Ecological Economics 69 (2009) 355–365

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Methods

Flooding risk and housing values: An economic assessment of environmental hazard

Vanessa E. Daniel [a,*], Raymond J.G.M. Florax [a,b], Piet Rietveld [a,c]

[a] Department of Spatial Economics, VU University, Amsterdam, The Netherlands
[b] Department of Agricultural Economics, Purdue University, West Lafayette, USA
[c] Tinbergen Institute, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 23 November 2007
Received in revised form 29 May 2009
Accepted 11 August 2009
Available online 1 October 2009

Keywords:
Valuation
Environmental risk
Meta-analysis
Hedonic pricing

JEL Classification:
D81
Q51
Q54

ABSTRACT

Climate change, the 'boom and bust' cycles of rivers, and altered water resource management practice have caused significant changes in the spatial distribution of the risk of flooding. Hedonic pricing studies, predominantly for the US, have assessed the spatial incidence of risk and the associated implicit price of flood risk. Using these implicit price estimates and their associated standard errors, we perform a meta-analysis and find that an increase in the probability of flood risk of 0.01 in a year is associated to a difference in transaction price of an otherwise similar house of −0.6%. The actual occurrence of a flooding event or increased stringency in disclosure rules causes *ex-ante* prices to differ from *ex-post* prices, but these effects are small. The marginal willingness to pay for reduced risk exposure has increased over time, and it is slightly lower for areas with a higher per capita income. We show that obfuscating amenity effects and risk exposure associated with proximity to water causes systematic bias in the implicit price of flood risk.

1. Introduction

The occurrence and consequences of natural disasters such as floods, windstorms, and heat waves receive increasing media coverage worldwide. This is partly caused by improved technology in communication and broadcasting infrastructure, but it is also a result of a higher incidence of natural disasters, among which floods have been particularly prominent. Sizeable human and material losses are associated with flooding disasters, and this is the reason why this paper focuses on this specific type of natural disaster. The increased incidence of flooding has both natural and anthropogenic causes, which are potentially interrelated. Changing natural circumstances as well as human behavior simultaneously cause climate change, and bring about increases in the frequency and the magnitude of floods. Indeed, there is an increased chance of intense precipitation and flooding due to "greater water-holding capacity of a warmer atmosphere", and it is expected that "such events will continue to become more frequent" (IPCC, 2007, page 783).

Anthropogenic impacts on river flooding are clearly visible in changed river management practices. Construction in floodplains, channel straightening, building of dikes, and construction activity generating impermeable surfaces such as transport infrastructure and residential areas are examples of urbanization that increases the risk of river floods in small catchment areas and small river networks. Land use conversion is also a factor changing the spatial distribution of environmental risk. Particularly in developing countries deforestation for agricultural purposes causes intensified sediment transport rates of rivers and of deposition downstream (Kron, 2003).

The occurrence of these disasters is associated with substantial costs, in the form of human and material losses or disruption of economic activity. Still, the total value of the chance that such hazards effectively happen, effectively including non-material and subjective losses, typically exceeds these actual costs. We are interested in the economic valuation of these environmental risks for at least two reasons.

First, a spatial economic assessment of environmental risk is important in view of decision-making on public and private investments in protective infrastructure to reduce the impact of environmental disasters. Typically, a simple cost-benefit rule guides rational investment behavior of economic actors. van Dantzig (1956, p. 279) already notes that the optimal height of a sea dike is determined by "taking account of the cost of dike-building, of the material losses when a dike-break occurs, and of the frequency distribution of different sea levels." The cost of protective infrastructure comprises outlay for the construction of a dike and the subsequent nuisance it generates, with benefits accruing in terms of avoided human losses, material losses and reconstruction costs, crops losses, and breaks in economic activity.

An appropriate economic assessment also assists in the design and provision of price-efficient insurance policies against environmental

* Corresponding author. Institute for Environmental Studies, VU University Amsterdam, De Boelelaan 1087, 1081HV Amsterdam, The Netherlands. Tel.: +31 20 59 89799.
E-mail address: Vanessa.Daniel@ivm.vu.nl (V.E. Daniel).

0921-8009/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.ecolecon.2009.08.018

risk. Reliable information regarding actors' willingness to pay for a reduced exposure to the risk of flooding is needed for efficient insurance pricing as well. Unpredictability and damage magnitude make price-setting behavior difficult, in particular given problems of asymmetric information and adverse selection (Akerlof, 1970). Two types of private insurance, the optional system and the package or bundle system, are generally distinguished (Paklina, 2003). The optional variant clearly suffers from adverse selection, because it extends the standard policy to flood damage coverage in return for a mark-up premium. In the package system, flood damage coverage is only available along with other risks, such as fire, earthquakes, and hurricanes.

