Economic impacts of behavioural responses to flood risk

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Chapter 8

Conclusions

Flood risk is increasing in regions located close to the coast or rivers. Trends of urban development in flood-prone areas combined with possible effects of climate change such as sea-level rise and increased river discharge are likely to lead to further increases in flood risk in the future. Projections of future disaster losses can help inform policy makers in designing suitable policy responses to encounter the threat of increasing risk. Most of the models used for such projections contain limited details on behavioural responses to risk. It is, however, well known that humans respond to environmental changes such as increasing risk. Responses such as moving out of harm's way has an impact on exposure. Excluding such responses could therefore lead to biased estimates of the overall risk. It is increasingly argued that models used for disaster impact analysis should incorporate such behavioural responses. This thesis broadly takes on this challenge, investigating the formation of behavioural responses to risk and the ensuing impacts on the macroeconomy using a range of economic models.

8.1 Overview and answers to research questions

The thesis sought to answer the following three research questions:

1. What are the short and long run impacts on population dynamics of large scale flood events?

2. Can flood risk affect household mobility through the housing market?

3. What are the macroeconomic impacts from household migration?

As a historical introduction to and an empirical investigation of the topics that are discussed later in the thesis, Chapter 2 presented empirical evidence of population dynamics

in the aftermath of the large flood in the Netherlands in 1953. The flood was followed by an extensive flood risk reduction programme – the Deltaworks. We found that the flood had temporary negative effects on population growth while the Deltaworks had permanent positive effects, suggesting that people not only respond to extreme weather events but also to implemented policy measures. These results support findings from previous literature that disasters have temporary effects on growth while policy measures have permanent effects. This is an important insight in the context of disaster risk reduction, due to the possibility of unintended consequences of risk reduction measures. In this specific case, the reduction of the flood probability was associated with an increase in exposure over the longer term.

Models providing quantitative estimates of the negative welfare impacts due to disaster events provide valuable inputs for policy decisions on how to respond to increasing risk. Chapter 3 introduced the two main types of macroeconomic models currently in use for disaster impact analysis, namely Computable General Equilibrium models and Input-Output models. We argued that these models suffer from limitations in modelling how risk affects households location decisions. In this part we also reviewed examples from the literature providing evidence that risk affects households' location decisions. We suggested that such behavioural responses could be incorporated by combining the traditional models with elements of Agent-based models.

Part II (Chapters 4 and 5) of the thesis investigated housing market dynamics from changes in expectations, as well as the interconnection between developments on the housing market and households' location decisions. More specifically, this part focused on feedback effects between the housing market and household mobility. Since a large amount of a households' total wealth is invested in its housing stock it is likely that flood risk is a factor for home-owners. Numerous empirical studies has found that flood risk capitalises in housing prices, providing evidence that flood risk matters in housing market choices.

Chapter 4 investigated whether flood risk on the housing market reduces households' geographical mobility. A key function of housing wealth is its collateral value. Declining collateral value of housing reduces the geographical mobility of households dependent on obtaining a mortgage for financing a move. A credit lenders' fear of declining housing prices in a flood-prone area reduces the collateral value of housing in this area and hampers the mobility of credit-constrained households. Using a general equilibrium model, it was shown how reductions in housing wealth can lead to an endogenous sorting mechanism resulting in an increased concentration of vulnerable households in areas at risk. The model spanned two regions (one risky, one safe) and two households, and included a fictive real estate agent operating on behalf of a credit lender, determining the collateral value of housing through real estate valuations. Real estate valuations were sensitive to flood risk, meaning

the estimated value was lower in the risky region than in the safe region. One household type (vulnerable) depended on obtaining a mortgage to finance a move and the other type (resilient) was not subject to such constraints. The chapter found that the endogenous sorting effects, leading to an increased concentration of vulnerable households in the risky region, were of a substantial magnitude only if the level of safety in the risky region was extremely low.

