

Asymmetric Information Provision and Flood Risk Salience

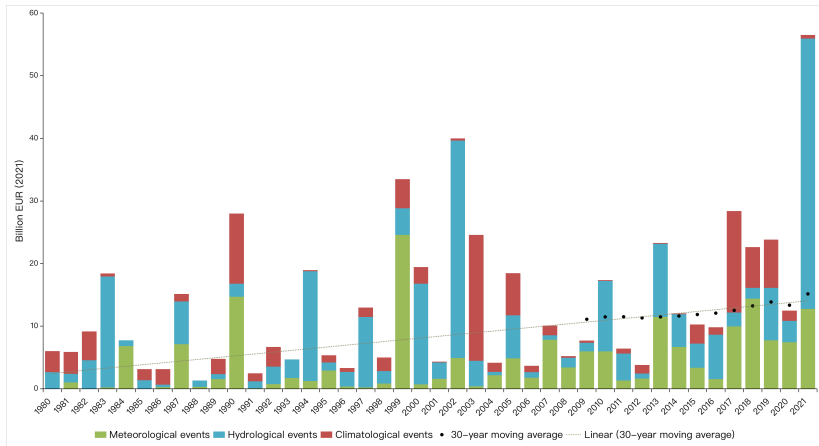
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Increase in damage from climate-related events in EU

Climate-related extremes amounted to an estimated EUR 560 billion



Source: European Environment Agency

Real estate industry is especially vulnerable

Increasing interest to understand the impact of climate risks

- ▶ Multiple aspects of climate risk can significantly impact property values
- ▶ Existing literature provides varied conclusions on the influence of climate risk on real estate market dynamics

What we know

Climate risk and transaction prices:

- ▶ Increasing climate risk lead to lower real estate price (Bin and Landry, 2013; Zhang, 2016; Ortega and Tapinar, 2018; Bernstein et al., 2019; Bauldalf et al., 2020; Holtermans et al., 2022)
 - ▶ *Only if you believe it!*

Climate risk and real estate financing:

- ▶ Higher probability of delinquency after disasters (Issler et al., 2021; Holtermans et al., 2022)
- ▶ Securitization activity in years following a billion-dollar disaster increases (Ouazad and Kahn, 2022)

Climate risk and migration:

- ▶ Severe disasters increase out-migration rates at the county level (Deryugina et al., 2018; Boustan et al., 2020)

Information asymmetry in real estate industry

- ▶ There is a noticeable deficit in the provision of precise and timely information on local climate risks, leading to a situation of information asymmetry

Information asymmetry in real estate industry

- ▶ Akerlof, 1970: sellers, being more knowledgeable about the quality of their products, tend to set prices as if their goods were defect-free
- ▶ Garmaise and Moskowitz, 2004; Kurlat and Stroebe, 2015: sellers typically possess more information about the structural attributes and neighborhood characteristics of the property being sold than buyers do
- ▶ Magontier, 2020: notes that jurisdictions tend to implement more mitigation projects when storms receive extensive coverage in newspapers
- ▶ Lee, 2022: Easing information friction of climate risks lowers population and flood damage in high-risk areas

Capitalization of climate risk information in housing market

Does information matter?

Research questions:

1. Quantifying the impact of information provision (text-based communication and real-life flood) on housing values
2. How does exposure to climate risk information influence the adaptation behavior of local residents

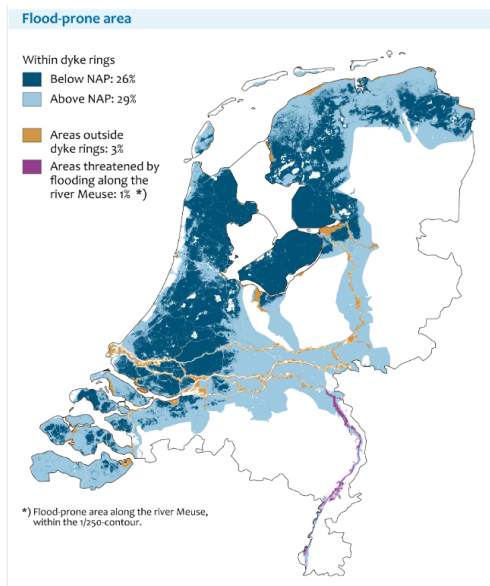
Capitalization of climate risk information in housing market

Does information matter?

