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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 potentially contaminated land ("brownfields") and believe that environmental liability is a hindrance to redevelopment. However, with land price adjustments, liability might not impede the reuse of this land. Existing literature has found price reductions in response to liability, but few studies have looked for an effect on vacancies. 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 and on reported brownfields in a panel of cities across the United States. 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 sites that are idle or under-used because of potential contamination (known as "brownfields"). Redevelopment of these sites is desirable because they are a disamenity and seen as a substitute for use of relatively pristine land (sometimes known as "greenfields"), which reduces open space and requires construction of new infrastructure. A survey by the U.S. Conference of Mayors (USCM) 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. 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, 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.

Despite the perception of a problem, the economics literature raises theoretical questions about the impact of liability on redevelopment (Boyd et al., 1996; Segerson, 1993, 1994). Much of the policy discussion 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 is at most a partial explanation for under-used industrial land. Previous literature has explored the effect of liability on prices (e.g., Jackson, 2002; Alberini et al., 2006). However, only a few studies focus on "mothballing" of land (Schoenbaum, 2002; Howland, 2000, 2004) or the deterrent to redevelopment (McGrath, 2000). This earlier research uses the level of contamination at a site to measure the extent of liability. This approach potentially confounds the variation in liability with other spatial heterogeneity.[1]

In this paper, I use panel data on cities across the US to estimate the effects of variation in environmental liability on prices and vacancy rates of industrial land. Most industrial land is

[1] For example, Schoenbaum (2002) finds a positive association between land values and brownfield status in Baltimore.

potentially contaminated (Noonan and Vidich, 1992) and thus may be affected by liability, even if it is not formally designated as a brownfield.[2] 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. The changing rules allow me to identify the effects of liability rules with fixed effects for other spatial heterogeneity.

I find a negative effect of joint and several liability on industrial real estate prices in central cities (with estimates of the reduction in prices from 16 to 26 percent) and 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. No substitution of greenfields is observed in states with high liability.

In addition to the industrial real estate market data, this paper analyzes the one national data set on reported brownfields acreage, the USCM survey mentioned above. Reported brownfield acreage is higher with joint and several liability, but not with strict liability. This analysis provides confirmation of the main effect on a different set of cities, over a different span of time, and with a different definition of affected land.

The outline of the paper is as follows. The next section discusses reasons that liability may deter redevelopment, even with price adjustment. It also advances hypotheses about the effects of alternative liability rules. Section 2 describes the data on state liability rules and industrial real estate markets. Section 3 presents estimated coefficients for industrial land prices and vacancy rates and tests for problems with the results because of serial correlation or endogeneity of liability rules. Section 4 describes the data set assembled for the USCM's brownfields survey and results from equations estimated on these data. A final section briefly concludes with policy implications.

[2]Noonan and Vidich (1992) report that land used for "heavy industrial manufacturing" has a probability of contamination of 88% and "light industrial manufacturing" and "industrial parks" have 75% probabilities. Conversely, nonindustrial land, especially public facilities and commercial land, may account for 30% of reported brownfields (Wernstedt et al., 2004).

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 who contributed or transported contaminants to the site.[3] The purchaser of land 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.

The previous literature suggests three reasons that liability might not just lower land prices, "capitalizing" liability, but also deter property sales or 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 be imperfect. Second, Boyd et al. describe "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. With imperfect detection or enforcement, 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, in her models, Segerson (1993, 1994) shows that shifting liability to buyers can result in inefficiently low sales when sellers may be judgment proof.

In the empirical analysis, variation in the extent of liability derives from the two rules used to impose liability: whether liability is strict and whether it is joint and several. Both these rules likely raise expected private clean-up costs.

