

Sea Level Rise and Urban Adaptation in Jakarta

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Jakarta

- World's second largest city at 31M (first by 2030)
 - By 2050, 35% below sea level
 - Proposed sea wall at up to \$40B
- **How does government intervention complicate adaptation?**

This paper

- **Moral hazard** as coastal development forces defense
 - If government cannot commit or regulate
 - Delays inland migration at high social cost
- **Dynamic spatial model** of development and defense
 - Estimated with granular data for Jakarta
- **Result:** severe moral hazard without commitment
 - Policy prescriptions from partial commitment to moving capital

Contributions

- **Adaptation frictions** under endogenous government intervention
 - Desmet et al. 2021, Barreca et al. 2016, Costinot et al. 2016
 - Kydland & Prescott 1977, Kousky et al. 2006, Boustan et al. 2012
- **Sea level rise** damages and policies
 - Kocornik-Mina et al. 2020, Balboni 2021, Castro-Vicenzi 2022, Fried 2022, Lin et al. 2022
- **Dynamic spatial model** of urban development
 - Kalouptsidi 2014, Hotz & Miller 1993, Arcidiacono & Miller 2011, Murphy 2018
 - Desmet et al. 2018, Caliendo et al. 2019, Kleinman et al. 2022

Outline

- ① Theory
- ② Empirics
- ③ Counterfactuals

Theory

Policy trade-offs

- **Spatial:** adapt in-place at the coast vs. migrate inland
- **Dynamic:** incur costs now vs. damages later
- Defending at the cost avoids costly retreat today
- But then coastal population grows, so big damages tomorrow

Distortion from moral hazard

- Time-inconsistent government saves coastal development
 - Ex ante, wants new buildings built safely inland
 - Ex post, after new buildings built at coast, wants to protect (sunk costs, lobbying)
- So development can exploit defense
 - Coastal development happens, forcing public defense
 - **Moral hazard**: uninternalized cost + time inconsistency (as magnifier)
- **Coastal lock-in** as inland retreat gets crowded out

Agent and principal

- ① Developers vs. government
- ② Coastal vs. local government
- ③ Local vs. national government
- ④ Current vs. future government

Empirics

Components

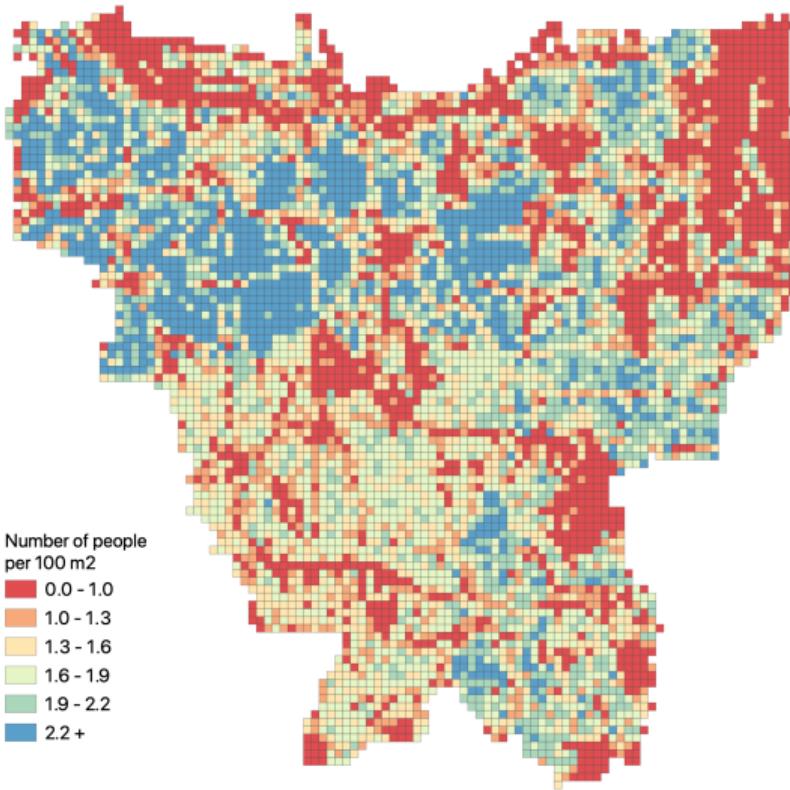
- **Spatial model** of residential demand
- **Dynamic model** of developer supply
- Hydrological model of flooding
- Engineering model of sea wall costs

