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# The impact of flood risk on England's property market



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Research Report

Real Estate Research Centre,

Bayes Business School, City, University of London

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Real Estate Research Centre,

Bayes Business School, City, University of London

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## Executive Summary

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- Based on our sample, one out of six properties in England are at risk of flooding and around half of those affected properties can be characterised as high risk. This is in line with current insurance underwriting assessments.
- Findings show that residential properties in England with flood risk are sold at a 8.14% discount compared to non-affected properties. The level of the price discount is strongly correlated with the probability of flood risk. The price discount reaches 31.3% for very high risk properties.
- The average flood risk of sold properties in the England between 2006 and 2021 is estimated at 8.01 per cent, compared to unsold property flood risk of 8.63 per cent. Zero exposure to flooding increases the saleability of a property from 63.3 per cent to 65.6 per cent, however flood risk is never the main driver of a sale.
- The regions most exposed to flood risk are East Anglia, North West and Yorkshire, where around 13%-18% of properties are affected. In terms of property types, semi-detached and terraced houses are more vulnerable to flooding since any temporary protection measures, such as blocking doors, windows, vents and pipes, will not be effective unless their neighbours take similar steps.
- Between 2050 and 2080, property-level flood risk is projected to increase further by 8%. Our empirical model suggests that one percentage point increase in properties' flood risk is associated with a decline of 0.11-0.19% in both sold and asking price.
- Our results suggest that market participants tend to underestimate the probability of flooding. Therefore, after periods of extreme weather events the one percentage point increase in flood risk results in a greater price discount (0.17 - 0.20%) for a short period.
- The research also confirms that the effect of flood risk is asymmetric and buyers of lower-priced properties are more sensitive towards flood risk compared to buyers of more expensive properties. A one percentage point increase in flood risk is associated with 0.16% discount in properties priced within the lower quantile of the sample, 0.13% for properties priced around the sample median and 0.10% for properties priced within the upper quantile of the sample.

## Introduction

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In 2015, the Paris Agreement coordinated a global response in the face of the imminent climate change threat. Countries agreed to adopt measures to limit global warming to well below 2 degrees Celsius by 2100, ideally aiming for an increase by 1.5 degrees Celsius or lower. According to Met Office data, since 1884 the annual mean air temperature in the UK increased by 13.4%. In the coming century it is expected that the number of hot and very hot days and the intensity and frequency of extreme precipitation events are very likely to rise further, resulting in more numerous natural disasters such as floods (Van Aalst 2006).

Over the last 10 years in the UK, there were at least three severe flooding events;

- the 2013/14 South England winter flooding,
- the 2015/16 Northern Britain winter flooding and
- the 2019/2020 floods in Northern England, the Midlands and on both sides of the English/Welsh border.

Climate change and extreme weather events have a severe adverse impact on the economy and property prices. According to the Environmental Agency only from the 2013/2014 winter flooding, the damage was estimated at around £1.3 billion for England and Wales. The property damage alone was at £320 million since more than 10,000 houses were affected. The damage was a combination of coastal, pluvial, fluvial and groundwater flooding (Muchan et al., 2015). More recently, the property damage from the 2019/2020 floods was severe for North England and the Midlands and the estimated insurance pay-outs reached £110 million (Sefton et al., 2021).

Global flood losses were estimated at \$6 billion per year back in 2005 and they are projected to increase above \$60 billion by 2050 in an optimistic scenario in which adaptation investments maintain sea-level rise and the probability of flooding (Hallegatte et al., 2013). Flood events affect house prices via various channels such as the destruction of capital and increases in insurance costs (Carney, 2015). In addition, extreme weather events result in unstable financial markets and consequently investments are significantly reduced since lenders are extra cautious in time of a crisis. Finally, such an event changes

