h=4$		$h=1$	$h=2$	$h=4$		$h=1$	$h=2$	$h=4$
Full Sample												
East Midlands	0.994	0.994	0.994	0.993	1.116	1.118	1.118	1.120	1.016	1.016	1.016	1.017
East of England	1.004	1.006	1.008	1.009	1.140	1.144	1.148	1.147	1.006	1.008	1.011	1.011
London	0.968	0.971	0.971	0.966	1.102	1.105	1.108	1.096	0.942	0.941	0.939	0.930
North East	0.975	0.975	0.975	0.973	0.811	0.812	0.812	0.812	0.945	0.944	0.944	0.941
North West	0.955	0.955	0.955	0.954	0.765	0.766	0.766	0.766	0.974	0.974	0.974	0.973
Northern Ireland	0.957	0.958	0.958	0.957	0.843	0.843	0.846	0.847	0.954	0.954	0.954	0.954
Scotland	0.874	0.874	0.874	0.874	0.867	0.868	0.868	0.868	0.863	0.863	0.863	0.863
South East	1.002	1.005	1.007	1.008	1.106	1.105	1.106	1.105	0.997	0.999	1.004	1.000
South West	0.994	0.995	0.995	0.995	1.180	1.180	1.180	1.175	0.973	0.973	0.972	0.970
Wales	0.971	0.971	0.971	0.970	0.936	0.936	0.936	0.935	0.952	0.952	0.952	0.951
West Midlands	1.008	1.008	1.008	1.007	1.178	1.178	1.179	1.177	1.001	1.001	1.001	1.000
Yorkshire and the Humber	0.954	0.954	0.954	0.951	0.805	0.805	0.804	0.804	0.960	0.960	0.960	0.958
Aggregate	0.992	0.993	0.994	0.993	1.061	1.062	1.062	1.062	1.012	1.012	1.012	1.011
Pre-GFC Sample												
East Midlands	1.040	1.041	1.044	1.103	0.705	0.705	0.708	0.874	1.041	1.043	1.023	1.027
East of England	0.999	0.998	0.997	1.041	0.922	0.920	0.917	0.999	1.027	1.025	1.021	0.996
London	0.983	0.983	0.983	0.990	1.014	1.025	1.042	1.060	0.963	0.971	0.972	0.970
North East	1.219	1.215	1.203	1.165	0.611	0.611	0.605	0.628	1.022	1.020	1.017	1.046
North West	1.178	1.181	1.162	1.122	0.910	0.910	0.905	0.943	1.067	1.067	1.066	1.113
Northern Ireland	0.979	0.976	0.974	0.962	0.995	0.972	0.978	0.929	0.958	0.937	0.929	0.950
Scotland	0.945	0.943	0.940	0.932	0.990	0.989	0.986	1.015	1.129	1.138	1.143	1.173
South East	0.977	0.976	0.976	1.007	0.882	0.912	0.941	0.981	0.978	0.982	0.981	0.973
South West	1.046	1.047	1.051	1.125	0.865	0.864	0.858	1.031	1.039	1.037	1.030	1.008
Wales	1.073	1.070	1.064	1.037	0.991	0.993	0.989	0.948	0.975	0.979	0.986	1.007
West Midlands	1.118	1.121	1.127	1.213	1.094	1.100	1.099	1.109	1.058	1.053	1.042	1.005
Yorkshire and the Humber	1.071	1.068	1.063	1.061	0.581	0.579	0.577	0.611	0.959	0.961	0.965	0.999
Aggregate	1.144	1.143	1.143	1.123	1.340	1.343	1.340	1.485	1.123	1.126	1.122	1.080
Post-GFC Sample												
East Midlands	1.164	1.163	1.166	1.175	0.643	0.653	0.662	0.681	0.836	0.844	0.858	0.887
East of England	1.130	1.137	1.148	1.158	0.547	0.572	0.590	0.637	0.913	0.951	0.984	1.062
London	1.014	1.034	1.039	1.037	0.775	0.838	0.850	0.875	0.928	0.966	0.979	0.998
North East	1.133	1.132	1.133	1.138	0.831	0.835	0.834	0.836	1.085	1.088	1.091	1.100
North West	1.153	1.152	1.146	1.148	0.671	0.683	0.682	0.691	0.855	0.873	0.880	0.908
Northern Ireland	1.206	1.200	1.187	1.184	0.476	0.475	0.473	0.476	0.709	0.755	0.771	0.838
Scotland	1.067	1.068	1.067	1.066	0.834	0.845	0.856	0.854	0.951	0.972	0.977	0.985
South East	1.134	1.145	1.154	1.159	0.589	0.647	0.687	0.727	0.929	0.975	1.018	1.081
South West	1.161	1.164	1.168	1.175	0.483	0.500	0.508	0.551	0.956	0.971	0.984	1.020
Wales	1.071	1.060	1.056	1.053	0.513	0.508	0.510	0.512	0.881	0.870	0.876	0.888
West Midlands	1.173	1.171	1.170	1.181	0.641	0.644	0.644	0.671	0.930	0.939	0.948	0.980
Yorkshire and the Humber	1.171	1.169	1.172	1.171	0.748	0.753	0.764	0.767	0.902	0.905	0.919	0.932
Aggregate	1.196	1.200	1.202	1.210	0.591	0.608	0.616	0.634	0.865	0.893	0.915	0.968