There are two ways to consider the assessment of the risk of flooding in developed countries. The value of this risk is either the cost of not being affected by the disaster, or the cost of bearing no loss when the disaster effectively occurs. In the empirical literature this value is typically elicited by means of revealed preference techniques, using housing market data. In practice, these studies search for an estimate of the implicit price for self-protection (the price of safety), or the capitalization of insurance premiums (when a market for flood risk insurance does exist) and uncovered damages in the price of the house. The latter includes the nuisance related to (partial) destruction of the house and belongings, and delays of reconstruction. An inventory of available flood risk valuation studies shows willingness to pay (WTP) estimates ranging from −52 to +58% of the average property price associated with a risk exposure of 0.01 per year (see Section 3). The variation in estimates may merely represent sampling or estimation variance, but it could also be caused by systematic variation in the unobserved population value of the willingness to pay. We are particularly interested in explaining the causes of variation in implicit price estimates. Meta-analysis, comprising an array of statistical techniques to analyze previously published empirical estimates, can be used to determine the extent of random versus systematic variation. It is a well-known tool in economics (see Roberts and Stanley (2005), for recent applications), with numerous papers on non-market valuation pertaining to air pollution, recreational fishing, health risks, endangered species, wetlands, and pesticide risk exposure (see, for instance, Smith and Huang (1995), Florax et al. (2005) and Brander et al. (2006)).

The remainder of this paper is organized as follows. The next section deals with the use of valuation techniques for risk of flooding assessment. Section 3 briefly discusses the sampling of studies, and provides the main characteristics of the estimated WTP for reduced flood risk exposure. We also investigate whether the sample drawn from the literature is homogeneous in terms of the underlying population value, and whether publication bias has a distorting effect on the sample. In Section 4, we provide an overview of factors that are potentially relevant in explaining structural variation of flood risk valuations, and we present the estimation results for the meta-regression analysis. Section 5 concludes.

2. Valuation, amenities and perception bias

Stated as well as revealed preference methods have been used to assess flood risks, with either method having its own advantages and disadvantages (see Freeman (2003), for an overview). Stated preference methods are based on interviews or surveys explicitly asking individuals about their willingness to pay for reduced flood risk exposure, using contingent valuation or choice experiments (e.g. conjoint analysis or contingent ranking). Arguably, the major disadvantage of stated preference methods is that it remains unclear whether the actual behavior of respondents corresponds to their self-reported potential behavior. List and Gallet (2001) show that, especially in risk assessment valuation, the impact of the so-called hypothetical bias is most likely strong.

The revealed preference method is concerned with actual consumer behavior in markets. The restriction to actual behavior obviously limits the method's ability to assess WTP values in different (real-world) constellations, and one cannot readily control the information shaping the risk perception of individuals. de Blaeij et al. (2000) and Florax et al. (2005) are examples of studies dealing with the valuation of risk. They both show that revealed preference techniques lead to significantly lower WTP values than stated preference techniques.

Most of the studies assessing the value of flood risk exposure use the revealed preference approach. The assumption underlying revealed preference studies in the presence of an environmental risk is that an exogenously determined (set of) risk(s) is considered when choosing the location of a house. House prices then reveal individual preferences regarding the acceptance of risk, assuming that appropriate controls for differences in the property and the location are included. A straightforward technique to assess such differences is to look at the average difference between prices of houses located inside and outside a specific flood risk zone, and to use a statistical test to assess the significance of the observed difference. Zimmerman (1979) and Shrubsole et al. (1997) use the difference in means approach.

A more elaborate technique derives from Rosen (1974) seminal paper, in which a housing unit is considered as a differentiated market good representing a bundle of quantitative and qualitative characteristics. Implicit shadow prices can be determined as the partial first derivatives of an econometric model that relates the observed selling price of a house to a set of characteristic features of the house, and the neighborhood or location of the house. It is important to note that p is the equilibrium price on the housing market, and variables describing the process of equilibrium price formation should not be part of the hedonic price function.[1] A subset of the neighborhood or location characteristics can be concerned with environmental aspects, such as the risk of natural hazards, or air quality (see, e.g. Kim et al., 2003). Location choices hence include the choice of consuming a particular level of (dis)amenity. This technique has the advantage of being able to control for every element that potentially affects house prices. Yet, in the context of flood risk valuation, two difficulties remain. One is the potential bias in subjective individual perceptions of the level of risk, especially because in hedonic pricing models, as compared with stated preference studies, no additional information or explanation is provided to consumers. Another problem relates to the coincidence of water-related amenities and water-related risks.

Perception bias means the divergence between the objective probability of a given risk and an individual's perception of the risk. A proper appraisal of objective hazards, determined on the basis of recurrent patterns, can interfere with individual personal characteristics and subsequently give rise to biases in the perception of hazards. Specifically, an individual may be completely blind to a risk, in which case revealed preference techniques would elicit insignificant WTP values. Alternatively, individuals may perceive reality through a distorting mirror; in which case revealed WTP values are over- or underestimated (Viscusi, 1991). Two key propositions in expected utility theory and in prospect theory state that individuals overestimate low probability events, especially if fears are present. On the other hand, individuals also underestimate risks over which they have active control (Kahneman and Tversky, 1979; Viscusi and Zeckhauser, 1996). A way to at least partly identify differences between objective and subjective probabilities of risk is to compare house prices before and after the event. New information that can potentially affect subjective probabilities includes the occurrence of the event at risk and the individuals' experience with such an event, a concurrent change in insurance premiums, a change in disclosure rules concerning a specific risk, and increased visibility of the risk due, for instance, to increased media coverage. An illustration of the

[1] Some studies include the number of days on the market as a conditioning variable in the hedonic price function, although this does not seem appropriate. Such a variable either reflects the accuracy of the asking price versus the actual market price, or it reveals an unexplained selling difficulty specific to a house.