Strict liability means that any action that causes contamination may give rise to liability; by

[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 clarifies these concepts (in particular, regulations issued in 2005 define "all appropriate inquiry") and may increase the frequency and reliability of this defense.

contrast, negligence (or "at fault") rules trigger liability only if the defendant failed to meet the legal standard of care (however the state defines this concept) in avoiding or cleaning up contamination. Strict liability thus should increase expected private cleanup costs by expanding the set of sites at which private parties may be held liable. Strict liability also lowers the information requirements for the government and thus its costs of bringing suit, reinforcing the incentives from higher expected awards.[4]

Joint and several liability may raise expected liability for developers. When some parties are judgment proof, joint and several liability obliges solvent parties to pick up "orphan shares," costs attributable to parties that have gone or might go bankrupt. These costs would be paid by the government under non-joint, "several only," liability, so private costs are higher with joint and several liability. Probst et al. (1995) estimate a 14% average orphan share at federal Superfund sites (excluding entirely orphan sites), so the cost differential may be substantial. Even if PRPs are not judgment proof, Chang and Sigman (2007) find that a sale raises private costs under joint and several liability (through a variety of effects of increasing the number of defendants) and thus that this specific form of liability is a particular problem.

2 Data

2.1 State liability rules

All U.S. states have "superfund" programs that impose liability for cleanup of contaminated sites not covered by the federal Superfund or the Resource Conservation and Recovery Act (RCRA). States vary in the nature of the liability rules they apply.[5]

The longest history of these policies is available from a series of approximately biennial stud-

[4]Previous papers find evidence of higher precaution with strict liability — reduced spills (Alberini and Austin, 1999b, 2002) and fewer violations of hazardous waste laws (Stafford, 2003). These results are consistent with expected liability costs that are higher with strict liability, although strict liability may also increase liability even if it does not increase precaution.

[5]Landowners and other parties face two liability regimes, the regime in their state and the federal law. However, state liability, which addresses sites that do not qualify for cleanup under the federal Superfund program, may be the relevant liability threat for run-of-the-mill industrial sites.

Table 1: Liability rules in states with industrial real estate market data, 1989–2000

State	Joint & several	Strict	State	Joint & several	Strict
Alabama	Never	Never	Mississippi	Began	Began
Arizona	Ended	Ended	Missouri	Never	Always
Arkansas	Began	Began	Nebraska	Never	Ended
California	Never	Always	Nevada	Never	Began
Colorado	Never	Never	New Hampshire	Always	Always
Connecticut	Always	Always	New Jersey	Always	Always
Delaware	Began	Began	New Mexico	Began	Began
DC	Ended	Ended	New York	Began	Began
Florida	Always	Always	North Carolina	Began	Began
Georgia	Began	Began	Ohio	Temporary	Temporary
Hawaii	Began	Always	Oklahoma	Began	Began
Idaho	Never	Never	Oregon	Always	Always
Illinois	Temporary	Temporary	Pennsylvania	Always	Always
Indiana	Always	Always	Rhode Island	Always	Always
Iowa	Always	Always	South Carolina	Always	Always
Kansas	Temporary	Began	Tennessee	Ended	Ended
Kentucky	Began	Began	Texas	Always	Always
Louisiana	Always	Always	Utah	Never	Always
Maine	Always	Always	Vermont	Always	Always
Maryland	Temporary	Always	Virginia	Never	Began
Massachusetts	Always	Always	Washington	Always	Always
Michigan	Always	Ended	Wisconsin	Began	Ended

Source: Based on ELI surveys.

ies from 1989 through 2000 by the Environmental Law Institute (ELI) (see Pendergrass, 2001). ELI surveys the state for its policy and says it captures not just the state's statute, but its current interpretation by the government. Table 1 reports the status of the two liability rules in the states with real estate market data from 1989 to 2000. The majority of transitions are permanent, at least as far as the data extend. The policies change as a result of legislative, judicial, and administrative decisions, including "tort reform" initiatives (Campbell, Kessler, and Shepherd, 1998).

The two liability rules are correlated, but do deviate spatially and over time. Although 96% of observations with joint and several liability have strict liability (see Table 2), 60% of observations without joint and several liability have strict liability; thus, it is possible to distinguish the effect of this rule, but principally in the several-only regime. More importantly for the fixed effects analysis, transitions between the rules do not always occur in tandem. From 1989 to 2000, ELI reports that thirteen states adopted joint and several liability; of these thirteen, only five adopted strict liability at the same time (some already had it). Two states and the District of Columbia report eliminating joint and several liability; of these, only the District of Columbia also eliminated strict liability. Similar unmatched transitions occur in the strict liability group.