Note: The values reported are the relative RMSE results that compares the EPU-based models with the benchmark (restricted) model. Hence, we expect values to be less than one for the EPU-based model to be preferred over the benchmark model. Values greater than one lend support to the benchmark model, while a ratio value of one indicates no relative difference between the two competing (nested) models. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed EPU data, as well as their first differences.

Table 10: Clark and West test for EPU-based models relative to the benchmark model

	Without Control Variables			With Control Variables			Asymmetry Effect		
	$h=1$	$h=2$	$h=4$	$h=1$	$h=2$	$h=4$	$h=1$	$h=2$	$h=4$
Full Sample									
East Midlands	0.160** [0.064]	0.158** [0.064]	0.161** [0.062]	0.119 [0.527]	0.110 [0.520]	0.071 [0.509]	0.621 [0.454]	0.614 [0.448]	0.587 [0.438]
East of England	0.254 [0.276]	0.230 [0.274]	0.212 [0.269]	0.218 [1.092]	0.178 [1.079]	0.155 [1.055]	0.445 [0.355]	0.413 [0.352]	0.401 [0.344]
London	1.155*** [0.350]	1.142*** [0.346]	1.190*** [0.340]	1.879 [1.228]	1.827 [1.215]	1.944 [1.189]	1.740*** [0.435]	1.745*** [0.430]	1.884*** [0.431]
North East	0.533*** [0.170]	0.530*** [0.168]	0.549*** [0.166]	4.465*** [1.157]	4.418*** [1.144]	4.326*** [1.119]	1.162*** [0.286]	1.168*** [0.282]	1.194*** [0.277]
North West	1.427*** [0.406]	1.412*** [0.401]	1.458*** [0.393]	4.012*** [0.926]	3.966*** [0.916]	3.890*** [0.896]	0.672** [0.276]	0.664** [0.273]	0.664** [0.266]
Northern Ireland	4.304*** [1.561]	4.253*** [1.543]	4.164*** [1.508]	10.503*** [2.140]	10.323*** [2.122]	10.149*** [2.075]	3.982** [1.709]	3.935** [1.688]	3.848** [1.649]
Scotland	3.686*** [0.784]	3.661*** [0.775]	3.631*** [0.757]	3.917*** [0.793]	3.888*** [0.783]	3.853*** [0.765]	3.783*** [0.738]	3.763*** [0.729]	3.726*** [0.712]
South East	0.459 [0.332]	0.427 [0.329]	0.410 [0.322]	0.083 [0.841]	0.062 [0.831]	0.061 [0.812]	1.091** [0.535]	1.037* [0.531]	1.056** [0.518]
South West	0.693** [0.346]	0.678* [0.342]	0.673** [0.334]	0.482 [1.254]	0.472 [1.239]	0.496 [1.210]	1.151** [0.474]	1.139** [0.468]	1.148** [0.457]
Wales	0.478*** [0.118]	0.474*** [0.117]	0.477*** [0.114]	1.085*** [0.316]	1.073*** [0.312]	1.060*** [0.305]	0.949*** [0.246]	0.942*** [0.243]	0.939*** [0.237]
West Midlands	0.007 [0.069]	0.005 [0.069]	0.012 [0.068]	-0.983 [0.721]	-0.976 [0.712]	-0.958 [0.695]	0.289 [0.258]	0.283 [0.255]	0.290 [0.249]
Yorkshire and the Humber	0.874*** [0.226]	0.866*** [0.223]	0.884*** [0.219]	3.422*** [0.717]	3.396*** [0.709]	3.334*** [0.694]	0.825*** [0.220]	0.815*** [0.218]	0.822*** [0.213]
Aggregate	0.836** [0.353]	0.822** [0.349]	0.809** [0.341]	0.497 [0.575]	0.483 [0.568]	0.471 [0.555]	0.971** [0.486]	0.957** [0.480]	0.949** [0.468]
Pre-GFC Sample									
East Midlands	1.389 [1.085]	1.310 [1.059]	0.767 [1.091]	6.821*** [1.538]	6.748*** [1.498]	5.783*** [1.643]	2.298* [1.202]	2.432** [1.176]	2.281* [1.126]
East of England	1.292* [0.677]	1.267* [0.659]	0.967 [0.668]	2.777*** [0.885]	2.757*** [0.861]	2.295** [0.911]	2.909*** [1.048]	2.874*** [1.019]	2.951*** [0.966]
London	0.342 [0.221]	0.335 [0.216]	0.287 [0.212]	1.386* [0.780]	1.303* [0.763]	1.211 [0.730]	3.725*** [1.268]	3.611*** [1.237]	3.501*** [1.179]
North East	-0.197 [1.408]	-0.072 [1.375]	0.332 [1.338]	7.681*** [1.813]	7.667*** [1.763]	7.482*** [1.684]	0.951 [0.935]	0.951 [0.908]	0.608 [0.906]