Residential demand

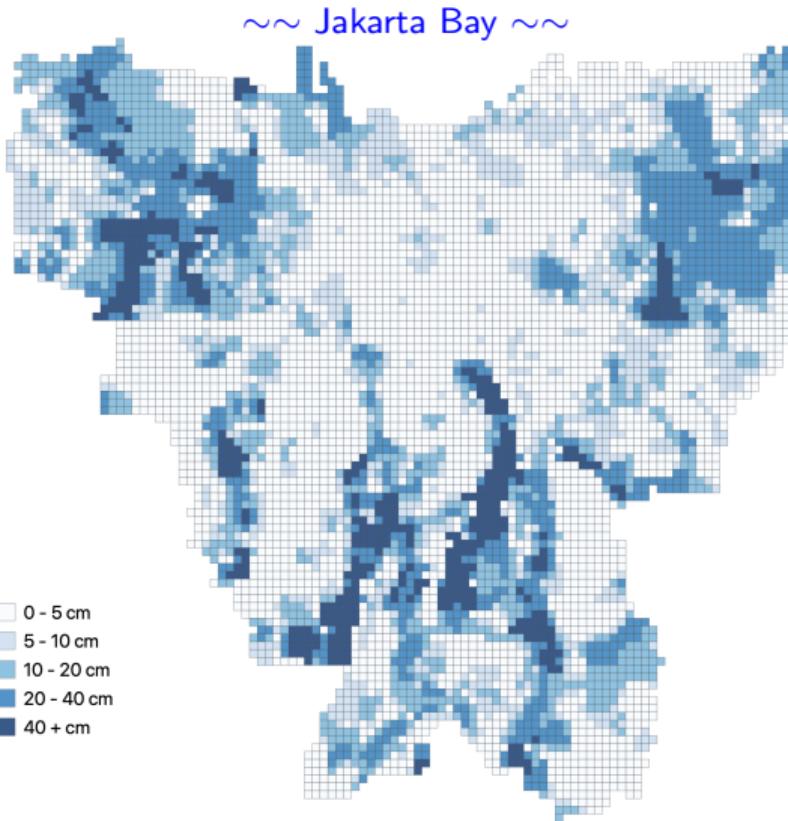
$$U_{ijk} = \alpha r_k + \phi f_k + x_k \gamma + \varepsilon_k + \tau m_{jk} + \epsilon_{ijk}$$

- **Spatial model** of resident renters i , destinations k
 - Benefit $\frac{\phi}{\alpha}$ of reducing flooding f
 - Moral hazard increasing in $\frac{\phi}{\alpha}$
- **Estimation:** match population shares (BLP 1995)
 - Rent endogeneity from unobserved amenities
 - IV with ruggedness as supply shifter

Population (global data)



Flooding (2013-2020, past → future)



Developer supply

$$V_{kt}(D, L) = \alpha r_{kt}(D) + \mathbb{E} \left[\max_{d \in \{0,1\}} \{v_{kt}^d(D, L) + \epsilon_{ikt}^d\} \right]$$

$$v_{kt}^1(D, L) = -c_{kt}(x, \varepsilon) + \beta \mathbb{E}[V_{kt+1}(D+1, L-1)]$$

$$v_{kt}^0(D, L) = \beta \mathbb{E}[V_{kt+1}(D, L)]$$

- **Dynamic model** of landlord developers i , locations k
 - Cost c of convert land L to development D
 - Moral hazard increasing in α
- **Estimation:** data as continuation values (Kalouptsidi 2014)
 - Rent endogeneity from unobserved costs
 - IV with residential amenities as demand shifter

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Data as continuation values

$$\ln p_{kt}^1 - \ln p_{kt}^0 = -c_{kt}(x, \varepsilon) + \alpha\beta(P_{kt}^D - P_{kt}^L)$$

$$V_{kt}(D, L) = \alpha(P_{kt}^D D + P_{kt}^L L)$$

$$P_{kt} = \mathbb{E}[P_{kt+1}]$$

- Simple IV estimation
 - Need efficient real estate market ($P \rightarrow V$, frictions as ε)
 - Flexible expectations without finite dependence (P as market offer)

