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Analysis

Is Flood Risk Capitalised Into Property Values?

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ABSTRACT

Economic theory suggests that, other things being equal, properties located within a floodplain should suffer a price discount. A survey of the existing evidence nonetheless reveals that this price discount lies anywhere between −75.5% to a +61.0% price premium. In this paper we summarise and explore the wide variation in the results to obtain 'best' estimates with which to guide policy. Results from our meta-analysis comprising 37 published works and 364 point estimates indicate marked differences between studies according to when and where they were conducted. For coastal regions the results show that properties located in the floodplain command higher prices; this finding is however likely to be caused by a high correlation between omitted coastal amenities and flood risk. There is moreover, evidence that publication bias affects the coastal flooding literature. Results from meta-regression analyses intended to uncover sources of heterogeneity confirm that controlling for time elapsed since the most recent flood is especially important. For inland flooding the price discount associated with location in the 100-year floodplain is −4.6%. Although other estimates are defensible, we suggest this figure be used as a rule of thumb to determine the benefits of flood relief projects to households.

1. Introduction

Since the year 2000, there have been over 2800 major flood events reported globally (EM-DAT, 2017).[1] The economic losses reported to have been caused by these floods exceeds 538 billion USD globally (EM-DAT, 2017). Asia has been the region most affected by flooding in terms of the number of flood events (40%), number of victims (70%) and total flood damages (59%). Other regions such as Africa and the Americas have also been badly hit with each of these regions accounting for about 20% of the total number of flood events. Although the number of flood events that occurred in Europe represents only 13% of the total the economic losses in this region over the last 15 years account for 22% of global damages (EM-DAT, 2017). By the year 2050 the annual expected losses from floods are predicted to exceed 1 trillion USD (Hallegatte et al., 2013; World Bank, 2013; Munich Re, 2013).

Because of the scale of the problem, combatting floods is a significant policy issue. Considerable sums continue to be earmarked for flood relief projects although it is widely accepted that it is neither desirable nor feasible to protect all localities from flooding. Cost-benefit analysis of such projects entails comparing the monetised costs and benefits of each alternative and determining which yield an acceptable cost-benefit ratio. This enables scarce resources to be efficiently allocated between flood prevention schemes and other public works. In such analyses however the main challenge is to provide accurate measures of the benefits, not least because these combine both market and nonmarket impacts.

Some studies quantify the economic benefits of structural flood protection measures using a damage cost approach (Brouwer and Van Ek, 2004; Blonn et al., 2010; Jongman et al., 2012). Others use stated preference valuation techniques to estimate willingness to pay (WTP) for flood protection (Brouwer et al., 2009; Phillips, 2011; Veronesi et al., 2014). There are also studies estimating the economic value of flood protection afforded by natural ecosystems (Bateman and Langford, 1997; Bateman et al., 2001; Gibbons et al., 2014) and other non-structural defence measures (Holway and Burby, 1990; Meyer et al., 2012; Troy and Romm, 2004). Kazmierczak and Bichard (2010), Bramley and Bowker (2002) and Osberghaus (2015) consider the determinants of private flood mitigation measures. Another popular approach is to use hedonic analysis to estimate the benefits of a reduction in flood risk.

In an efficient housing market the price of property located inside the floodplain ought to be lower than the price of equivalent property outside. This price discount is interpreted as a measure of the benefits of a reduction in flood risk. Numerous authors have investigated the effect

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[1] As reported by "EM-DAT: The Emergency Events Database". To consult the inclusion criteria for quantification of natural disasters in the EM-DAT database see: http://www.emdat.be/.

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of location in a 500-year or 100-year floodplain on property prices for both inland and coastal locations. The results are however inconsistent and sometimes point to the presence of a price premium rather than the expected discount. Without a meta-analysis it is difficult to suggest a 'best' estimate of the percentage discount for floodplain location.

The use of meta-analysis is ubiquitous in environmental risk analysis. Smith and Huang (1995) use meta-analysis to infer WTP for reductions in air pollution based on evidence from hedonic studies. Nelson (2004) also conducts a meta-analysis of hedonic estimates of WTP for a reduction of noise from airports. More recently, Hjerpe et al. (2015) estimate the value of ecosystem conservation by means of a meta-analysis combining different stated preference valuation studies whilst Bergeijk and Lazzaroni (2015) use a meta-analysis to analyse the macroeconomic impact of natural disasters. Siriwardena et al. (2016) estimate the value of tree cover using a meta-analysis of hedonic studies undertaken in the US.

We make four main contributions to the literature. First, we update the only other meta-analysis of the discount for floodplain location. In so doing so we double the number of research papers and treble the number of observations used. Second, our analysis changes the way that primary studies contributing more than one study are weighted. Third, we conduct tests for publication bias and, finding that studies of coastal locations are severely affected by publication bias, exclude them from further analysis. Finally and most importantly, we collect supplementary information enabling us to control for the recent flood-history of locations where studies were undertaken.