North West	-0.095 [0.787]	0.040 [0.777]	0.332 [0.767]	2.485** [0.930]	2.495*** [0.905]	2.184** [0.890]	0.071 [0.556]	0.055 [0.541]	-0.318 [0.587]
Northern Ireland	1.988* [1.003]	2.012** [0.976]	2.478** [1.051]	9.341** [3.949]	8.931** [3.863]	12.609** [5.275]	7.524*** [2.516]	7.795*** [2.460]	7.001*** [2.405]
Scotland	2.106** [0.883]	2.105** [0.859]	2.168** [0.822]	2.436* [1.214]	2.504** [1.182]	2.063* [1.173]	4.065** [1.771]	4.223** [1.729]	3.623** [1.692]
South East	0.877* [0.434]	0.855* [0.423]	0.663 [0.429]	2.961** [1.160]	2.952** [1.129]	2.729** [1.098]	4.103*** [1.217]	4.003*** [1.187]	3.857*** [1.128]
South West	1.107 [0.798]	1.048 [0.778]	0.497 [0.850]	2.775*** [0.749]	2.777*** [0.728]	1.880* [1.021]	2.813** [1.111]	2.796** [1.080]	2.836*** [1.022]
Wales	-0.062 [0.523]	-0.004 [0.512]	0.219 [0.512]	4.851** [1.818]	4.752** [1.771]	5.042*** [1.697]	0.640* [0.334]	0.571* [0.332]	0.385 [0.349]
West Midlands	0.698 [0.835]	0.624 [0.816]	-0.007 [0.896]	3.051** [1.465]	2.957** [1.428]	2.658* [1.370]	1.519* [0.888]	1.558* [0.864]	1.757** [0.830]
Yorkshire and the Humber	0.020 [0.515]	0.063 [0.503]	0.026 [0.479]	6.657*** [1.288]	6.582*** [1.255]	6.464*** [1.216]	0.546 [0.333]	0.505 [0.326]	0.251 [0.359]
Aggregate	-0.321 [0.341]	-0.321 [0.331]	-0.252 [0.318]	0.569 [0.820]	0.606 [0.798]	-0.190 [0.990]	1.952** [0.953]	1.912** [0.927]	2.071** [0.886]
Post-GFC Sample									
East Midlands	0.033 [0.739]	0.045 [0.723]	0.025 [0.691]	6.002*** [1.775]	5.882*** [1.739]	5.608*** [1.673]	2.082*** [0.456]	2.057*** [0.446]	1.939*** [0.435]
East of England	0.195 [1.065]	0.166 [1.041]	0.077 [0.999]	7.958*** [2.741]	7.754*** [2.686]	7.271*** [2.590]	3.423*** [1.034]	3.303*** [1.017]	2.867*** [1.019]
London	1.466 [1.186]	1.408 [1.161]	1.396 [1.110]	7.541*** [2.629]	7.336*** [2.577]	6.854*** [2.487]	2.529** [1.053]	2.433** [1.034]	2.172** [1.005]
North East	-0.069 [0.553]	-0.034 [0.541]	-0.037 [0.520]	4.536*** [1.639]	4.448*** [1.604]	4.297*** [1.538]	0.475 [0.547]	0.509 [0.536]	0.461 [0.515]
North West	0.099 [0.618]	0.185 [0.610]	0.206 [0.583]	4.101*** [1.139]	4.121*** [1.113]	3.982*** [1.069]	2.202*** [0.445]	2.319*** [0.450]	2.299*** [0.431]
Northern Ireland	0.292 [2.551]	0.742 [2.533]	1.008 [2.429]	18.462*** [5.152]	18.372*** [5.034]	17.645*** [4.840]	18.788*** [3.015]	19.570*** [3.048]	19.656*** [2.920]
Scotland	-0.024 [0.328]	-0.009 [0.321]	0.026 [0.308]	3.228*** [1.174]	3.210*** [1.147]	3.110*** [1.099]	1.204*** [0.402]	1.224*** [0.393]	1.250*** [0.377]
South East	0.423 [1.154]	0.348 [1.130]	0.281 [1.082]	9.114*** [2.911]	8.797*** [2.862]	8.270*** [2.761]	3.322*** [1.107]	3.098*** [1.105]	2.703** [1.092]
South West	0.117 [0.891]	0.132 [0.871]	0.078 [0.834]	8.539*** [3.041]	8.362*** [2.976]	7.918*** [2.863]	1.690*** [0.368]	1.681*** [0.360]	1.493*** [0.370]
Wales	0.134 [0.396]	0.178 [0.389]	0.198 [0.373]	4.007*** [1.273]	3.992*** [1.244]	3.857*** [1.193]	1.825*** [0.353]	1.889*** [0.350]	1.933*** [0.338]
West Midlands	0.051 [0.726]	0.103 [0.711]	0.081 [0.680]	7.026*** [2.383]	6.911*** [2.331]	6.584*** [2.240]	1.649*** [0.318]	1.702*** [0.315]	1.597*** [0.311]
Yorkshire and the Humber	0.073 [0.674]	0.089 [0.658]	0.123 [0.630]	4.153*** [1.193]	4.081*** [1.168]	3.942*** [1.121]	1.458*** [0.302]	1.451*** [0.295]	1.456*** [0.285]
Aggregate	0.135 [0.870]	0.147 [0.850]	0.107 [0.813]	5.231*** [1.845]	5.131*** [1.805]	4.872*** [1.736]	2.803*** [0.790]	2.773*** [0.772]	2.573*** [0.751]