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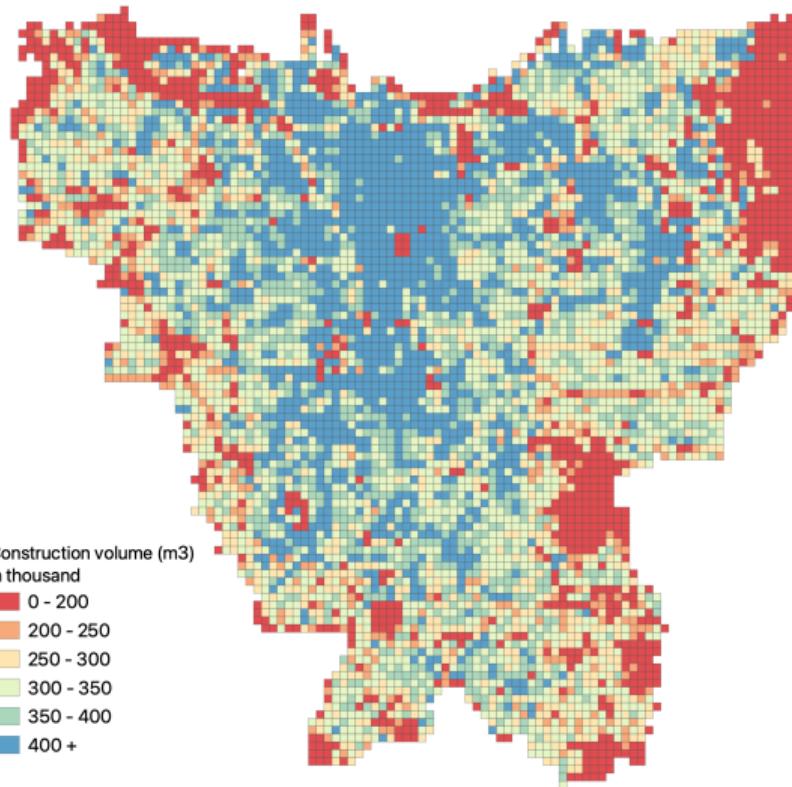
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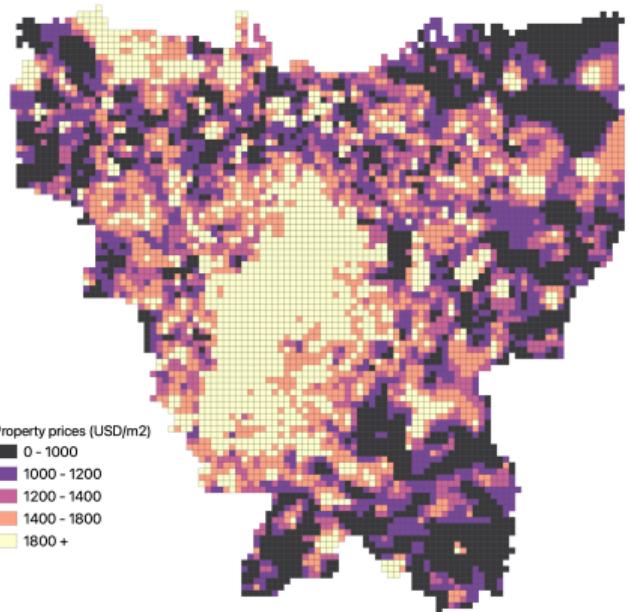
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Building construction (global data)

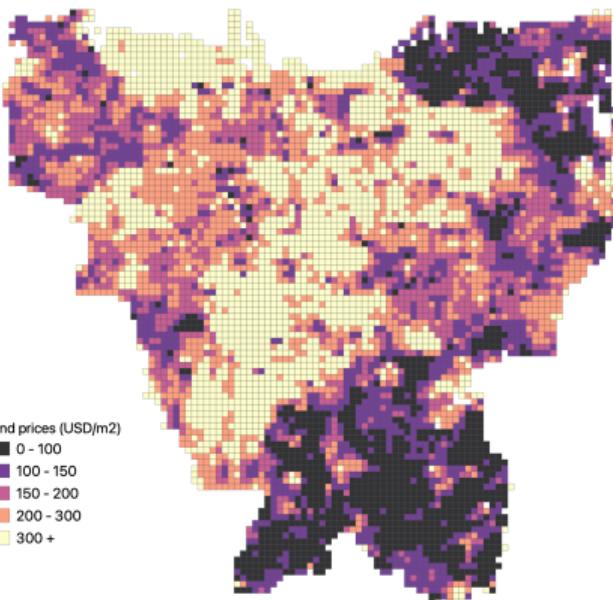


Real estate prices (urban data)

