



Climate-induced risks in coastal areas: governing public and private adaptation

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Outline

- Flood risk in coastal areas
- Public and private adaptation
- Dutch coastal towns
- Agent-based computational economics: land market
 - model description
 - results
- Conclusions

Flood risk in coastal areas

$$\text{Risk} = \text{Probability} * \text{Potential Damage}$$

Decrease risk

Increase safety level of dikes and dunes

Change spatial allocation and economic value

- 2/3 of world population live in coastal zones (CZ)
- Drivers of economic development in CZs:
 - Firms and households benefit from location close to each other => new developments are taking place close to historic economic centers (in proximity to trading paths and sea ports)
 - People value environmental amenities provided by the coast

Flood risk in coastal areas

- IPCC:
 - the damage from natural disasters in Europe has rapidly increased over the past decades mainly because of the growth of capital accumulated in flood-prone areas (Nicholls et al., 2007)
- LU patterns and economic value of spatial developments determine potential damage
- Climate change:
 - sea level rise
 - growing probabilities of storm surges
- To contain flood risks spatial adaptation is essential

Public and private adaptation^{1,2}

- Public (planned) adaptation
- Private (autonomous) adaptation
- In the Netherlands:
 - focus on public adaptation using state-funded engineering defense measures
 - private adaptation measures and promotion of behavioral adjustments at microeconomic level are largely neglected

 - are public infrastructural adjustments sufficient to reduce risks imposed by climate change?
 - can government create microeconomic incentives to achieve desirable macroeconomic outcomes?

1 – Stern, N.H. 2007. The Economics of Climate Change: The Stern Review. Cambridge University Press.

2 - World Bank, 2009. The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates. The Global Report of the Economics of Adaptation to Climate Change Study.

Individual choices in coastal land market

The slide features a map of a coastal area with a legend. The legend includes a solid line for 'Kernzone' and a dashed line for 'Beszon'. The map shows a coastline with 'Bergen' labeled on the left and 'Eendenvlak' in the center. A large blue text box is overlaid on the map, containing the following text:

- INDIVIDUAL RESPONSIBILITY...
- Individual incentives to make climate-resilient choices in a land market are not in place
- Open questions:
 - how do individual risk perceptions and location preferences capitalize in land prices?
 - what are the aggregated spatial patterns of many individual LM decisions?

At the bottom of the slide, there is a small inset map showing a coastline with a pier and a note: '(e) "Flight to the front" – now boulevard laid far into the sea, like a pier that will later be overtaken by coastal expansion.'

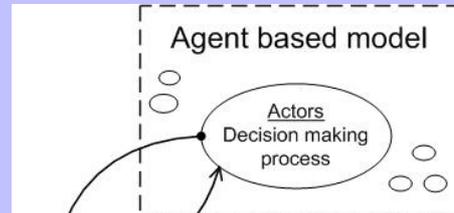
Rijkswaterstaat. Hoofdrichtingen voor risicobeheersing in kustplaatsen. Den Haag (2005).

Deltacommissie (2008)

Agent-based computational economics (ACE)^{1,2}

ACE

- Modeling markets
- Assumptions about a representative agent and perfect rationality are relaxed



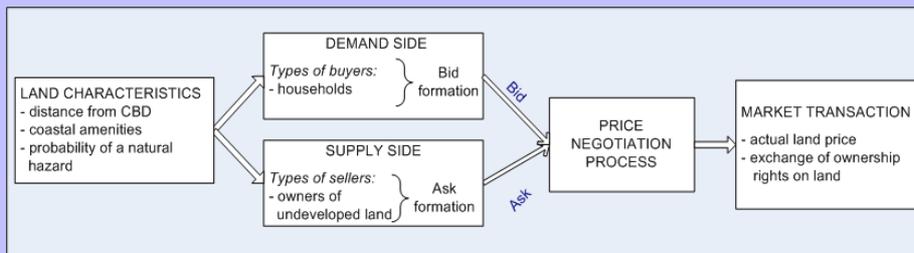
Spatial agent-based models

- Spatial landscape
- Individual behavior, e.g. economic

1 – Tesfatsion, L. and K. L. Judd (2006). Handbook of Computational Economics Volume II: Agent-Based Computational Economics Elsevier B.V.
2 - Arthur, W. B., S. N. Durlauf and D. Lane (1997). The economy as an evolving complex system II. Santa Fe Institute Studies in the Science of Complexity, Vol. XXVII, Addison-Wesley.