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The water management history of the Netherlands



Source: Netherlands Environmental Assessment Agency

The flood risk management in Dordrecht

- A city of three rivers crossing



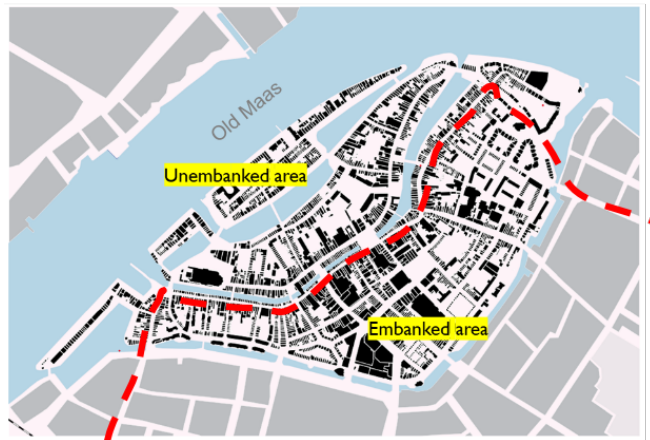
Catastrophic disaster in 1953

- ▶ *Watersnoodramp*: On 31 January 1953, North Sea Flood
- ▶ Inflicting 1800 deaths and widespread damage



Source: Hollandofwater

Study setting



- ▶ Unembanked area: Historical center with concentration of economic activity
- ▶ 10,000 residents (10%) living in unembanked area

Information provision of flood risk

Dear Sir/Madam ,

Storm season will begin soon. The season runs from Oct. 1, 2020, to April 1, 2021. During this period, high water can cause inconvenience. Because you live in an outer dike area, you may be affected. In this letter we tell you about the measures the municipality is taking. We also indicate where you can find more information about high water in Dordrecht.

When might a nuisance arise for you?

In the historic port area of Dordrecht, water can come onto the quays during the storm season. This occurs at water levels from 1.80 meters above NAP. Nuisance may occur at water levels higher than 2.00 meters above NAP. You can estimate for yourself whether water can reach your property by comparing the expected water level with the height of your street and property.

The height of your property

Your property stands at an elevation of approximately 1.80 meters above sea level. That is the height of the street about half a meter in front of your building. We assume the figures of the Actueel Hoogtebestand Nederland (AHN) are automatically measured. Therefore, we recommend that you allow for a margin of error of 5 centimeters in your estimate. It almost never happens that your building is actually 5 centimeters higher or lower than the estimated height. Of course, an indoor basement or a raised first floor affects the likelihood of flooding.

You can find the current water level on the Rijkswaterstaat website: waterinfo.rws.nl.

Warnings and information in case of imminent flooding

Rijkswaterstaat can predict high water well. We like to inform you in time. We do so through social media on Facebook and Twitter. You can also sign up for our flood e-mail service. This e-mail service is the quickest way for us to alert you. You can sign up at www.dordrecht.nl/hoogwater. You will then also receive notifications via e-mail at the start and end of the storm season.

- ▶ Text-based information: Letters with information about high water alert and recommended actions to residents in the unembanked area since 2010
- ▶ Real-life information: flooded twice in 2012

Empirical setting

Methodology is similar to existing studies

DID model using letter sending and real flood as two information shocks (Lee, 2020; Meltzer et al., 2021)

$$Price_{it} = \beta_0 + \beta_1 Outdike_i + \beta_2 Outdike_i \times PostLetter + \beta_3 Outdike_i \times PostFlood + \gamma Hedonics_{it} + \zeta_t + \epsilon_c + \mu_{ict}$$

- ▶ Price: transaction price of property i at year t
- ▶ Outdike: risk measure (0/1; in/out of the dike protection)
- ▶ Post: = 1 if transaction happens after each shock
- ▶ Year-quarter FE, 6-PPC FE (10-20 residents)