Property

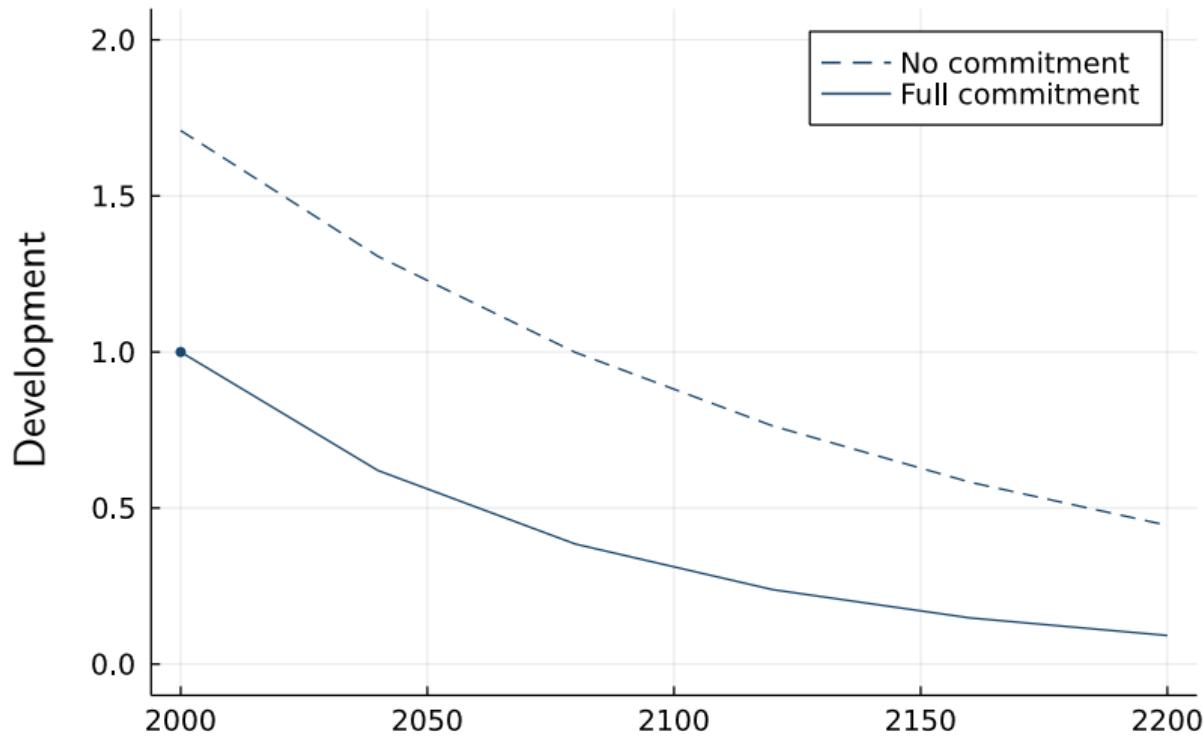


Land

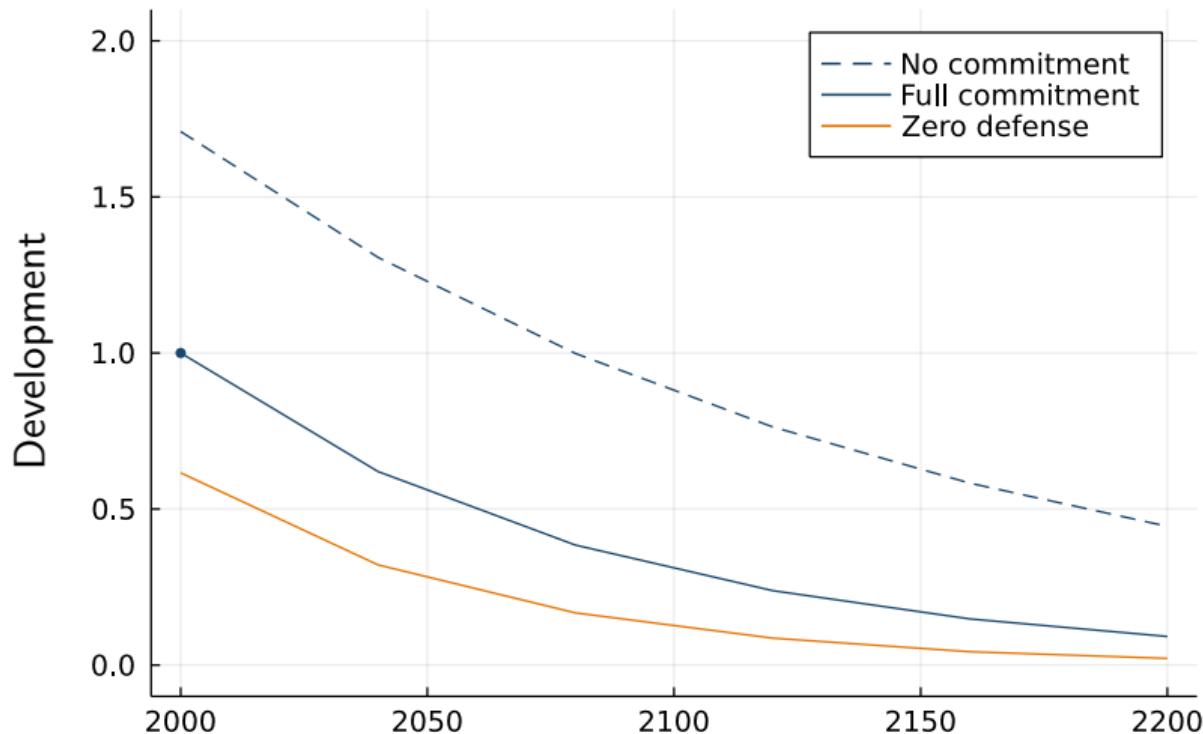


Counterfactuals