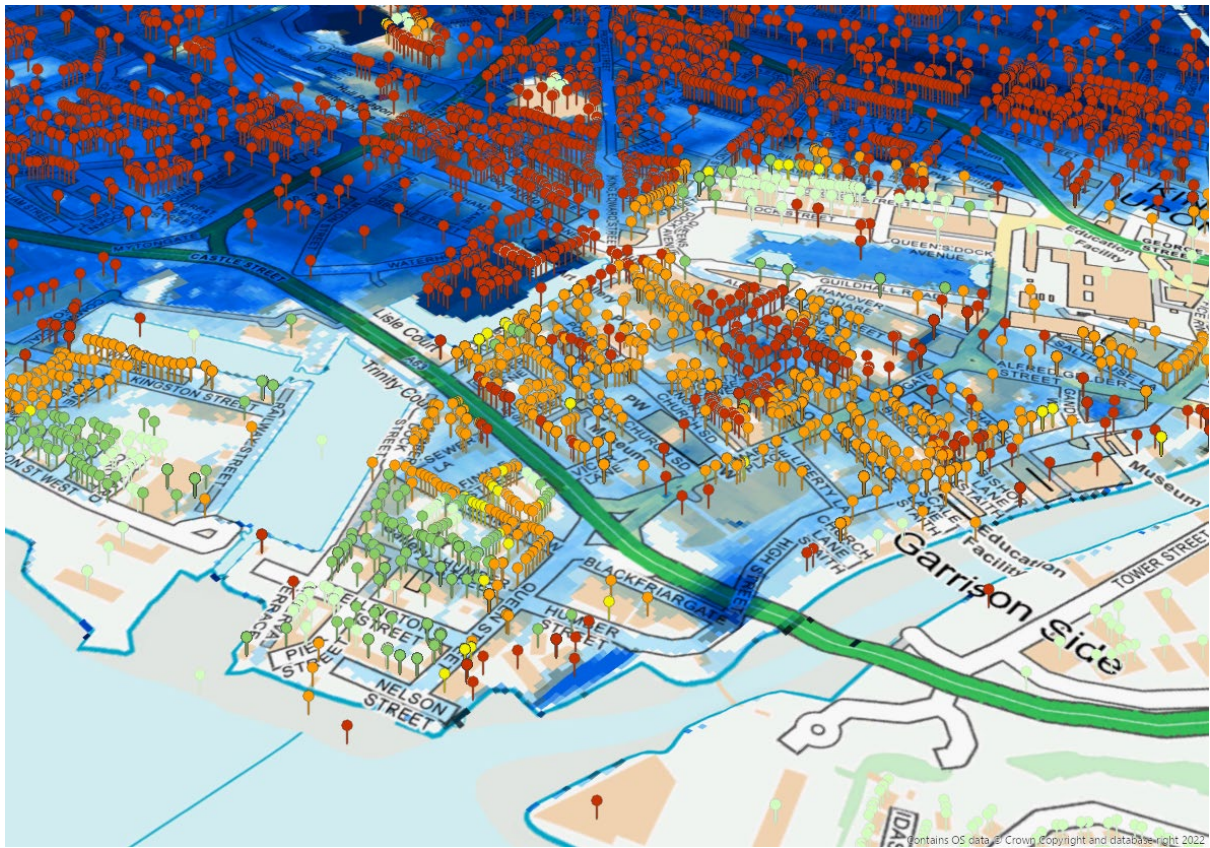
market dynamics and informed buyers could negotiate the price down since they have an advantage when the market is under distress after an extreme weather event.

This report provides insight into the dynamics between flood risk and property prices in England. The aim is to provide awareness to regulators, and policy makers regarding the effects of flood risk on the residential property market. Earlier literature focuses on specific case studies and the findings suggest that following a flood event, properties located in the affected area are sold at a discount. The discount varies from 10% to 50%, but the effect is found to be temporary. Belanger & Bourdeau-Brien (2018) provide insight of the effect of flood risk on a sample of more than 600,000 English residential properties through their distance from water. They capture flood risk based on the location of a property within a 100-year floodplain. Their findings show that a significant flood risk discount is found in waterfront properties but the impact is also considerable for dwellings further from the water body.

However, the distance from a water body is not necessarily the best indicator of flood risk. McKenzie & Levendis (2010) study Hurricane Katrina, which was a standing-water flood and therefore property elevation was of primary importance. They argue that the likelihood that flood risks and the associated discounts are inversely related to the elevation of the property within the floodplain. In other words, the location with a floodplain captures the risk of flooding, but not necessarily the extent of flooding and since its property is at a different elevation level, the flood effect won't be homogeneous. In addition, separating the price effect of a potential flood risk from the property price is often difficult and in some cases properties in coastal areas may even be sold at a premium as a result the benefits of living close to the water (ocean view, water-based recreation opportunities) which outweigh the risks from a future flood event. (Morgan, 2007 ; Beltran et al., 2018).

This report presents evidence of flood risk price effects on England's residential properties using a unique scoring technique by Twinn by Royal HaskoningDHV that allows us to quantify flood risk per property and overcome all the aforementioned limitations.

Figure 1: Twinn's Flood Map with affected properties



Source: Twinn by Royal HaskoningDHV. This image shows Twinn's Flood Map fluvial data in blue. Twinn Flood Score data points are overlaid, colour coded to describe the flood risk to properties, with red representing locations with very high flood risk predicted.

We aim to build the foundations for a better understanding of climate-related risk in the property market and to answer the following questions:

- Is flood risk already capitalised in property prices? And if yes, can we quantify the flood risk discount that exists in the market?
- Do both sellers and buyers take flood risk into consideration in their pricing?
- Is the effect homogeneous across all properties? What is the flood risk discount between low priced versus high priced – luxury properties?

## Property price data

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Property price data is provided by Rightmove, UK's no.1 property website and includes the asking and sold price and date, number of bedrooms and the year the property was built. Our sample only includes single-family properties built between 1970 and 2010 with a market sale between 2006 - 2022. The reason for the cut-off was to exclude any new build properties still under building warranties and attracting a new build premium. Also, condominiums were not found suitable for the analysis, as each flat within a building is affected differently and is sold with an individual price, but Twinn flood risk scores only apply to the whole building. In addition, for the purpose of this analysis all listings with a price below £10,000 and above £10,000,000 have been excluded and the number of bedrooms was capped at 10. The final sample of properties with sold-prices resulted in a total of 3,195,448 unique transactions.