Data

Property-level transactions (NVM)

- ▶ Municipality of Dordrecht (2004-2021), 11435 transactions
- ▶ Transaction date, price, location, hedonic attributes

	All	Outside dike	Inside dike	T-test
Price/m2	1905.51	1883.48	1907.42	-23.95
Area (m2)	122.36	128.35	121.82	6.529***
Num. of rooms	4.80	4.83	4.80	0.03
Num. of baths	0.94	0.94	0.94	0.00
1905~1960	0.32	0.34	0.32	0.02
1960~1970	0.09	0.07	0.09	-0.028**
1970~1980	0.19	0.17	0.19	-0.02
1980~1990	0.11	0.02	0.12	-0.103***
1990~2000	0.16	0.07	0.17	-0.094***
2000	0.05	0.06	0.05	0.01
Basement	0.01	0.01	0.01	0.00
Elevator	0.00	0.01	0.00	0.004***
Parking	0.30	0.26	0.31	-0.051***
Insulation	0.85	0.76	0.86	-0.100***
Boil heating	0.94	0.94	0.95	-0.01
Solar heating	0.00	0.00	0.00	0.002*
Observations	11,435	1,108	10,427	11,435

Data

CBS Socio-Economic Characteristics

- Home ownership, individual age, educational attainment, family size, wealth, and registration address

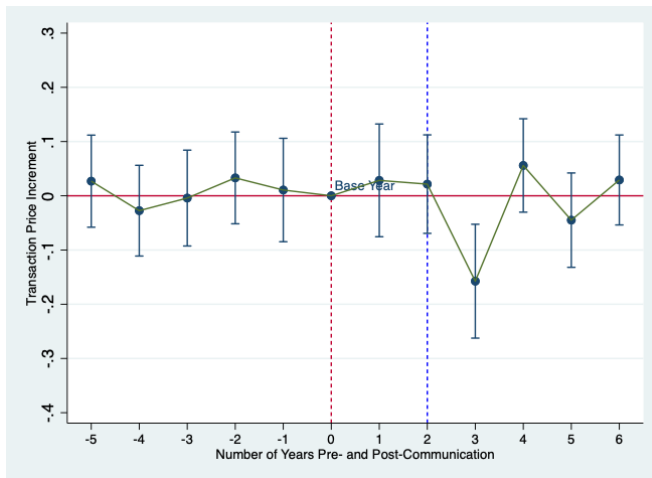
	All	Outside dike	Inside dike	T-test
<i>Household level</i>				
Owner-occupied	0.549 (0.498)	0.536 (0.499)	0.550 (0.498)	-0.014***
High-educated	0.074 (0.262)	0.087 (0.282)	0.072 (0.259)	0.015***
Household wealth	67.338 (103.8)	64.675 (107.2)	67.752 (103.3)	-3.077***
Family size	1.946 (1.109)	1.745 (0.922)	1.978 (1.030)	-0.233***
Risk aversion	0.037 (0.151)	0.050 (0.177)	0.035 (0.146)	0.014***
Observations	743,947	67,508	676,439	743,947
<i>6PPC level</i>				
Moving	0.146 (0.124)	0.174 (0.139)	0.142 (0.122)	0.032***
Moving to in-dike	0.115 (0.108)	0.087 (0.079)	0.119 (0.110)	-0.032***
Observations	34,508	2,253	32,255	34,508

