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DETERMINANTS AND EFFECTS ON PROPERTY VALUES OF PARTICIPATION IN VOLUNTARY CLEANUP PROGRAMS: THE CASE OF COLORADO

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Abstract

State Voluntary Cleanup Programs (VCPs) were established starting in the 1990s to encourage the environmental remediation and redevelopment of contaminated properties. These programs typically offer liability relief, subsidies and other regulatory incentives in exchange for site cleanup. This paper asks three questions: First, what type of properties are attracted to voluntary cleanup programs? Second, what is the interaction between these state programs and other incentives for remediation and economic development, such as Enterprise Zone and Brownfield Zone designations? Third, what is the effect of participation in the VCP on property values?

We use data from Colorado's VCP to answer these questions. We find that most of the properties enrolled in this program were not previously listed on EPA's contaminated site registries, and that most applicants seek to obtain directly a "no further action" determination without undergoing remediation. The main determinants of participation are the size of the parcel and whether the surrounding land use is primarily residential, while other incentives have little effect. Properties with confirmed contamination sell at a 47% discount relative to comparable uncontaminated parcels, and participation tends to raise the property price, but this latter effect is not statistically significant.

Taken together, these findings suggest that the participating properties are those with high development potential, and hint at the possibility that owners or developers may be seeking to obtain a clean bill of health from the State with only minimal or no cleanup efforts. Were these findings confirmed with data from other states, they would raise doubts about the effectiveness of voluntary programs in encouraging remediation and their usefulness in reversing some of the undesired effects of the Superfund legislation.

Key words: brownfields, contaminated sites, voluntary cleanup programs, incentives.

JEL classification numbers: R14 (land use patterns), Q58 (environmental economics: government policy), K32 (environmental, health and safety law)

Determinants and Effects on Property Values of Participation in Voluntary Cleanup Programs: The Case of Colorado

1. Introduction

Environmental regulation and enforcement-based environmental programs sometimes result in unintended consequences that defeat the purpose of the programs themselves. Many observers argue that the U.S. Superfund program is one such program. Over the last 25 years, Superfund has identified contaminated sites needing environmental remediation, tracked down the responsible parties and forced them to pay for the cleanup (or reimburse the US Environmental Protection Agency for the cleanups it initiated). Liability for the cost of cleanup is retroactive, strict, and joint-and-several, with potentially responsible parties to be sought among the owners and operators of the site, and transporters of the wastes.[1]

In theory, these features should deter firms from handling hazardous waste carelessly. In practice, since liability has in some cases been construed to apply to property owners and lenders that foreclose on contaminated properties (Fogleman, 1992), they have also been blamed for discouraging the purchase and reuse of contaminated or potentially contaminated sites, which have remained idle or underutilized.

Recent state programs and federal legislation have attempted to reverse these disincentives. For example, the federal Small Business Liability Relief and Brownfield Revitalization Act of 2002 provides conditional relief from environmental liability for property owners and purchasers of land. In addition, starting in the 1990s, several States began establishing Voluntary Cleanup Programs (VCPs) offering liability relief, other

[1] The Superfund program was established by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), passed in 1980 and amended and re-authorized in 1986.

economic inducements such as tax credits or low-cost loans, oversight and expedited approval of cleanup plans, and simplified cleanup standards in exchange for site cleanup (Bartsch and Dorfman, 2000; Meyer and Van Landingham, 2000).

Despite much interest in policy circles and the attractiveness of relying on economic incentives rather than enforcement-based approaches, the effectiveness of these programs in promoting environmental remediation has not been studied to date in the economics literature. Little is known about the responsiveness of cleanup and redevelopment activity to these inducements, and while several studies have examined the effects of contamination on the value of commercial and industrial properties, none has focused on the appreciation potential (if any) of parcels participating in voluntary cleanup programs. Yet, these are important environmental policy questions, especially if we consider that the emphasis of these Voluntary Cleanup Programs (VCPs) has gradually shifted away from environmental remediation goals towards economic development goals, and that participation in the VCP is in required in some states—such as Pennsylvania—for transferring contaminated properties (Meyer, 2000).

In this paper, we ask three related questions: First, what are the characteristics of parcels that make them attractive candidates for voluntary cleanup? Second, do other local and federal economic development programs (whether or not specifically targeted for contaminated sites, such as Enterprise Zone or Brownfield Zone designations) make voluntary cleanup more or less likely? Third, what are the effects of participation in voluntary cleanup programs on property values?

Given the wide variety in program features across states, and the dearth of data documenting program enrolment and the characteristics of participating and non-participating properties (Meyer, 2000), we do not attempt a national-level analysis of VCPs. Instead, we focus on one state, Colorado, which established its Voluntary Cleanup Program in 1994. We assembled a set of data documenting contaminated or potentially contaminated sites in Colorado, and estimate (i) a probit model of participation in the Colorado VCP, and (ii) a hedonic pricing model that relates property value to characteristics of the parcel and of the neighborhood, and on whether the parcel was signed up for the program. Participation in the program may be endogenous with the property value, so we explicitly account for this possibility in our econometric model.

Three important lessons emerge from our analysis. First, the program has not "absorbed" the existing supply of sites on EPA registries of contaminated sites, but has rather created a new "crop" of sites. Second, because the majority of these properties apply directly for a No Further Action determination, the program does not seem to have encouraged much environmental remediation. Third, the participating properties are probably those with the highest redevelopment potential.

Sites with *confirmed*—not merely suspected—contamination sell at a 47% discount relative to comparable contaminated properties. Participation seems to result in appreciation, but this effect is not statistically significant at the conventional levels. Taken together with the evidence about participation, these findings raise questions as to whether participation in voluntary cleanup programs may—depending on program features—be sought primarily as a way to improve the market attractiveness of the parcels with minimal or no environmental remediation. Were this possibility confirmed by similar findings for other states' programs, this would cast doubts about the incentives created by voluntary cleanup program and about these programs' effectiveness in encouraging cleanups by reversing some of Superfund's unintended consequences.