Note: The values reported are the Clark and West results that compares the EPU-based models with the benchmark model. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively. Positive and significant values indicate that the EPU-based model is preferred to the benchmark model. The model with control variables includes one period lag and first differences of output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed EPU, as well as their first differences..

5. Conclusion

In this study, we test whether uncertainty has predictive contents for real housing returns in the United Kingdom. We utilize both housing policy uncertainty (HPU) and economic policy uncertainty (EPU) data and our analyses cover twelve (12) regions namely East Midlands, East of England, London, North East, North West, Northern Ireland, Scotland, South East, South West, Wales, West Midlands, Yorkshire and the Humber. Unlike the aggregate data, the use of regional data and sector-specific uncertainty helps to circumvent any possible aggregation bias and by extension enables us to offer meaningful generalizations about the relationship being examined. We offer a number of scenarios to validate our results. First, for our main analysis involving HPU, we consider three predictive models of real housing returns: (i) the main model with HPU as the only predictor; (ii) an extended model that accounts for relevant covariates in addition to HPU; and (iii) an asymmetric (nonlinear) variant of the main model that accounts for asymmetries in HPU (positive and negative changes in HPU). Second, we consider three data samples namely the full sample (that utilizes all the available data), the pre-GFC sample which predates the global financial crisis and the post-GFC sample which captures its aftermath. Third, we replicate all the analyses for the economic (overall) policy uncertainty (EPU) in order to check the sensitivity of the results to uncertainty coverage. Forth, we consider multiple out-of-sample forecast horizons and the outcomes are compared with a benchmark model that ignores the role of uncertainty in the predictive model of real housing returns.