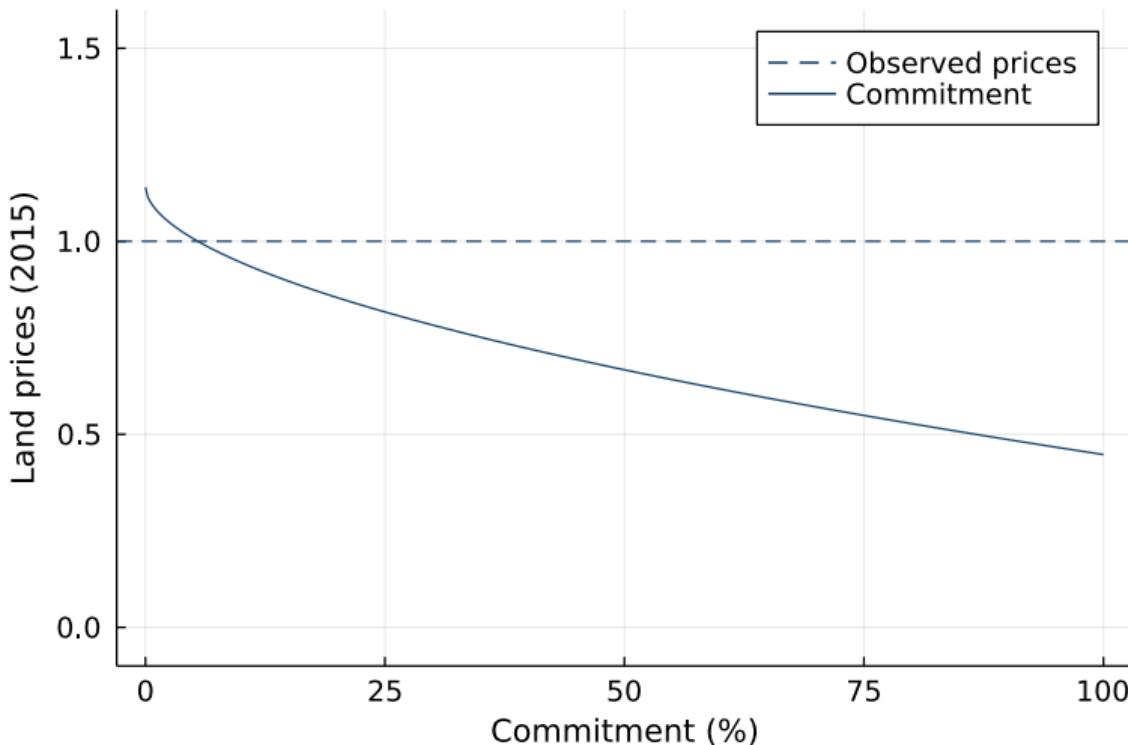
Moral hazard delays adaptation



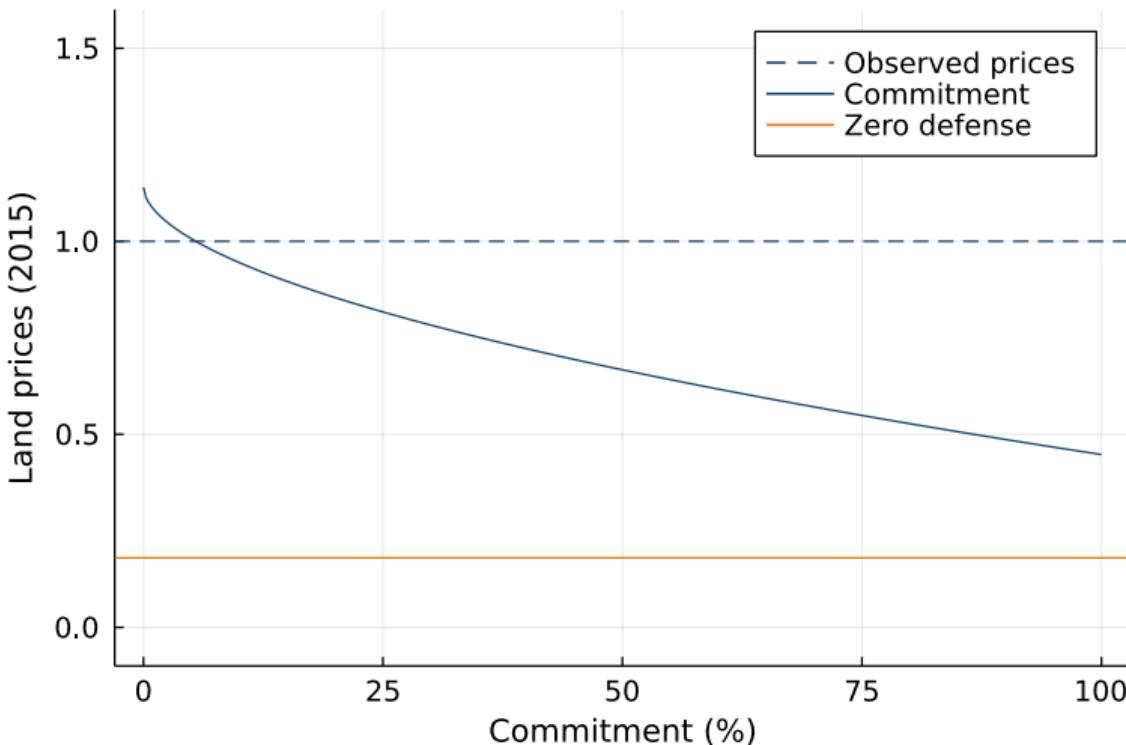
