THE IMPACT OF FLOODING ON THE PRICE OF RESIDENTIAL PROPERTY: A TRANSACTIONAL ANALYSIS OF THE UK MARKET

ABSTRACT *The increase in frequency and severity of flood events in the UK has highlighted the question of the impact of flooding on the value of property. Previous studies in the UK and internationally have measured a wide variety of impacts from no impact to discounts of more than 40% of property price. Transactional measurements have not previously been attempted in the UK property market due to lack of available data. In order to improve the available evidence base, a variation of the repeat sales methodology has been used to measure the impact of flooding on the price of transacted residential property for thirteen locations in the UK. The results reveal the impact of flood events to be highly variable and temporary and no effect of flood designation. The policy implications of these findings with regard to the perceptions and behaviours of property stakeholders are explored.*

KEY WORDS: property valuation, flood risk, residential, repeat sales, flood events

Introduction

Floods are the most common natural hazard event and their worldwide incidence is increasing. They can be devastating in their impact causing more fatalities than any other natural hazard and coming second only to windstorms in the amount of damage they cause (Munich Re 2004, United Nations Environment Programme 2007, Scheuren *et al.* 2008). The Foresight Future Flooding report (Evans *et al.* 2004) estimated that over £200 billion worth of UK assets are at risk from flooding.

The impact of flooding on buildings has been witnessed by an increasing number of UK residents in the last decade. The flood events of Easter 1998 followed a relatively dry period in the UK and sparked a renewed interest in the management of flood risk (Bye and Horner 1998). This interest was reinforced by widespread flooding across England and Wales in autumn 2000, (National Audit Office 2001, Environment Agency 2001, Clark *et al.* 2002), Boscastle in summer 2004, Carlisle and North

Yorkshire in 2005, and the severe summer flooding across much of the UK in 2007 (Pitt 2008). Coupled with forecasts of increased flooding due to climate change (Evans *et al.* 2004), these events have kept the flood issue high upon the political agenda.

The short term effect of flooding in terms of damage to and loss of property and displacement from homes is readily apparent. Dramatic coverage of emergency evacuations and the destruction of property are commonly presented in the media (Pook 2000, Thompson and Fitzwilliams 2005, Humphreys 2005). Surveys of flooded households document the wider impacts (Welsh Consumer Council 1992, Ketteridge and Fordham 1998, Samwinga *et al.* 2004, Pitt 2008). Less apparent but equally distressing to the victims, are the longer term detrimental impacts such as physical and mental health problems (Bennet 1970, Welsh Consumer Council 1992, Tapsell *et al.* 2002, Hajat *et al.* 2003, Reacher *et al.* 2004, Environment Agency /Department of the Environment Food and Rural Affairs 2005, Fewtrell and Kay 2008). Long term financial impacts relating to the insurability and saleability of their property are also a concern (Welsh Consumer Council 1992, Clark *et al.* 2002, Samwinga *et al.* 2004, Environment Agency /Department of the Environment Food and Rural Affairs 2005). Homeowners worry that flood events will lead to a decrease in the value of their major asset.

The valuation of property recently flooded property and of property at risk of flooding is a problematic area. Many professionals have had very little experience in this field, and there is a dearth of practical guidance. The primary aim of this study was to examine the evidence for flood discount of property values in order to provide better guidance for valuation professionals. However, the potential loss of property value due to environmental hazard has a wider implication to society than the financial

impact on direct investors. Loss of property value can negatively affect communities and may lead to blight (Adams and Cantor 2001, Bramley *et al.* 2004). Conversely, the absence of a price effect could allow continued profitable development of the floodplain for housing, increasing the vulnerability of UK housing stock to future events (Clark *et al.* 2002). Fear of the loss of property value may contribute to a culture of denial of flood risk. This culture may decrease the tendency to mitigate flood losses by community or individual actions (Harries 2007). The presence or absence of a flood impact on property price may also be indicative of levels of flood risk awareness or risk perception more generally. Perception of flood risk will influence public beliefs regarding the apportionment of costs and benefits of flood defence between property stakeholders, insurers and the wider society and therefore affect the cultural acceptability of public policy changes (Adams and Cantor 2001, Harries 2007). Therefore the results from the empirical analysis of property price changes described in this paper may have relevance to insurers, investors in property and policy makers as well as to professional valuers, construction professionals and property owners.

While this study focuses on flood risk in the UK market, the empirical results may demonstrate some features of the reaction of property markets to risk factors which may be more widely applicable. Furthermore the novel methodology employed within the study could be useful in conducting future studies of flood and other market risks to property.

Research Context

The inundation of water across areas that are normally dry, constitutes a flood and has a wide variety of impacts (Gruntfest 1995, Fleming 2001, Reacher *et al.* 2004, Environment Agency /Department of the Environment Food and Rural Affairs 2005).

As an extreme example, a tsunami may result in massive loss of life, land and possessions. At the other extreme, poor functioning of the internal plumbing system within a dwelling may result in an escape of water and minor damage to contents. In the UK, tsunamis are not usually considered a likely threat but the UK experiences regular river flooding (known as fluvial flooding), intense rainfall events (pluvial flooding), occasional and devastating coastal and estuarine flooding; groundwater flooding and failure of artificial water systems (Fleming 2001).

On the whole, when compared to worldwide flood incidents, UK flood events can be regarded as small in terms of their geographical scale, the number of the population affected and the number of fatalities. On an economic scale, however, the impact of flooding in the UK can be significant in world terms (Scheuren *et al.* 2008).