Agent-based land market model¹ (ALMA)

- Landscape: coastal town that resembles Dutch coastal towns under risk
- Individual behavior: individuals selling land and individuals buying houses
 - Start from conventional economic models (spatial economics, decisions under uncertainty) and gradually relax some of the assumptions



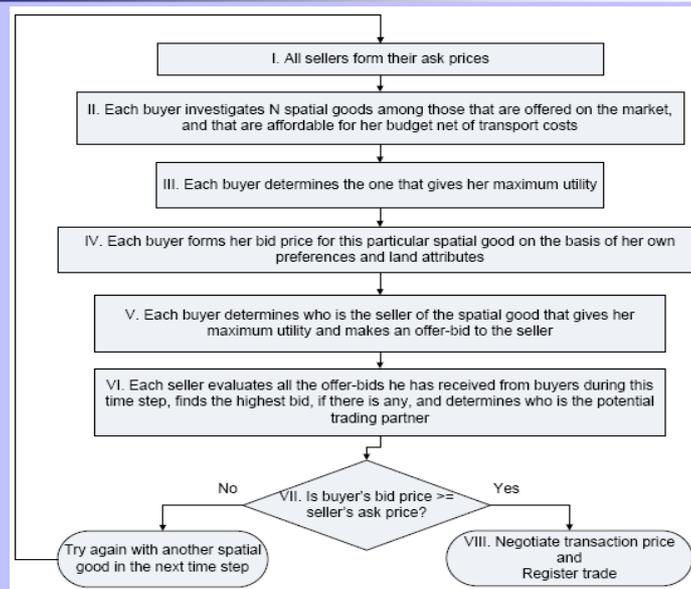
1 - Parker, D. C. and T. Filatova (2008). "A conceptual design for a bilateral agent-based land market with heterogeneous economic agents." Computers, Environment and Urban Systems 32: 454–463.

ALMA: Traders' behavior

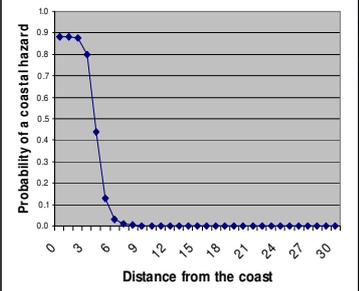
- Utility $U = \alpha \cdot \ln(A) + \beta \cdot \ln(Prox)$
- Expected utility $E(U) = PF_i \cdot U \cdot (1 - C_{dam}) + (1 - PF_i) \cdot U$
 $PF_i = PF_{obj} \pm \Delta_{dev}, \quad PF_i \in [0;1]$
- Disposable budget $Y = tc * D + R$
- Bid / ask price¹ $R = \frac{Y * E(U)^2}{b^2 + E(U)^2}$
 - Increasing with u; asymptotic to Y; b scales convexity of U
 - Replicates qualitative properties of an economic demand / supply function

1 - Filatova, T., D. Parker and A. van der Veen (2009a). "Agent-Based Urban Land Markets: Agent's Pricing Behavior, Land Prices and Urban Land Use Change." Journal of Artificial Societies and Social Simulation 12(1): 3.

ALMA: mechanism of trade

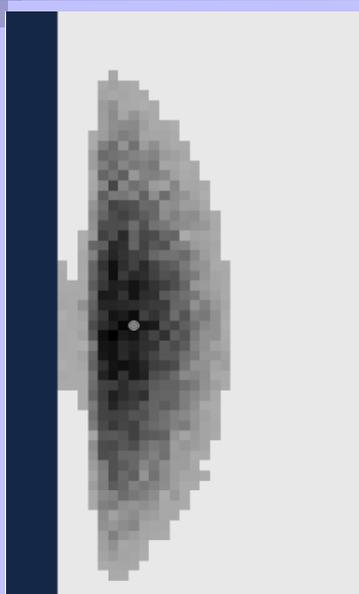


ous spatial attributes



- Conventional model:
 - Projections of the representative agent model – usually employed in policy decisions support tools
- Things to see:
 - Probability of erosion, if perceived, moves urban developments away from the coast

Agents heterogeneous in risk perceptions

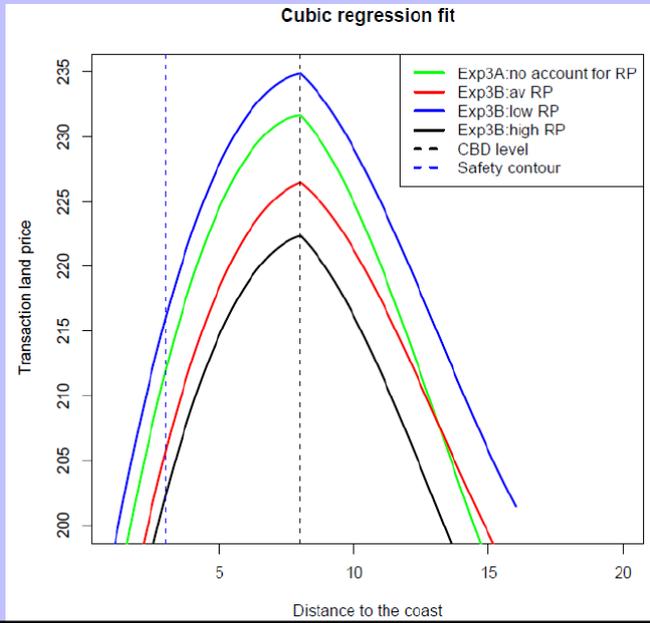
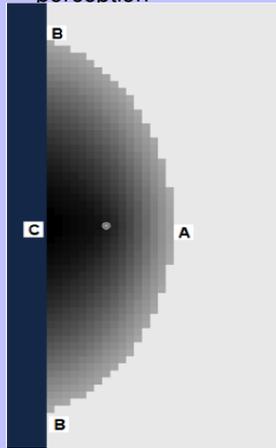


