Preliminary
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Environmental Liability and Redevelopment of Old Industrial Land

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ABSTRACT:

Many communities are concerned about the reuse of old industrial land and believe that environmental liability is a hindrance to redevelopment. However, with land price adjustments, liability might not impede redevelopment. Existing literature has found price reductions in response to liability, but few studies have looked for an effect on redevelopment. This paper studies variations in state liability rules — specifically, strict liability and joint and several liability — that affect the level and distribution of expected private cleanup costs. It explores the effects of this variation on industrial land prices and vacancy rates in a panel of cities across the United States from 1989 through 2000. In the estimated equations, joint and several liability reduces land prices and increases vacancy rates in central cities. Neither a price nor quantity effect is estimated from strict liability. The results suggest that liability is at least partly capitalized, but does still deter redevelopment.

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Many communities seek to encourage the redevelopment of old industrial land, especially sites (known as "brownfields") that are idle or underused because of potential contamination.[1] Redevelopment of old industrial sites is desirable because they are a disamenity and seen as a substitute for new industrial land (sometimes known as "greenfields"); introduction of new land may be costly because it reduces open space and requires construction of new infrastructure. A survey by the U.S. Conference of Mayors found about 25,000 brownfield sites in the 205 cities that responded (USCM, 2002).

Environmental liability — in particular, the threat of being compelled to pay for cleanup of contamination — is perceived as a significant barrier to redevelopment of old industrial sites. The respondents to the USCM survey cited liability as second only to lack of cleanup funding as the major obstacle to redevelopment. In 2001, Congress passed the Small Business Liability Relief and Brownfields Revitalization Act (Brownfields Act), which funded and codified an existing EPA grant and loan program for cleanup of brownfields and included several provisions to reduce the presumed liability deterrent. Reuse of contaminated land remains an active issue for state and federal policy in the U.S. and abroad (Reisch, 2003; Grimski and Ferber, 2001).

Despite the perception of a problem, theoretical questions have been raised about the impact of liability in discouraging redevelopment (Boyd et al., 1996; Segerson, 1993, 1994). Much of the policy literature fails to consider real estate price adjustments in face of expected liability and thus may overstate the deterrent to redevelopment. Empirical questions about the role of liability also remain. Urban and industrial decline long predates modern environmental laws, so liability can be at best a partial explanation for underused industrial land. With a few exceptions, previous literature has explored the effect of liability on prices but not on "mothballing" of land.[2]

In this paper, I use data on about 100 central cities in the US from 1989 through 2000 to estimate the effects of variation in environmental liability on prices and vacancy rates of industrial

[1] This discussion does not draw a distinction between brownfields and old industrial land more generally because brownfields just represent sites where contamination (always possible) is particularly likely. However, most definitions of brownfields include commercial land, in addition to the industrial land that is the focus of this study.

[2] Exceptions include McGrath (2000) and Schoenbaum (2002), which are discussed below. These studies use spatial heterogeneity in contamination to examine the question.

land. The variation in liability comes from differences in state liability regimes, including whether they rely on strict liability and on joint and several liability. As explained below, these regimes affect the level and the distribution of expected private cleanup costs. States adopted and rescinded both forms of liability in the period in question, facilitating a panel data analysis.

This paper builds on the existing empirical literature in a few ways. First, it focuses on vacancy of old industrial land, a variable of policy interest. It is the first study to look at vacancies that does not use spatial heterogeneity in contamination as its explanatory variable. Second, it analyzes the effects of alternative liability rules and thus provides direct information on plausible policy reforms: complete elimination of liability is unlikely (and a history of contamination cannot be undone), but some states have eliminated joint and several liability, and the U.S. federal government has increasingly moved to restrict it. European countries have also moved toward restricting reliance on joint and several liability. Third, it studies both urban and suburban data and thus provides some insight into not just the deterrent effect on redevelopment, but also substitution of greenfields.

I find a negative effect of joint and several liability on industrial real estate prices in central cities, with a reduction in prices of 13%. The estimates point to a positive effect of joint and several liability on industrial vacancy rates, which is also confined to central cities. One cannot reject no effect of strict liability on either prices or vacancy rates. Tests do not find evidence of policy endogeneity for either the price or vacancy equations, lending support to the estimated coefficients.

The paper also analyzes the USCM survey, the one national data set on reported brownfields acreage. The survey has only been conducted over a limited time and does not standardize the definition of brownfields. However, the results provide some validation of the results for overall vacant industrial land. Reported brownfield acreage is higher with joint and several liability, but not with strict liability.

The outline of the paper is as follows. The next section discusses reasons that liability may deter redevelopment and previous theoretical and empirical research in more detail. It also advances hypotheses about the effects of alternative liability rules. The third section describes the data on state policies, real estate markets, and other economic conditions merged for the analyses. A fourth section presents econometric results for equations that predict prices and vacancy rates with panel data techniques and a test for the endogeneity of public policies. A fifth section describes the data set that was assembled around the four years of the USCM survey and results from equations estimated on these data. A sixth section concludes with policy implications.

1 Liability as a deterrent to redevelopment

Under the federal Superfund and most state programs, liability for cleanup of contaminated sites may be imposed on a number of parties, including past and present owners of the site, as well as parties that contributed or transported contaminants to the site.[3] The purchaser of an old industrial site bears the risk of liability should the site turn out to be contaminated. In addition, the original owner may not find its liability eliminated by the sale, given the inclusion of past landowners among the liable parties. This section discusses studies of the effects of liability on redevelopment and then considers their implications for specific liability rules.

1.1 Previous research on liability and redevelopment

The previous literature suggests four reasons that liability might not just lower land prices, "capitalizing" liability, but also deter redevelopment.

First, sellers of land and potential buyers may have asymmetric information about the level of contamination and the nature of the required cleanup. As Boyd et al. (1996) and Segerson (1994) argue, the resulting adverse selection may be a source of underuse of old industrial land. Although insurance for buyers' cleanup costs has become increasingly available, this market too is likely to

[3] Since 1986, the federal Superfund program has allowed an "innocent landowner" defense, which exempts purchasers who did not know the parcel was contaminated, made "all appropriate inquiry," and exercised due care once contamination was discovered. However, courts have applied various criteria for allowing this defense and in practice have rarely found it applicable. The Brownfields Act of 2001 clarifies these concepts (in particular, regulations issued in 2005 define "all appropriate inquiry") and may increase the frequency and reliability of this defense.

be imperfect.

