Do Environmental Regulations Increase Construction Costs for Federal-Aid Highways? A Statistical Experiment

V. KERRY SMITH
Nicholas School of the Environment
Duke University
and Resources for the Future

ROGER H. VON HAEFEN
Center for Environment and Resource Economics
Duke University

WEI ZHU
Department of Economics
Duke University

ABSTRACT

This paper uses Federal-Aid Highway Program information for 1990 to 1994 to define a natural experiment that evaluates whether compliance with federal environmental regulations increases construction costs. This is accomplished by considering whether indirect measures of the environmental resources in each state affect construction expenditures for federal-aid highways. The test assumes that both positive and negative measures of environmental resources and amenities, such as counts of endangered species and historic sites, and the number of locations with Superfund sites, will serve as indirect indicators of the likelihood that environmental regulations could impact federally supported highway construction. Statistical analyses suggest that the expenditures for federal-aid highway construction and repair were influenced by these factors and by the regulatory activities likely to be associated with environmental mandates. Similar models applied to construction

V. Kerry Smith, Arts and Sciences Professor of Environmental Economics, Duke University, Box 90328, Durham, NC 27708-0328. Email: vks@duke.edu.

expenditures for state roads, which are not subject to the full set of federal regulations, did not find the proxy measures for the potential impact of these environmental regulations as positive influences on construction costs.

INTRODUCTION

Over 20 federal statutes impose a variety of environmental mandates on the construction, repair, and maintenance activities undertaken within the federal highway system.[1] Little is known about the added costs of these requirements.[2] One of the few sources of information, a retrospective set of cost allocations conducted by the Wisconsin Department of Transportation (DOT), suggests the added costs due to environmental regulations may well be 8% to 10% of construction expenditures for federal-aid highway projects (Novick 1995). Unfortunately, these estimates rely on practitioner judgments and not a specific record of the added costs for compliance.

A survey of all the designated environmental officials at state DOTs indicated only a few agencies kept records that would allow the costs arising from compliance with environmental regulations to be distinguished from other costs (see Smith et al. 1997). This response is surprising given the widespread belief that environmental regulations impose large costs and long delays. Indeed, the Wisconsin estimates would imply over $2 billion of the six-year appropriation for the National Highway System under the reauthorization of federal highway support (the Transportation Equity Act for the 21st Century—TEA-21) would be absorbed by compliance with environmental regulations.[3] Environmental regulations also involve a different type of compliance process, relying on negotiation among public agencies to meet the conflicting mandates of different federal statutes.

This study evaluates whether the Federal Highway Administration's (FHWA) statistics on construction expenditures for federal-aid highways provide evidence that environmental regulations have increased construction costs. We use the FHWA definition of construction costs for federal-aid and state-funded highways as reported in *Highway Statistics*. Federal-aid highway projects are subject to all federal environmental regulations. A comparison of the federal-aid construction costs with the construction costs for roads financed exclusively with state funds offers an approximate "natural" experiment to gauge the impacts of different regulations on each type of highway project.[4] To our knowledge, this type of statistical analysis has not been considered before.

Our findings suggest, after controlling for some of the primary characteristics of federal-aid and state roads, proxy measures likely to be related to increased regulatory stringency or the effects of environmental regulations had significant positive influences on construction costs for federal-aid projects. Most of these same variables did not affect the costs for roads completely financed with state funds. The measures of environmental resources included counts of endangered species, the number of historic sites, and the number of National Priority List (NPL) hazardous waste sites, as well as the size of coastal areas.

Our test uses a panel composed of states' construction expenditures (in constant dollars) from 1990 through 1994. It was assembled using

---

[1] See Smith and von Haefen (1996) and Tarrer (1993) for a summary of the relevant statutes. We have adopted a broad interpretation of environmental impacts that include historic and archeological effects as well as descriptions of more conventional impacts to environmental resources, because this is the framework most often used in the transportation literature.

[2] Carlin et al. (1996) present a summary of the most recent Environmental Protection Agency evaluation of the costs of environmental regulations. The economic literature has focused on three issues: welfare consistent measures of costs (Hazilla and Kopp 1990) and general equilibrium analysis (Jorgensen and Wilcoxen 1990); productivity impacts (Gray 1987; Gray and Shadbegian 1994); and most recently plant-level evaluations of the "net" costs of regulations (Morgenstern et al. 1998).