In total we have data for 4,882,880 individual listings at the Rightmove website of the average asking property price is £309,518. Of those listings around two out of three lead to a sale. The average sold price is £277,264, which is as expected lower (-10.42%) than the asking price. Data is then divided into five main categories depending on their property type. One out of three properties are classified as detached, which is the most expensive property type with an average sold price of £377,932. Semi-detached and terraced properties are priced at around £216,398 and £201,941 respectively. Bungalows are sold at £248,867 and finally 6-7% of our sample is unclassified.

Table 1 provides an overview of the entire sample distribution by property types and regions. Our sample include data from 9 English regions. The area around London (South East and Outer London) is most expensive with an average sold price of just above £350,000. East Anglia and South West are also priced higher than the rest of England at £286,011 and £279,533 respectively. The most affordable houses are in the Yorkshire and East Midlands regions with an average price of around £200,000.

**Table 1: Properties per sample**

Property Types						
	Number of observations	%	Average asking price	Number of observations	%	Average sold price
Detached	1,737,622	35.59%	£425,502	1,080,218	35.59%	£377,932
Semi-Detached	988,012	20.23%	£230,670	667,080	20.23%	£216,398
Terraced	1,117,052	22.88%	£212,658	755,107	22.88%	£201,941
Bungalow	713,836	14.62%	£269,015	489,167	14.62%	£248,867
Unclassified	326,358	6.68%	£350,824	203,911	6.68%	£290,149
Total	4,882,880	100%	£309,518	3,195,483	100%	£277,264

England Regions						
	Number of observations	%	Average asking price	Number of observations	%	Average sold price
South West	833,492	17.07%	£315,362	546,282	17.10%	£279,533
South East	1,266,904	25.95%	£407,969	835,196	26.14%	£358,726
East Anglia	983,559	20.14%	£315,115	642,177	20.10%	£286,011
West Midlands	681,178	13.95%	£225,068	451,518	14.13%	£205,600
East Midlands	454,333	9.30%	£247,868	297,993	9.32%	£224,291
Yorkshire	595,675	12.20%	£218,988	379,419	11.87%	£200,404
North West	3,109	0.06%	£281,598	1,708	0.05%	£243,251
North East	15,619	0.32%	£280,542	9,581	0.30%	£247,340
Outer London	49,011	1.00%	£409,472	31,649	0.99%	£364,307
Total	4,882,880	100%	£309,518	3,195,483	100%	£277,264

Source: Rightmove and Authors calculations

## Measuring flood risk

Flood risk is quantified by the Twinn *FloodScore*<sup>TM</sup>. The flood risk metric is based on every addressable property in Great Britain and Northern Ireland and considers risk from fluvial, pluvial and tidal sources. It uses advanced flood modelling techniques and incorporates the most current hydrology data from the Centre of Ecology & Hydrology,

building stock data from Ordnance Survey, and the latest high resolution LiDAR from the Environment Agency.

Figure 2 is provided by Twinn and illustrates how properties that are near a water body can have low exposure to flooding. This is the main advantage of this metric since it estimated the likelihood of an individual property being flooded, as well as the damage ability for different property classes. The data are regularly updated following UK flood events.

The metric provides us with a sophisticated and precise quantification of the likelihood of an individual property being flooded, due to rainfall, overflowing rivers and tidal surges, compared to more simple methods previously used, such as distance from a water body.

Twinn flood score data contains four alternative indicators of flood risk based on different emissions scenarios (low/moderate and high level of emissions) and two time epochs (2050 and 2080). Table 2 displays the average sold property prices for different flood risk classes. As expected, non-affected properties are priced higher than those of medium or high risk.

Figure 2: Visualisation of property-level flood risk



Note: The image illustrates how the Twinn Flood Score works for different properties. The visualisation shows that the distance from a water body is not the only criterion that affect the probability of a property being affected by a flood event. Source: Twinn by Royal HaskoningDHV

**Table 2: Average sold property prices by Flood Risk Scenarios**

Scenario	2050		2080	
	Low/Moderate	High	Low/Moderate	High
Zero Risk	£280,970	£280,970	£280,976	£281,002
Medium Risk	£271,858	£271,971	£270,318	£268,294
High Risk	£241,612	£242,386	£245,606	£249,728

Source: Rightmove, Twinn by Royal HaskoningDHV and Author calculations

For the research the selected benchmark model is the more optimistic 2050 low/moderate emissions scenario. Based on this scenario, 16.45% of all properties (803,057) in the sample are exposed to medium or high flood risk. When using the longer time horizon - 2080, the percentage of high risk properties increases by 3.03%. A change to the more pessimistic high emissions scenario, means 8.19% more properties are classified as high risk over the next thirty years (epoch 2050). The percentage of non-affected properties is constant across different scenarios at 80%-85%.

As mentioned before, the sample includes more than 4 million listings, however not all listing resulted in a sale. The average flood risk of sold properties is estimated at 8.01%, whereas unsold properties' flood risk is at 8.63%. In addition, based on data for the entire sample period 2006 - 2022, zero exposure to flooding increases the probability of a property to get sold from 63.3% to 65.6%.

However, flood risk is not the main driver of the relatively low percentages of sales completion. The average asking price of unsold properties is around £350,000, which is 22.6% greater than the asking price of properties that were sold. In total 74.61% of all completed sales were completed at a discount and in only 11.48% of cases the sold price was above the asking price. For the remaining 13.91% the buyer and seller's prices matched. Overall across the entire sample period 2006-2022, sales were completed at an average 3.6% discount of the asking price.

## Empirical model

The key objective of the report is to quantify the impact of flood risk on property prices in the UK. The analysis uses a logarithmic hedonic property price modelling technique that is based on the assumption that a good's pricing, in this case the property price, is driven by its characteristics. Therefore, as can be seen in Equation (1), the logarithm of the sold price of each property ( $i$ ) is the main variable of interest and flood risk enters the model as an explanatory variable. We expect a negative relationship between the two variables that would mean that the probability of flooding will be capitalised and these at-risk properties will be sold at a discount compared to non-affected houses.

### Logarithmic Hedonic Pricing Model

$$\text{Log}(\text{Price}_i) = \alpha + \beta_1 \text{Flood}_i + \beta_2 \text{beds}_i + \text{age\_group}_i + \text{year}_i + \text{month}_i + \text{region}_i + \text{type}_i + \varepsilon_i \quad (1)$$

,where  $i$  stands for each unique property transaction

In our empirical specification we include property characteristics such as number of bedrooms and the year the property was built. The two variables are available for the majority of listings in our sample and they allow us to control for size and quality of the property. We expect that modern larger properties (built more recently and with more bedrooms) will be priced higher than average.

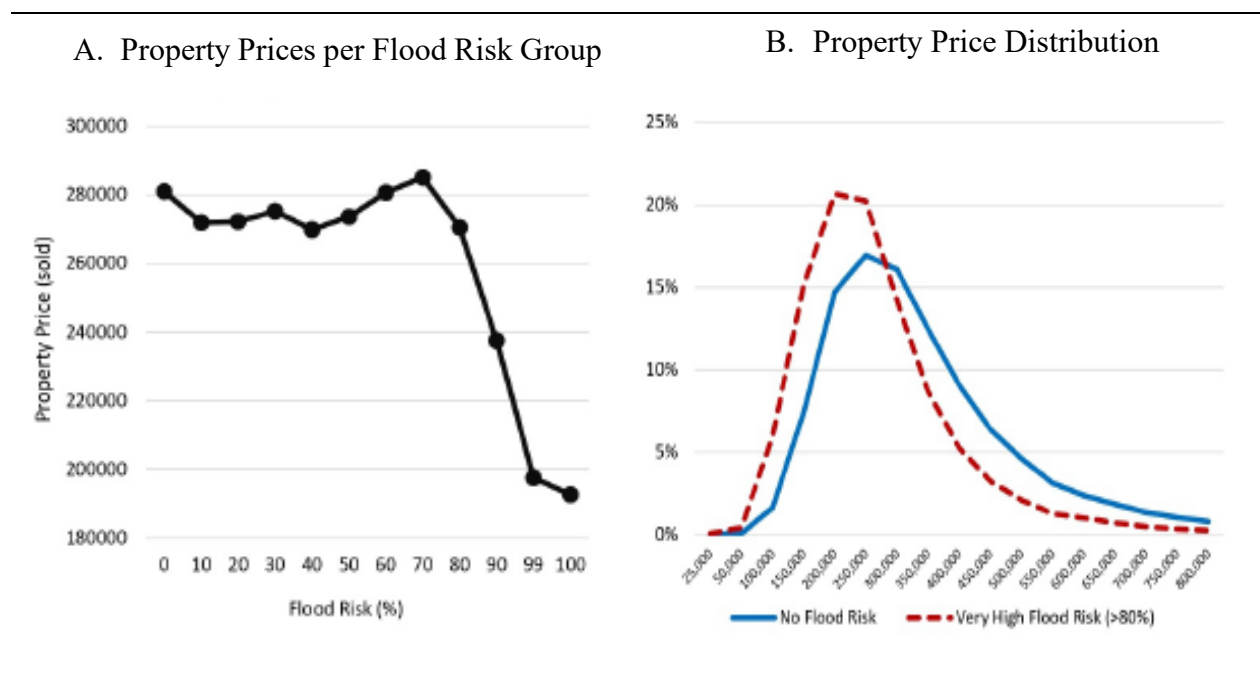
In addition, we have to take into consideration the fact that property prices exhibit significant seasonality. The data suggests that the average sold price is 3.55% higher in the beginning of the school year (September) than the sample average. The period between July-September is the quarter with the most sales (27.2% of the annual sales). On the other hand, only 6.6% of all transactions are completed in January and overall the first half of the year the market is not as busy as in the second half. To control for seasonality and time-related factors we include month and year controls. In addition, we control for property's region and type.

Our empirical findings are robust to a series of tests. We employ data from the Environment Agency on flood zones. Each property is matched to a flood zone level based on its postcode. We find that flood zone level is negatively associated with property prices, in accordance with our previous findings. In addition, we remove the COVID-19 and we find that the pandemic had no effect on the dynamics between flood risk and property prices. Finally, using alternative property controls, such as postcodes instead of regions, does not change our empirical results.

## Flood risk impact on property prices

Flood risk has a strong negative relationship with property prices, meaning property market participants take the probability of a flood event into their pricing consideration and the higher the probability of a flood risk the lower the property price. Our empirical findings from the hedonic pricing model suggest that for each one percentage point increase in the probability of flooding, properties are sold at a discount between 0.11% and 0.19%. and, if a low-risk property (with flood risk below 20%) experiences a flood event, its price is expected to decline by 9.6% to 13.6%.

Figure 2: Flood risk & property prices



Note: Figure A displays the average (sold) property price for different levels of flood risk. To measure flood risk we use the more optimistic 2050 moderate emissions scenario as provided by Twinn by Royal HaskoningDHV . The data covers the period 2006-2022. Figure B plots the distribution of (sold) property prices for properties with zero (solid line) and very high (>80%, dotted line). The distribution is based on the five-year period 2017 to 2022.

Table 2 and Figure 2A present the average property price for different levels of flood risk. We observe that property prices do not vary considerably for low/medium levels of flood risk. More specifically, properties with a flood score below 60% are sold at a discount between 2.6% and 4%. However, the flood risk discount is significantly greater reaching 15.5% in the very high risk ranges of above 81%-90% and 30% in the range between 91% and 100%. On the latter, properties with the highest probability of flooding in the near

future (flood risk of 1) are sold at a 31.3% discount. That indicates that flooding certainly affects real estate prices, however the impact is driven by properties at very high (extreme) risk.

Figure 2B displays the property price distribution (sold prices) for zero or very high risk for the period 2017-2021. The difference between the two distributions is clear with risky properties to be more skewed to the left. As illustrated in both Figures, the average sold price of very risky properties is below £190,000, whereas the average value for zero risk real estate assets is at £270,000. In addition, only 2.12% of zero risk properties are priced below £100,000 compared to 7.18% for properties with a flood score above 80%. On the other hand, the sample of non-exposed houses contains 13.5% of properties with a value of above £500,000. In the sample of risky properties percentage of expensive properties is just below 5.5%.

### Regional differentiation of flood risk

In addition, property prices vary significantly across the country. Properties in Outer London and South East regions are sold 70%-75% higher than those located in Yorkshire and East Midlands. In addition, there are variations within regions depending on property types. Detached properties are on average, 87% more expensive than terraced houses. In total our sample includes data from 9 English regions and the summary statistics are displayed in Table 3.

The area around London (South East and Outer London) is most expensive with an average sold price of just above £350,000. East Anglia and South West are also priced higher than the rest of England at £286,011 and £279,533 respectively. The most affordable houses are in the Yorkshire and East Midlands regions with an average price of around £200,000.

The effect of flooding has a very localised impact and the average flood risk varies across regions. The highest values are observed in East Anglia (11.88%), Yorkshire (10.72%) and North West (10.50%) average property flood risk (2050) respectively. In each of these regions ca. 13 – 18% of properties are affected. West and East Midlands present the low average property flood risk that varies between 3.77% and 4.73% and less 12% of the houses are at risk.

Data regarding property types are also presented in Table 3. Semi-detached and terraced houses are more vulnerable to flooding since any temporary protection measures, such as blocking doors, windows, vents and pipes, will not be effective unless their neighbours take similar steps.

**Table 3: Average property prices by flood risk per region**

<b>Regions</b>						
Region	Sold Price	Asking Price	Low/Moderate Emissions		High Emissions	
			Flood Risk 2050	Flood Risk 2080	Flood Risk 2050	Flood Risk 2080
Probability flood risk per property						
South West	£279,533	£315,362	8.54%	8.73%	9.10%	9.53%
South East	£358,726	£407,969	6.76%	6.98%	7.62%	8.75%
East Anglia	£286,011	£315,115	11.88%	12.17%	12.67%	13.72%
West Midlands	£205,600	£225,068	3.79%	3.89%	4.26%	4.93%
East Midlands	£224,291	£247,868	4.74%	4.86%	5.25%	6.01%
Yorkshire	£200,404	£218,988	10.72%	11.00%	11.31%	12.40%
North West	£243,251	£281,598	10.50%	10.64%	11.04%	11.96%
North East	£247,340	£280,542	5.57%	5.70%	6.16%	7.08%
Outer London	£364,307	£409,472	8.13%	8.61%	8.92%	10.07%