Can similar endogenous sorting effects also occur as a result of changed expectations among households themselves? Moreover, how are these effects shaped by behavioural responses to risk? These were the central research questions of Chapter 5. Using a one-region version of the model used in the preceding chapter, Chapter 5 showed how households' expectations regarding future housing prices can result in clustering of credit-constrained households in the flood-plain. Crucially, a drop in expected future housing prices implied a decline in the future resale value of housing, reducing the demand for housing, triggering a fall in current housing prices. As such, expected declines in future housing prices led to a decline in current housing prices. Loss aversion and probability weighting were key drivers of the results. If households were highly loss averse towards reductions in the resale price of housing, there were large reductions in current housing prices as well as in household mobility. In the limit case of expected utility (i.e. no loss aversion and rational households), there were only marginal impacts on housing prices. This chapter thus concluded that clustering effects only occur in cases where expectations were highly affected by behavioural anomalies.

Part III of the thesis investigated the macroeconomic effects of changes in expectations due to flood risk, focusing on regional impacts on labour and production. For this purpose, both chapters employed a Spatial Computable General Equilibrium model which has previously been used to analyse the macroeconomic effects of a flood in Rotterdam, the Netherlands.

Chapter 6 analysed whether potential losses in Rotterdam were reduced if investor expectations reflected the potential capital destruction in case of a flood in the region. Investor reactions were triggered by a policy change, amounting to a partial reallocation of risk from the public to the private sector. Lower levels of capital investments reduced the capital stock in Rotterdam, lowering the potential capital damage of a flood in Rotterdam. The reduction in capital stock also caused a reduction in production and higher unemployment in the region. Households decided where to locate by comparing welfare across regions. Risk was indirectly relevant for households' location decisions, as the reductions in the real wage following the reduction in production led to welfare reductions in Rotterdam. The model results indicated that the indirect effect of risk on households' location decisions was not

sufficient to lead to a reduction in population in Rotterdam. As such, even if potential capital losses from a flood in Rotterdam were reduced, the number of potential casualties stayed virtually unchanged.

What is the impact on losses if risk is directly relevant for households' location decisions? This is likely to be the case in the aftermath of a disaster. Disasters can elicit strong public reactions, possibly resulting in concern regarding the safety level of the disaster affected area. Chapter 7 investigated whether public concern generated by a flood event in Rotterdam exacerbated production losses from the flood. Public concern was shaped as thousands of individual agents exchanging opinions about the negative welfare effects associated with residing in a region at risk. The level of public concern was amplified by the amount of extremist opinions and by uncertainty among agents. Model results showed how public concern in the aftermath of the flood reduced the labour supply in the region of Rotterdam. This exacerbated production losses relative to model runs where the flood did not elicit public concern. However, production losses for the Netherlands as a whole were limited as the decrease in production in Rotterdam was compensated with increasing production in adjacent regions. As such, interregional substitution effects were more substantial than aggregate production losses.

8.2 Discussion and relevance for flood risk management

A key concern for policy makers in the context of disaster risk is to find optimal levels of protection, balancing the costs of protection against the benefits of avoided negative effects on welfare from disaster risk. Decision making under disaster risk can be portrayed as a situation where economic decisions are subject to a lottery of outcomes. Policy makers try to "change the lottery" by reducing risk to tolerable levels. As stated in the Introduction, flood risk management aims at reducing overall risk by implementing measures aimed at reducing combinations of hazard probability, exposure or vulnerability. In other words, policy makers can change the lottery by reducing combinations of probabilities or consequences. Completely eliminating risk is either impossible or likely to be extremely costly. In addition, the choice of instrument matters for the long term development of overall risk. For example, by focusing almost entirely on reducing probabilities, the risk reduction management strategy of the Dutch government may involuntarily have contributed to increasing exposure over time. In Chapter 2 we suggested a type of moral hazard effect where government responses may have crowded out individual responses.

