

# Should I Stay or Should I Go? The Effects of Floods on Firms' Location Choices

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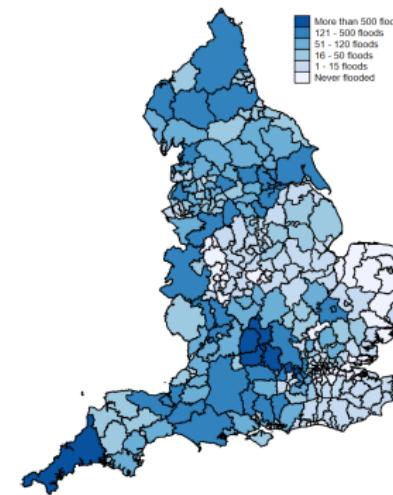
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## Context

- With the rise in CO<sub>2</sub> concentrations in the atmosphere, the frequency of extreme events has increased.
- The UK has particularly suffered from floods, due to storms or heavy rainfall (Henk, Babet).
- Floods in the UK are ubiquitous and their prevalence has increased.

Number of floods over 1998-2023



Prevalence

## Floods affect business premises at their core

- Floods destroy capital and render business premises inaccessible, making it impossible to conduct operations.
- To design adequate policies, we need to understand their effects, particularly on firms' location choices.



This Paper

*What is the spatial distribution of firms in the UK and how is it shaped by floods?*

- We leverage a unique dataset of UK firms' business premise addresses at the premise  $\times$  year level, overlayed with yearly flood maps and data on company ownership structure and characteristics.
  - We document the spatial distribution of corporate organisations across the UK.
  - We investigate the effect of floods on firms' location choices.
  - We examine the interaction with local productivity.
  - *In progress:* We look at the interaction with commercial real estate prices.

## Preliminary Results and Contribution

- ① Following a flood, firms are 10 % more likely to relocate.
  - There is heterogeneity across sectors, firm size, productivity.
- ② Companies that relocate after a flood internalise the risk of flooding.
- ③ Local productivity affects firms' location choices but doesn't seem to affect firms' location choice in response to a flooding event.
- ④ *Preliminary:* Floods have a significant effect on sale price declines, not necessarily on rental price.

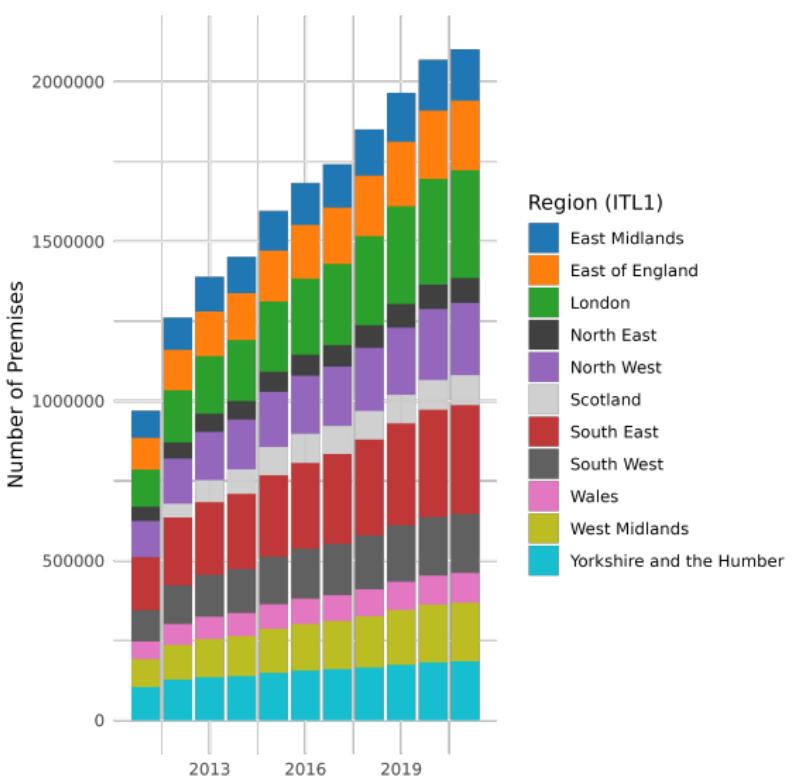
### Contribution:

- Few papers have attempted to look at the effects on firm relocation (Balboni et al. Forthcoming). → we provide the first evidence for the UK.
- We add the analysis of commercial real estate prices.

