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Proximity to a water supply reservoir and dams: Is there spatial heterogeneity in the effects on housing prices?☆

Jeffrey P. Cohen*,[a], Joseph J. Danko III[b], Ke Yang[c]

[a] Center for Real Estate and the School of Business, University of Connecticut, 2100 Hillside Road, Unit 1041-RE, Storrs, CT, 06269, United States
[b] Spatial Structures in the Social Sciences Initiative, Population Training and Training Center, Brown University, Providence, RI, USA
[c] Barney School of Business, University of Hartford, 200 Bloomfield Ave, West Hartford, CT, 06117, USA

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ABSTRACT

An understanding of the spatial variation in the impacts of living near reservoirs, dams, and undevelopable land is important in explaining residential property values. While there is a body of literature on the effects of proximity to dams and reservoirs on housing prices, little known research attempts to determine if various individual houses are impacted differently depending on their locations and years of sale. We examine properties in Barkhamsted, Connecticut that sold between 2000 and 2015. We utilize non-parametric regression to allow for the possibility that bodies of water, dams and undevelopable land areas, affect various house prices differently, depending on their locations and when they are sold. We find that in general, undevelopable land area is valued as a disamenity in this rural town. With our semi-parametric estimation approach, we find the signs of the effects of proximity to the nearest body of water vary – some properties benefit from proximity while others experience lower sale prices when they are closer to water. But on average, being far from the water lowers property values, after controlling for flood risk from being below the nearest dam. In other words, residents prefer to live near waterfronts. We also control for other key housing characteristics and environmental variables, such as elevation relative to the nearest dam, numbers of bedrooms and baths, age of properties, year of sale, square footage and acreage, and others. We plot the parameter estimates over time for some variables to demonstrate how the spatial heterogeneity changes after the recession that began in late 2008.

1. Introduction

Proximity to reservoirs and dams can have both positive and negative impacts on house prices. For instance, reservoirs can be considered "amenities" due to open space, wildlife, and aesthetics/views. On the other hand, there can be a higher risk of flooding near reservoirs and at elevations lower than nearby dams, which can be capitalized into house prices and lead to lower property values. An understanding of the potential positive and negative impacts of living near reservoirs, dams, and undevelopable land due to relatively steep slope, is important in justifying the operation of water (and possibly other) utilities near residential properties.

While there is a body of literature on the effects of proximity to dams and reservoirs on housing prices, little known research attempts to determine if various individual houses are impacted differently depending on their locations and years of sale. Also, relatively little is known about how proximity to these amenities affects house prices differently during a "boom" period versus a "bust" period. We examine all 495 arms-length single family residential property sales in Barkhamsted, Connecticut between 2000 and 2015. This sample covers a period of a significant housing boom (2002–2009) and also a bust (the housing crisis which began in 2009).

The reservoir in Barkhamsted supplies much of central Connecticut with its drinking water. We utilize non-parametric regression techniques (Geographically Weighted Regressions) to allow for the possibility that the major reservoir and dams in Barkhamsted affect various house prices differently, depending on their locations and when they are sold. Our nonparametric (and semi-parametric) approaches allow for a more general functional form for these relationships, compared with OLS. In other words, at some locations in Barkhamsted, we find that proximity

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* Corresponding author. .
E-mail addresses: jeffrey.cohen@business.uconn.edu (J.P. Cohen), joseph_danko@brown.edu (J.J. Danko), Kyang@hartford.edu (K. Yang).

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to water enhances property values while in other locations property values rise with greater distance from water. In contrast, OLS estimation leads to a result that all properties are affected equally by being closer to water. This flexibility is a key advantage of our nonparametric approach.

We follow a similar approach of Saiz (2010) and generate estimates of land with sufficiently steep slopes that inhibit development. We also estimate a set of partial linear (i.e., semi-parametric) models. We find that for the most part, proximity to dams with higher elevation than a particular property leads to lower housing sale price for that property, with the magnitudes of these effects varying across geographic space and over time. Properties with higher census block steep slope land area tend to sell for lower prices, implying this type of land is a disamenity in this rural town.

The signs of the effects of proximity to the reservoir vary – some properties benefit from proximity while others experience lower sale prices when they are closer to the reservoir. We also control for other key housing characteristics and environmental variables, such as elevation relative to the nearest dam, numbers of bedrooms and baths, age of properties, year of sale, square footage and acreage, and others. We generate figures showing the range of the coefficients for several of the key variables to illustrate the heterogeneity (e.g., see Fig. 3).

The remainder of this paper proceeds as follows. First, we review the literature on proximity to wetlands, dams, and water bodies. Then we describe our empirical approaches, followed by a discussion of the data. After presenting our results, we describe some robustness checks and finally conclude with a summary of the key findings of the paper.