Traditionally flood risk management has focused mainly on reducing probabilities. However, there has recently been a marked shift toward a more integrated approach that focuses on reducing exposure, not only probabilities. Several of the proposed policy instruments,

such as the introduction of flood insurance, amount to a partial reallocation of risk from the public to the private sector. Fundamental for these proposals is (i) the assumption that risk is relevant for agents' decision making - either directly, or indirectly through changes in prices and (ii) that behavioural responses translate into a reduction in potential or actual disaster losses. The models discussed in this thesis, which discuss behavioural responses, can inform public policy to make better decisions on how to reduce overall risk.

A central theme throughout the thesis has been to what extent risk leads to behavioural responses. Traditional economic models based on expected utility formulations incorporate the implicit assumption that probabilities and consequences are known and are relevant for decision making. Under convenctional expected utility decision makers do not distinguish between objective probabilities and subjective probability and behavioural anomalies play little role in the expectation formation process. In Chapter 4, where we assumed credit lenders evaluated the housing price impact of flood risk on the basis of an expected utility formulation, we found negative welfare effects from increasing probabilities but only in cases where probabilities were high to begin with. Similarly, in Chapter 6 where investors allocated capital based on a mean-variance model, increasing exposure was identified as the main driver behind welfare losses. These two chapters suggest that, in the case decision makers behave similar to expected utility – for example if all individuals are able to evaluate benefits from collective reduction of probabilities versus those from individual reductions in consequences – policy makers may be able to design combinations of policy instruments that are welfare maximising.

However, in environments of true uncertainty behavioural responses are likely to be affected by other factors than probabilities and consequences. In fact, much empirical literature suggests that behavioural responses to risk are highly context dependent: they may be shaped by recent experiences and they may be affected by the opinions of other people. Chapter 5 suggested that the relationship between probability and the magnitude of response can be heavily affected by behavioural anomalies such as loss aversion and probability weighting. In Chapter 7 we suggested that probabilities or consequences were even of minor importance for household location decisions in the aftermath of a flood event. Here we showed how location decisions may be influenced by self-organising processes whereby public concern was magnified through exchanges of individual risk opinions. Clearly, if decision makers are not rational, policy makers will have a difficult task in designing optimal policy responses to risk. There might not even exist combinations of probabilities and consequences that can be considered truly welfare maximising. As such, in the case where behavioural responses have particularly large economic impacts, policy makers may want to prioritise flexibility in policy design. Such flexible institutional design or adaptive

regulatory schemes would allow policy makers to adjust regulations to circumstances where behavioural failures have particularly detrimental welfare impacts.

8.3 Final remarks and suggestions for future research

How can economic modellers inform policy makers, contributing to better policy responses to increasing future flood risk? As highlighted in several places in the thesis, models providing quantitative estimates of total disaster losses provide useful inputs to such policy decisisions. However, the large heterogeneity in behavioural responses to risk complicate the representation of individual responses in such models. Of fundamental importance is the assumption of whether households are forward looking and risk averse or whether they are myopic decision makers largely ignorant of future increases in risk. A large number of studies has investigated households' risk judgements, mainly using experimental or valuation methods. These studies paint a multifaceted picture of the expectation formation process, providing evidence of large heterogeneity in risk judgements. However, these studies provide less details on how expectations translate into actual behavioural responses and aggregate outcomes. Several chapters of this thesis have shown that the chosen representation of expectation formation matters for aggregate outcomes and consequently also for estimated losses. This also has implications for the role of economic modellers in disaster impact analysis. Instead of providing reduced-form estimates of disaster losses, modellers may want focus on revealing drivers of behavioural responses and gaining an overview of the most important propagation mechanisms of individual responses. Such an approach will likely mean combining macroeconomic models with insights and results from models and experiments focusing on individual decision making under risk and uncertainty. An interesting task for future research is to investigate how heterogeneous risk judgements translate into behavioural responses to risk. This thesis represents a small step in that direction.