Second, Boyd et al. examine what they call “imperfect detection,” in which the government (and potentially even the owner) does not know about contamination until redevelopment, and “imperfect enforcement,” in which the government does not enforce cleanup liability for idle sites. In these circumstances, the sale of the property or requests for development permits may cause the owner to bear cleanup costs it could otherwise escape. If the cost of cleanup exceeds the value of the site clean, the property may go undeveloped.

Third, Segerson (1993) explores the effects of the “judgment proof problem,” the possibility that parties may escape full liability through bankruptcy. In Segerson’s model, without judgment proof parties, sales will be efficient regardless of whether the liability is transferred, i.e., whether it continues to reside with the seller or is partly or fully taken by the buyer. But with judgment proof parties, the extent of this shifting (and thus liability rules and rules on disclosure) affect the efficiency of the outcome. Segerson (1994) applies her earlier analysis to the incentives to clean up contamination before sale. Although Segerson shows that the effect of liability on sales is theoretically ambiguous, the legal rules in place largely shift liability to buyers, who are likely to have deeper pockets than current owners. Thus, a deterrent effect seems the likely implication of her model in practice.

Fourth, Chang and Sigman (2005) identify several deterrent effects that derive specifically from joint and several liability. Joint and several liability allows the government to hold any party liable for all of the cleanup costs regardless of its share of responsibility; this party may then sue any remaining liable parties for their share. The effects in Chang and Sigman result from the increase in the number of defendants that arises with sale of the property. At sites with multiple liable parties, adding an extra defendant may shift some third-party liability to the buyer. In addition, the buyer and seller may have collectively greater expected liability than the seller alone when the outcomes of the government’s potential lawsuits are imperfectly correlated among the different liable parties. Thus, joint and several liability in particular may be a culprit in any deterrent effect from liability.

Empirical research. A few previous studies have explored empirical determinants of redevelopment.[4] McGrath (2000) examines the sales prices and likelihood of redevelopment of industrial parcels in Chicago as a function of the probability of contamination, which he derives from historical land use. McGrath finds a price reduction of about $1 million per acre and, comparing this value to typical cleanup costs, suggests that the costs are fully (or even over-) capitalized. He also compares sites that sold for new industrial uses with sites that sold for current use and finds evidence that redevelopment was discouraged. However, this definition of redevelopment is narrow: most policy-makers are concerned about the "mothballing" of land, rather than the question of change in use. McGrath's study conditions on a transaction taking place and thus cannot address the broader question.

Schoenbaum (2002) provides the most rigorous previous examination of land vacancy. She constructs a history of land use in an industrially-zoned area in Baltimore. Categorizing some land as brownfields in 1963 and in 1999, she finds no evidence that either status affects the likelihood of vacancy in 1999. However, identification of the brownfield effect is potentially confounded with spatial heterogeneity; parcels with geographic advantages (for example, proximity to a highway) may be more intensively used and thus be both more likely to be brownfields and to be used again later. This concern is supported by the positive association between land values and brownfield status in her study.

Other studies focus on prices only. Jackson (2002) examines the price effect of known contamination and its cleanup on industrial land prices in Southern California and surveys other studies of the effects of contamination on land prices. These studies show price responses; however, they do not indicate the extent of capitalization or the effect on redevelopment.

Finally, two recent studies use stated-preference analysis to explore incentives to promote redevelopment. Alberini et al. (2005) surveyed European developers on the impact of liability reduction, regulatory relief (improved speed and flexibility in approving cleanup), and direct subsidies to the developer. They find liability relief is worth 21% of the value of the median development

[4] In addition to statistical analyses, case studies include Zabel (2003), Nijkamp et al. (2002) and Urban Institute et al. (1997).

project. Wernsted et al. (2006) surveyed land developers in the United States. Using a conjoint choice analysis, they find that protection from third-party lawsuits is worth 22% of the return on investment at the hypothetical site and cleanup liability protection is worth 16%. These stated preference studies, however, cannot diagnose whether liability causes only price adjustments or also has an effect on quantities.

1.2 Effects of alternative liability rules

In the empirical analysis, variation in the extent of liability derives from the rules used to impose liability. In particular, the empirical analysis focuses on two dimensions of liability rules: whether liability is strict and whether it is joint and several. In this section, I discuss hypotheses about the relationship of these rules to redevelopment.

Strict liability means that any action that causes contamination may give rise to liability; by contrast, negligence (or "at fault") rules trigger liability only if precaution falls below some legal standard of care. Strict liability should increase expected private cleanup costs by expanding the set of sites at which private parties may be held liable. Under a negligence rule, parties will only find themselves liable only if they fail to exercise the legal standard of care (however the state defines this concept) in avoiding or cleaning up contamination. Under a strict liability rule, the government may also find it less costly to bring suits because its information requirements are lower, reinforcing the incentives from its higher expected awards.

Earlier empirical research supports this view. Previous papers find evidence of higher precaution with strict liability — reduced spills (Alberini and Austen, 1999b, 2002) and fewer violations of hazardous waste laws (Stafford, 2003).[5] These results are consistent with expected liability costs that are higher with strict liability.

Joint and several liability may raise expected liability for developers for several reasons. As mentioned above, Chang and Sigman (2005) discuss ways that the increase in the number of liable

[5]Such higher precaution suggests legal standards of care below the social optimum (Cooter and Ulen, 1988; Tietenberg, 1989). However, expected cleanup costs could be higher with strict liability even if it does not elicit greater precaution (as would be the case if legal standards of care are optimal).

parties under joint and several liability creates disincentives for sale when all parties are solvent. In addition, joint and several liability obliges private parties to pick up "orphan shares," costs attributable to parties that have gone bankrupt; these costs would be paid by the government under non-joint, "several only," liability. Probst et al. (1995) estimate a 14% average orphan share at federal Superfund sites (excluding entirely orphan sites) so these costs may be substantial.

2 Data

Data from several sources were combined to yield a panel on real estate markets, liability regimes, and economic conditions across cities.

2.1 State liability rules

All U.S. states have "superfund" programs that address liability and funding for cleanup of contaminated sites not covered under the federal Superfund program or the federal Resource Conservation and Recovery Act (RCRA).[6] States vary in the nature of the liability rules they apply.

Landowners and other parties face two liability regimes, the regime in their state and the federal law. However, state liability, designed to capture sites neglected by the federal government, may be the relevant liability threat for run-of-the-mill industrial sites. These sites do not have the large-scale contamination that would qualify them for the federal program. When cleanup is undertaken under state programs, federal officials almost never intervene and developers do not ask for federal officials to sign off on cleanup plans (Boyle, 2005).

The longest history of these policies is available from a series of approximately biennial studies from 1989 through 2000 by the Environmental Law Institute (ELI).[7] ELI surveys the state for their policy and says it captures not just the state's statute, but its current interpretation by the

[6] Superfund addresses inactive contaminated sites, whereas RCRA's Corrective Action is responsible for sites with active hazardous waste management.

[7] The years of the data are 1989, 1990, 1991, 1993, 1995, 1997, 2000 (see Pendergrass, 2001). For the econometrics, continuity in liability rules is assumed for intervening years (1992, 1994, 1996, 1998-99) when no change is reported. When the reports indicate a change, liability regime variables are missing for intervening years.

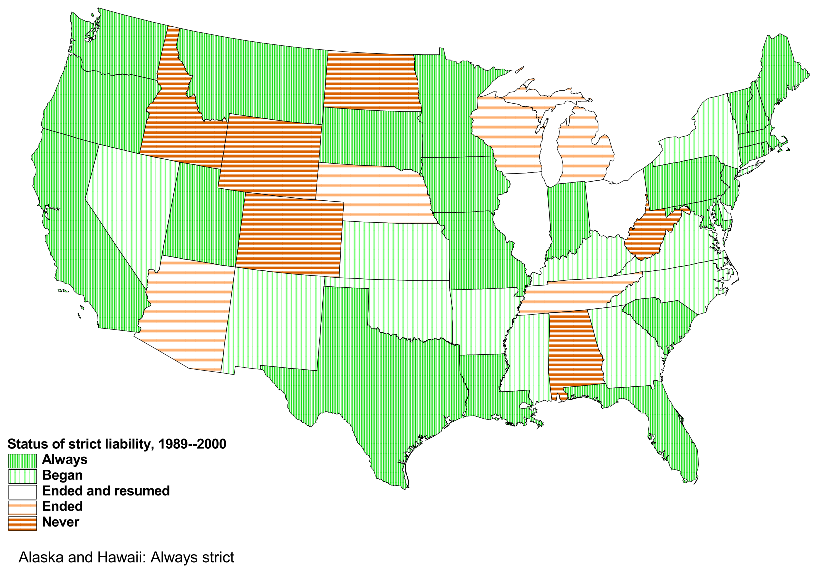

Figure 1: Reliance on strict liability, 1989–2000

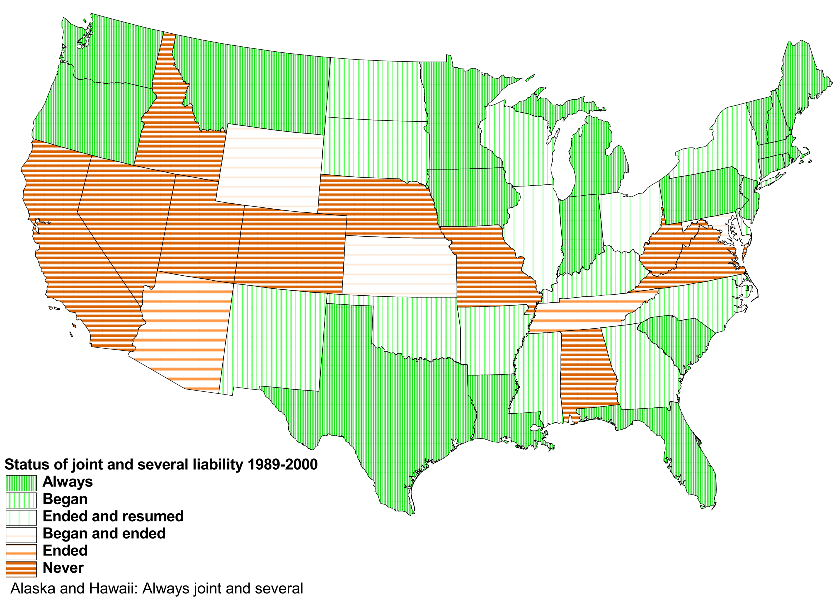

Figure 2: Reliance on joint and several liability, 1989–2000

government. Figure 1 reports states that had strict liability and those that did not throughout the period, as well as states that switched from one regime to another. Figure 2 reports the same data for joint and several liability. For both liability regimes, states switched both to and from the rules within the period. The majority of transitions are permanent, at least as far as the data extend. Correlation between strict and joint and several liability is imperfect and not all transitions occurred in tandem.

The policies change as a result of legislative, judicial, and administrative decisions. A number of legislatures enacted "tort reform" before and during this period (Campbell, Kessler, and Shepherd, 1998). Abolishing or severely restricting joint and several liability has been a common component of these reforms, although environmental liability is often specifically excluded from tort reform (American Tort Reform Association, 2005). Some of the shifts reported by ELI appear to be related to this wave of legislation and the judicial reaction. For example, a 1995 Illinois law barred joint and several liability, but the Illinois Supreme Court reinstated it in 1997; the hiatus in joint and several liability appears in the ELI data. In other instances, the policies are administrative. For example, Tennessee reports dropping joint and several liability in 1990, before a 1992 law passed.[8]

2.2 Land data

The Society of Industrial and Office Realtors' (SIOR) annual *Comparative Statistics of Industrial and Office Real Estate Markets* has data for many U.S. cities on prices of industrial real estate and vacancies. These data are available annually beginning in the early 1980s. The SIOR reports the expert opinion of local realtors rather than transaction data. Reliance on experts may add noise because of the influence of respondents' impressions, but may also reduce the noise in price data that a few large sales might have generated in some of the smaller urban areas.

[8]Good and Richards (2004) believe that some of the apparent time-series variation is spurious, resulting from inconsistencies in responses to questionnaires across years, and propose to use statuatory data only. However, this approach risks missing genuine policy shifts; environmental enforcement divisions may set a policy of not availing themselves of privledges the law affords. In any event, the measurement error from inconsistent responses to surveys should introduce a conservative bias to the empirical results.

Table 1: Means of variables used in equations, by joint and several liability

	All obs		Without J&S		With J&S	
	Mean	**St dev**	**Mean**	**St dev**	**Mean**	**St dev**
Price — center city (2000$/sq ft)	26.1	17.2	29.6	19.1	23.9	15.5
Price — suburb (2000$/sq ft)	29.5	15.5	34.8	20.7	26.9	11.2
Vacancy rate – center city	9.89	8.08	9.18	6.87	10.3	8.73
Vacancy rate – suburb	8.06	5.4	7.94	5.73	8.12	5.22
Strict liability	.829	.377	.596	–	.956	–
Joint and several liability	.645	.479	0	–	1	–
Metropolitan population (million)	3.48	11	2.05	2.75	4.23	13.4
Unemployment rate (%)	5.00	2.23	5.26	2.79	4.87	1.87
Manufacturing employment (thous)	105	138	131	190	91.1	96
Highway density	.264	.087	.265	.0887	.263	.0863
Real estate taxes (2000$/sq ft)	.800	2.35	.605	1.46	.889	2.66
State superfund lawyers per million people	.772	.814	.757	.825	.781	.809
League of Conservation Voters score	45.9	18	41.5	13.6	48.3	19.5
Abatement cost index	1.03	.347	.945	.256	1.07	.38
Contaminated sites/ sq mile	.0856	.0837	.0749	.078	.0913	.0861

For many cities, the SIOR data provide separate central city and suburban price and vacancy rates. Suburban sites may be less likely to be contaminated than urban sites and thus provide a comparison group. In addition, a frequent argument for brownfield redevelopment is that firms would otherwise substitute suburban for urban sites. The suburban data permit a direct test of this hypothesis, at least to the extent that the substitution would largely be toward suburban sites within the same metropolitan area.

Table 1 reports mean prices and vacancy rates for central city and suburban locations. Prices are substantially higher and vacancy rates lower in the suburbs. The table also distinguishes both variables for observations with and without joint and several liability. Center city and suburban prices are lower and vacancy rates higher with joint and several liability; the disparities are smaller between suburban values than urban values, consistent with an effect that depends on the likelihood of contamination.

Table 2 provides some data that use suburban data as a comparison for the central city development rates. For cities with both urban and suburban data, the table presents the ratio of urban to suburban land prices in 1989 and 2000. The average price ratios are divided into cities in states

Table 2: Urban-suburban price ratios by liability regime and transitions, 1989 and 2000

	Price ratios		Difference	
	1989	**2000**	**Mean**	**(St. error)**
Cities with joint and several liability	.943	.797	-.146	(.062)
	[30]	[29]		
Cities ending joint and several liability	.855	.778	-.077	(.191)
	[5]	[9]		
Cities without joint and several liability	.922	.815	-.108	(.083)
	[12]	[14]		
Cities beginning joint and several liability	.971	.833	-.138	(.137)
	[9]	[9]		

Note: Numbers in square brackets are the number of urban/suburban pairs with data.

that always used (or did not use) joint and several liability and those that switched regimes "permanently" during the study period. For all groups of cities the table, urban prices fell relative to suburban prices over the time period. However, the relative fall in urban prices was substantially smaller for the group that left joint and several liability than those that remained. Similarly, among cities that initially did not have joint and several liability, cities that began it experienced a greater relative reduction than those that did not. The differences in mean ratios, therefore, are consistent with a reduction in land prices from joint and several liability, although none of the differences are close to statistically significant. Sample sizes are small, especially in the transition categories.

2.3 Other explanatory variables

Other explanatory variables reflect economic conditions in the city, government services and taxes, influences on expected cleanup costs other than liability rules, and descriptions of other state environmental policies.

For economic conditions, the equations include the unemployment rate, manufacturing employment, and city population. The Bureau of Labor Statistics (BLS) provides data by city on unemployment rates and manufacturing employment; Wheaton and Torto (1990) suggest that the latter plays an important role in industrial real estate demand. Table 1 reports that the mean of this variable is much larger in states without joint and several liability than in states with it; however, the difference is almost entirely driven by the upper tail and the medians are similar. The population for the metropolitan area, from the Census, is also included; the entire metropolitan area is used, regardless of whether the area is center city or suburbs.

The services provided and taxes collected by the city also contribute to real estate demand. In particular, surveys find that access to transportation is a major determinant of location choices (Robertson, 1999). The Federal Highway Administration provides annual city-level data on highway miles that can be used to calculate a time-varying measure of highway density for each urban area. For taxes, SIOR provides an estimate of real estate taxes per square foot beginning in 1994.

Some additional sources of variation in the expected costs of liability can be captured for the analysis. First, the likelihood of contamination varies with past industrial land use. Fixed effects will remove the levels of these effects. However, for interaction terms, EPA's inventories of suspected and confirmed contaminated sites have been aggregated to the city level to create a measure of the density of contaminated sites.[9] Second, states may vary in the aggressiveness with which they pursue cleanup. Alberini and Austen (2002) capture this variation with the number of lawyers (full-time equivalent) working for the state on contamination, data which are available from ELI. As Table 1 reports, state have nearly identical staffing of their contaminated site programs regardless of whether they have joint and several liability.

Finally, explanatory variables are included to capture broad environmental policy stringency at the state level. This heterogeneity is potentially correlated with liability regimes and thus important to include in the equations. I use two variables: a measure of state environmental sentiment and a measure of manufacturing pollution abatement costs. The measure of environmental sentiment in the state is the average League of Conservation Voters (LCV) score for the House delegation of the state. The LCV score (which ranges from 0 to 100) represents the share of a legislator's votes on selected measures that the LCV considers pro-environment. As a measure of environmental

[9] The variable includes both sites in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) and sites that have been moved to the No Further Remedial Action Planned (NFRAP) list. Both inventories have a field for SMSA, but it is rarely filled in, so the variable aggregates sites to the SMSA level by county, which is almost always reported in the Superfund data.

sentiment, LCV scores have the virtue of varying over time and of perhaps reflecting the position of the median voter in the state (in contrast, for example, to environmental group membership, which focuses on the upper tail). I use House rather than Senate scores because the House scores usually average more individual legislators' data than Senate scores, reducing noise, and also can adjust more rapidly to changes in sentiment because of the potential for faster turnover in the House. As Table 1 reports, this variable is higher in states with joint and several liability, suggesting that it may be seen as the "greener" choice.

The measure of regulatory stringency is Levinson's industry-weighted abatement cost index (Levinson, 2000). Levinson adjusts the data from the U.S. Census survey on Pollution Abatement Costs and Expenditures (PACE) for the two-digit industry composition in the state. The resulting index has the advantage of varying over time and capturing not just legislative differences between states but also differences in monitoring and enforcement. A major disadvantage is that it ends in 1994 when the Census stopped conducting its annual survey. The series is linearly extrapolated for later years. The index differs very little between observations with joint and several liability and without, which is somewhat surprising given the higher LCV scores in joint and several states.