Baseline results

	Dependent Variable: Log (Price/sq. ft.)				
	(1) All homes	(2) All homes	(3) Before Letter	(4) Letter~Flood	(5) After Flood
Outside dike	0.053^{***} (0.016)	0.053^{***} (0.016)	0.049^{***} (0.012)	0.068^{***} (0.028)	0.048^{***} (0.012)
Outside dike × Post	-0.035^{***} (0.014)				
Outside dike × Letter		-0.043 (0.027)			
Outside dike × Flood		-0.035^{**} (0.014)			
Log Area (m ²)	-0.320 ^{***} (0.008)	-0.320 ^{***} (0.008)	-0.317 ^{***} (0.012)	-0.323 ^{***} (0.011)	-0.322 ^{***} (0.012)
Num. rooms	0.018 ^{***} (0.002)	0.018 ^{***} (0.002)	0.011 ^{***} (0.002)	0.022 ^{***} (0.002)	0.022 ^{***} (0.002)
Num. bath	0.015 ^{***} (0.003)	0.015 ^{***} (0.003)	0.023 ^{***} (0.006)	0.011 ^{**} (0.004)	0.014 ^{***} (0.005)
Year-quarter FE	YES	YES	YES	YES	YES
6PPC FE	YES	YES	YES	YES	YES
<i>Observations</i>	11,435	11,435	6,405	1,404	5,482
<i>R²</i>	0.589	0.589	0.543	0.611	0.615

Baseline results

Price effect over time



Asymmetric information provision

Variations in buyers' information exposure

	Dependent Variable: Log (Price/sq. ft.)			
	(1) Local buyers	(2) Other buyers	(3) Local buyers	(4) Other buyers
Outside dike	0.089** (0.031)	0.107*** (0.026)	0.089** (0.033)	0.109*** (0.027)
Outside dike $\times$ Post	-0.040*** (0.010)	-0.053 (0.038)		
Outside dike $\times$ Letter			-0.043 (0.027)	-0.017 (0.045)
Outside dike $\times$ Flood			-0.036** (0.014)	-0.060 (0.049)
Hedonic attributes	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES
6PPC FE	YES	YES	YES	YES
<i>Observations</i>	1,837	6,106	1,837	6,106
<i>R²</i>	0.482	0.478	0.483	0.478

Adaptation Actions of the Local Residents

Adapting to climate risks by...

- ▶ relocating to safe areas (Bakkensen and Ma, 2020; Garbarino and Guin, 2021)
- ▶ retrofitting current homes (Baylis and Boomhower, 2022)
- ▶ renting out the high-risk properties (Sheldon and Zhan, 2019)
- ▶ taking up insurance (Gallagher, 2014; Mulder and Kousky, 2023)

CBS database:

- ▶ allows us to trace migration behavior
- ▶ provides individual and family level characteristics

Adaptation Actions of the Local Residents

Renting homes out?

	(1) Renter ratio	(2) Owner ratio	(3) Renter ratio	(4) Owner ratio
Outside dike	-0.045 (0.052)	0.045 (0.052)	-0.045 (0.052)	0.045 (0.052)
Outside dike × Post	0.034*** (0.012)	-0.035*** (0.012)		
Outside dike × Letter			0.027*** (0.010)	-0.028*** (0.010)
Outside dike × Flood			0.036*** (0.014)	-0.037*** (0.014)
<i>Observations</i>	34,491	34,491	34,491	34,491
<i>R</i> ²	0.388	0.389	0.388	0.389

- ▶ Tenure choice theory (Sheldon and Zhan, 2019)
- ▶ Out-dike households shifted from home ownership to the rental market, resulting in a decrease in the home ownership ratio, especially after the flood in 2012

Adaptation Actions of the Local Residents

- ▶ Natural disasters lower the attractiveness of remaining in one's origin area (German and Miller, 2015; Mahajan and Yang, 2020)

	(1)	(2)	(3)	(4)
	Move to non-risk	Moving	Move to non-risk	Moving
Outside dike	-0.046*** (0.010)	0.004 (0.017)	-0.046*** (0.005)	0.004 (0.005)
Outside dike $\times$ Post	0.001 (0.003)	0.004 (0.006)		
Outside dike $\times$ Letter			-0.000 (0.007)	-0.001 (0.008)
Outside dike $\times$ Flood			0.001 (0.005)	0.006 (0.005)
<i>Observations</i>	34,491	34,491	34,508	34,508
<i>R</i> ²	0.157	0.177	0.157	0.177

Less affluent, small-sized, and more risk-averse families are leaving

Less affluent, small-sized, and more risk-averse families are leaving

-0.040***
(0.015)

Discussion

Does information matter?