## Dataset

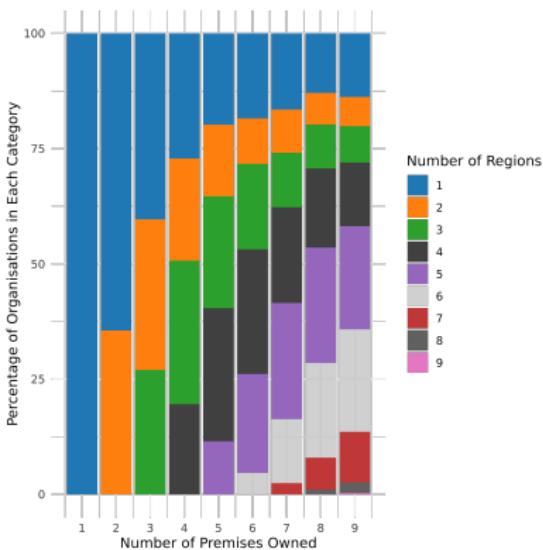
- Floodmaps from the Environment Agency (EA) and Natural Resource Wales.  
GIS Layer at 50m × 50m resolution from 1946 onwards.
- UK business premises' address information (geo-coordinates) and corporate organisation identifier from Ordnance Survey AddressBase Premium.
- Extent of each business premise from Energy Performance Certificates Area in square feet at the UPRN (premise ID) level.
- Corporate balance sheet information at the organisation level from Companies House in the UK (BVD).
- Final dataset: panel at the premise × year level recording information on business premise characteristic (area, organisation that operates from the business premise and its characteristics), flood information for the years 2011 - 2021.

## Stylised Fact 1 - Growing number of business premises over time



## Stylised Fact 2 - Organisations with multiple business premises operate from multiple regions

**Figure:** Number of regions organisations are present in, split by number of premises as of 2020



- Example: among organisations with two premises 70% are operating in one region, 30% in two.

## Stylised Fact 3 - The flooded sample of organisations differs from the whole sample

Figure: Flooded Sample

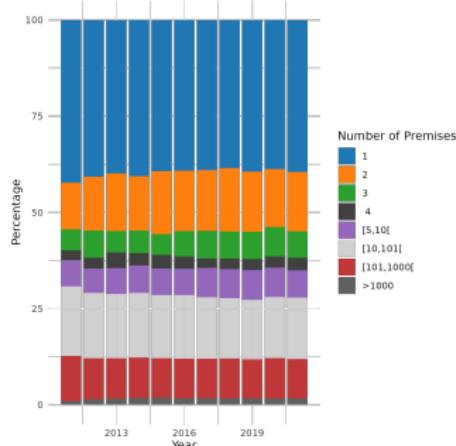
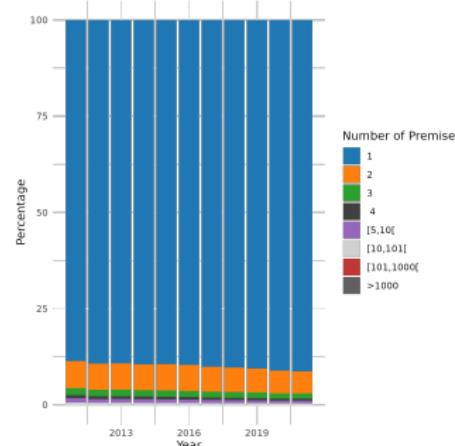