- Conventional model:
 - Heterogeneous agents only in 1D homogeneous landscape
- ALMA model:
 - coastal amenities (coastal view)
 - disamenities (probability of erosion)
 - Agents:
 - homogeneous preferences for location
 - heterogeneous perception of erosion probability (PF), $E(RP_{dev}) = 0$
- Things to see:
 - Developments occur in the risky zone (mean 38) even if the population of agents is on average the same as a representative agent who objectively perceives flood risk
 - Individuals who underestimate risk cause city to expand into a high risk zone

1 - Fratova, T., A. van der Veen and D. Parker (2009). "Land market interactions between heterogeneous agents in a heterogeneous landscape—tracing the macro scale effects of individual trade-offs between environmental amenities and disamenities." Canadian Journal of Agricultural Economics, 57 (4): 431-457

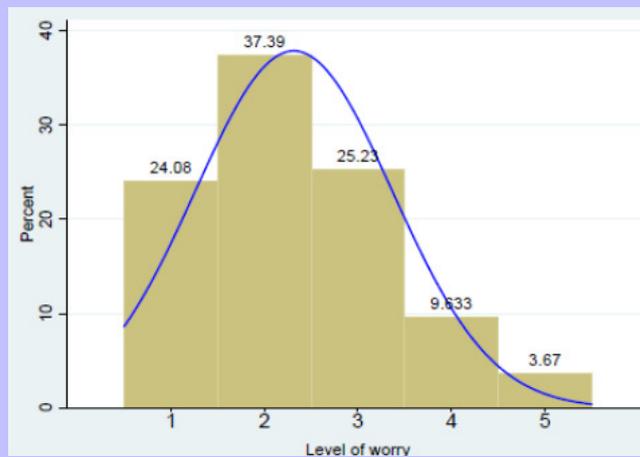
2D rent gradient

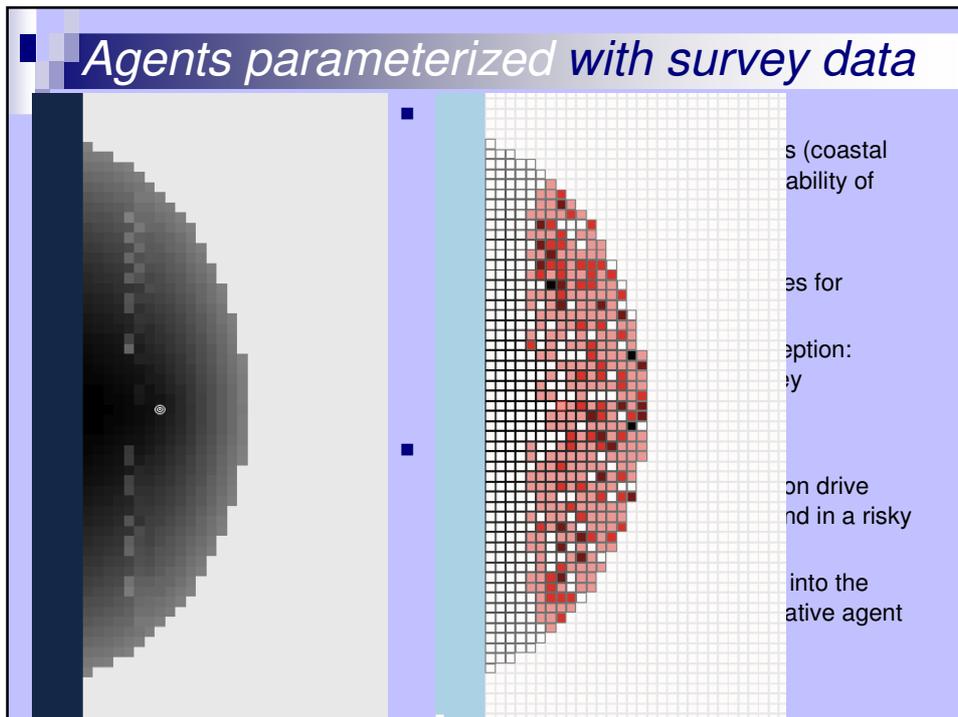
- Land rent gradient under different assumptions of individual risk perception



Skewed distribution of risk perceptions

- Survey carried out in February 2008 in Zeeland province





- ### Conclusions
- If individual heterogeneity is assumed
 - then urban development expands into the flood zone that a representative agent considers economically inefficient
 - land prices are higher than they supposed to be in high risk area
 - potential damage from natural hazards in coastal town will grow beyond the level anticipated by policy makers
 - To exploit the potential of private adaptation
 - a need to increase risk awareness
 - create stimuli to promote climate-resilient choices in a land market
 - flood insurance (risk communication tool; international experience)
 - ACE
 - a tool to explore and visualize emergent properties
 - a laboratory to explore macro-outcomes of various behavioral assumptions and aggregated effects of economic stimuli



Discussion

Thank you for your attention!

Questions and comments are very welcome

ACKNOWLEDGEMENTS:

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