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On the use of tradable development rights for reducing flood risk☆

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ABSTRACT

We explore the use of a system of tradable development rights (TDRs) as a method for reducing flood risks brought about by development in flood prone areas. Typical land management practice focuses on zoning policies which are able to increase economic efficiency, but result in an inequitable distribution of benefits. A TDR program has the potential to increase equity while maintaining the efficiency of the socially optimal land allocation. We begin with a graphical analysis and then present a theoretical model incorporating unidirectional spatial externalities, and demonstrate how a TDR program could be implemented to internalize these negative external costs.

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Introduction

In this paper we analyze the use of tradable development rights (TDR) programs to manage or reduce flood risk. TDR programs are a form of market-based land use management instrument that adds an element of flexibility in management decisions that is often not possible using standard land use management policies such as zoning regulations. While TDR programs have been implemented for conservation and preservation purposes, they have not yet been implemented for the purposes of flood risk reduction. Floods pose an immense risk to communities in the United States, both in terms of economic damages and human impacts. In fact, floods have been identified as the most damaging natural disaster in the United States during the twentieth century, in terms of both lives lost and property damage (Perry, 2000). From 1940 to 2010 there have been over $416 billion in flood-related damages (adjusted for inflation) and over 7000 flood-related fatalities (National Weather Service, 2012).[1] Flooding is a widespread problem in the U.S., affecting every state, over half of the overall communities, and roughly 7% of total land area in the U.S. is exposed to significant flood risk (White, 1975).

Floods can arise from various different causes including excessive regional rainfall, torrential downpours, storm surges, slow-moving frontal systems, snowmelt, and dam/levee failures. The U.S. is exposed to each of these sources of flood risk, though because these flood risk sources are often dependent upon location-specific characteristics, there is clearly a great deal of variation in the spatial distribution of the flood risk corresponding to each of these different types. In this paper, we will primarily be interested in fluvial floods (that is, floods arising along rivers or streams). These types of floods are particularly susceptible to man-made influences, since urban development in floodplains can influence the water cycle in several ways (relative to natural, undisturbed ground cover), which can have impacts on flood risks. First, development lowers evapotranspiration, so there is less moisture that is recaptured into the atmosphere. Second, development reduces the infiltration rate, so less moisture is absorbed into the soils. Third, development increases runoff, which can flow into drainage systems and are channeled into rivers or streams, increasing the potential that these discharges will overwhelm the river or stream flow capacities. In tandem, these factors can increase the potential for flood catastrophes (Burby and French, 1981), resulting in significant social costs that are not reflected in competitive land market transactions. The result is a market failure arising from a public good externality (Bator, 1958). The external social costs arise from the fact that development increases flood risk, which is a cost imposed on all inhabitants of the floodplain, rather than only the

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[1] These figures exclude flood-related damages and deaths arising from Hurricane Katrina. Authorities are yet to release estimates as to the proportion of the total damages and fatalities that are attributed to flooding as opposed to other proximate causes.

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agent constructing the development. Maintaining the undeveloped or natural aspect of the floodplain, on the other hand, provides a social benefit, in terms of reducing flood risk.[2] The benefits of undeveloped land and the resultant reduced flood risk are non-excludable, since the benefits of flood risk reduction are shared (though perhaps not equally) by all residents of the floodplain. Additionally, these benefits are non-rival, since one agent's enjoyment of the benefits will by no means preclude any other agent from partaking in the benefits at the same time. In a competitive market, the optimal land allocation would ignore these external social costs, resulting in a land allocation that is a competitive equilibrium allocation, but not one that is socially optimal. Specifically, because private concerns do not internalize these external social costs, the unfettered market allows too much land to be developed within floodplains, introducing allocative inefficiencies. In addition, the inefficiencies may arise from private sector expectations regarding the dynamic inconsistency in public sector objectives.[3] Because the competitive land market is sub-optimal from a social perspective, local authorities are often interested in measures that can produce more efficient allocations that either optimize or at least improve upon the sub-optimal allocations arising from the competitive market.

Land use management to reduce flood risks

In 1968, Congress passed the National Flood Insurance Act, which formally introduced the National Flood Insurance Program (NFIP). The NFIP is a federal insurance program that enables property owners in participating communities to purchase insurance as a protection against flood losses, and in exchange for this ability, states and communities were required to introduce floodplain management regulations that would reduce future flood losses. There are several approaches that communities can take in this regard (Berry and Steiker, 1977), but the most common strategy by which communities influence development in floodplains in through zoning regulations. Zoning, as a land use management strategy, has been employed in various forms and for various management purposes. In the context of flood risk management, regulators might set a limit on the level or density of development that can be implemented within a floodplain. There are some considerable economic complications arising from zoning regulations, specifically in terms of the distribution of the benefits. Given a sufficiently high demand for developing land, development will proceed to the legally imposed limit. But the external benefits of the undeveloped land (in terms of lower flood risk, environmental services, etc.) will accrue to the developed land, and the market capitalizes the value of these benefits in to the value of developable land, thereby driving a wedge between the value of developable land relative to the value of land that is not developable. Therefore, while zoning regulations may achieve a socially efficient land allocation and maximize the aggregate value of land, such regulations also introduce an inequitable distribution of benefits, often referred to as the problem of "windfalls and wipeouts". Those landowners in the developable zone receive windfalls in terms of higher land values, while those landowners whose development abilities have been zoned out suffer wipeouts. Even if the policies achieve a socially efficient allocation, additional social costs may arise due to rent-seeking behavior by landowners who attempt to gain the benefits produced by the zoning (Mills, 1989). The introduction of zoning policies can also produce perverse incentives for landowners to increase the pace of development in order to complete projects before regulations are enforced (what Miller, 1999 refers to as an attempt to "beat the regulatory clock"). Similarly, Burby and French (1981) found that land use management regulations had little impact on the rate of development encroachment into floodplains. Given that the communities most likely to participate in the NFIP were those with significant pre-existing development in floodplains, this suggests an increased development in these vulnerable areas, despite the implementation of NFIP-required land use regulations.[4] Burby and French conclude that, unfortunately, by the time the problem is identified, land use management may not be the most appropriate policy response.

By its nature, zoning infringes upon certain landowners' ability to develop their land in such a way that maximizes profit or enjoyment, often without adequate compensation, and the ability of the zoning regulations to withstand legal challenges depends much on the intended purpose of the zoning. Miller (1999) has suggested that, when zoning is imposed for the purpose of preventing or eliminating a public nuisance, such policies usually face little opposition, either from courts or from the general public. This is generally the case, and courts will often allow regulatory agencies a great deal of latitude in the operation of zoning ordinances under such circumstances. But when the policies are implemented for reasons with less obvious purposes, zoning authorities usually face a greater degree of resistance. It is not clear where flood risk management would fall in this regard. While zoning may not necessarily remove property from a private landowner, it does infringe upon landowners' rights to use that land as they choose, and as such these policies may be viewed as unconstitutional "takings" if suitable compensation is not provided to the landowners whose development rights are restricted. Several court cases have confirmed property owners' right to sue for monetary damages if their ability to use their land to their greatest economic advantage have been "regulated away", as would be the case with a strict zoning policy (Fulton et al., 2004).

An alternative approach for managing land allocations that has received attention in recent years is the concept of tradable (or transferable or marketable) development rights (TDR). These programs can be viewed as an extension of marketable permits, which were introduced by Dales (1968) and which have been applied for managing various pollutants, including sulfur dioxide emissions in the U.S. and carbon emissions in, for example, the European Union. In addition, marketable water rights have been used quite extensively in several states in the western U.S. The specific manner in which a TDR program operates varies by application, but they are usually implemented to achieve a particular land use objective, such as the preservation of a specific area or land use, or for the management of development density. The program goal may then be the redirection of development from one area (the

[2] There are, of course, other means of reducing flood risk than simply leaving land undeveloped. Such other approaches could include improvements in managing or re-routing flood waters, increasing drainage and infiltration, etc. In the present paper we focus only on land use management strategies, though as one reviewer pointed out, the optimal policy combines elements of these various methods.

[3] We thank an anonymous reviewer for suggesting this aspect. The dynamic inconsistency problem arises because private developers may anticipate changes in government preferences or optimal responses as it pertains to flood damages (e.g., they may expect to be compensated for flood losses even though government policy may currently not allow for such compensation) and will therefore overdevelop in floodplain areas.

[4] The findings of Burby and French (1981) suggest that the NFIP, as with many other voluntary insurance schemes, suffers from both adverse selection (the communities most likely to participate in the program are those with significant pre-existing flood risks) and moral hazard (the communities that participate in the NFIP have less incentive to introduce effective means of reducing their flood risk, since the NFIP will compensate the communities for the flood losses they experience).

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