Figure: Whole Sample

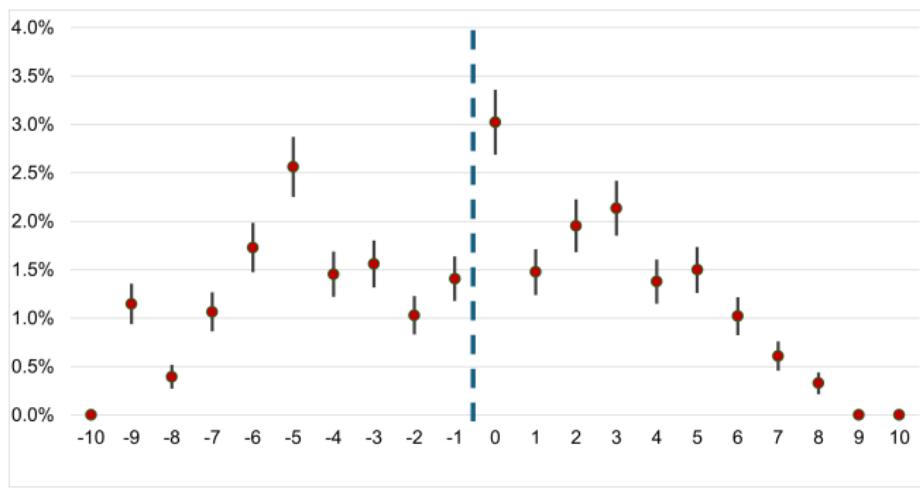


- Partly because having more business premises increases the likelihood of being flooded (by statistical definition).
- Partly as result of larger organisation searching for cheaper land and sorting in more flood-prone areas (Crampton et al. 2025).

## Raw Means

- For the flooded sample, we plot the percentage of firms that are moving out, with respect to the time of the flood.
- Excess mass at exactly the time of flood.

Figure: Raw Means: Probability to Move Out as a Function of Time to Flood ( $t = 0$ )



## Identification Strategy - Do organisations move following a flood?

- We want to understand what is the effect of floods on the probability of moving out.

$$\mathbb{P}(\text{Move Out}_{i,t} | \text{Flood}_{i,t} = 1) = \Phi(\beta \text{Flood}_{i,t} + \eta_i + \delta_t + \epsilon_{i,t})$$

- $\text{Flood}_{i,t}$  is a dummy for whether the premise  $i$  is exposed to flood in year  $t$ ,  
 $\eta_i$  and  $\delta_t$  are the premise and year fixed effects.
- $\text{Move Out}_{i,t}$  is a dummy for whether the company moved out of the premise  $i$ .
- Specifically,  $\text{Move Out}$  is equal to 1 if this is the last year an organisation is observed at this premise, but the organisation is still in business.
- We test our hypothesis by running our regressions using probit and logit models. *Extension:* Propensity score matching yields similar results.
- Identification assumption: floods are exogenous with respect to move out.

## Regression Results

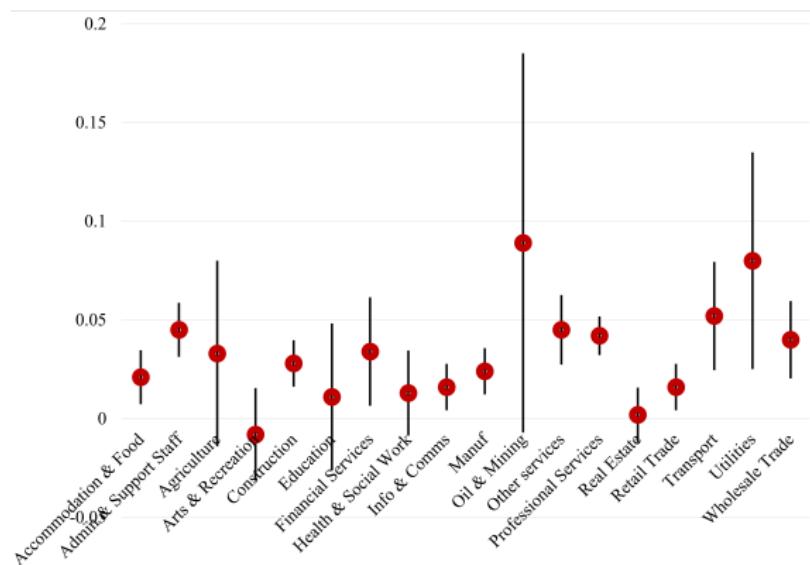
	<i>Dependent variable: Move Out</i>		
	OLS (1)	Logit (2)	Probit (3)
Flood	0.013*** (0.001)	0.723*** (0.060)	0.290*** (0.025)
Constant	0.013*** (0.00003)	-4.328*** (0.002)	-2.225*** (0.001)
Observations	16,877,929	16,877,929	16,877,929
R <sup>2</sup>	0.00001		
Adjusted R <sup>2</sup>	0.00001		
Log Likelihood		-1,173,274.000	-1,173,274.000
Akaike Inf. Crit.		2,346,552.000	2,346,552.000
Residual Std. Error	0.113		
F Statistic	153.798***		

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Marginal Effects

## Decomposition by sector

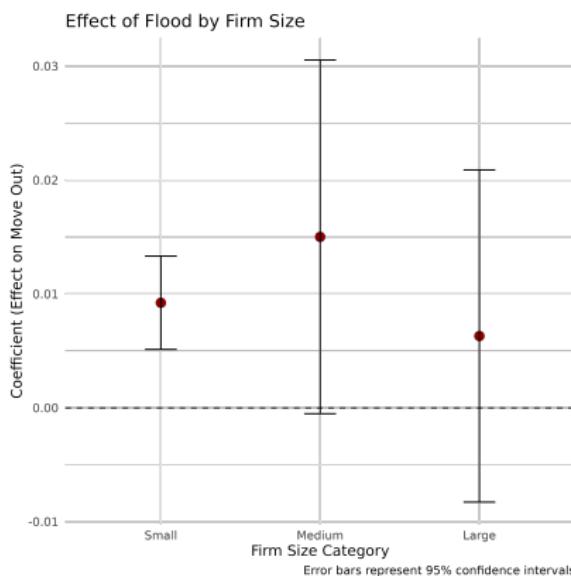
Figure: Effect of flood dummy on probability to move by sector



- Agriculture, Education, Oil and Mining not statistically significant.
- Services, Administration, Info and Communications more likely to move.