The study described in this paper was primarily concerned with the impacts of UK fluvial flooding and the empirical analysis was based on the flood events of autumn 2000. It was set within the context of a perceived increase in flood risk, increased flood awareness and risk aversion by insurers and improved fluvial flood risk information. These issues are critical factors in the notion of perfect market information inherent in economic modelling of housing markets and they are discussed further below. The study makes a novel contribution to a growing body of international research, from which lessons are drawn below, regarding the impact of flood risk on property value. It is the first to adopt a transactional approach within the UK housing market and can provide a useful comparison to results of earlier UK survey based analyses and international survey and transaction based studies.

The increase in flood impact

While noting in the introduction that flooding has been high profile news recently, flood risk must be considered in its historical context. The flood events of the past decade followed a relatively flood-free period but there have been other times when flood frequency has accelerated. The last of these wet periods prompted government intervention in the flood insurance market and led to the prevailing insurance regime (Arnell *et al.* 1984). The distinguishing feature of the present wet period is that flood frequency is predicted to continue to increase over the foreseeable future due to climate change. Forecasts for the UK (U.K. Climate Impacts Programme 2007) suggest that the country will suffer wetter winters and increasing numbers of intense rainfall events. This causes concern about the long term viability of floodplain property.

However, even without increased frequency of flooding, the impact of flooding is predicted to rise because of human actions. Recent development within floodplains has ensured that increasing numbers of properties are at risk of flooding (Crichton 2005, Pitt 2008). Urban creep and the failure to upgrade drainage systems in the light of new development has increased the risk of overland flooding (Pitt 2008). Flood awareness, defence effectiveness and community resilience declined during the relatively dry decades of the 1970s and 1980s (Clark *et al.* 2002) and despite recent investment in defences the situation has not improved significantly since 2000 (National Audit Office 2007). Lifestyle changes have increased the financial amount at risk as householders invest more heavily in their homes (Chagnon *et al.* 2000) and insurers increasingly replace old with new. When the increase in rainfall is coupled with human factors, the number of people at risk of flooding is expected to grow from 1.6 million to 3.5 million in the 2080s, and the estimated annual damages are

projected to rise from £1 billion to £21 billion over the same period (Evans *et al.* 2004).

Findings from previous studies of flood impact on property values

Many studies have looked for flood impacts on residential property values across a variety of international property markets. The findings from these researches vary a great deal, partly due to methodological differences and partly to the nature of the impact measured (Lamond *et al.* 2005). In the UK, three studies (Eves 2004, Building Flood Research Group 2004, Kenney *et al.* 2006) have surveyed the opinions of valuers and other stakeholders on the question of the impact of flood on the value of property. Prior to this study, significant transaction based research had not been attempted.

A key difference emerged between studies which measured the impact of flood risk designation (Zimmerman 1979, Shilling *et al.* 1989, Donelly 1989, Bialaszewski and Newsome 1990, Montz 1993, Harrison *et al.* 2001, Troy and Romm 2004) and those which studied the effect of flood events (Montz 1992, Tobin and Montz 1994, Tobin and Montz 1997, Lambley and Cordery 1997, Eves 2002, Bin and Polasky 2003). Typically the impact of a flood event was found to be greater than that of designation, but variation was still considerable within those categories depending on local factors (Tobin and Montz 1994).

The nature of the disclosure of flood risk designation was also seen to be important, in particular whether disclosure of flood risk was mandatory at the point of property sale. Donnelly (1989) analysed sales from an area which had not been flooded for a decade but which falls under the National Flood Insurance Program (NFIP). The NFIP is a scheme in the US which enforces development guidelines and ensures that

residents requiring mortgage finance are aware of flood risk and must purchase flood insurance. Donnelly measured a 12% discount in price for those properties situated on the floodplain. Troy and Romm (2004) observed an impact amounting to an average discount of 4% when a new regulatory disclosure regime was introduced in California.

Economic theory predicts an impact of flood risk on property price if information regarding the risk is openly available. Conversely, if purchasers are ignorant of flood risk they are powerless to respond with discounted offers. Flood risk is not a standard search within UK property transactions leading to potential asymmetry of knowledge between buyer and seller. Alternative mechanisms for discovery of flood risk at purchase include problems with insurance, either lack of availability or high insurance cost. The question of whether the recent changes in insurance regime (as described below) could be regarded as enforcing risk disclosure has been raised by previous studies but not fully addressed (Building Flood Research Group 2004, Eves 2004, Kenney *et al.* 2006, Lamond *et al.* 2007a).

Other important lessons also emerged from the literature regarding the time-varying nature of flood impact and the importance of riverside location. Previous studies which have considered the temporal variation in flood impact have found that impacts declined with time. Following the 1990 flood in Nyngan, Australia, Lambley and Cordery (1997) compared the average house value in Nyngan with its flood-free neighbour Gilgandra. For about 18 months following the flood there was a divergence in trends with the Nyngan property declining in absolute value. Two years after the flood property values in Nyngan had recovered and caught up with their flood-free neighbour. Tobin and Montz (1994) have studied multiple flood sites and observed different rates of recovery. In one example, Linda and Olivehurst in

California, where some houses had not been reinstated the most severely affected properties had not recovered completely after ten years. Building Flood Research Group (2004) had responses varying from shorter than one year to longer than an eight year impact.

Eves (2004) highlighted the expectation among professional valuers that the incentive of obtaining a river view can act in direct opposition to the disincentive to purchase a house at risk of flooding. This expectation is supported by empirical studies. In the US, Speyrer and Rajas (1991) found that the positive effect of lakeside location was greater than the discount due to flood zone status. Bin *et al.* (2006) tested coastal view in a GIS methodology designed to disentangle view from flood risk and found large positive impacts of view, larger than the flood zone impact.

The cost and availability of insurance

In the UK flood risk has been included as standard within the general domestic all risks insurance policy since the late 1960s. The cost of these standard policies has been largely unrelated to flood risk for two main reasons: the availability and quality of information on flood risk has made accurate risk based pricing problematic; the writing of policies in blocks linked to mortgage purchase has made premium differentiation difficult (Huber 2004). After the Easter 1998 floods the universal availability and low cost of flood risk cover was called into question by the Association of British Insurers (Dlugolecki 2000). There have been revisions to the principles underlying the provision of flood risk cover (Association of British Insurers 2002, Association of British Insurers 2005a, Association of British Insurers 2008) which allow for removal of cover from high risk properties and pricing of insurance more closely to risk. Information sources on flood risk have improved and trends towards more individual underwriting have led to some policyholders experiencing

difficulty in achieving renewed cover (Stevenson 2002, Poulter 2002, Lamond *et al.* 2006).

To address the question of the enforced disclosure of flood risk due to the changes in the UK flood insurance regime a parallel study (Lamond *et al.* 2009) was undertaken. The parallel study considered the cost and availability of insurance for five of the case study sites (Bewdley, Southsea, Shrewsbury, Malton and Norton and West Bridgford). A questionnaire survey was found to be appropriate due to the lack of systematic information regarding the experience of floodplain residents with insurance. In brief, the study found that some floodplain residents experienced difficulties in obtaining insurance but that others encountered no difficulty. Floodplain residents with compromised insurance (either no insurance or insurance excluding flood risk) represented only 10% of those at moderate or above risk of flood. Problems with the cost and availability of insurance at point of purchase in the current market were therefore unlikely to cause wholesale discounting of floodplain property. Insurance issues are therefore not discussed further in this paper.

The 2000 flood event

The analysis described below concentrated on locations which were flooded or narrowly avoided flooding during the 2000 flood event. Autumn 2000 was the wettest autumn for 270 years (Environment Agency 2001) and it followed on from a wet spring and early summer. Heavy and prolonged rainfall during October and November resulted in serious floods spread across England and Wales causing severe disruption to transport and business and requiring 11,000 people to be evacuated from their homes.

Estimates of the number of properties affected vary but the Environment Agency estimated that 10,000 homes and businesses were flooded while a further 280,000

were protected from flooding by flood defences. Insurance industry estimates of damage costs for the 2000 floods were £1bn (Association of British Insurers 2005b). The 2000 flood not only affected locations with long and frequent flooding history but also brought floods to areas which had not flooded in a generation. Description of the 2000 flooding as one event masks the fact that the flooding took place over the space of more than a month, commencing in October and going into November with many locations being inundated more than once and for prolonged periods (Environment Agency 2001).

The choice of this large scale national event as the basis for the empirical study had two major advantages: First, the number of properties affected was large in UK terms (albeit fairly dispersed geographically) providing a workable sample size; Second, sufficient time had elapsed since the event for recovery to take place and for the medium term impact of flooding on house prices to be assessed.

Research Method and Data

As previously noted, the approach taken was transaction based using data from locations which had flooded or nearly flooded in autumn 2000 and as such was unique in a UK context. The application of a transaction based method removes the dependence on the experience of valuers, which in the flooding context may not be high. The use of real transaction data also complements previous studies, providing a comparison to expert opinion. The wide variation in measured impacts reported by previous research led to the use of a case study approach. In this approach multiple flood locations are analysed individually, yielding understanding of the differences

between flood locations. Results from these individual models are then combined, thereby increasing sample size and allowing any common features to be identified.

The main method of analysis of the data was a novel variation of the repeat sales index model. The use of the repeat sales approach to measure environmental impacts on property prices is advocated by Palmquist (1982). This method uses ratios of the price realised from serial sales of the same property to estimate the growth in market prices. Differences in the growth rates between properties experiencing a locational disamenity (in this case flood risk status) and the rest of the market are attributed to the impact of the disamenity. The method is most useful where changes in the disamenity have occurred or perceptions of it have changed. Analysis of both affected and unaffected property is necessary.

For the study of UK flood locations the primary advantage of the repeat sales approach over the major alternative methodology of hedonic modelling is in data efficiency. As described at length in Lim and Pavlou (2007) and advocated by Leishman and Watkins (2002) and Costello and Watkins (2002) repeat sales analysis removes the need to collect large datasets of property details and allows multiple analyses to be carried out more quickly and cost effectively. Recent hybrid adaptations of repeat sales as advocated by Case *et al.* (2006) have been designed to combine the advantages of repeat sales and hedonic models but were impractical in the context of this study.

The additional advantage of repeat sales in the flooding context lies in addressing the issue of correlation of river view with flood risk. Comparing sales of the same property at different time periods equates to the comparison of sales of properties with identical locational amenities. The status of river view has not altered in the interval between sales, but flood risk status has changed.

The variation of repeat sales employed by this research also had the benefit of explicitly testing for impacts which varied over time. Differences in growth rates were aggregated annually by the date of the second sale of the repeat pair. Details of the method are contained in Lamond *et al*. (2007b).

This study encompassed thirteen locations, flooded or nearly flooded in the 2000 flood event. Study locations were usually small areas contained within small to medium sized towns or suburban areas of cities. Coastal flooding was excluded from the analysis and the majority of the locations suffered river flooding. Data from these locations were collected for seven years from April 2000 to December 2006, the time period being dictated by availability of property price data but containing data from before and after the 2000 event. Each location was considered individually and then the data was combined into global models based on common flood history.

For each flood location, repeat sales indices were constructed for the floodplain properties and for control areas which are close to but outside the floodplain. Two different tests were used to determine whether measured differences between the growth rates were more than just chance.

First, a chow test was employed to test whether the index models were significantly different from one another. This test, as used by Day (2003) tests whether the improvement in model fit to the data is caused by using twice the number of parameters (in the two models) or by real differences in underlying parameters. It states that when combining two regression models

$$\frac{(RSSR - SSR_1 - SSR_2)/k}{(SSR_1 + SSR_2)/(n-2k)} \sim F_{k,\, n-2k}$$

RSSR The sum of squared residuals for the combined model

SSR1 AND SSR2 the sum of squared residuals for the individual models

n = number of observations, k parameters common to both models.

Second, the difference in indexed growth rates was tested annually by estimating a regression model using data from both inside and outside the floodplain. A dummy flood index variable for each year was used to test whether the growth rates of floodplain properties sold in that year were significantly different from the rest.

Having derived models for each individual location the data were standardised by discounting each observation by its local growth rate (the index of local property outside the floodplain). This discounted data could then be combined into a global model free from the effect of local inflation. Combining the locations was designed to increase the sample size and hence robustness. An increase in the number of observations also allowed for finer categorisation of risk and flood history. At this stage properties which had sold both before and after the 2000 flood event were analysed in isolation.

Study Data

Data on property price were taken from the Land Registry database for all property transactions for the period April 2000 to December 2006. The Land Registry is a government organisation that records essential details of all property transactions requiring registration in England and Wales. The maximum coverage afforded by the Land Registry data was felt to be vital for this study as the areas studied were small and resulted in low sample sizes. The registry holds details of title, covenants and plot details for residential and commercial property in England and Wales. During 2005 a subset of this data became publicly available at an individual property level, and it can now be purchased directly from the Land Registry.

Indicative floodplain maps are available in England and Wales via the Environment Agency website (Environment Agency 2006). These maps are not the most accurate

method of assessing flood risk to an individual property as they only indicate areas at risk, contain no property details and are restricted to fluvial flooding (Kenney *et al.* 2006). However, for the purposes of this market based study the Environment Agency Maps have the advantage of representing the sort of information that potential purchasers can access as it is the best publicly available source of risk designation (Arnell and Chatterton 2007). As such, they have previously been used to assess the vulnerability of property to flood damage (Fedeski and Gwilliam 2007) and the vulnerability of floodplain populations (Fielding 2007).

The floodplain maps were used initially to identify postal code sectors which contained the flood risk areas in combination with an online mapping source, multimap (Microsoft 2008). On this basis the analysis areas were selected. Transaction data for these areas were then collected and each address was classified using the Environment Agency 'learn more' facility. This facility categorises postcodes into four risk classes significant (S), moderate (M), low (L) and outside the floodplain (O). The classes S, M and L represent properties inside the outline of the 1000 year return period flood (referred to as the 1000 year outline or FZ1000). Class O represents property outside the 1000 year outline. The maps are living documents and change when defences are improved for an area. Categorisation was effected in 2006; therefore the risk category assigned can be seen as the minimum category assignment over the period. However, changes in flood defences will not move properties in or out of the 1000 year outline because they are not designed to withstand floods of that level. Therefore, while properties may have changed from significant to moderate or low, or from moderate to low, they will not have changed from inside to outside the floodplain.

A large variety of textual sources was used for flood history information. Newspaper reports, flood defence scoping reports, crisis management reports, maps supplied by local EA offices, previous surveys of floodplain populations and the insurance survey were all employed in building up a picture of the flood history of the selected sites and the individual properties within them. Whereas the quality of the information on property price and designated flood risk was the same across flood study sites the flood history information used was the best available for that location and varied between sites. Brief details of flood histories are included below and a full list of sources can be found in Lamond (2008).

Flood history information was collected for three main purposes: First to identify flood locations suitable for analysis and to narrow down the collection of transaction data to areas close to the floodplain; second to categorise flood history for the selected sites; third to attribute a flood history category to an individual property. There is no database available which records whether or not a given property has been subject to flooding in the past - water company records are limited to those at known risk of flooding from water systems, the Environment Agency has no official list of properties flooding from the sea or rivers. A best assumption has therefore to be made from multiple sources including questioning the residents and local knowledge. While this may not be completely accurate, it is once again worth considering that prospective purchasers will have access to similar sources.

Study site selection

Selection of the analysis sites from the 700 locations flooded during the 2000 event was based on the need to represent the widest possible variation while encompassing sufficient flooded property. To that end only sites with greater than 100 affected properties were considered and their main features are summarised in Table 1.

Geographically they span from Northern England to the South coast, from the East to the West of England and North and South Wales. Past flood history of locations was also varied

Three of the selected sites had flooded frequently in the past. Malton and Norton are situated on opposite sides of the river Derwent in North Yorkshire, They suffered major flood events in 1947, in March 1999 and in November 2000 (Arup 2006). Shrewsbury, in the West Midlands is almost completely encircled by the river Severn and was flooded extensively three times in quick succession in 2000. Bewdley is on the banks of the river Severn in Worcestershire and is also extremely susceptible to flooding. According to the Environment Agency (2003) there are properties in Bewdley that are likely to have been flooded more than 50 times in the last 100 years.

Other locations had little recent flooding history due the protection of flood defences. Selby and Barlby are situated in North Yorkshire and are susceptible to flooding from the river Ouse. During the autumn 2000 floods the local defences were overtopped inundating 152 properties (National Audit Office 2001). Lewes is situated in the lower Ouse sub-catchment about ten miles from the city of Brighton in the South of England. In 2000 flood defences were overtopped at a number of locations and the town centre was flooded for three days. Southsea is an area of Portsmouth, on the south coast of England and is at risk of coastal flooding. The 2000 floods were the worst since records began, and were attributed to pumping station failure (Clark 2000). Mold is a town in Flintshire, North Wales sited on the river Alyn. The flooding during November 2000 was caused by a combination of defence overtopping and overland flow (Environment Agency 2005). Newport, the third largest city in Wales, is at risk of flooding from a number of sources. In the 2000 event flooding in Newport

was attributed to a state of tidelock on the Malpas Brook (Environment Agency 2005).

