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## Changes in implicit flood risk premiums: Empirical evidence from the housing market



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### ABSTRACT

Hedonic valuation models have shown that sales prices can capitalize property risk factors, such as flood zone; properties facing lower risk sell at a premium, all else being equal. Previous research has indicated that price differentials reflecting risk of flooding become much larger in the wake of a storm. We re-examine these findings for Pitt County, North Carolina, using multiple storm events within a difference-in-differences framework, and we compare flood zone price differentials for a more recent sample of property sales. Prior to Hurricane Fran in 1996, we detect no market risk premium for the presence in a flood zone, but we find significant price differentials after major flooding events, amounting to a 5.7% decrease after Hurricane Fran and 8.8% decrease after Hurricane Floyd. Results from a separate model that examines more recent data covering a period without significant storm-related flood impacts indicate a significant risk premium ranging between 6.0% and 20.2% for homes sold in the flood zone, but this effect is diminishing over time, essentially disappearing about 5 or 6 years after Hurricane Floyd. The lack of a persistent effect suggests that buyers' and sellers' risk perceptions may change with the prevalence of hazard events and that homebuyers are unaware of flood risks and insurance requirements when bidding on properties.

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### 1. Introduction

Smith [36] was the first to show how a properly specified hedonic price model can produce estimates of incremental option value for differences in real property risk. Subsequently, applications of hedonic price analysis to manmade and natural hazards have produced a set of stylized facts. First, provision of information that identifies areas of greater risk tends to create or exacerbate price differentials across risk zones [7,2,28,40]. Gayer et al. [15,16] also find that the release of information indicating a reduction in risk (e.g. cleanup of a local hazardous waste site) will reduce price differentials. Second, the occurrence of a catastrophic event (e.g. earthquake, flood, or hurricane) tends to increase price differentials across hazard zones [4,17,8,18,30]. Lastly, some research suggests that perceptions of risk and price differentials tend to diminish over time, in the absence of new information or recurring catastrophic events [28,18].

In this paper, we examine hedonic property prices and flood risk, as reflected in property flood zone defined by FEMA flood maps. Previous research has shown that property values capitalize flood risk, and incremental option values are often consistent with the discounted sum of future flood insurance payments [26,27,19,4,5]. With full insurance on flooding hazard, marginal implicit hedonic prices will reflect the sum of incremental option value (reflecting any differences in

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insurance payout and expected losses) and marginal insurance costs [26]. In the US, designated flood zones are designed to convey information on flooding probability, the government requires flood insurance mortgages in the 100-year flood zone [also known as special flood hazard area (SFHA)] originating from federally regulated lenders, and mortgage lenders must inform buyers if properties are located in the 100-year flood zone [41]. Under these conditions, one might expect a consistent incremental option value for flood risk over time, but empirical evidence suggests that this is not the case [4,17,8]. Rather, implicit flood risk premiums derived from hedonic property prices increase in the wake of flooding events.

In order to explore the variability in implicit flood risk premiums more thoroughly, we build upon the work of Bin and Polasky [4] by re-examining their findings using a difference-in-differences (DND) framework with two major flooding events, and we compare the flood zone price differentials from the DND model with price differentials from a more recent sample of housing sales data for the same location, explicitly allowing for temporal variation in the risk premium. Generally, we define flood zone as encompassing the 100-year (1% chance of flooding per year) and 500-year (0.2% chance of flooding per year) flood zones, unless otherwise specified. Our extensive dataset includes information on over 8000 housing sales in Pitt County, NC, spanning 17 years of transactions. As do Bin and Polasky, we find an increase in implicit risk premiums following significant flooding events, both Hurricane Fran in 1996 and Hurricane Floyd in 1999. But prior to Hurricane Fran, we detect no market risk premium for the presence in a flood zone. A home in the flood zone sells for 5.7% less after Hurricane Fran, and the risk premium decreases to 8.8% after Hurricane Floyd. For most households in the 100-year flood zone, flood insurance is required by the mortgage lender (via Federal dictate), but there is evidence that this requirement was not aggressively enforced in the late 1990s [23,25]. While extensive within the 100-year flood zone, flooding associated with Hurricane Fran caused a relatively small amount of damage in Pitt County. Hurricane Floyd caused widespread flooding across the 100-year and 500-year flood zones, eventually leading to an updating of the flood maps to reclassify land in the flood zones in 2002. Major damage associated with Hurricane Floyd, however, accrued to about 1% of the total housing units in Pitt County, primarily those located in the 100-year flood zone. Since flood insurance premiums remained roughly constant over this period and damage impacts were limited, the increase in price differential could reflect both a change in enforcement of flood insurance requirements and a change in incremental option value (reflecting uninsured losses).

Estimating a similar hedonic property price model for the same metropolitan area with recent sales data, however, reveals that the price premium for flood risk has decayed in the absence of additional large-scale flooding events. Model results indicate that the presence in the floodplain decreases sales price by 6.0–20.2% in the wake of Hurricane Floyd (in September 2002), but the price differential is diminishing over time—we estimate that the risk premium disappears about 5–6 years after Hurricane Floyd; this result is robust to different functional forms that allow for linear and non-linear temporal flood zone effects. Although housing prices in flood zones diminished in the wake of Hurricanes Fran and Floyd (as shown in the DND model), the market price risk premium did not persist over the longer term (through 2008), and the rapid disappearance of the risk premium is a novel finding in the literature. An examination of FEMA flood insurance data covering the study period provides corroborating evidence of fluctuating concern over flood risk; the number of flood insurance policies-in-force remained relatively stable until 1996 when it increased by 15%. It surged up by 171% after Hurricane Floyd in 1999 but declined by 43% in 2002, after which no substantial changes in the number of policies-in-force were observed—despite the fact that classified flood zones expanded in 2002. Given federal requirements for flood insurance that affect most buyers in the 100-year flood zone, the lack of a persistent risk premium suggests limited awareness of insurance requirements and flood risk factors at the time of bidding on property. It is also possible that there exist other unobservable amenities that compensate for the higher insurance cost and flood risk and complicate the analysis of flood risk premiums (although we do not believe this to be the case for our dataset).

## 2. Flood hazard and insurance in the United States

Floods are one of the most common and widespread natural hazards in the US (<http://www.fema.gov/hazards/floods>). In order to lessen the impact of floods on human beings and physical capital, Congress created the National Flood Insurance Program (NFIP) in 1968. Part of the motivation for providing flood insurance was to internalize the costs of floodplain occupation and reduce public expenditures for post-flood disaster relief. Flood insurance with risk-based premiums can facilitate economically efficient use of floodplains [24]. In order to promote mitigation, the NFIP requires communities to adopt floodplain management measures in order to be eligible for federal flood insurance.

Initially the NFIP suffered from low levels of enrollment among communities and low levels of insurance purchase by individual property owners within participating communities. Subsequent legislation mandated community enrollment in NFIP as a pre-condition for qualifying for federal disaster assistance and required flood insurance purchase for mortgages in the 100-year flood zone made by federally regulated lenders [32]. Nationwide, currently almost 20,000 communities have joined the Program. It has been estimated that about half of the residential properties in the 100-year flood zone are covered by flood insurance, and less than 1% of homes in the 500-year flood zone are covered [13,25].

When homeowners are well aware of flood risks and are fully insured, the reduction in property values from floodplain location should be greater than or equal to the capitalized value of flood insurance premiums.<sup>1</sup> On the other hand,

<sup>1</sup> Floods can cause non-monetary losses that cannot be covered by insurance; these are described below.

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