Our results are summarized as follows. First, on the average (i.e. using the full data sample), we find a negative relationship between HPU and real housing returns in the United Kingdom for virtually all the regions examined. In other words, increased uncertainties in the housing market may lower trading in the market and by implication lower housing returns. Second, we find that the model that accounts for HPU outperforms the benchmark model that ignores it. Third, when we controlled for relevant covariates such as real gross domestic product, financial stress index, and mortgage rate, the forecast performance of the HPU-based models improves. Fourth, the outcome of our distinct analyses for the sub-samples, i.e. pre- and post-GFC periods suggests that the out-of-sample predictability of HPU only becomes evident after using recent HPU data (i.e. the post-GFC period) albeit with relevant control variables. Fifth, the outcome of the HPU further reinforces the need to use recent data for improved predictability of HPU for real housing returns. Put differently, a longer data span that accommodates recent HPU data is encouraged for better

forecast outcomes. Finally, we are able to establish that sector-specific uncertainty measure contains higher predictive contents for house price movements than the aggregate economic policy uncertainty measure. A possible extension of this paper would be to examine the economic gains of including HPU in the valuation of housing stocks; this is an area we set aside for future research.

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Appendix

Table A1: Predictability of HPU for housing returns [Long range Sample (1982Q1 – 2019Q2)]

	Without Control	With Control	Asymmetry Effect	
			Positive	Negative
East Midlands	-0.690*** [0.023]	-1.329*** [0.051]	-1.502*** [0.042]	-1.621*** [0.048]
East of England	-0.780*** [0.159]	-2.689*** [0.215]	-1.810*** [0.045]	-2.133*** [0.047]
London	-2.469*** [0.048]	-3.816*** [0.188]	-2.906*** [0.095]	-2.920*** [0.100]
North East	-0.512*** [0.059]	-0.549*** [0.162]	-0.747*** [0.107]	-0.778*** [0.119]
North West	-0.313*** [0.045]	0.041 [0.043]	-0.822*** [0.010]	-0.875*** [0.016]
Northern Ireland	-0.774*** [0.124]	-1.136*** [0.065]	-2.104*** [0.118]	-2.223*** [0.122]
Scotland	-0.361*** [0.085]	-0.472** [0.215]	-0.945*** [0.111]	-1.005*** [0.116]
South East	-1.444*** [0.102]	-1.438*** [0.204]	-1.912*** [0.109]	-2.078*** [0.135]
South West	-1.284*** [0.088]	-2.864*** [0.069]	-2.765*** [0.164]	-2.933*** [0.175]
Wales	-0.807*** [0.009]	-0.894*** [0.065]	-0.857*** [0.126]	-0.832*** [0.136]
West Midlands	-0.433*** [0.023]	-1.016*** [0.142]	-0.306*** [0.062]	-0.315*** [0.062]
Yorkshire and the Humber	-0.744*** [0.076]	-1.159*** [0.162]	-2.016*** [0.054]	-2.166*** [0.052]
Aggregate	-2.221*** [0.091]	-1.907*** [0.058]	-3.047*** [0.092]	-3.258*** [0.093]

Note: The reported estimates are the slope coefficients and the corresponding standard error in square brackets associated with the one period lag of HPU-based models. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates a stance of predictability with respect to our HPU-based model is confirmed; otherwise, it's a case of no predictability.