Other locations had not been defended or recently flooded. Woking is a large heavily developed town in Surrey in the London commuter belt. In 2000 Woking flooded from the Hoe stream, a tributary of the river affecting 100 properties (Thrush *et al.* 2005). Hatton is a village situated in the Trent Valley lying wholly within the 100 year floodplain and flooded in autumn 2000 from the river Dove. Ruthin is the county town of Denbighshire in North Wales located around a hill in the southern part of the vale of Clwyd. Ruthin was affected by flooding three times within six days in 2000 (Environment Agency /Department of the Environment Food and Rural Affairs 2005).

Two locations did not flood in 2000 although they had flooded in the past and remain at risk from a 1 in 100 year event. West Bridgford is a leafy suburb of Nottingham situated within the flood plain of the river Trent. West Bridgford last experienced serious flooding in 1947 after which flood defences were constructed. The city of Wakefield is situated on the river Calder in West Yorkshire. In 2000 the centre of Wakefield was flooded by the river Aire (National Audit Office 2001) but the postcode sectors considered in this analysis escaped the flooding.

Results

The results of both the individual and combined models are summarised in this section and demonstrate the benefit of analysing multiple sites individually. Table 2 shows a summary of the individual case study sites. The first six columns show information obtained from textual sources and the Environment Agency Website regarding the main factors which might be anticipated to have a bearing on the

perception of risk borne by local residents. It is apparent that the locations exhibit many variations in these key factors and so it is reasonable to expect differences in measured impact. Combining all the data at the outset could potentially mask local effects.

Individual flood location models

An example of the outcome of the analysis of one individual case study site, Shrewsbury, is shown in Figure 1. It shows two indices, inside and outside the floodplain, and it can be seen that they are very similar. No impact of the 2000 flood is measurable but in 2005 a small negative effect (of about 5%) is seen. This impact, not significant at 5%, might possibly be attributable to a flood event which occurred in 2004 or to the launch of the Environment Agency maps and attendant media publicity also in 2004. However, the effect is temporary and disappears by 2006.

Table 2 summarises the results of the statistical testing of all the individual flood location models. Further details of the individual site analyses are contained in Lamond (2008). Two statistical tests were performed: the chow test examines whether the growth rates inside and outside the floodplain were significantly different over the whole time period; the index coefficients test whether a significant difference was measured for each year. The final column indicates whether any measured impact was positive or negative on the growth of the floodplain property. It can be seen that there are very few differences which are significant at the 5% level. In fact there are more flood index coefficients which are significantly positive than there are significantly negative ones. The supposition that flood designation will have an impact on property price is far from proved by this analysis.

No price discount was observable for the two locations at risk of flooding but not flooded in 2000. It is possible that some long term discount applies to floodplain

property which existed before 2000 but this has not been tested by the foregoing analysis. However, the events of the last six years have not resulted in a change in the relative value of floodplain and non-floodplain property.

Two of the previously flooded locations, Bewdley and Mold, showed significant flood index variables. These statistically significant impacts had disappeared within three years of flooding. At the end of the six years only one location, Lewes, demonstrated any effect of floodplain location. In Lewes a discount of 5% was maintained but it was not significant. Special circumstances regarding various regeneration schemes in and near flood prone areas may make Lewes a unique location and further tracking of this location may prove interesting. These findings strengthen the belief that it is necessary to examine the impact across time.

The significant temporary price impacts immediately following the 2000 event varied from no impact to a maximum of 30%. Some locations saw floodplain property outperform the rest. The choice of the 1000 year outline as the definition of floodplain property may explain some of this variability as in some locations such as Lewes the 1000 year outline is a good predictor of flood history, whereas in others, notably Shrewsbury, it is fairly poor. However, in order to maintain consistency during the combined analysis, the 1000 year outline was used to define the flood-free price index.

Combined model

Discounted growth data were generated from the individual repeat sales analyses by discounting the growth figures by the local price index calculated from the property outside the floodplain. The data from the 13 sites were combined into a global database limiting the repeat sales pairs to those which had a first sale before the flood.

Mean average discounted growth rates were calculated on an annual basis using the date of the second sale.

When all categories of flood site were combined there was no discernable difference between the discounted growth in property inside or outside the 1000 year outline. This is an important finding because it is suggestive of the conclusion that flood designation alone has no impact on property value growth despite several factors which may have increased the importance of flood designation in the mind of the floodplain population.

Control sites, those which had not flooded in the year 2000, were then removed and the analysis repeated. The results are shown in Table 3. It is clear that the averages are close to zero and not negatively biased within the floodplain. There is no negative effect of flood designation on growth in property price even in those areas which suffered a flood event.

However, if instead of the 1000 year outline, the Environment Agency risk categories are used then those significantly at risk of flood emerge as of lower rank as shown in Table 4. This weak result, which is significant at the 10% level, shows that there is a tendency for the price of properties within the significantly at risk category and in locations which flooded in the year 2000 to grow at less than the average rate. Those moderately at risk, at low risk and outside the floodplain appear to grow at comparable rates.

The sites were further subdivided into those which had flooded once and those flooded 'frequently' defined as subject to more than one flood in the period 1998-2006. This disaggregation further confirmed the tendency within significantly at risk properties in areas which were subject to flooding in 2000 to grow more slowly.

For those which were flooded only once, the effect on growth was very limited. This is consistent with the analysis of individual sites. Within locations which flooded more than once, stronger trends were observed. The average discounted growth is shown in Figure 2. For significantly at risk properties the average discounted growth is consistently negative. This implies that significantly at risk properties in flood locations which flooded frequently grew at less than the average rate after the area suffered flooding in 2000. While these averages are not significantly different from zero, they are consistently negative and of greater magnitude than the property outside the floodplain.

For those moderately at risk, the effects are smaller and in 2006 a positive impact is seen. However, even for the most at risk properties in the areas with the most frequent flood history these are small scale impacts averaging only 9%. It is also worth noting that these are changes in growth rate. In fact, on average, property within the floodplain continued to grow in price throughout the period but grew at a slightly reduced rate. Also of note is the fact that the largest impact was observed in the year 2005. This is the year after minor flooding in 2004, the re-launch of the Environment Agency maps and Boscastle. It is also the year of the high profile flooding in Carlisle.

The conclusion suggested by this analysis is that the impact of flood risk designation on the growth in residential property price is small even in the aftermath of actual flood events and non-existent in the absence of flood events. The greater the number of recent events and the more significant the designated risk the higher the effect is likely to be.

Analysis of frequently flooded locations

Further analysis of the most frequently flooded locations, Shrewsbury, Malton and Norton and Bewdley, was made possible by use of extra information about flood

history. In the foregoing analysis frequency of flood was assumed for the risk categories as a whole because property by property flood history was not available. More detailed flood history information was available for the three frequently flooded locations via the questionnaire survey but also from extra information provided by the Environment Agency for these three locations. A flood history variable was therefore constructed for individual properties based on a judgement, nearest neighbour approach. A property was defined as flooding never, once, twice or more than twice.

The results of this analysis are in line with expected patterns as shown in Figure 3. The properties flooded most frequently display lower discounted growth rates in the immediate aftermath of the 2000 event. The impacts are seen to decline with time.

The maximum average impact is seen for those properties flooded more than three times: a discount of 35% in the year following the 2000 event. For some properties this represented a reduction in absolute price mainly for properties in Bewdley which sold in 2000 and again in 2001. It is possible that these properties were sold in a compromised condition.

The analyses point to the same broad result. There is a small effect of flood for the most significantly at risk properties in areas which have suffered a recent inundation and it is worst for those frequently inundated. This suggests that house purchasers are behaving in an entirely reactive manner and evaluating risks based on recent experience rather than scientifically calculated probabilities. The absence of any measured impact in towns which have not suffered recent flooding reinforces this view.

Comparison with existing evidence

There are several factors which will lead to confidence in the results of this analysis. Crucially they do not contradict theory. Although a rational consumer should be

willing to pay to avoid flood risk, the assessment of flood risk is a highly individual and subjective matter in the UK. Disclosure is not standard practice and problems with insurance have been shown to be lower than anticipated and do not force disclosure for all property transactions.

The findings are also within the range of previously published studies of the impact of flooding on property value. The maximum measured impact is at the upper limit of previously measured average impacts but this impact is temporary, declines quickly and only observed for those properties which have flooded frequently and are significantly at risk of flood. It is also possible that some of these properties may have been sold in an unrestored condition. The observation that designation alone produces no impact has also been duplicated in previous studies and may be seen to be reasonable in the absence of enforced disclosure of risk during the property transaction.

The findings from this research agree with practitioner beliefs in many respects. In the survey of valuation professionals carried out by the Building Flood Research Group (2004) the median discount for flooded property was estimated at 12-15% which can be regarded as consistent with 15% discount for property flooded more than once, maximum discount was up to 40% which can be regarded as consistent with the average 35% discount for property flooded more than 3 times. Furthermore in the Building Flood Research Group investigation (2004) and also in the study by Eves (2004) large variability was observed in the responses from professionals and this is supported by the transactional analysis. Finally the consensus view from these two surveys of practitioners was that flood impact would decline with time elapsed after a flood, a conclusion which the current research strengthens.

However, for the more detailed conclusions, the temporary impacts which were observed were measured with a great deal of surrounding uncertainty and can be described as weak results. There is a tendency towards discount in frequently flooded property but the scale of discount is unpredictable. Attempting to make point estimates on a property by property basis of the impact on price in the year following flood would be unwise. The results can be regarded as a general framework of guidance on the impact of flooding rather than a detailed predictive tool.

Discussion

The fear that experiencing a flood will devastate the value of a residential home is not supported by the evidence of this research. Typically, flooded property retains the majority of its value once it has been reinstated. The findings from the price impact model that, for the vast majority of floodplain properties, flood impacts on property prices are small and temporary imply that the natural concern experienced by property owners about long term equity in their home is largely unfounded unless market conditions alter. For homeowners, this is a reassuring message which is somewhat unexpected given the amount of media speculation on the issue and the views of some valuation professionals.

A recommendation which stems naturally from the study is that, for the overwhelming majority of flood affected property and where finances allow, property owners can invest with confidence in the restoration of their property to pre-flood condition. If possible, any subsequent sale of the property might be delayed until the market recovers. Where this is not possible, discount need not be anticipated in the asking price because in many instances recently flooded property suffers no discount

at all. For professional valuation purposes flood risk will not materially affect price expectations in the vast majority of instances. In the prevailing market if insurance is available the medium term investment potential of floodplain property appears to be comparable to non-floodplain property.

For those frequently flooded properties where continuous flooding makes impacts seem longer term, impacts are still small and have been dwarfed by the impact of inflation over the study period. In a more difficult housing market it is possible that the picture would be less advantageous and it is recommended that further study of frequently flooded property and property in static markets should be carried out if data allows.

The widely reported problems with obtaining insurance for flooded property appear not to be severe enough to provide a disincentive to purchase in most cases. For property changing hands in this study, problems with availability or cost of insurance did not appear to obstruct the property transactions. The consideration of transacted property alone may have limited this finding but the majority of vendors can take steps to reduce the chances of insurance problems halting a sale. A vendor can establish in advance that their insurer would be willing to continue to provide cover with a future owner subject to that owner's status in accordance with the ABI statement of principles (Association of British Insurers 2005a).

The fact that designation in the absence of flood events produced no measurable impact implies that the official view of flood risk is not capitalised into the price of floodplain property. This raises the further possibility that, if designation regimes changed- for example if new regulation made the disclosure of flood risk a compulsory part of the property transaction process, or if better sources of information were freely available - floodplain property might suffer value loss. Where

forced to consider flood risk by regulated disclosure or where mandatory flood insurance is present some long term capitalisation into value is possible but not inevitable. Fear of the loss of property value may contribute to a culture of denial of flood risk which may decrease the tendency to mitigate flood losses by community or individual actions (Harries 2007). Policy makers should be aware of these possible additional risks to floodplain occupants.

The absence of a property price effect due to flood risk could indicate a lack of concern about the impact of flooding which may lead to increases in flood impact. If development of the floodplain remains financially viable, because the market underestimates the future cost of flood damage, more homes may be built which are vulnerable to flooding (Clark *et al.* 2002). This lack of concern may influence opinions about flood protection discouraging individual action and even the desire to contribute to flood defences.

Conclusion

The research described in this paper represents a unique approach to the analysis of the impact of flood risk on property price. The approach has several features which made it suitable for the difficult problem of measuring flood impact in the UK but the novel adaptation of the repeat sales method would also be appropriate for analysis of flood affected property elsewhere. Further validation of the methodology using future flood events would be welcome.

The methodology could also be used in studies of the impact of other natural or man made hazards on property markets. It may be particularly useful where the impacts are likely to vary over time and where data efficiency is a consideration.

The findings from the analysis are credible and reinforce some of the findings from previous studies among professional valuers. The main conclusions are that, for UK property in the current disclosure regime, the impact of flood events on property value are temporary and highly variable and that flood designation on its own has no impact on value.

However, through this empirical analysis and comparison with previous studies it is clear that the results may be highly sensitive to insurance and risk disclosure regimes. In that these findings suggest a picture of a general lack of awareness of flood risk they are seen to have far reaching implications for policies which may improve awareness. Further research into the impact of changes in regimes is recommended.

More generally, the results suggest that the reaction of property markets to risk can be highly subjective in the absence of enforced disclosure. The implications of this conclusion are wide reaching as it is unlikely that buyers will be able to effectively evaluate all possible risks to their property. Markets may become distorted by any event that changes the perceived importance of previously ignored risks.

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Table 1 : Locations selected for empirical analysis

LOCATION	ROLE OF DEFENCES	SOURCE	FLOOD STATUS	No. FLOODED/ PROTECTED	REGION
Malton and Norton.	No protection	main river	Flooded	169	North East
Woking	No protection	main river	Flooded	100	Thames
Shrewsbury	No protection	main river	Flooded	230	Midlands
Bewdley	No protection	main river	Flooded	140	Midlands
Selby and Barlby	overtopped defences	main river	Flooded	152	North East
Lewes	overtopped defences	main river	Flooded	800	Southern
Hatton	overtopped defences	main river	Flooded	142	Midlands
Ruthin	Ordinary watercourse	non main river	Flooded	250	Wales
Mold	Ordinary watercourse	non main river	Flooded	181	Wales
Newport	Ordinary watercourse	non main river	Flooded	130	Wales
Southsea	surface water	non main river	Flooded	200	Southern
West Bridgford	Not flooded	Not flooded	Not flooded	9700	North East
Wakefield	Not flooded	Not flooded	Not flooded	1150	North East

Table 2 : Summary of individual location models

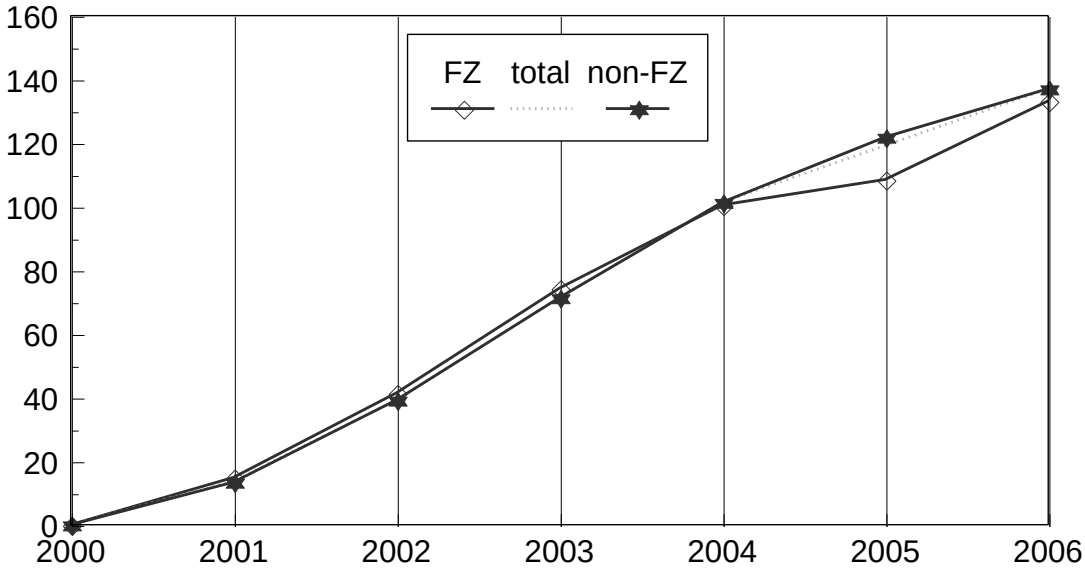
LOCATION	Last flood affecting property before 2000	Highest Risk property in location	Flooded in 2000	Number flooded	Number of floods 1998 to 2006	Chow significance level at 10% or better	flood index coefficients significant at 5% or better	Positive or negative impact
Malton/Norton	1999	Significant	Yes	169	2	Not sig	None	
Shrewsbury	1998	Significant	Yes	230	4	**10%**	None	
Bewdley	1998	Significant	Yes	140	3	**1%**	**2001** **2003**	negative negative
Ruthin	1960	Significant	Yes	250	2	**10%**	None	
Barlby	1947	Moderate	Yes	152	1	**5%**	None	
Lewes	1979	Significant	Yes	800	1	Not sig	None	
Hatton	1957	significant	Yes	142	1	**1%**	None	
Woking	1968	Significant	Yes	100	1	**5%**	None	
Mold	1976	Significant	Yes	181	1	Not sig	**2002**	negative
Newport	1957	Significant	Yes	130	1	Not sig	None	
Southsea	1953	Low	Yes	200	1	Not sig	**2003** **2004**	positive positive
West Bridgford	1947	Significant	No		0	Not sig	None	
Wakefield	1983	Significant	No		0	Not sig	**2004** **2006**	positive positive

Table 3 : Mean discounted growth rate for properties inside and outside the extreme flood outline

Date of Second sale	**Within 1000 year outline**	**Outside 1000 year outline**
2001	0.10	0.07
(n)	(47)	(120)
2002	-0.01	0.04
(n)	(70)	(197)
2003	-0.01	-0.01
(n)	(62)	(187)
2004	0.04	0.00
(n)	(68)	(167)
2005	-0.04	-0.04
(n)	(52)	(158)
2006	0.00	-0.01
(n)	(40)	(135)

Table 4 : Mean rank of discounted growth rates by flood designation category

EA Category	Number of Sales Pairs	Mean Rank
Outside Floodplain	963	656
Low Risk	239	670
Moderate Risk	41	632
Significant Risk	60	535
Kruskal-Wallis Test	0.087	



Source: Land Registry/Environment Agency

Figure 1 : Repeat Sales Indices for Shrewsbury

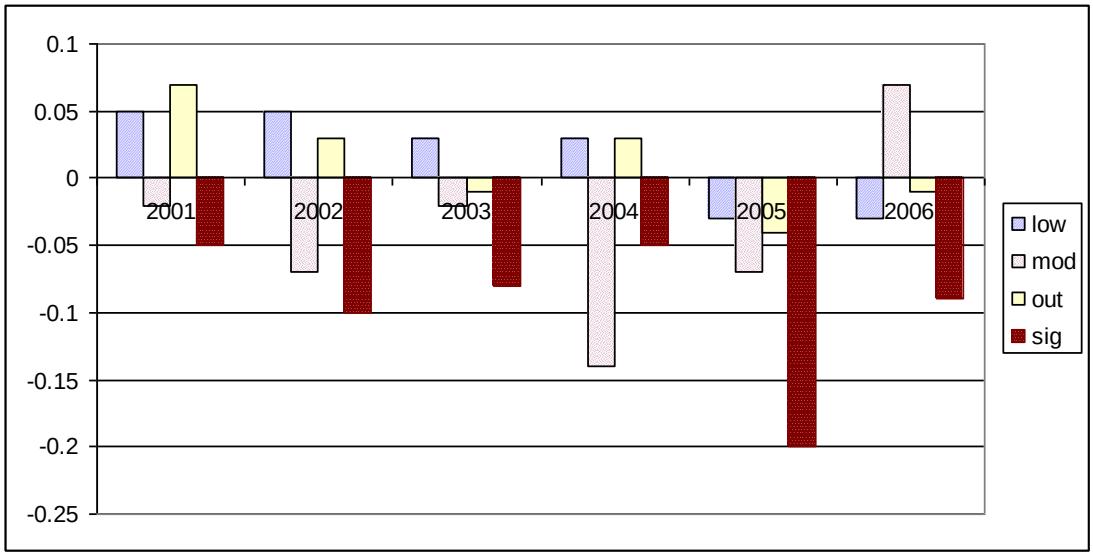


Figure 2 : Discounted growth rate, frequently flooded locations, by designated risk category

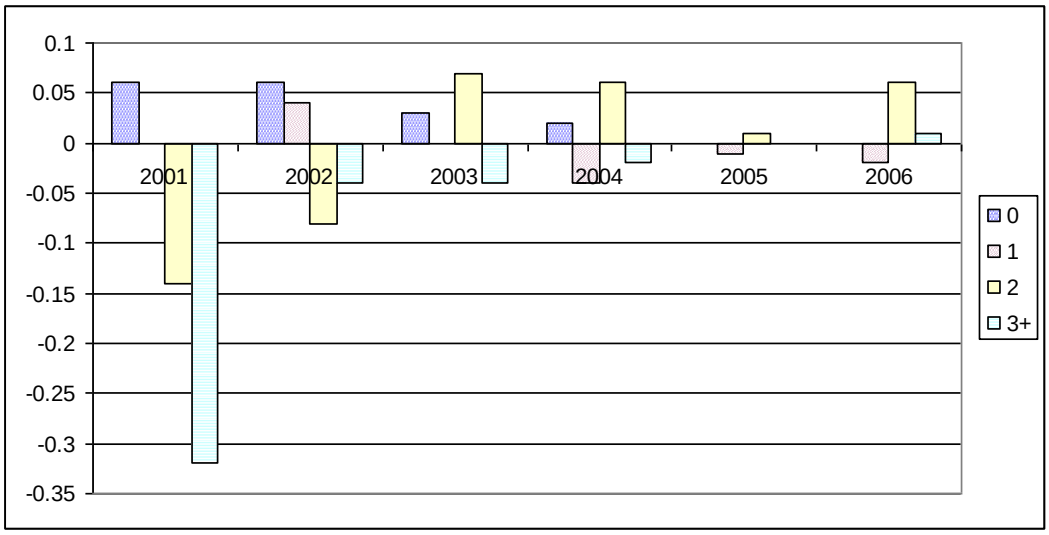


Figure 3 : Discounted growth rate, frequently flooded locations, by flood history