1.1. Literature review

There are several studies on the relationships between housing prices and proximity to water and/or dams. Cohen et al. (2015) consider wetlands and water impacts, but they ignore the important aspects of dams, undevelopable land, and elevation, and they examine a shorter sample period that stops before the beginning of the housing crisis. They find that while overall proximity to water is an amenity, various properties are affected differently by proximity to wetlands and water. Their results are different from the findings in our paper because their focus was on wetlands and water bodies, while here we have relatively few properties in the wetlands, and we focus more of our attention here on the impacts of elevation of nearest dam and undevelopable land.

Other relevant recent studies include Atreya et al.(2016), who find a different effect of distance to the coastline in Texas, depending on flood risk. Somewhat ironically, they also find that the willingness to pay for avoiding flood risk is higher for properties that are further away from the shore. However, they do not use a semi-parametric estimation framework to arrive at these conclusions.

Rouwendal et al. examine the effects of proximity to water, using a sample of identical Dutch houses. This simplifies the hedonic housing problem because it is not necessary to "control" for differences in characteristics, other than proximity to water. They find that in this context, the potential benefits from water proximity are smaller, possibly due to "specification bias" that can occur in the typical hedonic model.

Lewis et al. (2008) examine willingness to pay for removal of a dam in Maine. Their approach is rich in the sense that their examination of house prices pre- versus post- dam removal, for various distances from the dam, enables the identification of the benefits of living far from the dam.

Bohlen and Lewis (2009) study another river and dam in Maine, and in this instance, they find a 16% premium for living closer to the river. They also find a premium for living closer to the dam, although the level of statistical significance is lower for this variable. These conflicting findings of the impacts of a dam on housing prices, for two studies of different dams in the state of Maine, imply that a semi-parametric approach could be fruitful in our case of dams in Barkhamsted, Connecticut. The potential benefits of a semi-parametric or nonparametric approach are that these approaches allow for heterogeneity in the marginal effects of proximity to dams that are higher than a particular property - these marginal effects can vary in different locations throughout a geographic area.

McKenzie and Levendis (2010) consider elevation of houses (although not the relative elevation with respect to dams), and they find that higher elevation houses tend to sell for higher prices.

Another important consideration is whether or not to examine flood zones. Speyer and Ragas (1991) note that there can be biases when using a dummy variable to represent flood zones, because the FEMA flood zones typically encompas broad areas. Therefore, a flood zone dummy likely also reflects the effect of other factors besides being in a flood zone. Also, Barr et al. (2017) find that often during major storms, the FEMA flood maps are inaccurate predictors of where the flood waters will reach. For these reasons, as well as for some data limitation issues for the Barkhamsted flood maps discussed below, we avoid including flood zones as a control variable.

In rural and urban areas the issue of undevelopable land is worthy of attention. Saiz (2010) is a more broad study, at the U.S. Metropolitan Statistical Area (MSA) level, of the impacts of water bodies and elevation on the amount of developable land in each MSA. He finds that development is detrimentally affected in MSA's with greater amounts of "steep-slope terrain" . However, it is not obvioius, a priori, whether this finding is robust to examining undevelopable land in rural areas and at the Census block level opposed to the MSA level.

To further explore these issues and the importance of considering spatial heterogeneity, we control for elevation relative to the nearest dam, and undevelopable land area, in a non-parametric manner in our analysis. We find that properties in census block groups with greater steep-slope terrain sell for lower prices, which implies the steep-slope terrain is a disamenity in this rural setting (consistent with the Saiz, 2010 disamenity findings for MSAs, which mostly are comprised of urban areas).

2. Approach

Our analysis of the impacts of water bodies and dams on housing prices is based on a hedonic housing price model. Our hedonic model with linear regression function takes the following form:

$$Y_i = X_i\beta + u_i, \quad i = 1, \cdots, N \tag{1}$$

where Y_i is the logarithm of sale price and X_i is a vector of house characteristic variables, including number of baths, bedrooms, age of the property at time of sale (which we present in levels rather than logarithms because some properties have an age of zero), logarithm of square footage, logarithm of acres, as well as neighborhood variables such as physical locations (longitude and latitude), logarithm of distance to the nearest water body, a dummy variable for whether a property's elevation is below the nearest dam, and fixed effects for each sale year.

2.1. Locally weighted regression (LWR)

In addition to the ordinary least squares (OLS) estimation of the model, we use a non-parametric approach - locally weighted regressions (LWR), also commonly referred to as Geographically Weighted Regression (GWR) - to approximate the regression function, considering the fact that the data are prices of houses at fixed points with spatial coordinates and years of sale. In a LWR model, the spatial coordinates of the data are used to calculate distances that are used in a kernel function to determine weights of spatial dependence between observations. Time of sales are used similarly to determine weights of time dependence between observations. The hedonic house price function is assumed to take the following form: