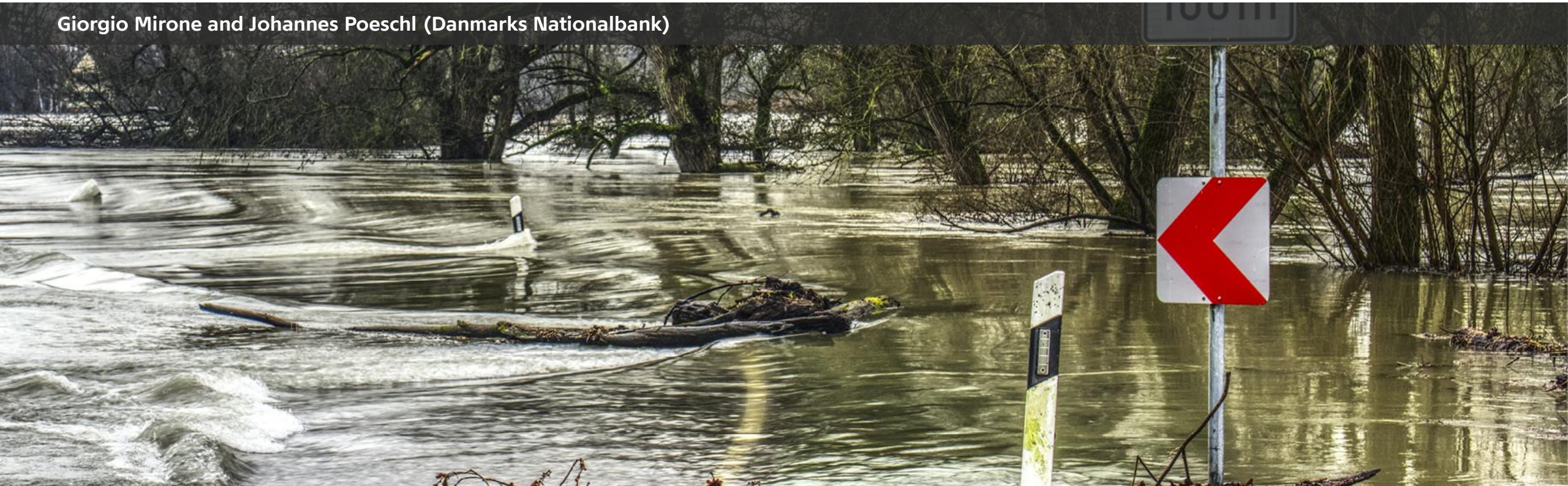


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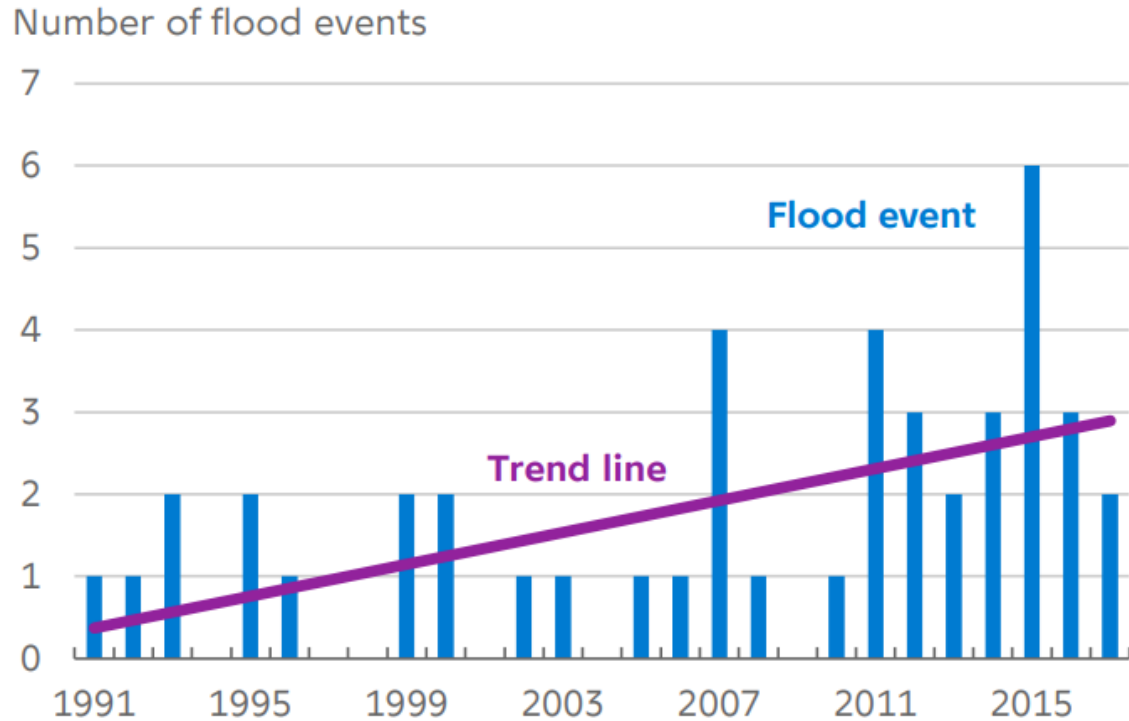
FLOOD RISK DISCOUNTS IN THE DANISH HOUSING MARKET

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Motivation



Floods are frequent and economically costly, and are expected to become even more so due to sea level rise

Understanding the consequences of flood risks for the housing market is important, as houses are...

- ... immobile assets and therefore especially exposed to flood risk
- ... often the most important assets of households
- ... an important source of collateral for loans and mortgages

What we do

We use microdata from Denmark to ...

- ... document the geographic distribution of flood risk of single-family homes
- ... estimate whether home buyers price
 - flood risk today
 - future flood risk due to sea level rise

This is important question:

- Are households aware of flood risks?
- Increase in flood risk premiums (e.g. due to increased climate change awareness) can have real economic consequences

What we find

Current flood risk

- Between 0.9 and 1.3 percent of single-family houses are exposed to flood risk today
- Exposed houses are priced at a 6 percent discount compared to similar, unexposed houses
- The flood risk discount rises temporarily after a severe flood in 1999

Increase in flood risk due to sea level rise

- Between 1.7 and 3 percent of houses could be exposed to flood risk by 2071
- Houses exposed in the future are priced at a 3-4 percent discount compared to similar, unexposed houses

**How important are flood risk and sea level rise
for the Danish housing market?**



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Measuring flood risk

Based on

- local, historical water level distributions from gauge stations all over Denmark
- simulations based on a detailed topographical map of Denmark

Result: current flood risk for each house

- Exposure of individual houses to 20-, 50-, and 100-year floods
- e.g. a 20-year flood has a 5 percent probability to occur in a given year in a given location

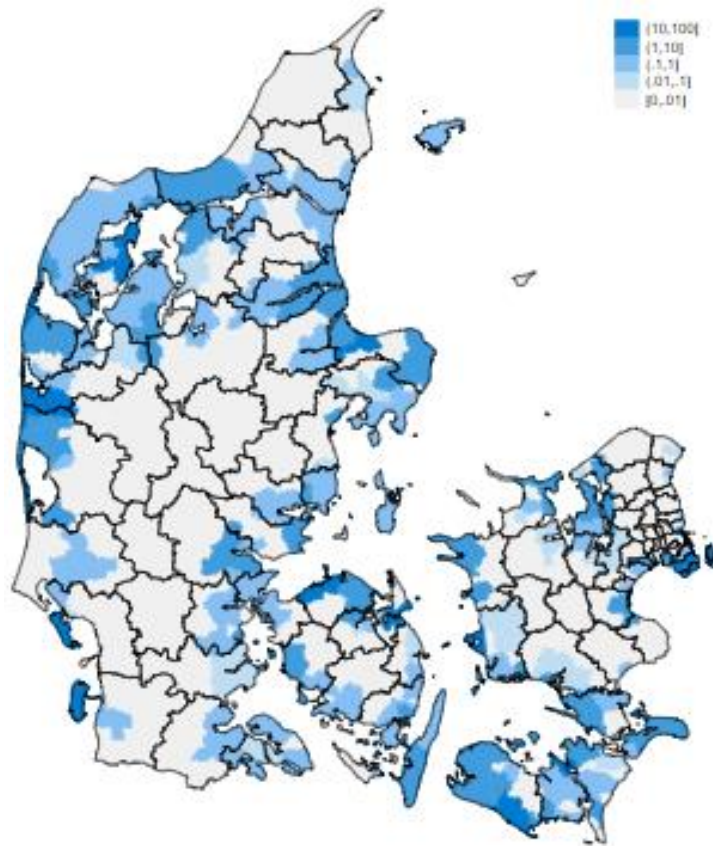
Future flood risk is measured similarly:

- Historical water level distribution plus average expected sea level rise for Denmark
- Expected sea level rise is uncertain: use baseline (RCP 4.5) and pessimistic (RCP 8.5) scenarios

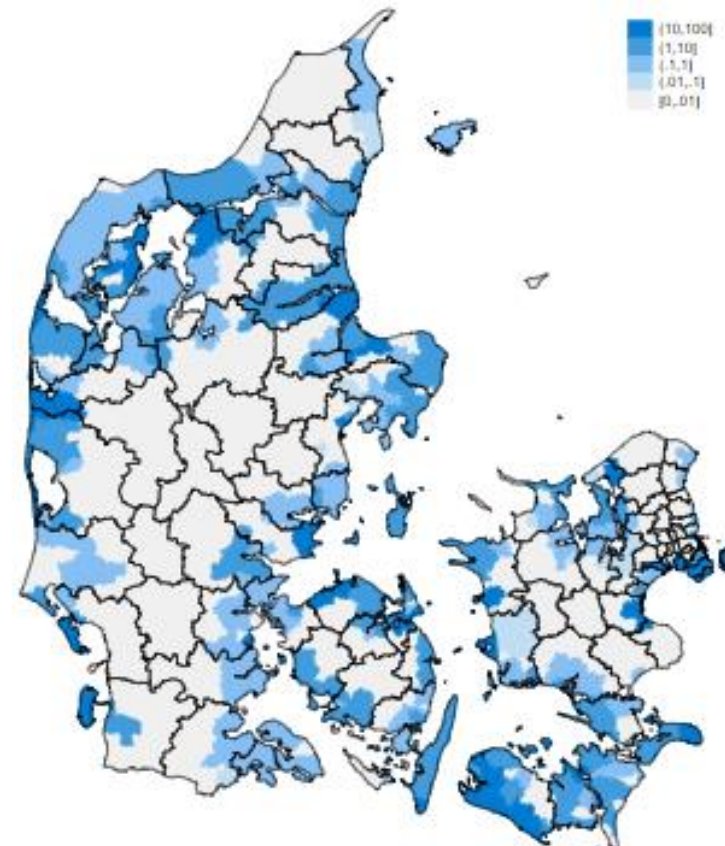
Fraction of Danish houses exposed to flood risk

time	20-year horizon (flood risk > 5% per year)	100-year horizon (flood risk > 1% per year)
2021	0.93	1.26
2071, baseline scenario (RCP 4.5)	1.72	2.21
2071, pessimistic scenario (RCP 8.5)	2.39	2.95