3 Econometric analysis

In this section, I present estimates of the relationship between liability rules and two real estate market outcomes: prices and vacancy rates. The first two subsections use fixed effects estimators to capture unobserved heterogeneity, but otherwise assume exogeneity of the policy regime. In the last subsection, I discuss a test of exogeneity of liability regimes.

The equations are estimated only on data from 1989 through 2000. Because it is unclear when in the year the ELI survey describes, I use a one year lag to assure that the variable has the value relevant when planning for any transaction occurred. Thus, the remaining observations begin in 1990, which is convenient because it is also the first year in which manufacturing employment and highway density are available and avoids some complications from redefinition of urban areas between decennial Censuses.

For both price and vacancy rates, the estimated equations have the form

$$Log(p_{it}) = f(L_{it}, E_{it}, G_{it}, S_{it}) + \alpha_i + \beta_t + u_{it},$$

where variables are as follows: p_{it} is the price (or later the vacancy rates); L_{it} is a vector of state liability rules; E_{it} are economic conditions, such as unemployment and population; G_{it} are government variables (highway density and real estate taxes); and S_{it} are measures of state environmental policy. The equations also include a city fixed effect, α_i; Hausman tests reject random effects. Year effects, β_t, capture changes in interest rates. A log-log function form is used to allow variables that reflect the scale of activity, such as population, to interact multiplicatively with other variables.

The error is allowed to have an AR(1) structure within a panel,

$$u_{it} = \rho u_{it-1} + \varepsilon_{it}.$$

This error structure may capture not only the gradual change in unobservable characteristics, but also some tendency for slow adjustment in the opinions of the realtors who report data. The test suggested by Wooldridge (2002, p. 275) for autocorrelation in fixed effects models strongly rejects the hypotheses of no autocorrelation for both sets of equations. Estimates of ρ are large, as reported in the tables.

3.1 Panel data analysis: Prices

Table 3 presents estimates of the relationship between liability rules and prices. Three different equations are shown in Table 3. The first two equations restrict the sample to center city data only. This restriction is intended to focus attention on properties where some contamination is likely. The third equation in Table 3 includes all data from the SIOR, including both center city and suburban data.

I discuss the coefficients on the liability variables first and then discuss the other covariates.

Table 3: Panel estimates for price with fixed effects and AR(1) disturbances

	Dependent variable: Log(Price)		
	Center only		**All obs**
State liability rules			
Strict liability	.109	.331	.053
	(.067)	(.193)	(.057)
Strict * Log(Site density)	–	.060	–
		(.052)	
Strict * Center city	–	–	.038
			(.084)
Joint and several liability	-.143	-.400	-.044
	(.073)	(.242)	(.064)
Joint and several * Log(Site density)	–	-.080	–
		(.073)	
Joint and several * Center city	–	–	-.104
			(.094)
Other variables			
Log(City population)	-.143	-.217	-.048
	(.129)	(.135)	(.079)
Log(Unemployment rate)	.041	.006	.012
	(.058)	(.056)	(.038)
Log(Manufacturing employment)	.103	.182	.069
	(.145)	(.163)	(.094)
Log(Highway density)	-.106	-.091	-.045
	(.092)	(.088)	(.048)
Log(Real estate taxes)	.031	.036	.033
	(.024)	(.023)	(.018)
Log(State superfund lawyers)	.057	.059	.050
	(.023)	(.023)	(.015)
Log(LCV score)	.015	.034	.025
	(.053)	(.051)	(.035)
Log(Abatement cost index)	.002	.010	.020
	(.080)	(.079)	(.050)
F-test for strict & strict interaction		2.30	1.46
p-value		.101	.233
F-test for J&S & J&S interaction		2.58	2.53
p-value		.077	.081
ρ for AR(1) process	.45	.49	.46
Number of cities	85	82	177
Number of observations	537	522	1195

Notes: Standard errors in parentheses.
Not shown: year dummies, dummy for missing highway observations, missing tax, and missing manufacturing employment.

Liability variables. In the first equation, joint and several liability has a statistically significant negative effect on prices. Prices are 13% lower (based on the coefficient of -.143) with joint and several liability, suggesting substantial capitalization of expected private cleanup costs. This price reduction compares with the value of cleanup liability relief equal to 16% of site value in the stated preference study by Wernsted et al. (2004).

Strict liability is not observed to have an effect on prices. In the first column, the coefficient on strict liability is positive, but close to zero in magnitude and statistically insignificant. In the second column, the coefficients on strict liability are also not significant, individually or jointly. The failure to find effects of strict liability, here and below, may indicate that this form of liability is in fact no more stringent than the alternative of negligence rules. If standard of care required to avoid negligence is high relative to the distribution of care actually taken to avoid the contamination, negligence rules protect few parties from liability.[10] Similarly, if the standard for care is sufficiently uncertain, liable parties may regard negligence rules as similar to strict liability.

The second equation in Table 3 explores the effect of the intensity of contamination, using the log of the density of hazardous waste sites in the area as a measure. One might expect a stronger effect of adverse liability rules in areas with higher contamination. Although the point estimate on the interaction is negative as expected and the two joint and several liability variables are jointly significant at 10%, this interaction is not individually significant. For strict liability, the effects remain insignificant and opposite in sign.

In the third equation, suburban observations are added. A number of suburban observations have been discarded, however, because the areas in question span more than one state, so the liability regime is ill-defined. The liability rules are interacted with a dummy for center city location to allow differentiated effects. The point estimates suggest a negative effect of joint and several liability overall that is strongest in city centers. However, neither coefficient is individually statistically significant and the two joint and several coefficient are jointly significant only at 10%.

[10] These results could be consistent with earlier studies that find effects of strict liability on current precautions (Alberini and Austen, 1999b, 2002; Stafford, 2003). The analysis here compares the distribution of past precautions that caused contamination with the due care standard. Current precaution levels may be sufficiently higher that the due care standard is relevant.

The sum of the two effects (the net effect in center cities) is similar in magnitude to the center city effect in the first equation. With negative point estimates for suburban areas, the results do not suggest substitution of suburban sites for central sites within the same metropolitan area in response to joint and several liability. Effects of strict liability remain statistically insignificant, small in magnitude, and perverse in sign.

Timing issues are a concern for these and other equations: a prospective property developer will consider the expected current and future liabilities. Current liability rules will be a component of these expectations both for its direct effect and also for its indications about the future. However, unobserved expectations about the future will also play an important role. If rules change over time, developers respond to future expected rules that differ less across states than current rules; failure to measure expected future policy results might would result in coefficients closer to zero than the coefficients would be on permanent rules.