## Decomposition by size

Figure: Effect of flood dummy on probability to move by size

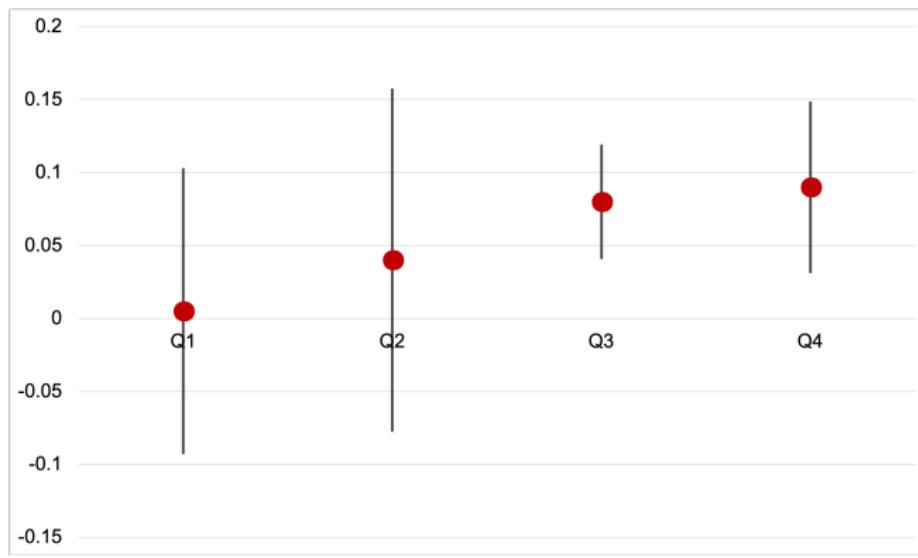


- Results driven by small firms.
- Similar trend for turnover.

## Decomposition by productivity

- Compute the labour productivity of the parent company.
- Assigns each premise to a productivity quartile.

Figure: Effect of flood dummy on probability to move by productivity quartile

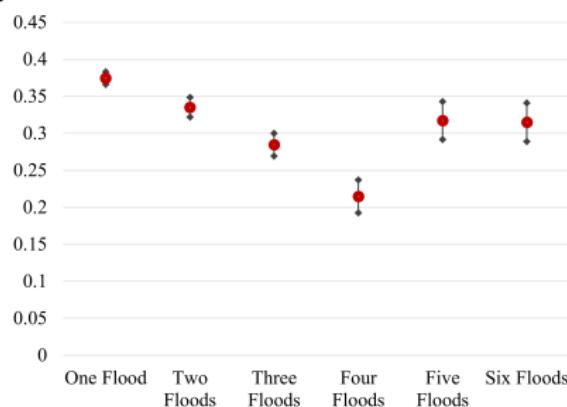


## Repeated floods still have an effect on the propensity to move out

- At the organisation  $j \times$  UPRN  $i \times$  year  $t$  level, assign the total number of floods the organisation has experienced from 2011 until that year.

$$\mathbb{P}(\text{Move Out}|\text{Flood})_{i,j,t} = \Psi\left(\sum_{k=1}^6 \alpha_k \mathbf{1}_{\text{Number of Floods}_{i,j,t}=k} + \eta_{i,j} + \delta_t + \epsilon_{i,t}\right)$$

Probability to Move Out as a function of the Number of Floods



But some firms continue to stay... Potential channels:

- Stickiness because of financial constraints.
- Adaptation via operational resilience.

## Effects on Average Risk

- We observe flood risk exposure for each business premise (identified by UPRN).
- Define the following variables:
  - *Average Risk<sub>j,t</sub>*: average risk across all UPRNs organisation  $j$  operates from in year  $t$ .
  - *Average Risk Move In<sub>j,t</sub>*: average risk across the new UPRNs organisation  $j$  moves into in year  $t$
  - $\Delta \text{Risk}_{j,t} = \text{Average Risk Move In}_{j,t} - \text{Average Risk}_{j,t-1}$
  - *Flood<sub>j,t</sub>*: total number of floods the organisation has been exposed to that year (sum across the UPRNs the organisation has been operating from)
- Run the following regression

$$\Delta \text{Risk}_{j,t} = \kappa \text{Flood}_{j,t-1} + \mu_j + \nu_t + \epsilon_{j,t}$$

## Effects on Average Risk - Results

Table: Effect of Floods on Average Flood Exposure

	<i>Dependent variable:</i> $\Delta Risk$	
	(1)	(2)
$Flood_{t-1}$	-0.068*** (0.014)	-0.039*** (0.014)
Constant	0.007*** (0.002)	
FE	NO	YES
Observations	129,046	129,046
R <sup>2</sup>	0.0003	0.677
Adjusted R <sup>2</sup>	0.0002	0.139
Residual Std. Error	0.599 (df = 129044)	0.556 (df = 48448)
F Statistic	32.681*** (df = 1; 129044)	

Note:

\*p&lt;0.1; \*\*p&lt;0.05; \*\*\*p&lt;0.01

## Do Local Characteristics Matter?

- How does the probability to move out depend on local productivity?
- At the regional level (ITL3)  $\times$  year level, use ONS measures of labour productivity and compute the number of firms per square meter.
- Compute the z-score of each region for each of these variables, i.e. the deviation from the average number of business premises, rescaled by the standard deviation. A higher z-score would mean that a region is more productive.
- Run the following regression:

$$\mathbb{P}(\text{Move Out}_{i,r,t}) = \Phi(\alpha + \beta Flood_{i,t} + \gamma ZScore_{q_{r,t}} + \delta Flood_{i,t} \times ZScore_{q_{r,t}} + \eta_i + \delta_t + \epsilon_{i,t})$$

- Coefficients of interest:  $\beta, \gamma, \delta$
- Control for year and premise fixed effects

## Agglomeration Effects On Move Outs

	<i>Dependent variable:</i>	
	Move Out	
	(1)	(2)
Flood	0.013*** (0.001)	0.014*** (0.002)
Z-Score <sub>ONS</sub>	-0.001*** (0.00003)	-0.001*** (0.00003)
Flood × Z-Score <sub>ONS</sub>		0.004 (0.005)
Constant	0.013*** (0.00003)	0.013*** (0.00003)
Observations	16,653,776	16,653,776
R <sup>2</sup>	0.00004	0.00004
Adjusted R <sup>2</sup>	0.00004	0.00004
Residual Std. Error	0.113 (df = 16653773)	0.113 (df = 16653773)
F Statistic	316.189*** (df = 2; 16653773)	210.996*** (df = 3; 16653773)

Note:-

\* $P \leq 0.1$ ; \*\* $P \leq 0.05$ ; \*\*\* $P \leq 0.01$

### Other definitions

# Agglomeration Effects On Move Ins

	<i>Dependent variable:</i>	
	Move In	
	(1)	(2)
Flood	-0.019*** (0.003)	-0.023*** (0.005)
Z-Score <sub>ONS</sub>	0.004*** (0.0001)	0.004*** (0.0001)
Flood × Z-Score <sub>ONS</sub>		-0.009 (0.013)
Constant	0.090*** (0.0001)	0.090*** (0.0001)
Observations	16,653,776	16,653,776
R <sup>2</sup>	0.0002	0.0002
Adjusted R <sup>2</sup>	0.0002	0.0002
Residual Std. Error	0.285 (df = 16653773)	0.285 (df = 16653772)
F Statistic	1,397.734*** (df = 2; 16653773)	931.984*** (df = 3; 16653772)

*Note:*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Other definitions

## Investigating the link with commercial real estate prices - (*Preliminary!*)

Postcode districts



- CoStar: Rent, sale prices per square feet for commercial real estate between 2005 and now.
- Instrument floods by the percentage of each postcode district that has been flooded each year.
- For now: hedonic regression with postcode and year fixed effects.

Commercial Real Estate: Results (*Preliminary*)

$$\ln(Price)_{p,t} = \beta_{p,t} Share\ Flooded_{p,t} + \rho_p + \eta_t + \epsilon_{p,t}$$