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. All of the 75 largest cities (by employment) and some smaller cities are in the SIOR data. Figure 1 shows the central cities with data for any period, classified by their average vacancy rate. The data are the expert opinions of local realtors rather than transaction data. Reliance on experts may add noise because of the influence of respondents' heterogeneity, but may also reduce the noise in price data that a few large sales might have generated in some of the smaller urban areas.

The SIOR reports separate information for central city and suburban locations. Suburban land is less likely to be contaminated than central city land and thus provides a comparison.[6] In addition, a frequent argument for brownfield redevelopment is that firms would otherwise use suburban sites. The suburban data permit a direct test of this hypothesis, if firms substitute suburban sites within the same state as the urban sites they reject. If they substitute sites in more distant suburban areas, however, this approach will not register the substitution.

Table 2 reports mean prices and vacancy rates for industrial land for the central city and suburban data sets. Prices are lower with joint and several liability in both the central cities and suburbs. However, vacancy rates are only higher with joint and several liability in central cities; suburban vacancy rates are essentially the same across the two sets of cities.

[6] 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.

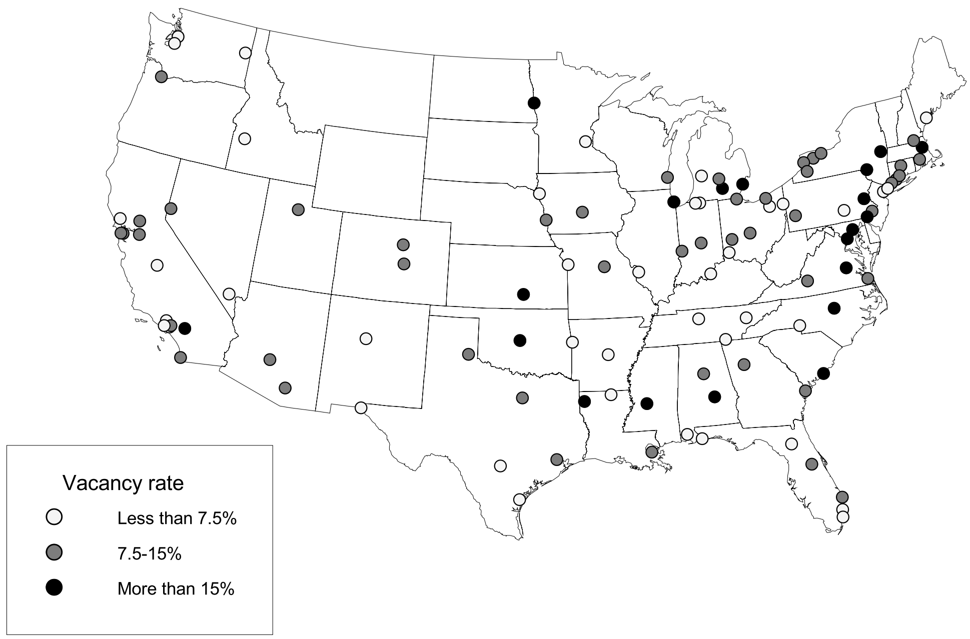

Figure 1: Central cities in the SIOR data set, by average vacancy rate

Table 2: Summary statistics for industrial real estate markets, by joint and several liability

	All obs		**Without J&S**		**With J&S**	
	Mean	**St dev**	**Mean**	**St dev**	**Mean**	**St dev**
Central city site price (2000$/sq ft)	3.38	5.63	4.13	5.51	2.85	5.67
Suburban site price (2000$/sq ft)	2.48	3.45	3.91	5.56	1.87	1.61
Central city vacancy rate	9.97	8.10	9.34	6.37	10.40	8.97
Suburban vacancy rate	8.10	5.27	8.15	5.93	8.07	4.93
Joint and several liability	.82	–	0	–	1	–
Strict liability	.63	–	.60	–	.96	–