The remainder of the paper is organized as follows. In section 2, we present an overview of the effects that of liability at contaminated site on real estate development and of recent voluntary cleanup programs. In section 3, we review the relevant previous literature. In section 4, we describe the Colorado Voluntary Cleanup Program and our study plan. In section 5, we present the model. Section 6 describes the data and section 7 the estimation results. Section 8 offers our concluding remarks.

2. Background

In the United States, there is a large supply of properties where prior industrial uses have resulted in contamination of soil, surface water and/or groundwater with pollutants that are noxious to human health and ecological systems. The US General Accounting Office (1995) estimates that there are 130,000 to 450,000 contaminated commercial and industrial sites in the US.[2]

It is widely felt that contamination, or the mere *suspicion* that a site might be contaminated, seriously hampers its reuse. The US Environmental Protection Agency defines as *brownfields* "abandoned and underutilized properties where redevelopment is

[2] For comparison, the US Conference of Mayors (1996) estimates that there are 43,000 acres of browfields in 16,000 sites among the 39 cities surveyed, including about 20 larger cities with population over 100,000. One problem with this figure, however, is that the definition of brownfield varies across cities. Simons (1998) reports that as of 1994 brownfields in 31 US cities add to a total of 115,000 acres. Other estimates of the number of brownfields can be formed by examining the list of contaminated sites compiled by the US Environmental Protection Agency (EPA) and state agencies under various environmental programs. For examples, the EPA maintains a registry of active contaminated sites (the CERCLA Information System, or CERCLIS), and has archived some 35,000 sites previously placed on CERCLIS and subsequently delisted because the site was cleaned up, or was found not be contaminated in the first place. The EPA also maintains a registry documenting roughly 418,000 Leaking Underground Storage Tanks (LUSTs) (http://www.epa.gov/swerust1/cat/index.htm). On adding up several registries of contaminated sites, and correcting for sites that appear simultaneously on more than one registry, the total number of brownfields in the US is pegged at 384,000 (Simons, 1998).

complicated by actual or perceived contamination" (US EPA, 1996), and some observers have argued that Superfund has *created* the brownfield problem, to the point that they equate the supply of brownfields with EPA's registries of (potentially) contaminated sites. They further claim that removal from such registries—de-listing—automatically removes contamination stigma (Bartsch et al., 1996).[3]

Another consequence of the Superfund law is that fear of liability has driven developers to turn to pristine properties in suburban areas, contributing to urban sprawl and congestion and to the loss of open space and agricultural land. Policies that encourage cleanup and reuse of (potentially) contaminated sites are, therefore, attractive to communities and policymakers because they (i) reduce health risks to residents and workers, (ii) mitigate the adverse effects of pollution on ecological systems, (iii) avoid development patterns that result in sprawl and congestion, and (iv) may stimulate economic growth in inner cities.

Starting in the 1990s, the States, realizing that their enforcement-based programs did not have sufficient funding to address the large number of contaminated sites needing attention, began developing voluntary cleanup programs, which rely on a different approach to the problem of remediation of contaminated sites (GAO, 1997).

By 2000, over 90% of the states had a VCP in place (Meyer, 2000). Programs offering and requirements vary widely across states (US GAO, 1997; Meyer, 2000; US EPA, 2005). Many state-level voluntary cleanup programs grant liability relief in exchange for voluntary cleanup, provided that the latter is approved by the state agency,

[3] Contamination stigma is defined as "a market-imposed penalty that can affect a property that is known or suspected to be contaminated, a property that was once contaminated but is now considered clean, or a never contaminated property located in proximity of a contaminated property" (Dybvig, 1992). Chan (2002) discusses other definitions of stigma, and refers to it as "the detrimental impact on property value due to the presence of a risk perception driven market resistance."

in the form of a letter of no further action, a certificate of completion, or a covenant not to sue.[4]

Voluntary cleanup programs often spell out simplified or variable cleanup standards linked to land use, and hence to residents and workers' likely exposure to contaminants. Some states allow for engineering controls, such as caps, fences, or other physical means of preventing contact with pollution, in lieu of a more permanent cleanup, and/or offer institutional controls, such as permanent land use restrictions at the site or monitoring of the contamination plume, in place of (more stringent) cleanups.[5]

In addition, the State often offers fast-track oversight of cleanup plans. This helps reduce the time it takes before remediation is undertaken, as well as the uncertainty associated with stringency of cleanup standards (Meyer, 2000). At many locales, completion of voluntary cleanups at eligible sites can be combined with local, state and federal "brownfields" programs that offer subsidies in the form of tax credits or low-cost loans. State VCP managers believe that the programs have resulted in the reporting of contaminated sites that were previously unknown to the state agency, and have truly encouraged cleanups, as long as the program requirements are not too burdensome to the applicants.[6]

Although thousands of voluntary cleanups have been undertaken throughout the nation (US EPA, 2005), and despite numerous case studies regarding specific properties

[4] A covenant not to sue is generally regarded as the strongest form of assurance, since for all practical purposes it is a contract by which the State commits not to sue over contamination at the site, as long as certain conditions are met.

[5] The US Government Accounting Office (1997) notes that with many of the 17 state VCP programs they surveyed over 50% of the cleanups entailed non-permanent remedies and/or selected industrial land use standards.

[6] For example, the 1997 US GAO study notes that public involvement requirements are generally judged inappropriate, and hence a hurdle to remediation, for the type of sites—industrial sites with light contamination—usually targeted by VCPs.

(Simons, 1998, Rafson and Rafson, 1999) relatively little is known about the type of sites that tend to enroll in VCPs and the reasons why property and business owners undertake voluntary cleanups. Presumably, they do because the benefits exceed the costs, but what exactly are the benefits and the costs, and how do they vary across parcels and locales? Does participation in VCPs raise the value of the parcels? Answering these questions is important and should provide useful information for designing better programs and economic inducements in the future.

3. Previous Literature

A. The Effects of Liability and Liability Relief

Voluntary cleanup programs are based on the premise that protection from liability is desirable and should increase the attractiveness of a property, thus encouraging market transactions. But what does theory say about how liability affects land use and transactions? Boyd et al. (1996) identify a role for asymmetric information about the contamination of a parcel and the cleanup costs, which may result in a "market for lemons," and the role of risk aversion, which is concluded to deter transactions only if buyers as a group are more risk averse than sellers. They also consider "imperfect detection," i.e. the situation where the degree of contamination is unknown to the government and the owner. In this situation, the owner may forgo otherwise desirable transaction to avoid scrutiny.

In Segerson (1993), the effect of liability of land transactions depends crucially on whether the parties are solvent. Imposing liability on the seller or buyer does not matter, and efficient outcomes are reached, when parties are solvent. Results are ambiguous when liability is shifted to one or the other parties. Sigman (2005) examines whether land development rates and prices are affected by the type of liability *imposed* by the state mini-Superfund programs, finding that the presence of joint-and-several reduces development rates and prices. Her study, however, cannot be used to predict the effects of voluntary programs that aim at *removing* or *reducing* liability.

We are aware of only few studies about the effects of a document of no further action from the state. Using data from the State of Ohio for 1989-1992, Sementelli and Simons (1997) find receiving a letter of "no further action" from the State does not improve transaction rates for sites with leaking underground storage tanks (LUST), which remain much lower than those for non-tank commercial properties. Lange and McNeil (2004a, 2004b) survey over 100 EPA brownfield grant recipients and other stakeholders. They find that community support, consistency with local plans, cost minimization, financial incentives, and minimizing the time it takes to put the site back into productive use are the most often cited variables that influence brownfield development success.

B. The Effects of Contamination and Cleanup on Property Prices

In principle, it may be possible to infer the attractiveness of voluntary remediation from the difference in values across properties that are and are not contaminated. However, there is mixed evidence about the effects of contamination on the value of commercial and industrial properties and on the market transactions involving them. In one analysis of previously contaminated industrial properties in Southern California Jackson (2001b) concludes that prices are not statistically different from those of comparable but uncontaminated properties. In another, which covers 140 industrial property sales in Southern California in the period 1995-1999, Jackson (2002) finds that industrial contaminated properties sell at prices approximately 30% less than unimpaired levels, but that prices recover after cleanup to the same levels as those of comparable uncontaminated parcels.

McGrath (2000) finds that contamination *risk*—i.e., the probability that a previously used site is contaminated, based on the previous use—does affect urban industrial redevelopment in Chicago both directly, and indirectly, via the differential in price before and after redevelopment. The price differential—about $1 million per acre—is high relative to typical cleanup costs, suggesting that the costs are fully or even over-capitalized.

Howland (2000, 2004) finds that parcels in two industrial areas in Baltimore *are* significantly lower when the property is contaminated, but that turnover is not affected by contamination. Based on interviews with real estate agents, Howland (2004) suggests that incompatible land uses, inadequate infrastructure and obsolete buildings are more important barriers than contamination to the revitalization of brownfields in Baltimore. Focusing on a third industrial area in Baltimore, Schoenbaum (2002) finds no significant difference in assessed land values, vacancy rates, property turnover, and redevelopment rates across brownfield and non-brownfield properties over 1963-1999. Evidence that contamination in one area affects the prices of nearby commercial and industrial properties is also mixed and locale-specific (Ihlanfeldt and Taylor, 2004; Longo and Alberini, 2005).

C. Economic Incentives

Economic inducements have been advocated as potentially effective for stimulating cleanup and redevelopment of brownfields (Bartsch et al., 1996; DeSousa, 2004; Howland, 2000, 2004; Yount and Meyer, 1999).

On their part, real estate developers claim that they *are* responsive to a broad range of inducements. In surveys in Europe (Alberini et al., 2005) and in the US (Wernstedt et al., forthcoming) choice experiments reveal that developers can be attracted to contaminated sites by offering them subsidies, liability relief, and less stringent regulation. Prior experience with projects at contaminated sites matters, in the sense that these incentives do not appeal to the same extent to all developers. Meyer and Lyons (2000) suggest that low property prices have played a larger role than subsidies in stimulating entrepreneurial redevelopment activity on contaminated sites, and that obtaining subsidies may entail significant transaction costs that offset their value.

Since it is sometimes argued that contaminated properties are located in economically disadvantaged areas (Simons, 1998) and that incentives are needed to encourage their reuse, in empirical work it is important to distinguish for incentives that are explicitly linked with cleanup and incentives to economic development and location decisions that are *not* linked with cleanup, such as industrial development bonds, tax credits for job creation or business location, property tax abatement, tax increment financing, and downtown development authorities.[7]

[7] The effectiveness of economic development incentives remains a controversial matter even with non-contaminated properties. For example, recent studies suggest a statistically significant, positive relationship between tax incentives and regional and local growth and property values (Bartik, 1991; Greenstone and Moretti, 2003; Newman and Sullivan, 1988; Wasylenko, 1997), but researchers dispute the magnitude of the impacts of incentives on overall economic gains in targeted areas (Fisher and Peters, 1998; Fox and Murray, 2004; Peters and Fisher, 2002). Research in this area is afflicted by the problem that concurrent incentives make it very difficult to disentangle the effects of each, a problem that can be remedied only by deploying very careful quasi-experimental approaches with control and treatment groups (Bartik, 2004; Greenstone and Moretti, 2003). It remains difficult, however, to ascertain whether incentives were

4. Study Design

We focus on the Colorado Voluntary Program, which was established in 1994. We first relate participation to the characteristics of the parcel, restricting attention to properties on the Front Range, and controlling for other economic development policies that offer economic incentives to businesses. We then examine whether participation in the VCP influenced the market value of a parcel. To answer this question, we estimate a regression equation where we compare participating and non-participating sites, as well as participating site before and after enrolment in the VCP. In this analysis, we allow participation and property value to be potentially endogenous with one another.

A. The Colorado VCP

The Colorado Voluntary Cleanup Program was passed in 1994. The Statute clearly emphasizes that cleanup and program participation are purely on a voluntary basis. There are two possible modes of participation: the applicant can request a No Action Determination, provided that he can show that the site is virtually clean or that the likelihood of exposure to the contamination is low. Applicants have also successfully requested a No Action Determination when they were able to show, in the case of contaminated groundwater, that the pollutant had migrated to the site from elsewhere.

The second mode of participation is a Voluntary Cleanup (VCUP), whereby the applicant proposes to undertake remediation at the site. Once the application is approved, and the cleanup has been completed and approved by the State, the applicant submits a

effective or business locations and/or area redevelopment would have taken place even in their absence (Peters and Fisher, 2004).

separate application to receive a No Action Determination. When the No Action Determination is granted, the applicant is given a letter of no further action relieving him of further liability over the site. Once cleanup is completed and the letter of no further action issued, VCUP properties that satisfy certain requirements qualify for tax credits through the State (or federal) Brownfield program.

To participate in the Colorado Voluntary Cleanup program, parcels must meet certain eligibility criteria.[8] An application of $2000 is due at the time of the application, and decisions must be notified to the applicants by the Colorado Department of Public Health and Environment within 45 days.

B. The Sample

One goal of this paper is to establish which characteristics of a parcel (size, structures, distance from transportation nodes, availability of specified incentives, etc.) and its neighborhood make it more likely to participate in the Colorado VCP. To accomplish this goal, we assembled a database of sites that are (i) known to be contaminated or previously believed to be contaminated,[9] and (ii) meet the VCP eligibility requirements.

Specifically, to form our universe of eligible sites, we pooled (i) Colorado sites in the CERCLA Information System database (CERCLIS) (n=222), (ii) Colorado sites in the CERCLIS archives, which consist of sites previously placed in CERCLIS, but de-

[8] Sites on the Superfund National Priorities List are not admitted. Sites with leaking underground storage tanks, landfills, and uranium mining sites are not eligible for participation in the Colorado VCP, and are specifically addressed by other programs of the State. Sites with radioactive waste are similarly regarded, unless radioactive waste is a small fraction of the overall contamination problem.

[9] Sites that are only suspected of being contaminated may participate in the VCP under its "No Action Determination" provision, perhaps because the owners wish to rid the parcel of any undesirable reputation (contamination stigma).

listed in 1995 because they were not found to pose meaningful risks (or had been cleaned up) (n=456), and (iii) sites that participated in the Colorado VCP as of August 2000 (n=188).[10] We then excluded sites that do not meet the eligibility requirements, such as sites on the NPL, solid and hazardous waste sites, leaking UST sites, and sites covered under the Uranium Mining and Tailing Recovery Act (UMTRA). We also excluded military installations and federal sites. This reduced the sample from 857 to 623. We further restrict attention to sites in the nine Front Range counties (Adams, Arapahoe, Boulder, Denver, El Paso, Jefferson, Larimer, Pueblo and Weld), which results in a final sample size of 432 sites.

For many, but not all, of the sites, we were able to find parcel identification numbers and to obtain information about the size of the parcel, and the presence, size and age of the buildings from each county's tax assessor's office. Regarding contamination, we consulted dockets at the Colorado Department of the Environment and US EPA. Contamination can be described using through dummy variables for the presence (actual or suspected) of specified pollutants at the site (e.g., heavy metals, petroleum, solvents, etc.) and the contaminated environmental medium (e.g., groundwater or soil). Alternatively, as Howland (2000, 2004), one can create a dummy denoting whether contamination was confirmed (or was simply suspected and eventually ruled out).

All site locations were geocoded and used to compute distances to the central business district, the nearest interstate highways with restricted access, state highways and county roads, and secondary and local roads, the nearest airport, and to employment

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[10] Voluntary cleanup programs have been argued to encourage the reporting to the State agency of contaminated sites that were not previously known. This justifies merging (iii) with (i) and (ii).

centers. We used data from EPA's Multi-resolution Land Characteristics Consortium[11] to compute the percentage of land used for residential purpose, and industrial and commercial use, within a 1500-meter radius of each parcel. We also constructed dummy variables to capture whether the parcel is an Enterprise Zone and if it is in a Brownfield Zone. Finally, we obtained information from the 1990 and 2000 Censuses about median housing rents in the parcel's census tract and characteristics of the residents in the parcel's zipcode and county (education, race, votes for the Democratic candidate in the most recent presidential elections, sources of drinking water).

5. The Econometric Model

A. The Model

We assume that a parcel is enrolled in the VCP if net benefits of participation are positive. Let VCP* denote the net benefits of participation in the program, and assume that:

$$VCP_i^* = \mathbf{x}_i\beta + \eta_i \,, \tag{1}$$

where **x** is a vector of site characteristics, β is a vector of unknown coefficients, and η_i an error term with mean zero and variance 1.

We cannot observe the net benefits of participation, but we assume that properties are signed up (i.e., *VCP*=1) when the net benefits of participation are positive. This allows us to estimate a probit equation:

$$E(VCP_i = 1) = \Pr(VCP_i^* \geq 0) = \Phi(\mathbf{x}_i\beta) \,, \tag{2}$$

[11] These data are available at www.epa.gov/mlrc.

where $\Phi(\bullet)$ is the standard normal cdf.[12] Because a site can only participate in the program once, we specify the log likelihood function as:

$$\text{(3)} \qquad \log L = \sum_{t=1994}^{2000} \sum_{i \in \Im} \left[VCP_{it} \cdot \log \Phi\left(\mathbf{x}_{it}\beta\right) + (1 - VCP_{it}) \cdot \log\left(1 - \Phi\left(\mathbf{x}_{it}\beta\right)\right)\right],$$

where i denotes the site, t denotes the year of the program, and $\Im$ is the set "at risk" (i.e., the set of sites that have not participated yet).[13]

Turning to the equation describing property values, let y denote the log market value of a property, and $\mathbf{z}$ denote a vector of physical characteristics of the parcel, structural characteristics of the building and neighborhood characteristics thought to influence value. Formally,

$$\text{(4)} \qquad y_{ij} = \mathbf{z}_{ij}\boldsymbol{\gamma} + VCP_{ij}\delta + \varepsilon_{ij} \,,$$

where i denotes the parcel and j the sale (j=1, …, J_i), and ε is an econometric error term that we assume to be normally distributed. Coefficient δ captures the effect on participation on property values.

To estimate equation (4) it is necessary to gather sale information for the properties in our sample that do and do not sign up for the program, and, for those which do, for sales before and after participation. Estimation is complicated by the fact that participation and value may be influenced by common unobservable parcel

[12] This is a reduced-form model of participation in which we control for site characteristics, location, and economic inducements available if cleanup is performed at the site, but do not attempt to explicitly model the decision to participate as a function of the appreciation or depreciation in the parcel's value accruing from participation. The latter equation is appropriate for understanding the types of models that signed up for the VCP over its lifespan, but is not appropriate for controlling for the endogeneity of participation and sale price when a sale takes place.

[13] This equation is, for all practical purposes, a discrete-time duration model, and is well suited as the first stage of the two-step estimation approach detailed below. We also estimated a model that simply predicts whether participation ever occurred. The latter model uses a sample size of 432 observations (each site is an observation), and gives results similar to, but often statistically stronger than, those obtained from equation (3).

characteristics, which make ε and η correlated within a parcel, *y* and *VCP* endogenous, and the OLS estimates of δ in equation (4) biased.

To estimate equation (4) consistently when ε and η are jointly normally distributed, we express the expectation of *y* conditionally on observing participation or non-participation:

(5) $$E(y_i \mid VCP) = \mathbf{z}_i\boldsymbol{\gamma} + VCP_i \cdot \delta + \alpha\lambda_i ,$$

where $\alpha = Cov(\varepsilon, \eta)$ and λ_i is equal to $\phi(\mathbf{z}_i\boldsymbol{\beta})/\Phi(\mathbf{z}_i\boldsymbol{\beta})$ if VCP_i=1 and to $-\phi(\mathbf{z}_i\boldsymbol{\beta})/[1-\Phi(\mathbf{z}_i\boldsymbol{\beta})]$ if VCP_i=0. On appending an error term, equation (5) becomes an econometric equation, which we estimate using a two-step procedure.

In the first step, we fit the probit model of participation (equation (3)). We then plug the probit estimates $\hat{\beta}$ into λ_i, replace λ_i in (4) with the $\hat{\lambda}_i$ thus obtained, and run an OLS regression, making sure that we use heteroskedasticity-robust standard errors. (It can be shown that the error term in the second step, which is a normal truncated on a correlated normal variate, is heteroskedastic; see Greene, 2003, page 783. The problem is compounded by using the probit estimates in lieu of the true parameters.)

B. The Benefits and Costs of Participation in the VCP

We assume that the owner of a property will enroll a parcel in the Colorado VCP if the net benefits of participation are positive. The benefits of participation should include the avoided expected liability costs, plus any reduction in the environmental assessment of the site, preparation of cleanup plan and cleanup costs afforded by participation in the program and due to agency oversight and simplified cleanup standards.

An additional component of the benefits of participation may be (the value of) the reduction in uncertainty surrounding remedial work (Urban Institute et al., 1997). Another potential benefit of participation is the tax credit that is incurred if the site meets certain requirements and the property owner, upon completing cleanup and receiving a 'No Action Determination' from the Colorado Department of Public Health and Environment, applies for such a credit through the state's brownfield program. Finally, whether or not any actual remediation work takes place, the final 'No Action Determination' may well serve as a clean bill of health from the state, dispel any possible contamination stigma, and raise the value of the site by more than the mere saving in cleanup and liability costs.

The costs of participation include, of course, the cost of cleanup (if any), the participation fee charged by the state ($2000), plus the cost of dealing with the state agency during the various stages of participation in the program. All else the same, one would, therefore, expect the costs of participation to be low at those sites where it can be shown that cleanup is not necessary (or where the owner or operator can escape the responsibility for cleanup because pollution has migrated from an off-site source).

C. The Choice of Independent Variables

We do not observe the net benefits of participation, nor any of the individual categories of costs and benefits described in the previous section. We therefore capture them with characteristics of the parcel and of the neighborhood.

These include the size of the parcel, a dummy for the presence of structures at the site (BUILDING), and capital intensity (CAPITAL), defined as the square footage of the buildings divided by the size of the site. Earlier studies of residential or industrial real estate have consistently found these factors to be associated with the value of a parcel (see Dobson and Goddard, 1992; Sivitanidou, 1994; Sivitanidou and Sivitadines, 1995). They may also influence remediation costs and any demolition costs. For example, heavily built sites may differ from others in terms of demolition costs and cleanup costs because of toxic construction materials (e.g., asbestos, heavy metals).

Distance to the central business district and to transportation nodes should influence the attractiveness of a site. Our regressors also include a dummy for whether the parcel lies in a Brownfield Zone (BZ), in which case the owner (or developer) is entitled to tax credits after cleanup. We also include dummies and continuous variables for economic incentives or burdens that are not linked to cleanup, but are in effect when a business is established at the parcel's location or for owning property at the parcel's location. Specifically, we form a dummy indicator for whether the lot is in a Colorado or federal Enterprise Zone (which grants tax credits for establishing a business in a zone designated as such) (EZ), and property tax rate that applies to the parcel (MILLLEVY).[14]

Some of our parcel addresses were incomplete, so we were sometimes unable to determine whether the site is in an Enterprise or in a Brownfield Zone. If so, we created a dummy variable to keep track of this. These two dummy variables (EZ_UNKNOWN and BF_UNKNOWN) are entered in the regression, along with the EZ and BF dummies. The coefficients of the latter should then be interpreted as capturing the effect of being in such zones on participation in the program, conditional on the availability of information.

[14] The US GAO (1997), for example, argues that voluntary cleanups are unlikely at sites that have little development potential because, among other reasons, of high tax rates, crime, old infrastructure, etc. Howland (2004) emphasizes the importance of infrastructure and access as important determinants of the chance of successful redevelopment of brownfields and contaminated properties. We control for access, but do not have good information about the age and quality of the infrastructure on the premises.

The benefit-cost calculus driving participation could also be influenced by the land use around the site. We have information on the percentage of land in the 500 and 1500 ft. buffer around the parcel slated for residential, industrial and commercial use.

Finally, we created several dummies to capture contamination at the site, which should influence directly the cost of cleanup. These include whether there is actual versus merely suspected contamination, groundwater and soil contamination (groundwater should be more expensive to clean up), and whether specific types of pollutants are present. The latter two types of information are available for roughly 73 percent of the sites.

The variables that we have described thus far are good candidates for the vector $\mathbf{x}$ of determinants of participation in the VCP. They are also good candidates for the vector $\mathbf{z}$. For identification purposes (see Wooldridge, 2002, page 564), $\mathbf{x}$ must contain at least one regressor that is not included in $\mathbf{z}$. We choose the descriptors of surrounding land use to be such excluded regressors.

6. The Data

Our first order of business is to examine the composition of our sample in terms of site contamination and participation in the VCP. Table 1 shows that of the 432 eligible sites in the Colorado Front Range, 159 (36.5%) applied for participation in the Colorado Voluntary Cleanup Program. The majority of the participants (102, or 64.5%) entered the program by directly applying for a letter of ‘No Action Determination’. The remaining 57 (35.5%) submitted a cleanup proposal for review by the Colorado Department of Public Health and Environment.

Only 6 sites in the CERCLIS registry and only 3 sites in the CERCLIS archives signed up with the Colorado VCP.[15] This suggests that the Colorado VCP has not "absorbed" contaminated sites or brownfields from these sources, and has solicited participation from an entirely new "crop" of parcels. This is consistent with the notion that VCPs lead to the discovery of new contaminated sites (US GAO, 1997), but casts doubts about the extent of the actual cleanup activity.[16]

Table 1: Sites and participation in the Colorado VCP

Description	**N**
Eligible contaminated or potentially contaminated sites in 9 Front Range counties	432
Applied to VCP… (as of August 2000)	159
…directly for NAD	102
…to do voluntary cleanup (VCUP)	57

Descriptive statistics of our universe of parcels are reported in Table 2. We were able to obtain acreage and improvement information for 61% of parcels. The average parcel size is 1,421,033 square feet. Almost 51% of the parcels for which we have improvement information contain a building. The mean "capital intensity" is 0.36, and our parcels are at an average distance of 5,429 meters from the central business district and at an average of 770 meters from the nearest road.

[15] Three of the participating CERCLIS sites applied directly for 'No Action Determination,' (NAD) and one of the sites from the CERCLIS archives applied directly for NAD.

[16] For comparison, we assembled a dataset of sites that are contaminated or believed to be contaminated in Maryland using the same registries of contaminated sites used in this paper, plus the state mini-Superfund program list, as of 2002. Out of 527 such sites in Maryland, we estimated that 443 are eligible for Maryland's VCP. A total of 62 participated in the Maryland VCP, and of these only 13 (about 21%) are from CERCLIS and the CERCLIS archives. The remainder is previously unlisted parcels.

Table 2.
Descriptive Statistics: Physical Characteristics of the Site.

Variable	Acronym	Mean	Std. Deviation
Size of the parcel (sq. ft)*		1,421,033	10,417,650
Log size of the parcel (sq. ft)	Sqftage	11.9348	1.9067
Size of the parcel missing	Sqftmiss	0.3889	0.4881
Building dummy	building	0.5069	0.5005
Building Capital intensity*	Capital	0.3576	1.0865
Distance to central business district (in meters)	Dist_cbd	5429.14	6398.13
Distance to nearest road of any kind (in meters)		770.53	1648.67

*: based on 264 valid observations

Table 3. Descriptive Statistics: Economic Inducements and Land Use

Variable	Acronym	Mean	Std. Deviation
Site is an enterprise zone (dummy)*	EZ	0.3671	0.4827
Missing info on enterprise zone (dummy)	EZ_UNKNOWN	0.2685	0.4437
Site on brownfield zone (dummy)*	BF	0.3911	0.4886
Missing info on brownfield zone (dummy)	BF_UNKNOWN	0.1065	0.3088
Tax per $1000 assessed value*	MILLLEVY	73.7911	16.2806
Missing info on tax (dummy)	MISSMILL	0.5116	0.5004
Percent residential use (high and low density) in 1500m buffer around a commercial or industrial property	RESAROUND1500	0.1631	0.2094

*: Valid observations: enterprise zone 316, brownfield zone 386, mill levy 211.

Table 3 presents economic inducements and land use for our universe of sites. Of the parcels for which we have this information, we know that 36.7% are in an Enterprise

Zone, and 39.11% in a Brownfield Zone.[17] The property tax is on average $73.79 per $1,000 assessed property value, and there is quite a bit of variability in property taxes within and between counties. On average, residential property accounts for 16.31% of the 1500 meter buffer zone around our parcels.

The presence of some contamination is confirmed at 31.5% of the sites. Groundwater and soil are contaminated at almost 44% and 31.6% of these sites, respectively. Solvents are the most common pollutant, and they are present at 45% of the contaminated sites, followed by petroleum and hydrocarbons (30% of the contaminated sites).

Regarding sale price data, we were able to identify a total of 245 transactions that took place between 1974 and 2002. We restrict attention to the 119 arms-length sales with positive price recoded by the tax assessor's office between 1980 and 2002. Of these, 43.70% were for sites that at some point enrolled in the program. Ninety sales took place at non-participating parcels (67) or at participating parcels (23) before they enrolled in the program. Twenty-nine parcels occurred after a participating sale signed up for the VCP.

The sale price, expressed in 1988 constant dollar, is on average about $797,000, ranging from $1667 to $6.5 million. Split-sample t tests suggest that the mean price does not differ across participating and non-participating parcels, and that no difference exists among the mean prices of participating parcels before and after participation. It remains

[17] We remind the reader that tax credits are offered to the developer for cleaning up and redeveloping a parcel located in a Brownfield Zone. However, Enterprise Zone tax credits are given to business that locate in areas with such a designation, and are not related to cleanup. We control for EZ, and for the level of the property taxes in the area, to proxy for general desirability of parcels to current and future owners and investors.

to be seen, however, if these results are confirmed or refuted when we run regressions that control for site characteristics.

7. Estimation Results

A. Participation in the Colorado VCP

In this section, we report the results of our probit model of participation in the Colorado VCP. By participation, we mean a direct application for either a No Action Determination or an actual cleanup proposal (VCUP application).

Table 4. Probit regression results. Participation in the Colorado VCP. Probit model based on the set "at risk." Total number of sites: 432. Total number of observations: 2682

	Specification A		Specification B	
	coefficient	T statistic	coefficient	t statistic
Intercept	-2.0234	-5.82	-1.6127	-3.44
Lsqftage	0.0531	2.00	0.0169	0.59
Sqftmiss	-0.2195	-0.60	-0.8423	-2.06
Building	-0.2353	-2.05	-0.0868	-0.69
Capital	0.0302	0.71	0.0454	1.04
dist_CBD	-0.00002	-1.54	-0.00001	-0.83
Bf			0.0357	0.36
Ez			0.0156	0.14
bf_unknown			-0.2125	-1.07
ez_unknown			-0.0526	-0.43
Milllevy			-0.00328	-0.85
Missmill			0.2283	0.75
resaround1500	0.6667	2.98	0.5993	2.66
contam_p	0.1317	1.41	0.1493	1.56
Log L	-474.253		-483.225	

The results of two specifications of the probit model are reported in table 4. Specification A is the more parsimonious of the two and suggests that the size of the parcel has a positive and statistically significant impact (at the 5% level) on the likelihood of participating in the program. Doubling the size of the parcel increases the likelihood of participating in any given year for the average parcel from 0.04 to 0.07, a 73% increase. Since lot size information was missing for a number of sites, we included a dummy (SQFTMISS) taking on a value of 1 if no information on the size of the parcel is available.[18] The coefficient on this dummy was statistically insignificant, implying that sites for which we were not able to gather acreage information are not systematically different in their probability of participation from those for which we do have this information.

The presence of a building is negatively and significantly associated with participation. For properties without buildings the likelihood of participating in any given is over 61 percent greater than that for comparable properties with buildings. Capital intensity is not a significant determinant of participation. Sites located farther from the Central Business District are less likely to participate, but in this specification the coefficient is not statistically significant at the conventional levels.[19]

We attempted various proxies for the site's contamination and in the end we settled for a dummy denoting whether contamination was confirmed, or simply suspected and then ruled out, at the site. The coefficient on this dummy is positive, but not significant at the conventional levels.[20] This confirms our earlier assessment that most of the sites participating in the program are not on official registries and wish to obtain a No Further Action determination without offering to conduct remediation at the site.

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[18] The square footage variable is then set to zero for observations with no information on lot size. Both the square footage variable and the dummy denoting a missing value for the square footage are included in the regression.

[19] We experimented with distance to various types of roads and distance to airport, but the coefficient on these variables were insignificant, whether or not we controlled for distance to the central business district. We are thus unable to confirm Howland's point (2004) that access is an important determinant of the attractiveness of brownfields.

[20] Dummies for the presence or absence of specific substances and for whether groundwater or soils were contaminated at the site were often significant, but the coefficients were relatively unstable with respect to relatively small changes in specification.

The variable most strongly associated with participation is the percentage of land slated for residential use with 1500 meters of the parcel, interacted with a dummy for whether the parcel is intended for commercial or industrial use. The coefficient on this variable is positively and significant at the 1% level, suggesting that property owners or developers may have had in mind conversion to residential use and residential development when they opted for participating in the VCP.[21, 22] The elasticity of participation with respect to the percent of residential area in the immediate vicinity is about 0.20.

Specification B adds controls for other economic development incentives or disincentives. In this specification, the physical characteristics of the parcel are no longer statistically significant, perhaps as a result of the collinearity between several of the regressors,[23] but their coefficient retain the signs they had in specification A.

The coefficients on the Enterprise Zone (EZ) and Brownfield zone (BF) dummies are positive—a result consistent with our expectation that being in an enterprise incentive zone may increase the attractiveness of a site for investment purposes, and hence the likelihood of participation in voluntary cleanup—but small and insignificant. Dummies denoting lack of information for these variables are likewise statistically insignificant, confirming that these sites are not different in their probability of participation from those

[21] When we use a land use variable that simply measures the percentage of land for residential use in the 1500 meter buffer around the property, we get similar results. We conclude that being surrounded by land used for residential purposes makes it more likely to participate in the VCP.

[22] Property owners or developers may have also responded to local residents' pressures. However, as discussed below, we do not find any evidence of an association between the characteristics of local residents (e.g., their education, political views, etc.) and participation.

[23] For example, the coefficient of correlation between log size and mill levy is 0.60, that between log size and Enterprise Zone is 0.21, and that between Enterprise Zone and Brownfield Zone is 0.24.

for which we do have information. The property tax rate has the expected negative coefficient, but again the association with participation is very weak.[24]

In specification not reported, we also checked whether the socio-economic characteristics of the population living around the parcel—which may capture the informal pressure they exert on property owners—matters. Median rent, education, and percentage of non-white population at the census tract level were not significantly associated with the likelihood of participation, nor were the percentage of democratic votes in presidential elections and the percentage of households that obtain their running water from wells in the county.

B. Effects on price

We report the estimation results for two specifications of equation (5) in table 5. Specification A is the full model, which includes the inverse Mills' ratio to account for possible endogeneity of participation and value. Property prices increase significantly with lot size and building capital. (In addition, parcels for which we do not have size information are not different in value, on average, from those for which we do.)

Contrary to expectations, distance to the CBD is not a significant determinant of value, nor is the applicable property tax rate. It is interesting that parcels in an Enterprise

[24] For comparison, the probit model of participation over the entire lifespan of the program—rather than year by year—suggests that size and the presence of a building are important determinants of participation. In addition, the property tax rate is negatively and significantly associated with the likelihood of participating (at the 5% level), the elasticity of participation with respect to MILLLEVY being equal to–0.85 for the average parcel. This model also implies that CONTAM_P is positively and significantly associated with participation in dispels these doubts. A site of average characteristics has probability of participating equal to 0.28 if contamination is only perceived, but this probability jumps to 0.41 if contamination is real. These predictions are in sharp contrast with the observation that the owners of most participating parcel do not seek to complete cleanup.

Zone transact at a 43% discount with respect to comparable lots in other areas, but being in a Brownfield Zone does not have a discernible effect on price.

The confirmed presence of contamination also implies a discount relative to parcels where the contamination was ruled out. This discount is about 47%, which is comparable to that estimated by Jackson (2002) and Howland (2000, 2004). If a parcel in our universe is sold after it signs up with the VCP, its value would appear to rebound by 55% over its pre-participation price. Taken at face value, this would suggest that participation in VCP is beneficial to property values and that prices recover completely to those of comparable uncontaminated sites. However, this effect is not statistically significant at the conventional levels.

We experimented with re-running the regression after excluding several regressors with insignificant coefficients, and obtained similar coefficient and p-values for the coefficients on contamination and participation. Since the coefficient on the inverse Mills' ratio is insignificant, we also re-ran the regression after excluding $\hat{\lambda}$. This time the magnitude and significance levels of most coefficients were virtually the same, except for that on participation in the VCP, which was pegged at 0.2536 (t statistic 0.96), implying a much lower appreciation of 29%. We also attempted interacting the contamination dummy with participation, but were unable to detect a statistically significant appreciation for contaminated properties after they are signed up for the VCP. We conclude that the data hint at the possibility that participating parcels appreciate in value, but the evidence about this effect is statistically weak.

Table 5. Hedonic pricing model. N=119 (All prices in constant 1988 dollars.)

	Coefficient	Heteroskedasticity-robust t statistic
Intercept	7.80598	5.37
lsqftage	0.40825	5.37
sqftmiss	1.54169	1.38
Capital	1.10792	4.35
ldist_cbd	0.1006	0.76
Milllevy	-0.00939	-1.10
missmill	-0.09585	-0.13
Ez	-0.53445	-1.90
Bf	0.10266	0.39
ez_unknown	-0.41806	-1.32
bf_unknown	0.55193	1.48
Contam_p	-0.64448	-2.23
comm_ind	0.10588	0.24
Participant*	0.58046	1.27
Inverse Mills' ratio term	-0.09876	-0.96
R square	0.4211	
Adj R square	0.3431	

*= dummy equal to one if the sale occurs when the property is enrolled in the VCP

8. Conclusions

This paper explores the determinants of participation in the Colorado Voluntary Cleanup Program and the effect of participation on the property's value. We find that very few of the properties that participate in the program are on the EPA's registries of contaminated sites or of sites previously thought to be contaminated. This confirms the remark that VCPs may lead to the discovery of new sites. In Colorado, however, these sites are probably not very seriously contaminated and/or their owners tend to apply directly for a No Further Action determination, rather than proposing to undertake environmental remediation.

The most important factors associated with participation are the size of the site and whether the site is surrounded by properties slated for residential use. Additional incentives to economic development and remediation, such as the availability of

Enterprise or Brownfield zone tax credits, do not discernibly affect the likelihood of participation. These findings should be interpreted with caution, since the presence/absence of these incentives tends to be correlated with other site characteristics (see Bartik, 2004, for a discussion of this problem). We conclude that sites that are more likely to participate in the Colorado VCP are probably those with comparatively high redevelopment potential.

Does participation raise property value? We find that contamination reduces substantially property values, all else the same, and that there may be some appreciation associated with participation in the program, but our results are statistically weak. This is probably a limitation due to the relatively small number of arms'-length sales we were able to identify over 1980-2002.

Based on these findings, we wonder whether the VCP is truly attaining its original cleanup and environmental remediation goals, or whether participation is driven exclusively by the desire to rid the parcel of any stigma associated with current or previous use of the land—which may raise the suspicion that the site is contaminated among future buyers—or to prevent such an effect. Since the 1997 GAO study finds that permanent remediation was undertaken for less than 50% of the voluntary cleanups, it would seem that the reliance on voluntary cleanup program may be insufficient to encourage true environmental remediation, and/or may create its own set of perverse incentives, rather than reversing those linked with liability- and enforcement-based programs. Clearly, more research is needed in this area, and data from programs of different states must be collected and analyzed to answer these questions.

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