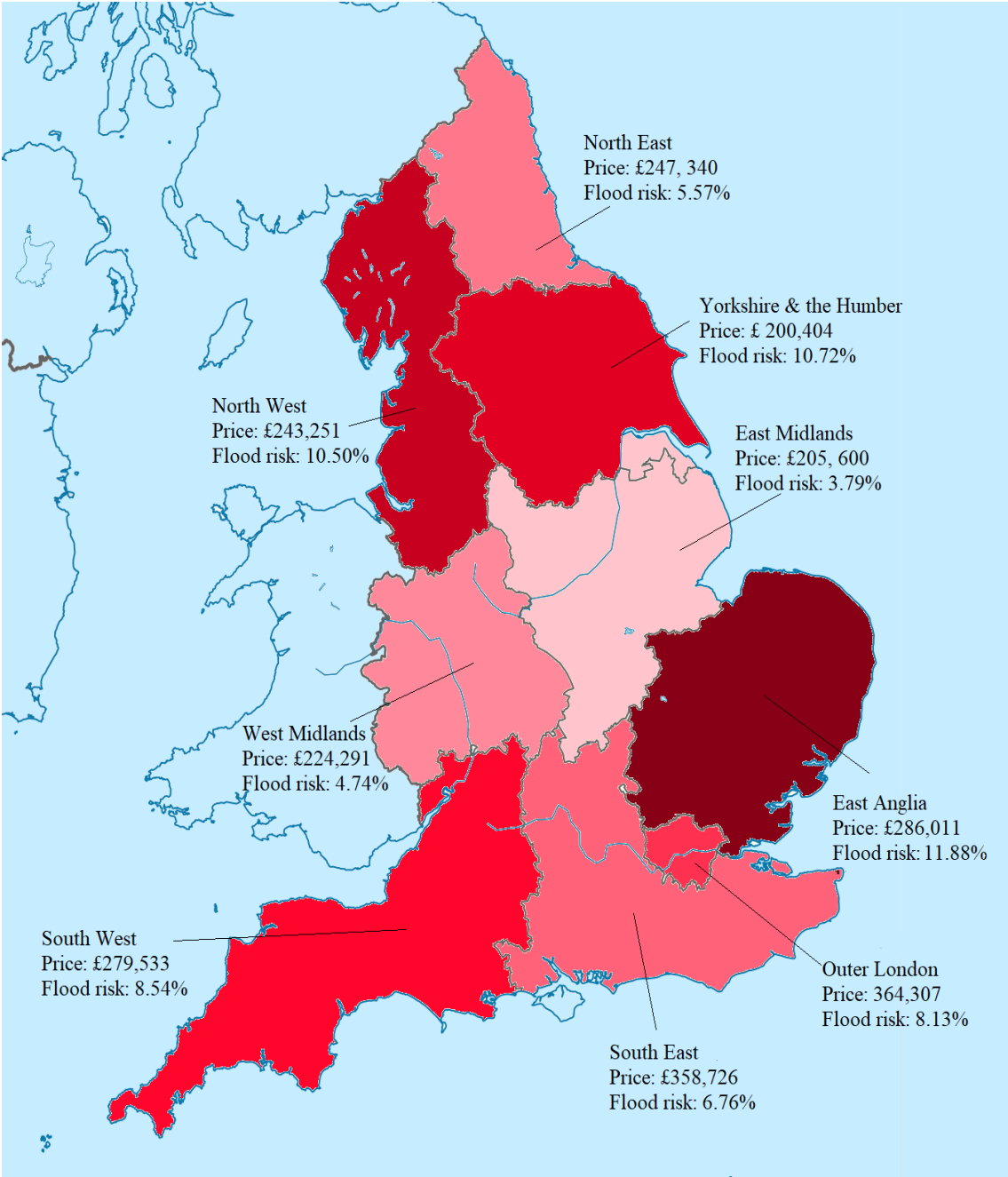
  

<b>Property Types</b>						
Type	Sold Price	Asking Price	Low/Moderate Emissions		High Emissions	
			Flood Risk 2050	Flood Risk 2080	Flood Risk 2050	Flood Risk 2080
Probability flood risk per property						
Detached	£377,932	£425,502	6.99%	7.20%	7.61%	8.50%
Semi-Detached	£216,398	£230,670	7.60%	7.82%	8.26%	9.21%
Terraced	£201,941	£212,658	9.00%	9.27%	9.85%	11.03%

Note: The Table presents the average sold and asking price and the probability of a flood event across different regions. The data refers to the period 2006-2022 and the flood risk metrics are based on the moderate emissions scenario.

Source: Rightmove, Twinn by Royal HaskoningDHV and Authors calculations

Figure 3: Regional property price differentiation, low/moderate scenario 2050



Note: The Figure illustrates the average (nominal) regional sold price for the period 2006-2022H1. The Flood risk is based on the same sample period and the 2050 low/moderate emission scenario as provided by Twinn by Royal HaskoningDHV

## Do sellers take flood risk into consideration?

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A separate analysis was run on using the properties asking prices only since not all listings result in a sale. The inclusion of all asking property prices increases our sample to 4,882,880 observations and provides a good robustness test. Asking property prices indicate whether sellers incorporate their flood risk in pricing their properties

- When using Asking prices, owners that recognize the probability of a flood event also offer their properties at a discount. Similarly to our previous findings, the flood risk discount is estimated at 0.11%-0.19% per one percentage point increase in flood risk.

Unsurprisingly, how recently a property was built and how many bedrooms it has are both relevant variables, which are positively correlated with the property's asking price. We then estimate the model including the gap between sold and asking price as the main variable of interest. Our results show that there is a positive association between flood risk and the asking and sold price difference. In other words, this empirical finding suggests that between two identical properties (same number of bedrooms, year built, region and type) that were sold at the same time period, the buyer of the property with higher flood risk has more negotiating power and the property will be sold at a greater discount from the initial asking price.