[3] This estimate is based on the Department of Transportation's summary of TEA-21 at website http://www.istea.ORG/DOCS/tea21/suminves.htm/.

[4] The term "natural experiment" is used in social science research to describe a set of circumstances representing constraints or existing conditions similar to a policy being evaluated. In this type of analysis, selected cases mimic the hypothesis to be tested (a "natural" variation) and it is argued that the results of the analysis will shed light on the effects of the policy. See Moffitt (1991) for discussion of the term in a different policy context.

FHWA statistics on construction expenditures for federal-aid highways and for state roads. The Federal-Aid Highway Program is a grant-in-aid program supported by the federal Highway Trust Fund. It allocates funds to states based on formulas that take account of population, area, mileage, relative costs, and percentage of prior apportioned funds. This fund derives revenues from motor fuel taxes and federal excise taxes on highway users. Federal-aid support to state and local projects generally involves an 80/20% federal/state (or local) share of costs in response to specific apportionment rules.[5]

The next section presents a brief overview of the environmental regulations that can affect highways. We describe the data and results in the following section, and conclude with a summary of the qualifications to and implications of our findings for reforms in the process of implementing environmental mandates.

BACKGROUND

Two statutes are especially important in order to understand the effects of environmental regulations on federal-aid highways: Section 4f of the 1966 Department of Transportation Act, and the 1970 National Environmental Policy Act (NEPA). Section 4f prohibits the use of publicly owned parks, recreation areas, wildlife areas, and historic sites of national, state, or local importance from being used in transportation projects unless the Secretary of Transportation determines there are "no feasible and prudent alternatives." A Supreme Court ruling in 1971, *Citizens To Preserve Overton Park v. Volpe*, made Section 4f and subsequent environmental laws serious concerns for federal-aid transportation projects. Indeed, DOT's Deputy Chief Council noted that in the initial period after this decision senior federal DOT officials felt compelled to review Section 4f provisions personally (Kussy 1996).

The second key statute, NEPA, was intended to enumerate the potential environmental impacts of and mitigation for any federally funded projects before the resources for them were committed. It does not have a direct regulatory role. The Federal-Aid Highway Program has been responsible for about 10% of the approximately 6,000 NEPA cases (Kussy 1996, 12). Three types of actions document the effects of a proposed project: environmental impact statements (EIS); findings of no significant environmental impact (FONSI); and environmental assessments.[6] An EIS is the most extensive documentation NEPA requires.

The set of regulatory mandates for federal-aid projects is complex and overlapping. Table 1 summarizes, by type of resource, a selection of the primary statutes and Executive Orders along with the oversight agency and the regulatory mechanism(s) used in implementation (see Freeman (1978) and Jafee et al. (1995) for a related discussion of environmental regulations). This summary uses a fairly broad definition of what comprises an environmental impact. To some degree, the NEPA requirement for preparing an EIS as well as the documentation required by Section 4f serve to identify the problem areas caused by regulations related to environmental resources. The timing of this coordination, however, has not always assured that the design and planning process will avoid

[5] Table FA-4A of FHWA's 1994 *Highway Statistics* provides an example of these rules. It outlines the apportionment formulas for the Federal-Aid Highway Program for fiscal year 1994. States are keenly aware of their payments into the trust fund in relation to their receipts.

[6] The final product of the NEPA review process is a summary report detailing all the environmental concerns. This can be an EIS, an Environmental Assessment, or a Categorical Exclusion. The latter is associated with a FONSI. For large projects, state DOTs must prepare the EIS and may jointly file it with an interested federal agency. The standard format for an EIS includes the following components: a) purpose and need for the project; b) alternatives considered; (c) description of the effect of environmental resources of the project; (d) nature of the environmental consequences; and e) identification of irreversible commitments of resources.

After the draft EIS is circulated, a public hearing identifying concerns is held and a final EIS is distributed. A Record of Decision issued within 30 days of the final EIS's release signifies project approval.

A final EIS is a record of the final selection and a subset of the alternatives considered along with discussion justifying the decision. Comparison of the final alternative with others reported does not reveal incremental mitigation costs to meet regulations because the EIS records the consensus that was reached, not all the alternatives avoided through the negotiation process. See Smith and von Haefen (1996) for further discussion.

TABLE 1 Selected Environmental Statutes Impacting Highways by Resource[a]

Resource	Statute/Executive Order	Agency	Regulatory mechanism
All resources	NEPA (1970)	Council on Environmental Quality	EIS
Land Public parks	Section 4f, DOT (1966)	FHWA	Documentation and permits
Wildlands	Wilderness Act (1988)	U.S. Forest Service	Land-use restrictions
Historic sites Coastal areas	National Historic Preservation Act (1966)	State Historic Preservation Office	Cultural Resource Assessment
	National Wildlife Refuge Administration Act (1988)	Department of the Interior	Land-use restrictions
	National Forest Management Act (1988, 1993)	Department of Agriculture	Land-use restrictions
	Endangered Species Act (1973) — Habitat	Departments of the Interior and Commerce	Conservation Plan listing
	Coastal Zone Management Act (1988, 1991)	Department of Commerce	Coastal Zone Management Plan Certification; funding restrictions
	Coastal Barrier Act (1982)	Department of Commerce	
Wetlands	Clean Water Act Section 404 (1972)	Corps of Engineers EPA	404 permits
	Executive Order (1977)	FHWA	EIS
	DOT Order 5660.1A (1978)	FHWA	Public review
Navigable waterways	Rivers and Harbors Act (1899)	Corps of Engineers	Section 10 permits
Fish and wildlife, including endangered species	Fish and Wildlife Coordination Act (1988)	Fish and Wildlife Service	NEPA provisions
	Migratory Bird Treaty Act (1918)	Fish and Wildlife Service	Permits
	Endangered Species Act (1973)	Departments of the Interior and Commerce	Biological Assessment Conservation Plan
	National Wildlife Refuge Admin. Act (1988)	Department of the Interior	Land-use restrictions
Rivers	Wild and Scenic Rivers Act (1988, 1993)	Department of the Interior	Prohibits development
Water	Clean Water Act (1972); Clean Water Act Sections 208 and 319 (1978) Safe Drinking Water Act (1988)	EPA State water quality agencies	NPDES permit for point source management plans, Memoranda of Understanding
Air	Clean Air Act (1970, 1977, 1990)	EPA	National Ambient Air Quality Standards for criteria air pollutants; State Implementation Plans; restrictions imposed on activities in nonattainment areas
Noise	Noise Control Act (1972)	EPA	Standards on construction

[a]This table is based on a detailed summary in Smith and von Haefen (1996) and Tarrer (1993). It does not include Executive Orders and statutes governing farmland, floodplains, and Superfund and other hazardous waste sites.

delays and adjustments for environmental regulations. The table also omits additional mandates that could be considered a part of this process. These requirements are related to preservation of private farmlands, liability related to hazardous waste sites, or requirements imposed on projects undertaken in floodplain areas that can be important to the design of highway projects.

The impact of this process on wetlands best illustrates its complexity. While the Army Corps of Engineers has primary responsibility for the Section 404 permitting process, the set of agencies with concerns about a wetlands decision varies with each proposed action and by state. Wetland-related legislation gives six federal agencies responsibilities in this area: the U.S. Army Corps of Engineers and the Environmental Protection Agency (EPA), along with the Natural Resources Conservation Service (previously the Soil Conservation Service) and the Agricultural Stabilization and Conservation Service (both Department of Agriculture), the Fish and Wildlife Service (Department of the Interior), and the National Marine Fisheries Service (Department of Commerce). Thus, substantial coordination with multiple federal and state agencies can be required. With such a diverse group, it is not surprising that one of the key difficulties that has arisen in this process stems from the differences across agencies in the definition of a wetland.[7]

This brief overview suggests that two types of balancing are inherent in the ways environmental regulations impact federal-aid highways. The first is illustrated by the provisions summarized in table 1 and involves compromises across different types of environmental resources, because highways can impact several different resources simultaneously. Here the decisions convey judgments about the relative importance of impacts across different environmental resources. These tradeoffs implicitly assign values to the resources involved, such as wetlands versus historic sites or air quality. The second type of balancing is among the priorities as defined by the statutory mandates of the different agencies for the same class of resources. While these can be linked to the resource balancing process, they need not be.

As part of a larger review of the impact of environmental regulations, we looked at several final Environmental Impact Statements. These EISs confirmed our observations about the process. The alternatives described in each final EIS include a range of different types of resource effects. One example can be found in a 1991 EIS for a project involving a six-mile roadway through downtown Wilmington, North Carolina. The project had wetlands impacts (about 23.1 acres), encountered two landfills with hazardous substances, and had a potential water supply impact due to the possibility of releasing hazardous substances into a nearby aquifer from proposed bridge pilings required to avoid one of the waste sites.[8] Air quality was also likely to be an issue for the Wilmington project, but was not discussed in the supplementary EIS. Finally, the project was in the 100-year floodplain for the Northeast Cape Fear River and three large creeks. This feature alone required elevating the roadway above the 100-year flood level. It also impacted four areas of environmental concern identified in North Carolina's Coastal Management Plan (a requirement of the Coastal Zone Management Act). Adjustments to the final route and the specific design criteria responded to some of these concerns. These adjustments are due to both the project and presumably different agencies' requirements to protect "their" resources.

Cross-agency negotiation can be expected to differ with each project considered. Our statistical analysis is based on annual costs, so it reflects the outcomes of final projects and the negotiation to balance ongoing projects.[9] These aggregates reflect

[7] After a period of considerable controversy about a proposed reconciliation of definitions, practice has reverted to the Army Corps' 1987 definition for most activities that would affect highways. For a summary of this controversy and of the permitting process see Kusler (1992) and the National Research Council report on wetlands (NRC 1995).

[8] See Smith and von Haefen (1996) for a more detailed summary and USDOT (1991) for the original source.

[9] FHWA is not specific about how the states' construction expenditures for work in progress is reported. Based on what is reported, it would appear to include expenditures related to payments made to states for work in progress.

different mixes of complexities arising from environmental regulations and other mandates related to the projects included in each year's construction expenditures. As a result, the expenditure data do not allow us to isolate the effects of the individual environmental regulations that may have been associated with specific highway projects in a particular state. Instead, the best our approach can recover is whether differences in construction costs, after controlling for the federal-aid system's general characteristics in each state, can be attributed to measures of the environmental resources that are likely to be associated with the regulations relevant to projects in that state.

Clearly, statistical "control" using these types of proxy variables is not as desirable as more detailed information with direct measures of compliance costs. Unfortunately, as we noted earlier, these data do not exist. Thus, this more approximate scheme may result in underestimation of the effects of the regulations. For example, the actual costs of meeting environmental mandates may be temporally shifted or "averaged in" with costs from projects with few impacts. As a result the environmental requirements may appear to have little to do with the temporal and cross-sectional variations in construction costs.

DATA AND RESULTS

Highway construction costs have two primary components. The first arises from the expenditures to support the staff and equipment of state (and local) transportation departments. The second involves public expenditures for the private contractors involved in highway projects. Environmental regulations affect both sets of activities. Our cost measure will not fully reflect both of these effects. As we noted, however, without a special purpose cost study it would be difficult to include a more complete record of the costs. Few states track the environmental compliance costs for construction and repair projects or for their ongoing maintenance programs for highways. Indeed, the General Accounting Office's 1994 review of agencies' practices preparing environmental reviews noted that:

> Although the agencies have developed the integrated processes to expedite NEPA and Section 404 reviews, they have not developed a system to evaluate their success. Specifically, the agencies have not developed baseline data on the time required to complete reviews under the traditional processes, nor have they developed plans to track projects' time frames under the integrated processes. (USGAO 1994, 7)

In describing state's activities the same report observed that:

> FHWA and the American Association of State Highway and Transportation officials (AASHTO) do not collect or track data on all environmental costs associated with highway projects. FHWA has collected information on the costs related to noise barriers, and AASHTO has collected data on the costs of mitigating impacts on wetlands.... In addition, none of 11 states we contacted routinely tracks data on all environmental costs. (p. 10)

Our analysis exploits the ability to construct a panel data set using FHWA's *Highway Statistics* from 1990 to 1994, along with variables designed to represent changes in key environmental resources over this time in each state. The latter data were assembled from a diverse array of sources.[10] Table 2 defines some of the primary variables used (or evaluated for use) in the analysis and documents their sources. Our focus is on the annual federal-aid construction expenditures in each state as the source of our "experiment;" we developed our models using this variable. Models for construction expenditures on state roads are treated as providing a crude "control" relationship.

The statistical model used to evaluate our panel of states' reported experience over the period 1990 to 1994 assumes there are two errors. We follow the simplest form of the random effects framework (see Baltagi (1995) for more details) as in equation (1):

$$y_{jt} = a + b^T Z_{jt} + u_j + \epsilon_{jt} \tag{1}$$

where a is the intercept, b is a $K \times 1$ parameter vector for the determinants of the dependent variable y_{jt} (in our case an expenditure measure) that is

[10] A more detailed data appendix is available on request from the first author.

TABLE 2 Federal-Aid and State-Funded Highway Expenditure Analysis: Data Description and Documentation

Variable	Description	Source	Notes
construct	Total annual capital outlays for highway construction	From Table SF-12 series, *Highway Statistics*, published annually by the Federal Highway Administration (FHWA), U.S. Department of Transportation, adjusted to 1994 dollars by the Bureau of Labor Statistics' Producer Price Index for intermediate materials, supplies, and component materials.	Costs associated with highway improvements, including land acquisition and other right-of-way costs, engineering, construction and reconstruction, resurfacing, rehabilitation, restoration costs of roadway and structure, and installation of traffic service facilities.
lanemiles	Total estimated lane mileage	Calculated from Table HM-60, *Highway Statistics*.	Number of lanes multiplied by center-lane mileage on the existing roads.
miles	Total public road and street mileage	Tables HM-10, HM-14, HM-15, *Highway Statistics*.	Center-lane mileage on the existing roads.
bridges	Total count of bridges	Table HM-41, *Highway Statistics*.	A continuously updated inventory of vehicle bridges greater than or equal to 20 feet.
eis	Counts of all EISs (draft, final, supplemental, etc.) issued to all federal agencies for each year, 1990–95	These counts were constructed from a computer printout of all EISs issued in the period January 1, 1990 to December 31, 1995. This printout was generated by the EPA Office of Federal Activities' Environmental Review Tracking System.	1995 values inserted for missing 1996 values, and 1990 values inserted for missing 1989 values.
fhw_eis	Counts of all EISs (drafts, final, supplemental, etc.) issued to FHWA for each year, 1990–95	See documentation for eis.	1995 values inserted for missing 1996 value, and 1990 values inserted for missing 1989 values.
spec	Count of federal endangered/threatened species protected by the Endangered Species Act of 1973	A February 29, 1996, snapshot of the counts of endangered species for each of the 50 states was obtained from the Endangered Species Program's Web page, http://www.fws.gov/~r9endspp/listmap.html. This information was combined with a chronological listing of species obtained from the ESP to construct the ES List for the years 1990–95.	

(continued on next page)

TABLE 2 Federal-Aid and State-Funded Highway Expenditure Analysis: Data Description and Documentation *(continued)*

Variable	Description	Source	Notes
npl	Count of Proposed and Final National Priority List Sites for the years 1989–95	These data are compiled annually in the *Statistical Abstract of the United States*, Bureau of the Census, from EPA press releases and proposed rules. Also, *The World Almanac & Book of Facts*, World Almanac Books, compiles the same information from similar EPA documents.	1995 counts were inserted for 1996 missing values.
hist	Count of National Register Sites, Objects, Structures, and Districts in each state for the years 1989 to present	Obtained from John Byrne, Database Manager at the National Register of Historic Places, Department of the Interior, a data set consisting of all National Register Sites as of July 1996, which allowed us to construct these yearly counts.	These data are cumulative counts for each of the years.
coastmi	Miles of coast (counting barrier islands) for each state	Obtained from NOAA's Coastal Zone Management Plan Web page, http://wave.nos.noaa.gov/ocrm/czm/welcome.html.	These estimates were assumed constant across the panel years.
fed/spec	Estimated acres of all federally owned lands for 1989–93, divided by the count of federal endangered/threatened species (i.e., the variable spec defined above)	For years 1989–91, the annually published *Public Land Statistics*, a U.S. Department of the Interior, Bureau of Land Management document. For 1992–93, the publication, *Summary Report of Real Property Owned by the United States Throughout the World*, U.S. General Services Administration, was used.	A comparison of the data suggests that the two data sources are consistent. No estimates were available for 1994–96, so 1993 values were substituted for the missing data.
farm	Estimated acres of farmland where a farm is defined as any establishment from which $1,000 or more of agricultural products are sold or would normally be sold during the year	These data are published annually in *Farm Numbers and Land in Farms*, U.S. Department of Agriculture, National Agricultural Statistics Service.	No estimates were available for 1995–96, so 1994 values were used for these years.