3 Econometric analysis: Industrial real estate markets

Table 3 contains estimates of the coefficients α_L from equations of the form

$$Log(p_{it}) = L_{i(t-1)}\alpha_L + \beta_t + \gamma_i + f(E_{it}, G_{it}, V_{it}) + u_{it}, \quad (1)$$

where p_{it} is the price or the vacancy rate and $L_{i(t-1)}$ is a vector of state liability rules.[7] The equations also include time fixed effects β_t, and either city fixed effects, γ_i, or region fixed effects. Some equations include additional explanatory variables: E_{it} are economic conditions (city population, unemployment rate, and manufacturing share of employment), G_{it} are government variables (highway density and real estate taxes), and V_{it} are measures of state environmental policy (the number of contaminated site lawyers, the League of Conservation Voters score for the state's House delegation, and the abatement cost index from Levinson (2000)). The explanatory variables are described in the appendix. Equations without city fixed effects also include variables for the legacy of contamination (historical manufacturing employment and reported contaminated site density). All the equations have a log-log functional form.

3.1 Prices

In Table 3, neither strict nor joint and several liability has a statistically significant effect on prices when the equations are run without city effects in column (1). When city fixed effects are included in column (2), the point estimates remain similar, but the coefficient on joint and several liability is now statistically significant at 5%. Prices are 16% lower (based on the coefficient of -.169) with joint and several liability than without, suggesting substantial capitalization of expected private cleanup costs. This price reduction is similar to the value of cleanup liability relief (16% of site value) in the stated-preference study by Wernstedt et al. (2004). When time varying covariates are added in column (3), the absolute value of the coefficient falls and it is no longer statistically sig-

[7] The equations use a one-year lagged value of ELI-reported liability rules to try to capture the planning window for transactions. It is unclear what point in the year the ELI survey reflects.

Table 3: Estimates of the effects of liability rules

	Center city						Suburbs	
	Log(Price)			**Log(Vacancy Rate)**			**Log (Price)**	**Log (Vac Rate)**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Joint and several liability	-.124	-.169	-.092	.400	.362	.326	.032	.045
	(.119)	(.082)	(.065)	(.131)	(.136)	(.132)	(.057)	(.100)
Strict liability	.041	.024	-.042	-.317	-.232	-.206	-.058	.094
	(.123)	(.094)	(.087)	(.118)	(.131)	(.132)	(.056)	(.119)
Geographic fixed effect	Region	City	City	Region	City	City	City	City
Other explanatory var?	Yes	No	Yes	Yes	No	Yes	Yes	Yes
R-squared	.52	–	–	.17	–	–	–	–
R-squared (within)	–	.06	.11	–	.11	.12	.19	.27
Number of cities	91	97	92	100	107	101	106	104
Number of observations	522	592	525	661	749	667	753	722

Notes: Standard errors (in parentheses) adjusted for clustering at the city level.
All equations also include year dummies.

nificant, although the point estimate remains negative.[8] Thus, these equations offer some support for capitalization of joint and several liability.

The coefficient on strict liability is counter-intuitively positive and is not statistically significant in any price equation in Table 3. The failure to find effects of strict liability on prices (and below, on vacancy rates), may indicate that this form of liability is in fact no more stringent than the alternative negligence rules. If the standard of care required to avoid negligence is high relative to the distribution of care actually taken, negligence rules protect few parties from liability.[9] The equations were also run with an interaction term between the strict liability and joint and several, but the coefficient on this interaction was not individually statistically significant in any equation for price or vacancy rate.

Timing may be a concern for these and other equations: a prospective property developer will care about current and expected future liability. Current liability rules will be a component of expectations both for their direct effect (cleanup is likely to be required immediately before development can begin) and for their indications about the future. However, unobserved expectations about the future may also play a role. If rules change over time, developers respond to expected future 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.[10]

[8] The number of observations drops from column (2) to (3), but the effect on the joint and several liability results from the inclusion of the population variable, rather than the change in the data set.

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

[10] One quick check for timing effects is removing 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 potentially influential with the "within" estimator. Dropping these observations does not markedly change the point estimates on either liability rule.