One quick check for timing effects is to remove cities in states that temporarily changed rules in the study period; these are cities in Maryland, Kansas, Illinois, and Ohio. Although only a small number of observations are dropped, they are influential with the "within" estimator. Dropping these observations in the equation in the first column of Table 3 does not markedly change the point estimates, but does render the coefficient on joint and several liability statistically significant at only 10%.

Other covariates. The equations include a number of time-varying covariates in addition to the liability rules. With the fixed effects included in the equation, few of these variables have statistically significant coefficients. The indicators of overall economic conditions — unemployment, manufacturing employment, and population — do not enter with statistically significant coefficients.

The number of lawyers working on contamination for the state enters with a statistically significant positive coefficient in the second and third equations. The positive coefficient suggests that this variable may capture something other the direct effect of an aggressive program for contaminated sites; an aggressive program would have the same effect as greater private liability, reducing land prices. Perhaps this variable reflects state government resources and indicates the benefits of government spending.

3.2 Panel data analysis: Vacancy rates

The second dependent variable of interest is the vacancy rate of industrial space.[11] As above, the estimated equations include city fixed effects and allow an AR(1) process for the errors. Equations are estimated that are limited to center cities and that include suburbs as well.

Liability variables. In the first equation in Table 4 with center cities only, joint and several liability has a statistically significant positive effect on vacancy rates. The magnitude of this coefficient is substantial: it corresponds to about a 40% increase in vacancy rates in the presence of joint and several liability. Although this effect seems large, vacancies may represent a small share of industrial space, so the effect as share of the full market is less dramatic, accounting for less than 4% of the market. Consistent with the price equations above, the equations do not point to an effect of strict liability on vacancy rates. The point estimate on strict liability is negative, contrary to expectations, and not significant.

Results for the other equations are also similar to the price equations. The interaction between joint and several liability and site density does produce a positive coefficient, but it is not individually statistically significant. As before, the strict liability interaction does not have the expected sign.

In the third equation with suburban data, joint and several liability and its interaction with center city are jointly significant at 5%. The net effect in center cities continues to be positive as before. Interestingly, the point estimate on joint and several liability outside of central cities is negative, although not statistically significant. A negative effect of joint and several liability

[11] SIOR provides both vacant square feet and vacancy rates. I focus on the latter because the data do show dramatic year-to-year changes in available space, presumably due to changes in the definitions employed by the realtors who report each year, whereas vacancy rates exhibit less volatility. In any event, changes in the reporting realtor are unlikely to be systematic. With fixed effects, using the absolute vacant space did not change the conclusions of the analysis.

Table 4: Panel estimates for vacancy rate with fixed effects and AR(1) disturbances

	Dependent variable: Log(Vacancy rate)		
	Center only		All obs
State liability rules			
Strict liability	-.135	-.564	.239
	(.146)	(.479)	(.143)
Strict * Log(Site density)	–	-.108	–
		(.125)	
Strict * Center city	–	–	-.349
			(.196)
Joint and several liability	.353	.801	-.103
	(.147)	(.512)	(.148)
Joint and several * Log(Site density)	–	.117	–
		(.145)	
Joint and several * Center city	–	–	.461
			(.205)
Other variables			
Log(City population)	-.169	-.206	-.117
	(.272)	(.297)	(.178)
Log(Unemployment rate)	-.041	-.043	.078
	(.118)	(.122)	(.082)
Log(Manufacturing employment)	.110	.168	-.010
	(.263)	(.298)	(.184)
Log(Highway density)	-.212	-.211	.079
	(.180)	(.182)	(.101)
Log(Real estate taxes)	.030	.029	-.002
	(.051)	(.052)	(.040)
Log(State superfund lawyers)	.050	.053	.109
	(.048)	(.050)	(.034)
Log(LCV score)	.159	.164	.126
	(.103)	(.105)	(.073)
Log(Abatement cost index)	.059	.100	.136
	(.155)	(.161)	(.109)
F-test for strict & strict interaction		.96	1.76
p-value		.38	.17
F-test for J&S & J&S interaction		3.36	3.40
p-value		.04	.03
ρ for AR(1) process	.60	.59	.56
Number of cities	91	88	185
Number of observations	571	556	1208

Notes: Standard errors in parentheses.
Not shown: year dummies, dummy for missing highway observations, missing tax, and missing manufacturing employment.

on vacancy outside central cities might be consistent with substitution of suburban land in places where urban land is subject to high liability costs.

For strict liability, the coefficient is positive, but only in suburban areas. The effect is not statistically significant, however, so is probably consistent with the general conclusion that strict liability does not have a detectable effect on real estate markets.

Other covariates. As with the price equations, the other covariates do not explain much of the time series variation in vacancy rates in Table 4. One pattern that is interesting is that the variables reflecting state environmental stringency — state superfund lawyers, LCV score, and abatement costs — all increase vacancy rates; these results would be consistent with the somewhat elusive interstate pollution haven effect (Levinson, 1996). However, of these variables, only Superfund lawyers is statistically significant and only in the final equation. This coefficient is consistent with more aggressive liability enforcement increasing vacant land, but conflicts with the (unexpected) positive effect of this variable in the price equation.

3.3 Endogeneity of liability rules

A nonrandom assignment of liability regimes is a concern for interpretation of the analyses. Although exploiting the panel structure of the data may help to address endogeneity of liability rules, time-varying unobserved heterogeneity remains a potential problem. Liability rules may reflect other unmeasured attributes, such as amount of public concern about contaminated sites.

The rules may also depend on progress on the brownfields issue if states adjust their rules in ways they hope will encourage redevelopment. However, the choice of liability regime is not mentioned as a factor in brownfields in the policy or legal literature; to my knowledge, the possibility has only been raised in the technical papers of Segerson (1993, 1994). The arguments for choice of liability regime almost uniformly turn on the trade-off between perceived fairness of expansive liability and the resources it achieves for cleanup. Thus, reversed causality seems to be less likely than unobserved heterogeneity as a source of endogeneity.

In this subsection, I explore the endogeneity in the liability rules, using an instrumental variable approach. The previous literature suggests three instruments. First, Alberini and Austen (1999a) study the determinants of liability regimes, focusing on the role of industry mix and environmental preferences. In particular, they find that the number of mining establishments in the state predicts adoption of strict liability, with differential effects for large and small firms. I construct a time series on the number of large and small mining establishments by state from the 1992 and 1997 Census of Mineral Industries, with forward and backward imputation for the remaining years.