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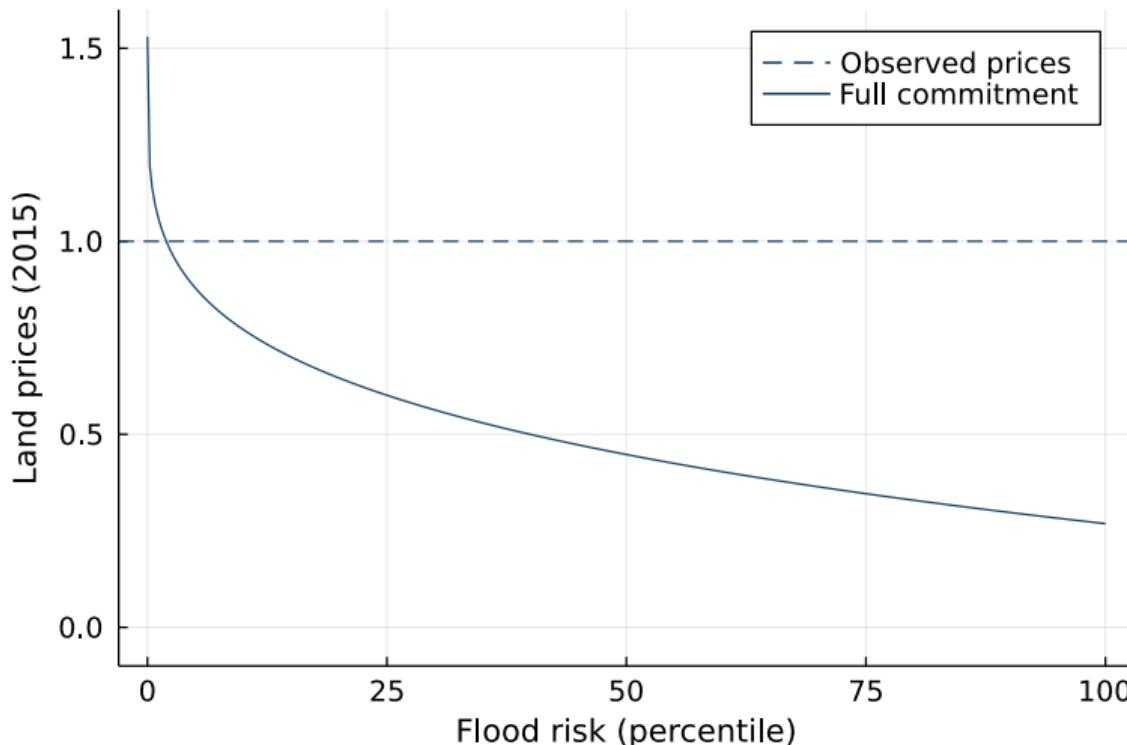
Moral hazard can rationalize observed prices