The only existing meta-analysis of flood risk is Daniel et al. (2009a) who employ a meta-sample comprising 19 empirical studies and 117 estimates. They use meta-regression to explore the variation encountered using a set of 18 explanatory variables describing the spatio-temporal features of the studies, the design characteristics and the controls included in the original studies. Their paper finds that an increase in the yearly risk of flooding of 0.01 results in a change in house prices of −0.6%.

We by contrast argue that knowing the flood history of areas in which primary studies were undertaken is of fundamental importance. The meta-analysis of Daniel et al. (2009a) distinguishes between those studies undertaken in periods during which there were no floods as well as difference in difference (DID) studies that provide separate estimates of the effect of floodplain location both before and after a flood event. They ignore the fact that all study locations possess a prior flood history the consequences of which may still be present. Distinguishing between studies by adding dummy variables identifying a before-the-flood or an after-the-flood DID estimate does not adequately control for recovery in prices. Our paper uses meta-regression to control for time elapsed since the most recent flood event in all of the primary studies.

Judging by the information we have assembled, existing studies tend to be undertaken in areas hit by recent floods rather than in areas which, although located in the floodplain, have avoided recent flooding. But by focusing on such sites the floodplain discount might have been overestimated.

Once we eliminate studies dealing with coastal flooding and control for the time elapsed since previous flood events, our preferred price discount for location within a 100-year floodplain is almost an order of magnitude different to that of Daniel et al. (2009a). Our findings call into question the simple pooling of studies undertaken in locations with different flood histories. They also serve as an example of how including in meta-analyses a set of observations that are severely affected by various forms of bias can seriously alter findings.

The remainder of our paper is arranged as follows. Section 2 describes the theory used to infer the impact of floodplain location, carefully distinguishing between the different sorts of evidence. Section 3 describes the data. Section 4 provides a meta-analysis of the change in property prices encountered in 100-year and 500-year floodplain locations. Section 5 addresses the issue of publication bias. Section 6 attempts to explain sources of heterogeneity in published results using meta-regression. Section 7 discusses these findings, assesses their robustness and explains why they differ from earlier ones. Section 8 concludes.

2. The Theoretical Model

This section defines the hedonic price function (HPF) in such a way as to consider explicitly the flood risk associated with particular properties. Based on the model of Hallstrom and Smith (2005), the subjective probability p that a property will be flooded is a function $p(i,r)$ of the information set i that the individual possesses about flood risk in the vicinity, and r that represents all of the site attributes related to the risk of flooding e.g. elevation or proximity to water bodies. It is vital to differentiate the *subjective* assessment of the probability the house will be flooded from π which is the *objective* probability of flooding (Knuth et al., 2014). Nevertheless, in areas where the disclosure of the existence of flood risk is mandatory or publicly available, the set of information, i, might include the objective probability of flooding, π. The HPF is represented by the equation:

$$P = P(Z, r, p(i, r)) \quad (1)$$

Here P denotes the price of the house and, whilst this is exogenous to prospective buyers and sellers, depends on the subjective risk perception $p(i,r)$; Z represents an additional set of structural, environmental and locational characteristics of the house not indicative of flood risk. Following Brookshire et al. (1985) the decision of the household is modeled using a state dependent expected utility (EU) function:

$$EU = p(i, r)\bullet U^F[Z, r, Q] + (1 - p(i, r))\bullet U^{NF}[Z, r, Q] \quad (2)$$

$U^F(\cdot)$ is the homeowner's utility in a state in which a flood occurs and $U^{NF}(\cdot)$ is the homeowner's utility when no flood occurs. The variable Q denotes a composite commodity. The household's budget constraint is given by Eq. (3) where M represents income:

$$M = P(Z, r, p(i, r)) + Q \quad (3)$$

Maximising expected utility with respect to p subject to the budget constraint and then dividing through by the expected marginal utility of income results in the following expression:

$$\frac{\partial P}{\partial p} = \frac{U^F - U^{NF}}{p(i, r)\frac{\partial U^F}{\partial Q} + (1 - p(i, r))\frac{\partial U^{NF}}{\partial Q}} \quad (4)$$

Eq. (4) gives the coefficient on the subjective risk variable in the HPF. For optimality the implicit price of flood risk is equal to the difference in utility across states divided by the expected marginal utility of household income. Hence the household's locational decision provides a measure of WTP for a marginal change in the probability of flooding.

Empirical applications of the hedonic technique can be divided into two sorts. The first sort is able only to identify the impact on prices of changes in the subjective probability of flooding. The second sort is able to identify both the impact on prices of changes in the subjective probability of flooding as well as the impact on prices of the changes in information affecting the subjective probability of flooding. And whilst there are other sources of information, the variable that most obviously impacts the subjective probability of a flood is the actual occurrence of a flood. Consider the following HPF:

$$ln\, P_{it} = \alpha_0 + \sum_{j=1} \alpha_j Z_{ij} + \beta r_i + \gamma FPD_i + \delta Flood_{it} + \theta(Flood_{it} \times FPD_i) + \varepsilon_{it} \quad (5)$$

Here, lnP_i indicates the log of the sale price of house i *Flood* is a dummy variable that assumes the value unity if the transaction of