3.2 Vacancy rates

Columns (4) through (6) in Table 3 report the coefficients α_L when the dependent variable is the vacancy rate in central cities. Both liability variables have statistically significant coefficients without city fixed effects in column (4). Joint and several liability has a positive sign, suggesting that industrial land is more likely to be vacant when private liability is greater. Strict liability has a counterintuitive negative coefficient in column (4). In the equations with fixed effects, the effect of joint and several liability continues to be statistically significant at 5%, with only a small reduction in its magnitude as additional controls are added. The counter-intuitive coefficient on strict liability, however, is no longer statistically significant when city fixed effects are included, so may be an artifact of unobserved geographic heterogeneity.

These results support the view that land price adjustments are insufficient to offset the costs imposed by environmental liability. The coefficient of .326 on joint and several liability in column (6) corresponds to a 39% increase in vacancy rates in the presence of joint and several liability or a reduction in occupied land of 4%. Since the difference is only between a less extensive form of liability and a more extensive form of liability, the results suggest that environmental liability overall is a substantial source of vacancy.

3.3 Suburban results

Columns (7) and (8) of Table 3 report the effect of liability on price and vacancy rate (respectively) estimated on suburban data. The results suggest no effect of either liability rule on either outcome variable in suburban locations: the point estimates of α_L are all very close to zero and none are statistically significant. These estimates have two implications. First, they support the interpretation of the earlier results as the effect of environmental liability, rather than some regional economic or regulatory condition with which it is correlated; such other conditions would affect suburbs as well. Second, they fail to support the hypothesis that suburban sites within the same state are substitutes for central city sites when liability discourages development of the latter.

3.4 Robustness tests

Retroactive liability. In addition to the two liability rules addressed in the table, state liability rules also vary in whether liability may be retroactive. Retroactive liability requires firms to pay for cleanup from activities that predate the cleanup law. Data on this dimension of liability are only available beginning in 1995, with few transitions, so a fixed effects analysis of the variable is impossible.

Adding a variable for retroactive liability to the cross-sectional equations (and restricting the analysis to 1995 through 2000) does not yield a statistically significant coefficient on retroactive liability for either price or vacancy rate. Retroactive liability has a very small coefficient (-.02) on vacancy rates; the coefficients on the other liability rules remain about the same as in column (4) in Table 3 (but the coefficient on strict liability is not statistically significant at 5%).

Serial correlation within a state. The equations rely on discrete changes in liability rules in a subset of states and are thus subject to a standard concern about "difference-in-differences": serial correlation in errors within a state may bias the estimated standard errors. In particular, Bertrand et al. (2004) argue that ordinary tests may dramatically over-reject the hypothesis that the policy has zero effect. The earlier equations address this issue with standard errors that are clustered by city, but the standard errors may still be biased because of the small number of policy transitions.

For this reason, the hypothesis tests were re-constructed using a "pairs cluster bootstrap-t," a method suggested by Cameron et al. (2008).[11] The economic conclusions from the bootstrap analysis do not differ from those in Table 3. The coefficients on joint and several liability are statistically significant for both price and vacancy rate in central cities. All the remaining α_L are not statistically significant with the bootstrapped t-distributions.

[11] A first stage equation on city-level data was used to calculate state unexplained variation by year, which is then the dependent variable for a panel analysis of state policies. This state panel equation is subject to the cluster bootstrap-t. Samples are repeatedly drawn with replacement from the set of state histories in the data set and used to find an empirical distribution of the t-statistics for the coefficients. Because it is based on the data, this empirical distribution does not require assumptions about the nature of the serial correlation and addresses the small sample issues. The point estimates of the coefficients differ slightly because of somewhat different treatment of heterogeneity in the unbalanced panel, but are similar to those reported above.

Endogeneity of liability rules. Nonrandom assignment of liability regimes is another concern. In particular, more extensive liability may be correlated with other characteristics that make states less hospitable to development. Although fixed effects can address unobserved heterogeneity across places, time-varying unobserved heterogeneity in a given place remains a potential problem. Endogeneity might also derive from reverse causality. The brownfields issue has not been raised in discussion of liability reform outside the economics literature, however, so reverse causality is a less likely source of endogeneity than unobserved heterogeneity.