Table A2: Likelihood Ratio Test Results [Long range Sample (1982Q1 – 2019Q2)]

	Without Control Variables			With Control Variables			Asymmetry Effect Incorporated		
	Restricted	Unrestricted	LR-Test	Restricted	Unrestricted	LR-Test	Restricted	Unrestricted	LR-Test
				Full Sample					
East Midlands	-41.221	45.139	172.720***	-60.837	77.579	276.833***	-18.162	133.473	303.268***
East of England	63.559	81.914	36.709***	-48.900	27.059	151.917***	-71.778	32.718	208.992***
London	-101.211	3.126	208.674***	-99.054	51.394	300.896***	-96.411	-13.885	165.053***
North East	-30.942	-16.332	29.220***	37.646	105.361	135.431***	-32.982	-19.123	27.717***
North West	-9.504	21.014	61.037***	57.37334	115.483	116.2194***	-15.092	38.656	107.497***
Northern Ireland	-93.090	-77.557	31.066***	24.222	192.640	336.836***	-82.5466	-22.19061	120.712***
Scotland	-25.812	-3.998	43.628***	-39.629	26.881	133.019***	-45.844	-13.554	64.580***
South East	-54.655	-19.291	70.729***	-64.151	12.048	152.398***	-4.444	52.754	114.395***
South West	-57.801	-17.614	80.374***	-164.339	7.532	343.742***	-30.053	57.276	174.658***
Wales	-47.338	151.890	398.456***	74.909	223.764	297.710***	-8.762	38.993	95.510***
West Midlands	124.808	234.990	220.364***	-64.829	26.120	181.896***	-1.465	60.857	124.642***
Yorkshire and the Humber	59.676	87.671	55.989***	-147.172	51.155	396.655***	-58.998	154.806	427.607***
Aggregate	10.421	92.810	164.779***	-41.515	100.718	284.466***	-45.000	104.090	298.181***

Note: The reported estimates are the log likelihood of the restricted (historical average) and the unrestricted (HPU-based) models, as well as the likelihood ratio test statistics, which is based on the Chi-Square statistics. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU data, as well as their first differences. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively, where significance indicates preference of the HPU-based model over the restricted benchmark model; otherwise, the latter is preferred over the former.

Table A3: Relative RMSE Results [Long range Sample (1982Q1 – 2019Q2)]

	Without Control Variables				With Control Variables				Asymmetry Effect			
	In-Sample	Out-of-Sample			In-Sample	Out-of-Sample			In-Sample	Out-of-Sample		
		h=1	h=2	h=4		h=1	h=2	h=4		h=1	h=2	h=4
East Midlands	0.953	0.953	0.953	0.952	0.976	0.976	0.976	0.976	0.957	0.957	0.957	0.957
East of England	0.980	0.981	0.982	0.983	0.828	0.832	0.834	0.835	0.958	0.964	0.968	0.974
London	0.871	0.872	0.871	0.867	0.759	0.763	0.762	0.759	0.891	0.892	0.892	0.889
North East	0.977	0.977	0.976	0.976	0.933	0.933	0.933	0.933	0.966	0.966	0.966	0.965
North West	0.990	0.990	0.991	0.991	0.885	0.885	0.885	0.885	0.943	0.943	0.943	0.942
Northern Ireland	0.993	0.993	0.993	0.993	0.950	0.950	0.951	0.951	0.971	0.971	0.971	0.971
Scotland	0.993	0.994	0.994	0.993	0.989	0.989	0.989	0.989	0.981	0.981	0.982	0.981
South East	0.931	0.933	0.934	0.932	0.934	0.937	0.938	0.942	0.897	0.902	0.904	0.905
South West	0.957	0.957	0.957	0.956	0.846	0.846	0.846	0.845	0.895	0.896	0.896	0.895
Wales	0.983	0.983	0.983	0.983	0.962	0.962	0.962	0.962	0.999	1.000	1.000	0.999
West Midlands	0.979	0.979	0.979	0.978	0.899	0.899	0.899	0.899	0.993	0.993	0.993	0.992
Yorkshire and the Humber	0.988	0.988	0.988	0.988	0.936	0.936	0.936	0.936	1.020	1.020	1.020	1.020
Aggregate	0.871	0.871	0.871	0.869	0.819	0.820	0.820	0.821	0.881	0.883	0.883	0.881

Note: The values reported are the relative RMSE results that compares the WN-type distributed lag (unrestricted) model with the historical average (restricted) model. Hence, we expect values to be less than one for the WN-type distributed lag model to be preferred over the historical average model. Values greater than one lend support to the historical average model, while a ratio value of one indicates no relative difference between the historical average model and our WN-type distributed lag model. The model with control variables include one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed aggregate economic policy uncertainty, as well as their first differences.