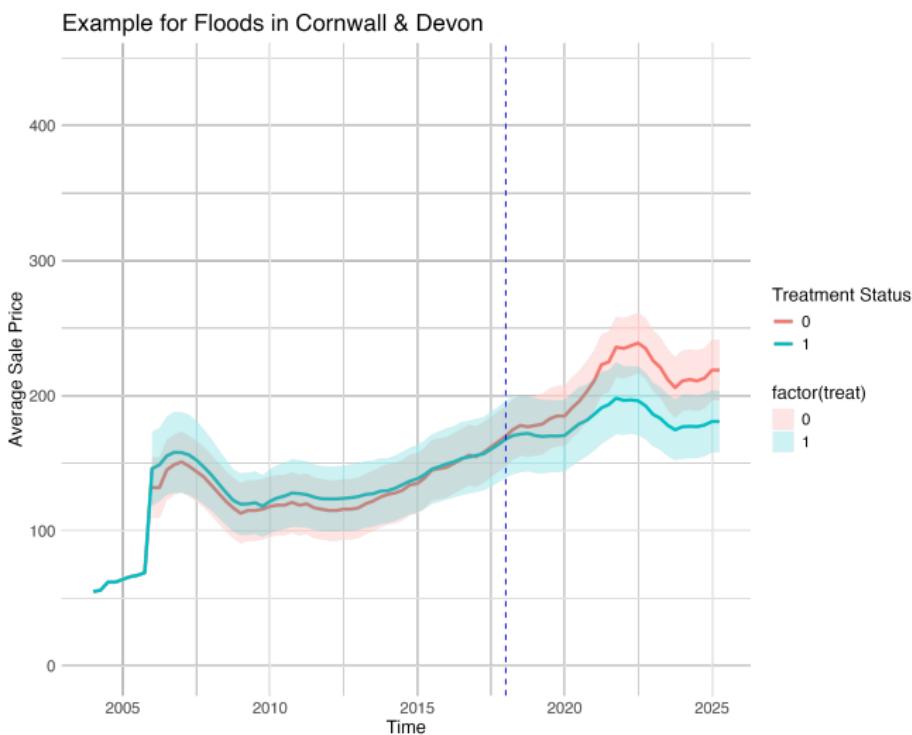
- Where  $p$  is the postcode district,  $t$  is the year.
  - Price is the price per square feet recorded across all transactions that took place per year in that postcode district.

Dependent variable:				
	ln(Sale Price)		ln(Rent Price)	
	(1)	(2)	(3)	(4)
Share Flooded	-0.0486*** (0.010)	-0.052** (0.021)	-0.029 (0.084)	0.056 (0.038)
Constant	4.870*** (0.002)		2.405*** (0.002)	
Observations	119,800	119,800	119,800	119,800
Year FE	NO	YES	NO	YES
Postcode FE	NO	YES	NO	YES
R <sup>2</sup>	0.0002	0.964	0.0001	0.811
Adjusted R <sup>2</sup>	0.0002	0.963	0.0001	0.808
Residual Std. Error	0.663 (df = 119798)	0.128 (df = 117933)	0.640 (df = 117145)	0.280 (df = 115405)
F Statistic	22.673*** (df = 1; 119798)		11.949*** (df = 1; 117145)	

*Note:*

\* $p < 0.1$ ; \*\* $p < 0.05$ ; \*\*\* $p < 0.01$

## Example for floods in Devon & Cornwall



## Conclusion and Policy Implications

- Following a flood, premises are more 10% more likely to move out.
- Strong sectoral effects driven by firms in more mobile sectors.
- Flooded companies internalise the flooding risk when making subsequent location decisions.
- Local productivity significantly drives firms' location choices.
- But local productivity doesn't manage to retain firms in response to flooding.
- Floods seem to negatively impact commercial real estate sale price, not necessarily rent.

What does this mean for policy?

- Floods will shape the corporate landscape in the UK and potentially elsewhere.
  - Some immobile sectors and large firms will not move: adaptation policies are essential.
  - Firms internalise the risk of flooding when they have been flooded: how to convey information effectively?
  - General equilibrium effects: impacts on regional productivity, inequality, employment.