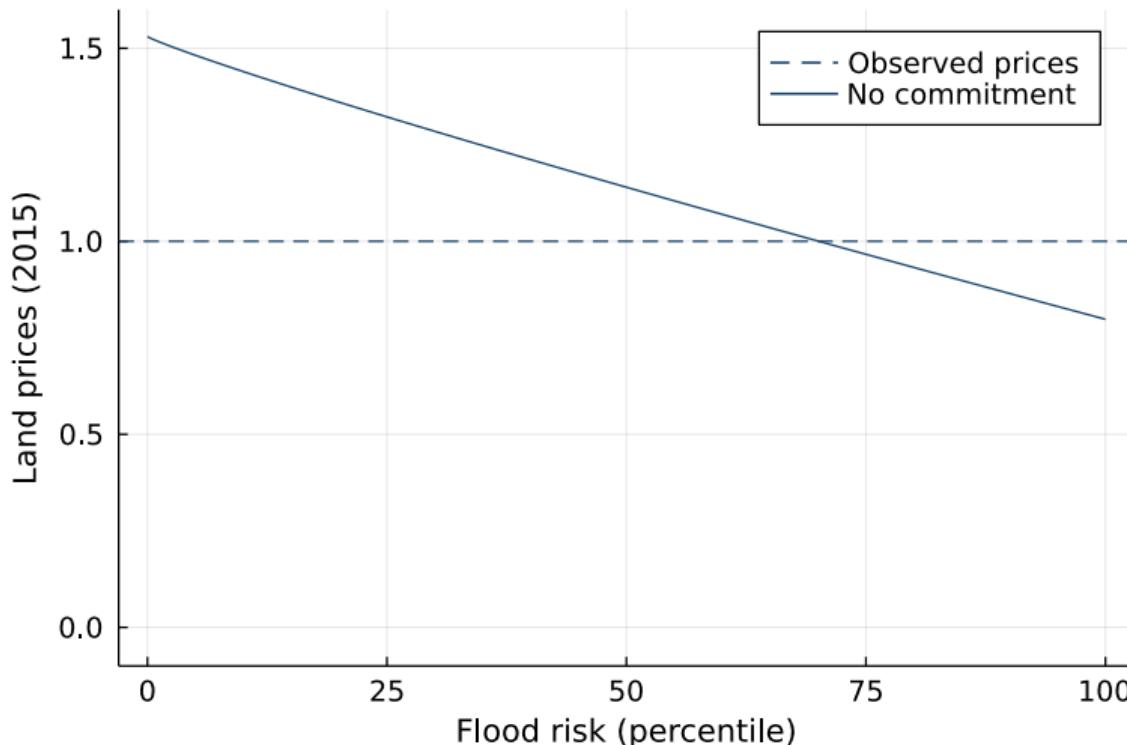
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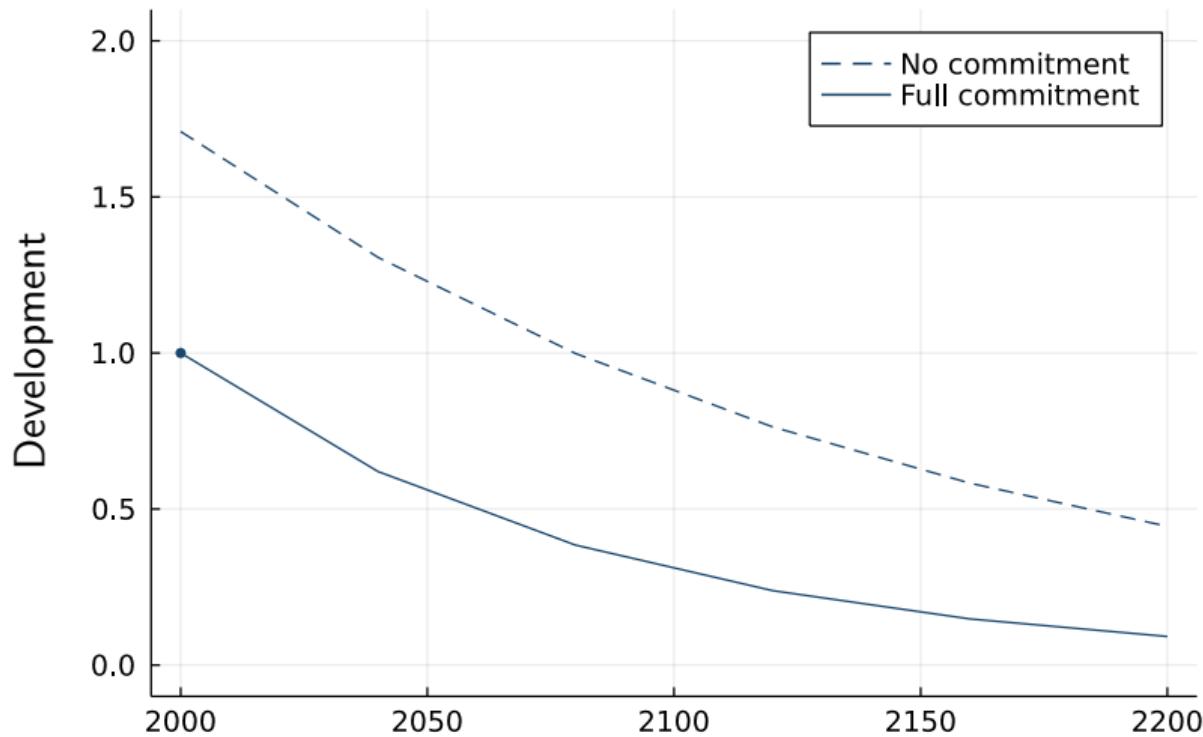
Flood risk cannot rationalize observed prices



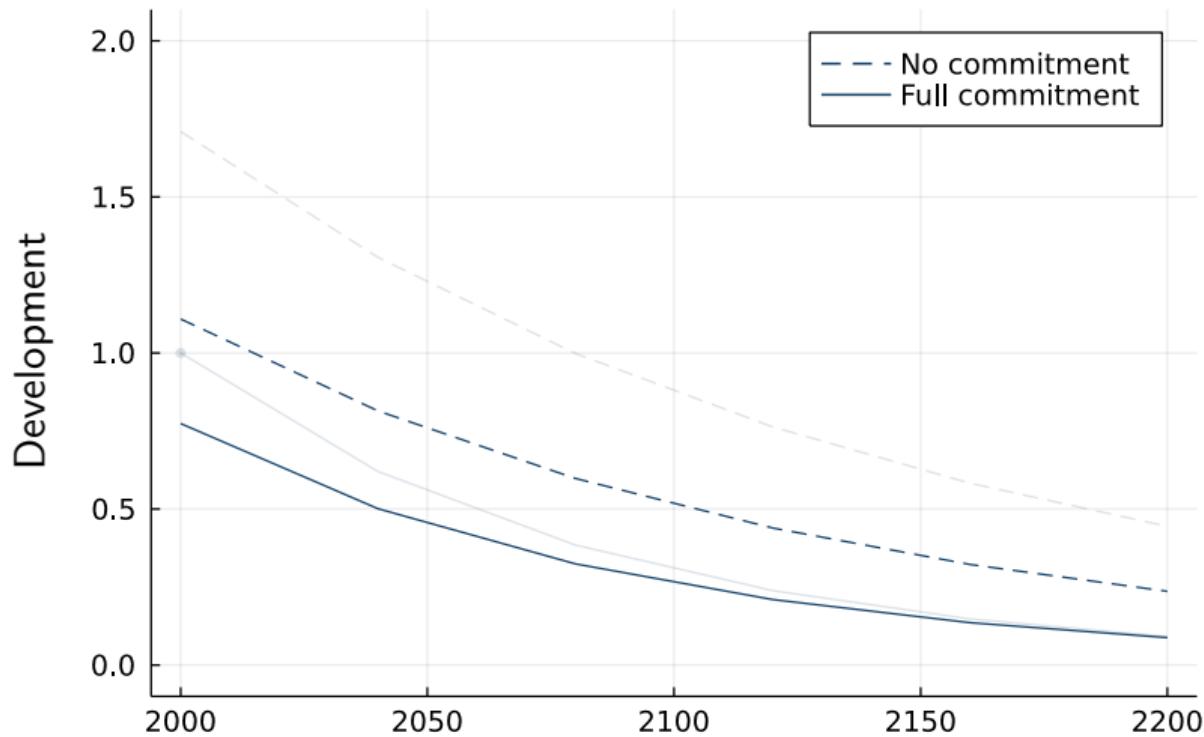
Flood risk cannot rationalize observed prices



Moving the capital reduces moral hazard



Moving the capital reduces moral hazard



Distributional consequences

- Simple sorting model
 - Wage-specific price elasticities
 - Endogenous prices
 - Granular wage and flooding data for Jakarta
- Sea level rise exacerbates sorting on flood exposure
 - Coastal flooding leads high-wage individuals inland
 - Bids up prices, pushing low-wage individuals elsewhere
 - The rich crowd out the poor in pursuit of higher ground

Conclusion

Summary

- **Moral hazard impedes adaptation** to climate change
- **Jakarta** foreshadows sea level rise that threatens 1B people by 2050

1	Miami	6	Mumbai
2	Guangzhou	7	Tianjin
3	New York City	8	Tokyo
4	Kolkata	9	Hong Kong
5	Shanghai	10	Bangkok

Hanson et al. (2011)