Second, Alberini and Austen (2002) find the lagged frequency of accidental spills to affect adoption of liability rules. The idea is that states may react to a flurry of accidents by toughening their liability regimes. Current accidental spills at active facilities should not affect the brownfields problem, which involves past contamination of inactive sites, and thus may be a suitable instrument for this analysis. I construct a variable for the number of spills by state and year from the raw Emergency Response Notification System (ERNS). To mirror Alberini and Austen's measure, I restrict the count of spills to those that occurred at fixed facilities (as opposed to transportation accidents, dumping, and other categories).

Third, Campbell et al. (1998) use total lawyers per capita in a state as an instrument in their analysis of the economic effects of tort reform. The argument for its inclusion is a political one: lawyers have a substantial stake in tort reform and may be major opponents or proponents. Because restriction of joint and several liability was an important component of tort reform over this period, I use this measure. The American Bar Association reports this data at irregular intervals (four times over the period of the data); missing years have been linearly interpolated.

When these instruments are used to test for exogeneity of the liability rules, the results fail to reject exogeneity in both equations. Table 5 reports the Davidson-MacKinnon version of the Hausman test for the hypotheses of exogeneity of strict and joint and several liability, using the instruments proposed. The test statistic is moderate for the price equations, leaving the possibility of endogeneity, but very low for the vacancy rate equations.[12]

[12] If one does run the IV equation on the basis that endogeneity remains a reasonable likelihood for price, the results are disappointing. The coefficient estimates on both joint and several and strict liability are negative as expected, but

Table 5: Tests of exogeneity of liability rules

	Equation	
	Price	Vacancy rate
Test of exogeneity		
Test statistic	1.96	.40
p-value	.14	.67

Notes: Instruments for liability rules: Laggeds spills, lagged mining (small and large) establishments, lagged total lawyers per capita.
Equations as in column (1) in Tables 3 and 4.

In evaluating these tests, it is worth noting that the instruments seem relatively successful. Large and small mining establishments have significant first-stage coefficients for both liability regimes. The coefficients on accidental releases are positive and statistically significant for strict liability (as Alberini and Austen (2002) report), but are not statistically significant for joint and several liability. Tests of overidentifying restrictions fail to reject exogeneity of the instruments for the price and vacancy equations, supporting to the validity of the instruments.

4 Reported brownfields

The analysis above uses data on the overall industrial real estate market, taking the view that any used industrial land — even that not formally labelled as a brownfield — may be subject to the effects of liability. However, the effects of liability rules on reported brownfields may also be of interest, so this section conducts analyses of these effects.

standard errors are large, especially for joint and several liability.

4.1 Data on reported brownfields

The best available data set on reported brownfield acreages is from surveys conducted by the U.S. Conference of Mayors. Respondents to the USCM survey range from the largest cities to towns of about 10,000 people. The USCM conducted surveys annually between 1997 and 1999 and again in 2002. The total number of reporting cities/towns available for analysis is 359; 25% of the locales are present in three or more years. The survey does not attempt to impose consistency in the definition of brownfields, so the cities' definitions may be quite varied.

The USCM data was matched with the ELI data on the liability regimes. Unfortunately, the narrow time range of the USCM surveys limits the study to cross-sectional identification of the effects of liability rules. During the relevant period, the ELI data on liability rules are available only in 1997 and 2000, with no transitions in liability rules. No ELI data are available for 2002, so liability rules are assumed to be the same then as in 2000.

The other covariates are as similar as possible to those used before. Population figures derive from the USCM data itself, so are specific to the reporting locale. For several other characteristics, many locales are too small for city-level data to be available. The USCM locales were therefore matched to one or more counties based on place names. Local variables were then assigned based on county-level data, taking averages where multiple counties matched. These variables include local unemployment rates and the manufacturing share of employment from the BLS.[13] The data on density of suspected contaminated sites discussed earlier was also merged by county.

A measure of local real estate taxes was constructed from the USCM data. Respondents to the survey provide a range for the estimated tax loss from the failure to redevelop brownfields. Dividing the midpoint of this range by the acres of brownfields provides a measure of the tax rate for the locale. However, this tax rate may measure not only real estate taxes, but also anticipated sales and wage taxes if the property were developed in the way the city would like.

State characteristics used in the earlier equations are also included. The equations include the

[13]Manufacturing share of employment is used instead of total manufacturing employment as before because it seems better to scale the data for the use of a county or counties that may not conform well to city or town reporting brownfields.

Table 6: Summary statistics for USCM data set, by joint and several liability

	All obs		**Without J&S**		**With J&S**	
	Median		**Median**		**Median**	
Brownfield acres	100		100		115.5	
	Mean	**St dev**	**Mean**	**St dev**	**Mean**	**St dev**
Brownfield acres	758	4038	374	725	882	4623
Joint and several liability	.755	.43	0	–	1	–
Strict liability	.848	.36	.788	–	.867	–
Metropolitan population (thousand)	201	637	165	196	213	724
Unemployment rate (%)	4.73	1.96	5.23	2.87	4.57	1.52
Manufacturing share of employment	.154	.0689	.133	.0512	.161	.0724
Taxes forgone (2002 $/acre)	41.3	138	22.9	46.4	46.3	154
Contaminated sites/ sq mile	.179	.313	.127	.124	.196	.352
State superfund lawyers per million	.779	.801	.667	.791	.815	.802
League of Conservation Voters score	50.3	19.7	43.0	15.2	52.7	20.4

average LCV score for the state's House delegation and the per capita number of contaminated site lawyers working for the state (from ELI).[14]

Table 6 provides summary statistics for the full data set and for the subsets with and without joint and several liability. In the full data set, the cities claim an average of 758 acres of brownfield sites. The average city has a population of 201,000, but the median is lower because the range in city size goes up to 8 million (New York).

A large difference appears in reported mean brownfield acres between the cities with and without joint and several liability. Although the mean brownfield acres in the joint and several cities is much larger, the distributions of acres appear almost identical until the 95th percentile, where the joint and several cities include a few reports of tens of thousands of acres. Both groups have medians (reported in the first row of Table 6) of about 100 brownfield acres.[15]

Cities with joint and several liability differ from the other cities along a number of dimensions. The former are larger, more industrial, and have more contaminated sites.[16] Unlike in the

[14]Because ELI data are not available for 2002, the lawyers data for this year is assigned from 2000. The pollution abatement cost index used previously as a measure of environmental stringency would have to be entirely extrapolated for this data set, so is not used.

[15]Dropping cities reporting more than 10,000 acres did not substantively change the estimates in the next subsection.