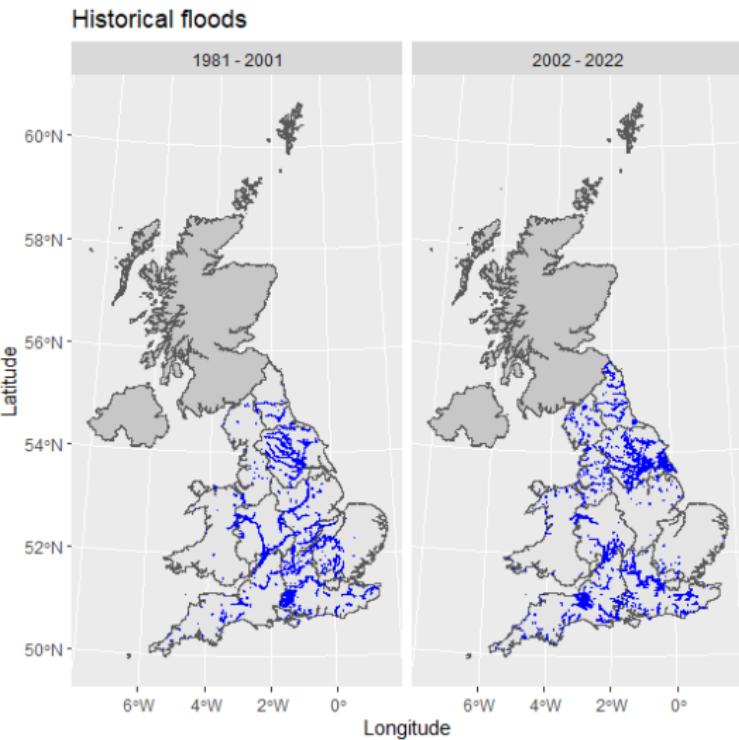
## Next steps?

- Propensity Score Matching to deal with unobservable firm characteristics.
- Refine the analysis on CRE prices.
- How do CRE prices affect firms' decisions?
- Model on regional productivity.
- Think about insurance? Keen to have your thoughts.  
Data on premia / insurance penetration at the sub-regional level?

Thank you! ☺

Comments and suggestions welcome:  
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# Prevalence of Floods



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# Marginal Effects, Probit Move Out

Table: Marginal Effects

<i>Dependent variable: Move Out</i>						
	AME	SE	z	p	Lower Bound	Upper Bound
Probit	0.097	0.008	11.58	0	0.0812	0.1143
Logit	0.093	0.008	12.13	0	0.0928	0.0931

**Note:** \* $p<0.1$ ; \*\* $p<0.05$ ; \*\*\* $p<0.01$

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# Move Out Interaction with Agglomeration Effects

	<i>Dependent variable:</i>	
	Move Out	
	(1)	(2)
Flood	0.013*** (0.001)	0.015*** (0.002)
Z-Score <sub>Density</sub>	-0.001*** (0.00003)	-0.001*** (0.00003)
Flood × Z-Score <sub>Density</sub>		0.006* (0.003)
Constant	0.013*** (0.00003)	0.013*** (0.00003)
Observations	16,653,776	16,653,776
R <sup>2</sup>	0.0001	0.0001
Adjusted R <sup>2</sup>	0.0001	0.0001
Residual Std. Error	0.113 (df = 16653773)	0.113 (df = 16653772)
F Statistic	547.760*** (df = 2; 16653773)	366.251*** (df = 3; 16653772)

*Note:*

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

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# Agglomeration Effects On Move Ins - Density

	<i>Dependent variable:</i>	
	Move In	
	(1)	(2)
Flood	-0.019*** (0.003)	-0.018*** (0.004)
Z-Score <sub>Business Density</sub>	0.004*** (0.0001)	0.004*** (0.0001)
Flood × Z-Score <sub>Business Density</sub>		0.004 (0.009)
Constant	0.089*** (0.0001)	0.089*** (0.0001)
Observations	16,653,776	16,653,776
R <sup>2</sup>	0.0002	0.0002
Adjusted R <sup>2</sup>	0.0002	0.0002
Residual Std. Error	0.285 (df = 16653773)	0.285 (df = 16653772)
F Statistic	1,857.695*** (df = 2; 16653773)	1,238.554*** (df = 3; 16653772)

Note:

\*p<0.1; \*\*p<0.05; \*\*\*p<0.01

*Note:* \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

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