## Do future expectations about flood risk matter?

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Based on the data from Twinn, by 2080 flood risk is projected to increase for 380,098 properties in our sample. In other words, 11.9% of all sold properties or all 73.4% of exposed properties. The average projected flood risk increase of the exposed properties is estimated to be 8.5%. In a more pessimistic scenario of high emissions, the average increase can be up to 20.5% or in other words the average flood score is estimated at 9.65%. Analysing the sample of properties for which flood risk is projected to increase finds the following:

- Based on our empirical results, one percentage point increase in flood risk is associated with a 0.09% price discount, however if the flood risk of the examined property increases in the future, the discount is twice as large (0.18%).

Table 4 displays the difference between the flood risk scenarios. When distinguishing by property types, projected increases between 2050 and 2080 are highest for terraced houses and semi-detached houses (+1.5% - 2%), while the impact is lower for bungalows and detached houses (+0.5% - 1%). This highlights again, that potentially lower priced properties and lower-household income owners will be more affected by price changes due to flood risk and hence should be a focus of government policies.

**Table 4: Flood risk probability by property type**

Property type	Low/Moderate Emissions		High Emissions	
	Flood Risk 2050	Flood Risk 2080	Flood Risk 2050	Flood Risk 2080
Probability flood risk per property				
Detached	6.99%	7.20%	7.61%	8.50%
Semi-Detached	7.60%	7.82%	8.26%	9.21%
Terraced	9.00%	9.27%	9.85%	11.03%
Bungalow	9.35%	9.61%	9.89%	10.69%
Unclassified	7.87%	8.11%	8.60%	9.60%

Source: Rightmove, Twinn by Royal HaskoningDHV and Author calculations

The two scenarios also predict differences between the regions, with some of the most radical increases projected for regions with currently relatively low flood risk such as Outer London and the South East, which contain some of the most populated areas and high priced properties around the UK.

### The perception of flood risk over time

Furthermore, we examine whether the relationship between flood risk and property price is homogeneous across time. More specifically, we aim to explore if weather events alter market participants' understanding and behaviour towards flood risk. Hence this part of the analysis focuses on the last decade floods (2010-2022) instead of the entire period 2006-2022. Our findings show that market participants are taking flood risk into consideration in their property buying--selling decisions. However, the effect could be

mitigated by buyer's irrational behaviour or incomplete information. Pryce et al. (2011) suggest that market participants evince "myopia" and "amnesia" and thus perceived risk could diverge considerably from actual risk. We test whether buyers alter their behaviour and they are more sensitive to flood risk information after an extreme weather event occurs.

Some of the major hydrological events as defined by the National River Flow Archive and the UK Centre of Ecology & Hydrology:

- The 2019-2020 flooding: After a prolonged dry period (2016-2019), the UK experienced a number of severe flood events between June 2019 and February 2020. The most affected areas were North Wales, North England and the Midlands. The property damage was severe for areas such as Derbyshire and Lincolnshire with the estimated insurance pay-outs to be estimated at £110 million (Sefton et al. 2021).
- The 2015-2016 flooding: A series of heavy rainfalls resulted in flooding in the period between December 2015 and February 2016 in North West England. For the UK, December 2015 was the wettest month and it was the second wettest winter since 1910 (Barker et al. 2016).
- The 2013-2014 flooding: From December 2013 to February a succession of persistent rainfall and strong winds affected the UK. According to the Environmental Agency the damage was estimated at around £1.3 billion for England and Wales. The property damage alone was at £320 million since more than 10,000 houses were affected. The damage was a combination of coastal, pluvial, fluvial and groundwater flooding (Muchan et al. 2015). The effect was spread across the country and mostly South England.
- The 2012 flooding: Following a dry period between 2010 and early 2012, in spring of 2012 and through the winter of 2013, there was extensive flooding across much of England. This was an extreme expression of the variability of UK climate. Flood alerts were widespread from South West England to Scotland.

We focus on the aforementioned recent major hydrological events and we construct an Extreme Weather Event (EWE) dummy variable that takes the value equal to one during periods that a specific region experiences a flooding event, and zero otherwise. Then we assign an EWE value for each property based on the region it is located.

The empirical findings confirm the following:

- In the period shortly after extreme weather has (just) occurred, the impact of flood risk on property prices is stronger.
- Based on results, one percentage point increase in property flood risk is associated with a 0.13-0.19% decline in sold property prices. However, in periods of extreme weather events the impact is between 0.17 and 0.23%.