[16]The average density of contaminated sites is much greater in this data set (.18 per square mile) than in the general real estate market data (.09 per square mile). The disparity is largely in the upper tail; the medians are similar (.07 versus .05 respectively). The difference seems to result from greater ability to pinpoint counties in the USCM data set.

earlier data, joint and several liability is also associated with more aggressive contaminated-site programs, as measured by the number of state superfund lawyers. These cities also have greener Congressional representatives.

4.2 Results with reported brownfields data

Table 7 reports the results of panel data analyses of the USCM survey. In the first two equations, only the years 1997 through 1999 are used because they are within the range of the ELI data. In the final column, data for 2002 are added, assuming that rules are the same as in 2000. Because no city experiences a transition in liability rules, all identification of these variables comes from the cross-section and only random effects are included. The equations allow within-panel AR(1) errors as before.

Liability variables. In the first column in Table 7, the coefficients on the liability rules show a similar to pattern to the pattern found in the overall vacancy rate. Joint and several liability has a statistically significant and surprisingly large effect in raising the number of acres of brownfields. The coefficient of .485 corresponds to 62% more brownfields with joint and several liability. This coefficient thus suggests a larger effect than the 40% increase found for vacancy rates; the comparison may be consistent greater effects of liability rules on sites with greater likelihood of contamination (as the point estimate on the earlier interaction suggested). On the other hand, the coefficient on strict liability is not statistically significant and has a very small point estimate.

A concern with this analysis is the role of the tax rate variable, which enters with a counter-intuitive negative, but very precisely estimated, coefficient. To construct this variable, reported foregone taxes are divided by the number of acres, with the goal of calculating a tax rate. However, the effect is that the inverse of the left hand side variable is on the right hand side and presumably drives much of the estimated relationship. The remaining equations in the table drop the tax variable to avoid these problems. One might question the need for its inclusion anyway; even if it does

For example, the highest values in the USCM data (3 sites per square mile) are for cities located in a single county in Northern New Jersey. In the earlier data, a handful of Northern New Jersey counties are in a single observation.

Table 7: Panel estimates for brownfield acreage with city random effects and AR(1) disturbances

	Dependent variable: Log(Brownfield acres)		
	1997–99		**1997–1999, 2002**
State liability rules			
Strict liability	.038	.100	-.127
	(.268)	(.273)	(.234)
Joint and several liability	.485	.315	.371
	(.225)	(.223)	(.192)
Other variables			
Log(City population)	.759	.738	.747
	(.091)	(.088)	(.077)
Log(Unemployment rate)	.120	.241	.252
	(.247)	(.254)	(.226)
Log(Manuf share of employment)	.139	.163	.069
	(.194)	(.199)	(.178)
Log(Tax rate)	-.314	–	–
	(.039)		
Log(Superfund site density)	.001	-.029	-.011
	(.075)	(.076)	(.070)
Log(State superfund lawyers)	.304	.268	.162
	(.114)	(.108)	(.089)
Log(LCV score)	-.135	-.352	-.304
	(.199)	(.209)	(.147)
1998	.243	-.002	-.043
	(.132)	(.131)	(.118)
1999	.331	.170	.112
	(.146)	(.144)	(.138)
2002	–	–	.242
			(.157)
Constant	-2.62	-2.73	-2.93
	(1.50)	(1.48)	(1.22)
ρ for AR(1) process	.28	.16	.57
Number of cities	247	294	359
Number of observations	365	454	636

Notes: Standard errors in parentheses.
Not shown: dummy for missing lawyer data.
In final column, 2002 liability rules and state Superfund lawyers assigned 2000 values.

reflect property taxes, they should be capitalized into land prices.

In the second column of Table 7, without the tax variable, the point estimate of the coefficient on joint and several liability falls substantially and is now not statistically significant. About half of the reduction results from including observations previously excluded for lack of tax data. The final column of the table includes the 2002 survey, expanding the data set but relying on extrapolated liability rules. With the inclusion of 2002, the coefficient on joint and several liability is statistically significant at the 10% level and again large in magnitude.

These equations are not strong evidence by themselves because it is not possible to use fixed effects to control for heterogeneity and because cities may have very different meanings for what they report as brownfields. However, the consistency with the early results (showing a deterrent effect of joint and several liability but not of strict liability) suggests robustness for these results.

Other variables. The relationships of reported brownfields acreage with some of the other variables are also interesting. Reported brownfield acreage increases with the city's population, but with an elasticity less than one. This coefficient suggests that the smaller cities face greater relative burdens from brownfields than larger cities, all else equal.

The regressions do not point to any relationship with unemployment rates or the manufacturing share of employment. Somewhat surprisingly, the number of sites reported to the Superfund inventory also does not have a statistically significant coefficient and the point estimate is very small or even negative. The number of inventory sites has sometimes been used as measure of the number of brownfields (e.g. Simons, 1998). This result suggests that it does not agree well with city governments' assessment of their brownfields problem.

Finally, the coefficients on the two state environmental stringency variables have signs that suggest differing effects. On the one hand, more state superfund lawyers per capita raises the number of brownfields, perhaps because more aggressive programs identify more sites or raise the costs of developing contaminated sites. On the other hand, states with higher LCV scores have fewer brownfields acres (in all but the first equation). The latter effect could be the result of more stringent controls on the behaviors that give rise to contamination or of more extensive previous cleanups.

5 Conclusions

The results of the empirical analysis are consistent with the view that joint and several liability not only drives down industrial real estate prices, but also increases the vacancy of industrial land. Both the price effect and quantity effects are concentrated in central cities, as might be expected. One cannot rule out the possibility of substitution of greenfields for brownfields in cities with joint and several liability, but the estimated equations do not provide positive evidence of this effect. In addition, the results provide little support for either a price or a quantity effect from strict liability: I speculate that standards for due care are sufficiently high or uncertain that negligence rules provide little protection from liability. In analysis of a limited data set on reported brownfields, joint and several liability is associated with more brownfields, but strict liability is not.

The results thus suggest that liability is at least partially capitalized but still deters redevelopment. The mechanism for the deterrent may be a general one, such as adverse selection or judgement proof problems. It may also be specific to joint and several liability. In either event, the results provide an argument for reducing reliance on joint and several liability. However, joint and several liability does have advantages that should be weighed against these costs. It provides the government with greater resources for cleanup and may facilitate settlement (Chang and Sigman, 2002). A targeted approach that provides protection from joint and several liability only when properties are sold might therefore appropriate.

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