To address this concern, the equations were estimated with an instrumental variables approach, using three instruments suggested by previous literature.[12] When these instruments are used to test for exogeneity of the liability rules, the Hausman test fails to reject exogeneity for either strict liability or joint and several liability in the fixed effects equations. The test statistic is low for the price equations and moderate for the vacancy rate equations.[13]

4 Econometric analysis: Reported brownfields

The analysis above considers the entire industrial real estate market, taking the view that liability may affect any used industrial land whether or not it is formally a brownfield. This section analyzes a more limited data set with information on reported brownfields.

4.1 Data on reported brownfields

Surveys conducted by the U.S. Conference of Mayors (USCM) provide the best available national data on brownfields. Respondents to the USCM surveys range from the largest cities to towns of

[12] First, Alberini and Austin (1999a) find that the number of mining establishments in the state predicts adoption of strict liability. Second, Alberini and Austin (2002) find that the lagged frequency of accidental spills affects adoption of liability rules; they hypothesize that states 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, and thus may be a suitable instrument for this analysis. 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, which often restrict joint and several liability. The appendix provides more detail on construction of the instruments.

[13] According to the Hausman tests, endogeneity of the liability rules does remain a reasonable possibility in the vacancy rate equations. When the central city vacancy rate equations are rerun with instrumental variables, the coefficients on both joint and several and strict liability are positive, but standard errors are very large.

Table 4: Summary statitics for brownfields data, by joint and several liability

	All observations	Without J&S	With J&S
Median of brownfield acres	100	100	116
Mean of brownfield acres	723	375	829
Standard deviation of brownfield acres	3964	727	4509
Percent joint and several liability	76.5	0	100
Percent strict liability	85.3	78.7	87.3

about 10,000 people. The USCM surveyed municipalities annually between 1997 and 1999 and again in 2002. The total number of reporting cities/towns available for analysis is 376; 25% of the locales are present in three or more years. The survey does not attempt to impose consistency in the definition of brownfields.[14]

The brownfields data was matched with the ELI data on 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 only one transition in liability rules (Arizona eliminated strict liability after 1997). The 2002 data extrapolates 1999 values for the liability rules.

Table 4 reports summary statistics for the brownfields data. In the full data set, the cities report an average of 723 acres of brownfield sites. 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 cities reporting tens of thousands of acres. Both groups have medians (reported in the first row of Table 4) of about 100 brownfield acres.[15]

[14]The brownfields data show positive correlation with the vacancy rate data studied earlier. Although it is difficult to match the individual observations because of different samples and city definitions, the state average vacancy rate has a correlation of .4 with the state brownfield acres per capita in 1997 and in 2002.

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

Table 5: Estimates of liability effects on brownfield acreage

	Dependent variable: Log(Brownfield acres)		
	(1)	(2)	(3)
Joint and several liability	.462	.690	.639
	(.205)	(.313)	(.332)
Strict liability	-.141	-.062	-.147
	(.206)	(.249)	(.268)
Log(City population)	.806	.776	.801
	(.090)	(.090)	.(097)
Region effects?	No	Yes	Yes
Other explanatory variables?	No	No	Yes
R-squared	.21	.24	.25
Number of cities	376	376	366
Number of observations	678	678	663

Notes: Standard errors (in parentheses) clustered at the city level.
All equations also include year effects.

4.2 Results for reported brownfields

Table 5 shows the results of equations with the log of reported brownfield acreage in a city as the dependent variable. The reported equations pool the data with city-level clustering of errors; city random effects models yielded very similar estimates. The equation in column (1) of Table 5 includes only liability variables, the size of the city (from the USCM survey), and year dummies. The effect of joint and several liability is positive and statistically significant. As before, there is no statistically significant effect of strict liability.