Table A4: Clark and West Results [Long range Sample (1982Q1 – 2019Q2)]

	Without Control Variables			With Control Variables			Asymmetry Effect		
	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$	$h = 1$	$h = 2$	$h = 4$
East Midlands	0.717*** [0.177]	0.713*** [0.175]	0.720*** [0.173]	1.087** [0.525]	1.074** [0.521]	1.070** [0.514]	1.055** [0.411]	1.050** [0.408]	1.039** [0.402]
East of England	0.812** [0.323]	0.797** [0.320]	0.775** [0.315]	3.813*** [0.828]	3.764*** [0.821]	3.702*** [0.807]	1.416*** [0.405]	1.379*** [0.403]	1.303*** [0.399]
London	3.594*** [0.615]	3.581*** [0.611]	3.643*** [0.605]	7.196*** [1.403]	7.150*** [1.394]	7.174*** [1.375]	4.330*** [0.781]	4.309*** [0.776]	4.346*** [0.766]
North East	0.440** [0.174]	0.441** [0.173]	0.445** [0.170]	1.398*** [0.449]	1.387*** [0.445]	1.363*** [0.437]	0.664*** [0.239]	0.661*** [0.237]	0.665*** [0.233]
North West	0.391 [0.270]	0.387 [0.267]	0.376 [0.262]	1.580*** [0.354]	1.564*** [0.351]	1.540*** [0.344]	0.795*** [0.200]	0.786*** [0.198]	0.780*** [0.194]
Northern Ireland	1.361 [0.824]	1.348 [0.818]	1.325 [0.807]	5.093*** [1.573]	5.039*** [1.563]	5.006*** [1.542]	2.595*** [0.960]	2.594*** [0.953]	2.564*** [0.940]
Scotland	0.245* [0.148]	0.242 [0.147]	0.241* [0.145]	0.597** [0.282]	0.591** [0.280]	0.586** [0.276]	0.588** [0.250]	0.580** [0.248]	0.575** [0.245]
South East	1.691*** [0.443]	1.672*** [0.439]	1.667*** [0.431]	2.368*** [0.663]	2.334*** [0.658]	2.261*** [0.647]	1.896*** [0.432]	1.862*** [0.429]	1.824*** [0.422]
South West	1.604*** [0.414]	1.592*** [0.411]	1.590*** [0.405]	5.080*** [0.959]	5.050*** [0.953]	5.006*** [0.940]	3.235*** [0.648]	3.214*** [0.643]	3.205*** [0.634]
Wales	0.566*** [0.194]	0.563*** [0.193]	0.563*** [0.190]	1.167*** [0.373]	1.159*** [0.371]	1.146*** [0.366]	0.534* [0.283]	0.531* [0.281]	0.533* [0.277]
West Midlands	0.448*** [0.129]	0.445*** [0.128]	0.450*** [0.126]	2.273*** [0.556]	2.255*** [0.552]	2.228*** [0.545]	0.280** [0.114]	0.277** [0.113]	0.277** [0.112]
Yorkshire and the Humber	0.518** [0.207]	0.516** [0.206]	0.515** [0.203]	3.035*** [0.775]	3.030*** [0.769]	2.990*** [0.759]	0.870 [0.732]	0.871 [0.727]	0.878 [0.717]
Aggregate	2.426*** [0.455]	2.424*** [0.452]	2.457*** [0.446]	3.317*** [0.579]	3.294*** [0.576]	3.250*** [0.569]	2.833*** [0.566]	2.813*** [0.563]	2.799*** [0.555]

Note: The values reported are the Clark and West results that compares the HPU-based models with the benchmark model. The ***, ** and * indicate statistical significance at 1%, 5% and 10% levels, respectively. Positive and significant values indicate that the HPU-based model is preferred to the benchmark model. The model with control variables includes one period lag and first differences of real output growth, Financial Stress Index and mortgage rate; while the model with asymmetry effect incorporates one lag each of the positively and negatively decomposed HPU, as well as their first differences.