### The impact of property characteristics on flood risk

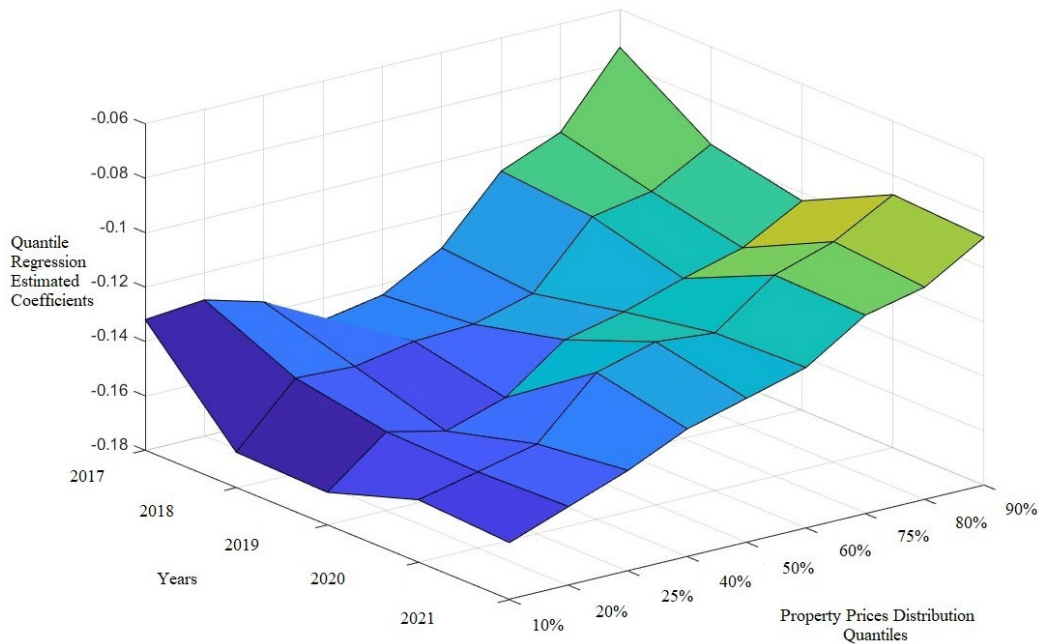
Property characteristics are not priced the same across the property price distribution. Research findings show that higher-priced homes value certain characteristics, such as the number of bathrooms and property size, differently from buyers of lower-priced homes (Zietz et al. 2008), which proportionally are more sensitive to flood risk and will reflect this in their pricing.

Using a quantile regression model allows to analyse whether higher-priced property buyers behave differently from buyers of more affordable properties. Zhang (2016) adopts the same empirical approach to study the Fargo-Moorhead Metropolitan Statistical Area between 2000 and 2013 and finds that among properties located within a 100-year floodplain, low-priced properties have a larger flood risk penalty.

The analysis includes property characteristics, such as the number of bedrooms in the house and the year built. The two variables are available for the majority of listings in our sample and they allow us to control for size and quality of the property. We expect that modern larger properties (built more recently and with more bedrooms) will be priced higher than average.

Figure 4 displays the quantile regression coefficients estimated for each year separately between 2017 and 2021. The estimated coefficients are negative, since greater probability of flooding is associated with lower property prices. The greater the coefficient, the larger the effect of flood risk on prices.

Figure 4: Quantile Regression Coefficients



Note: The Figure displays the estimated quantile regression coefficient of flood risk on property prices. The explanatory variables also include number of bedrooms and the year the property was built. The estimation was for each year separately between 2017 and 2021 and for quantiles between 10% and 90%. The estimation of the variance-covariance matrix is based on bootstrapping and 100 replications.

Figure 4 clearly illustrates the homogeneous effect of flood risk on house prices and the consistency of the findings over the last five years. The average estimates suggest that one percentage point increase in property's flood risk is associated with -0.16% discount in the lower 10- 25% percentile of the property price distribution (most affordable properties). The estimated discount is at -0.13% discount for properties priced around the median (40%-60%) and less than -0.10% for the most expensive properties.

## Conclusions

The report highlights how flood risk can directly affect England's residential real estate market and builds the foundations for a better understanding of climate-related risk in the property market. Across all empirical model specifications, flood risk has a strong negative relationship with property prices, meaning that property market participants take the probability of a flood event into their pricing consideration in sold and asking prices. The discount affects both sold and asking property prices and is analogous with

properties' level of exposure. In addition, our empirical model suggests that one percentage point increase in properties' flood risk is associated with a decline of 0.11% to 0.19% in both sold and asking price. In a pessimistic scenario, the average property flood risk is projected to increase by 11.73% and that could cause a 1.29-2.23% decline in property prices. The impact is significantly greater when the examined property's probability of flooding is projected to increase in the future.

Overall, the findings confirm a non-linear relationship between property prices and flood risk. We find evidence that market participants are more sensitive to flood risk in periods soon after an extreme weather event occurs. Furthermore, the analysis shows that flood risk impacts properties differently depending on various characteristics such as bedrooms, type of property or year build. Our findings suggest that flood risk has a stronger effect on lower-priced than higher-priced properties. Therefore, buyers of low-priced properties are more sensitive to high flood risk compared to buyer of higher priced properties.

In summary:

- Across all model specifications, flood risk has a strong negative relationship with property prices, meaning that property market participants take the probability of a flood event into their pricing consideration in sold and asking prices
- For each one percentage point increase in the probability of flooding, properties are sold at a discount between 0.12% and 0.17%.
- For a low-risk property a flood event means, its price discount will increase from 9.6% to 13.6% compared to an equivalent non-affected property.
- The results are also true when considering the different property characteristics such as differences across regions and property types. Overall, additional rooms increase property prices by 28% to 36%, and the more recently a house is built, the higher is its property price and the lower the flood risk price discount.
- The effect of flood risk is asymmetric and lower priced properties are more affected by flood risk price discounts than more expensive ones, showing that buyers of lower-priced properties make a higher price discount for food risk.

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