To explore the influence of other geographic heterogeneity on the results, columns (2) and (3) add first region fixed effects (for the nine Census Regions) and then covariates for economic conditions and government activities in the city. Inclusion of this additional geographic heterogeneity increases the point estimate on joint and several liability, so at least these forms of heterogeneity do not seem to bias the liability coefficients upward. With the full set of covariates, however, the joint and several liability coefficient is only statistically significant at the 10% level.

The effects of joint and several liability in Table 5 are large. The coefficient of .639 in column (3) corresponds to 90% more brownfields with joint and several liability than without. By comparison, the earlier estimates suggested 39% higher vacancy rates. Brownfields sites have higher expected contamination levels, so liability rules should have greater impact on these sites than a typical vacant site.

5 Conclusions

The empirical analysis in this paper suggests that joint and several liability not only drives down industrial real estate prices, but also increases the vacancy of industrial land. Both price and quantity effects are found only in central cities where land is most contaminated and not in suburban areas. The estimated equations show neither a price or a quantity effect from strict liability: standards for due care may be too high or too uncertain for negligence rules to provide much liability protection. The paper also estimates equations on a separate data set of brownfields reported by cities to a national survey. These equations provide additional support for the conclusion that joint and several liability discourages redevelopment, whereas strict liability does not.

Thus, although liability is at least partially capitalized, it still deters redevelopment. Deterrence may result from a general inefficiency from liability, such as adverse selection or the judgment-proof problem. It may also be specific to joint and several liability. With any of these causes, 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 gives the government greater resources for cleanup and may facilitate settlement (Chang and Sigman, 2000). A targeted approach that protects only buyers from joint and several liability might therefore be better than broader liability relief.

A Explanatory and instrumental variable construction

Industrial real estate market data set:

Liability variables: The ELI surveys are for 1989, 1990, 1991, 1993, 1995, 1997, 2000 (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. Because the ELI survey does not specify the time of year, the equations use a one-year lag of liability variables to represent the liability status at the time when transactions were planned. Thus, the remaining observations begin in 1990.

Unemployment rate and manufacturing share of employment: The Bureau of Labor Statistics (BLS) provides data by city on unemployment rates, manufacturing employment, and total employment. Wheaton and Torto (1990) find that manufacturing employment plays an important role in industrial real estate demand.

Population: The population for the metropolitan area is from the Census; the entire metropolitan area is used, regardless of whether the area is center city or suburbs

Highway density: 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.

Real estate taxes: SIOR provides an estimate of real estate taxes per square foot beginning in 1994.

Contaminated site lawyers per capita: Full-time equivalent lawyers in the state superfund program, from ELI, divided by state population.

League of Conservation Voters score: 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 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, reducing noise, and can adjust more rapidly to changes because of the potential for faster turnover in the House.

Pollution abatement cost index: Levinson (2000) 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.

Contaminated site density: The variable includes sites on the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) and sites that on the 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 (using the 1990 SMSA definitions).

Historical manufacturing employment: Decennial county level data from 1940 through 1970 are averaged and divided by land area to create a measure of the past spatial intensity of manufacturing for the city. Counties were aggregated to the SMSA level.

Instruments for liability rules: Three instruments are used: (i) the number of large mining establishments by state. This variable is from the Census of Mineral Industries for 1992 and 1997, with forward and backward imputation for the remaining years. (ii) Number of spills aggregated by state and year from the raw Emergency Response Notification System (ERNS) data. To follow Alberini and Austin, I restrict the count of spills to those that occurred at fixed facilities (as opposed to transportation accidents, dumping, and other categories). (iii) Total lawyers per capita in state. The American Bar Association reports the number of lawyers in a state at irregular intervals (four times over the period of the data); missing years have been linearly interpolated.

Explanatory variables for brownfields (USCM) data:

Population: Figures are reported by the survey respondents and so are specific to the reporting locale.

Unemployment rates and manufacturing share of employment: County data from BLS. The USCM locales were matched to one or more counties based on populated place names. For a few places where the populated place spans multiple counties, these variables are the average over these counties.

Density of suspected contaminated sites and historical manufacturing: As discussed earlier and merged by county.

Environmental policy measures: State contaminated site lawyers and LCV scores as above. 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.

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