Flood risk across municipalities



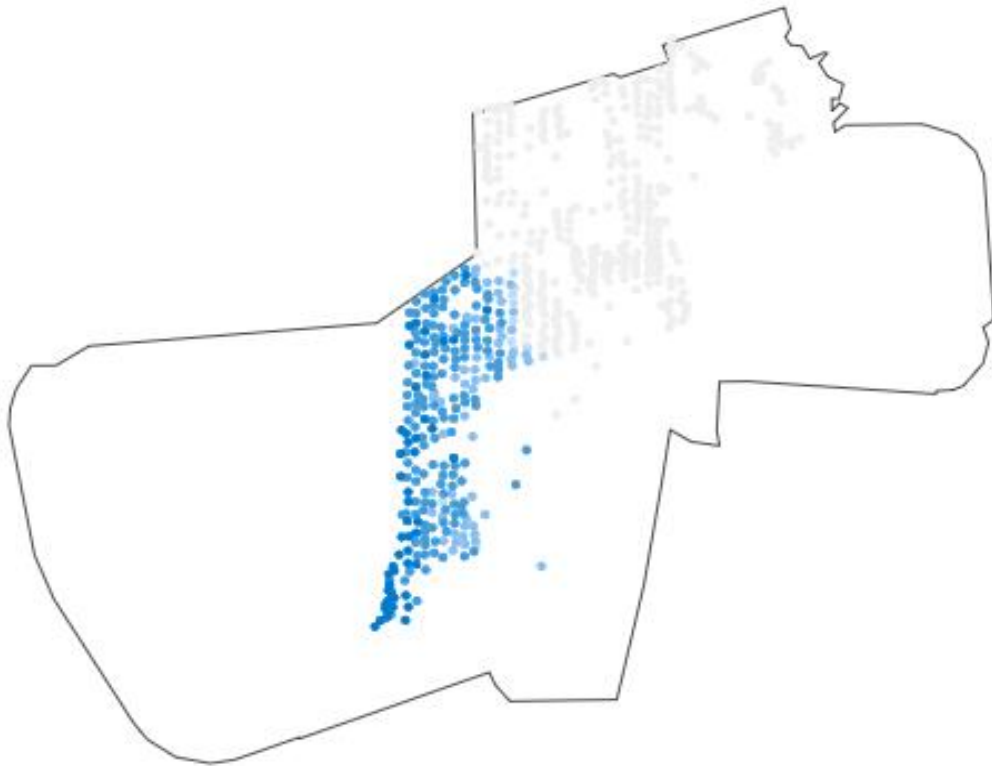
2021



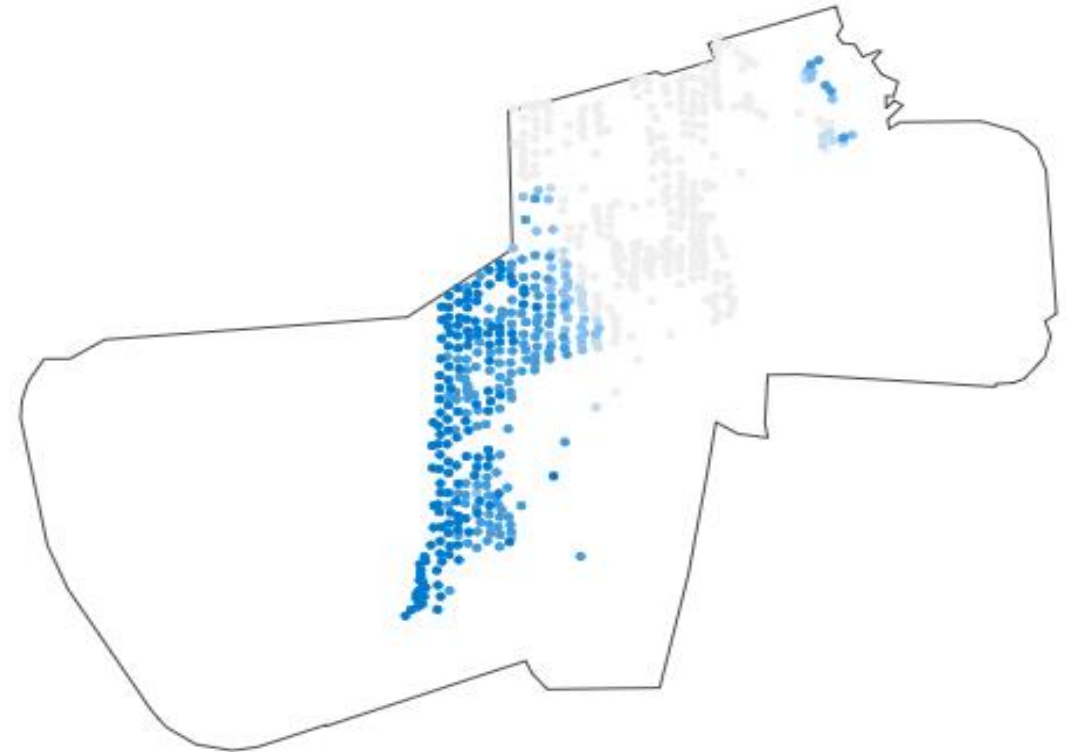
2071 – baseline scenario



Flood risk within municipalities



2021



2071 – baseline scenario

Do home buyers price flood risk?

We use three additional datasets to answer this question

Universe of real estate transactions, going back to 1991

- E.g. house price, date of sale, ...

Housing characteristics from building registry

- E.g. number of rooms, square meters, age of the house, ...

Geographic characteristics

- E.g. distance to the sea, elevation above sea level, ...

Econometric challenge: houses with and without flood risk are different

	all houses	never exposed	exposed today
price per m2 (2015 DKK)	9551.18	9526.88	10111.83
	(7958.71)	(7919.61)	(9026.39)
total m2	144.55	144.67	139.02
	(46.13)	(46.15)	(45.39)
distance to sea (km)	7.84	7.99	1.39
	(8.90)	(8.94)	(1.68)
Observations	1255520	1227742	15776

Mean coefficients, sd in parentheses

Flood risk exposure leads to a discount of between 6 and 7 percent

	(1)	(2)
Flood risk exposure (100 years)	-0.0245	-0.0632***
	(-0.21)	(-3.32)
Age controls	Yes	Yes
Size controls	Yes	Yes
Zip code x distance to sea x time of sale x number of bedrooms dummies	No	Yes
Observations	910095	507959

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Do home buyers price sea level rise?

Future flood risk due to sea level rise is priced at a lower discount

	(1)	(2)
Exposed in 2021	-0.0632***	-0.0682***
	(-3.32)	(-3.54)
Only exposed from 2041, RCP 4.5		-0.0336**
		(-2.16)
Only exposed from 2071, RCP 4.5		-0.0403*
		(-1.91)
Age & size controls	Yes	Yes
Zip code x distance to sea x time of sale x number of bedrooms dummies	Yes	Yes
Observations	507959	507959

Observations in parentheses
 * p<0.1, ** p<0.05, *** p<0.01

Conclusion

How important are flood risk and sea level rise for the Danish housing market?

- Around 1.2 percent of Danish houses are exposed to flood risk
- This number will double by 2071

Are these risks priced?

- houses exposed to current flood risk are priced at a **6 percent discount**
- houses exposed to future flood risk due to sea level rise are priced at a **3-4 percent discount**