- ▶ The flood risk communication campaign is not as effective as real floods in raising flood risk awareness
- ▶ Buyers who have witnessed the flood increase their assessment of the risk of future floods
- ▶ "Real-inundation effect": learning in a hard way (Atreya and Ferreira, 2015)
- ▶ Rapid recovery is not necessarily such a positive message, given the recurrent risk of flooding (Kocornik-Mina et al., 2020)
- ▶ Cities that are built in flood-prone areas may be locking in exposure to flood risk for a long time

Contribution

Increasing our understanding

- ▶ We add to the current discussion on the price effect of natural disasters on the housing market, particularly in the Netherlands (Bosker et al., 2021)
- ▶ This paper contributes to the literature investigating individuals' response in the aftermath of natural disasters
- ▶ This paper also contributes to the literature investigating whether information asymmetry affect transaction patterns in the real estate market

Conclusion

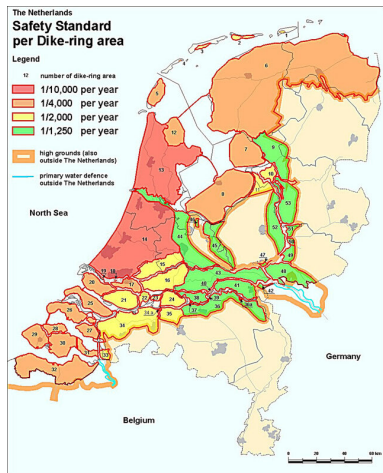
- ▶ Climate risk information provision lead to transaction price decline. Experiencing a real flood event is associated with 3.5% declines in property values in Dordrecht, the Netherlands, with a rapid recovery in one year
- ▶ Local residents opt to rent out their properties or move to the less-risky area as a response
- ▶ Smaller-sized families, more risk-averse, and less affluent households are more likely to relocate from high-risk areas upon being exposed to flood information

Thank you

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Appendix: Dike ring in the Netherlands



Dike protection

We have collected maps of the dike ring in the Netherlands from the *Dutchdike* website that provides comprehensive mapping of Dutch dike systems.

Source: Van Zuilekom et al. (2005)

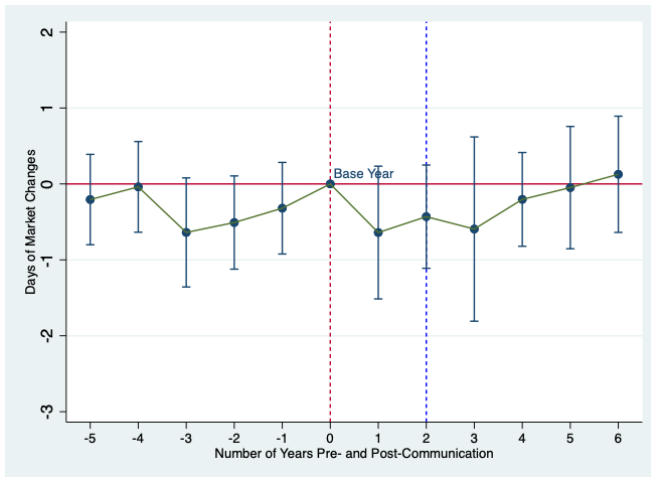
The flood risk management in Dordrecht

- ▶ Catastrophic flooding history due to low elevation: Water level 3.73 meters above sea level



Baseline results

Market liquidity effect over time



Robustness Checks

PSM properties and restricted sample

	Dependent Variable: Log (Price/sq. ft.)			
	(1)	(2)	(3)	(4)
	PSM		Restricted Sample	
Outside dike	0.057 (0.057)	0.057 (0.057)	0.107*** (0.013)	0.107*** 0.013
Outside dike $\times$ Post	-0.081*** (0.028)		-0.046*** (0.013)	
Outside dike $\times$ Letter		-0.104 (0.066)		-0.048 (0.032)
Outside dike $\times$ Flood		-0.078*** (0.029)		-0.049*** (0.017)
Hedonic attributes	YES	YES	YES	YES
Year-quarter FE	YES	YES	YES	YES
6PPC FE	YES	YES	YES	YES
Observations	1,532	1,532	7,191	7,191
R-squared	0.792	0.792	0.476	0.476