assumed constant across the j and t dimensions and with the levels of the $K \times 1$ vector, Z_{jt} of independent variables. u_j is constant over the t dimension and varies with j. In the analysis of federal-aid expenditures, j will be states. ϵ_{jt} varies with both j and t. The time subscript, t, in this case will be years. Both u_j and ϵ_{jt} are assumed to be classically well behaved. The composite error yields a nonspherical covariance matrix, because the covariance for different time periods in the same state is not zero, $E((u_{jt} + \epsilon_{jt})(u_j + \epsilon_{js})) \neq 0$. One common measure of the importance of u_j is defined by equation (2):

$$\theta = 1 - \frac{\sigma_\epsilon}{\sqrt{T\sigma^2_u + \sigma^2_\epsilon}} \tag{2}$$

where σ_ϵ = standard deviation for ϵ_{jt}
σ_u = standard deviation for u_j
T = the number of time periods observed for each cross-sectional unit.

The measure of importance of states' effects in equation (2) assumes balanced samples. When they are not, the available time periods will vary with the sample of time periods for each state, so T would be replaced by T_j in (2) (see Baltagi and Li 1990). The random effects estimator uses the structure assumed for u_j and ϵ_{jt} to construct feasible generalized least squares (FGLS). Estimates using FGLS are reported for most of the random effects models. The Hausman (1978) specification test compares the ordinary least squares (OLS) fixed effects format with the generalized least squares (GLS) estimator associated with the random effects error structure.[11] This test gauges orthogonality of the random effects with the independent variables. Testing this hypothesis is one way to evaluate whether a random effects specification is superior to a fixed effects approach for taking account of differences in states.

Federal-aid construction costs are deflated to 1994 dollars using the Producers Price Index (adccf) and the dependent variable is expressed in logarithmic form.[12] A semi-log model was adopted after plotting the deflated federal-aid construction costs by year. These plots are reported as figures 1a and b and suggest that the log transformation appears appropriate for these data, especially since our statistical tests rely on the assumption of normally distributed errors. The panel is unbalanced because of missing data for some states.[13]

The second column in table 3 reports a model that evaluates whether compliance costs due to environmental regulations can account for the variation in federal-aid construction costs after accounting for the highway system variables center-lane road mileage, lane-miles, and a count of bridges as control factors. These variables' estimated effects are given in the rows labeled 1 through 3 of the table. The specification of our model avoids two other sources of problems with a test of the effects of environmental regulations. One of these arises from the regulations and a second from the implications of the federal-aid system's funding formula. As we noted, the ultimate form of environmental regulations is the outcome of a negotiated process. Thus, measurement of their impacts would be problematic even if we had access to project-level information. The stringency and form of the regulations at the project level would be endogenous outcomes of the process. At the state level, we do not have records of these resolutions. Instead, our proxy measures indicate the extent of environmental resources (or problems) that would likely be associated with the need for such negotiations on projects. Thus, while these indirect variables make our test more difficult they avoid the

[11] Both are consistent estimates under the null hypothesis and OLS is inefficient. Under the alternative, OLS is consistent and GLS is not. Thus, a failure to reject the null hypothesis provides support for the random effects formulation of the model.

[12] With a neoclassical cost function including factor prices, there would be no need to deflate. Because such cost functions are homogeneous of degree one in factor prices, adjustment for inflation that affects all factor prices equally is unnecessary. One can interpret our deflator as an attempt to use the price index as a control for factor prices over time. This follows because our deflated cost is expressed in logarithmic terms (i.e., ln(adccf) = ln(ccf/PI) = ln(ccf) – ln(PI)). Ideally, one would like to account for differences in factor costs by state, but the required factor price indexes were not available.

[13] The data reporting system is voluntary so that in some years states failed to report some key variables for the model. Rather than impute the missing values for construction cost or the mileage variables, we deleted the observations from the panel.

FIGURE 1a Real Construction Costs for Federal-Aid Projects: Log Normal Scale

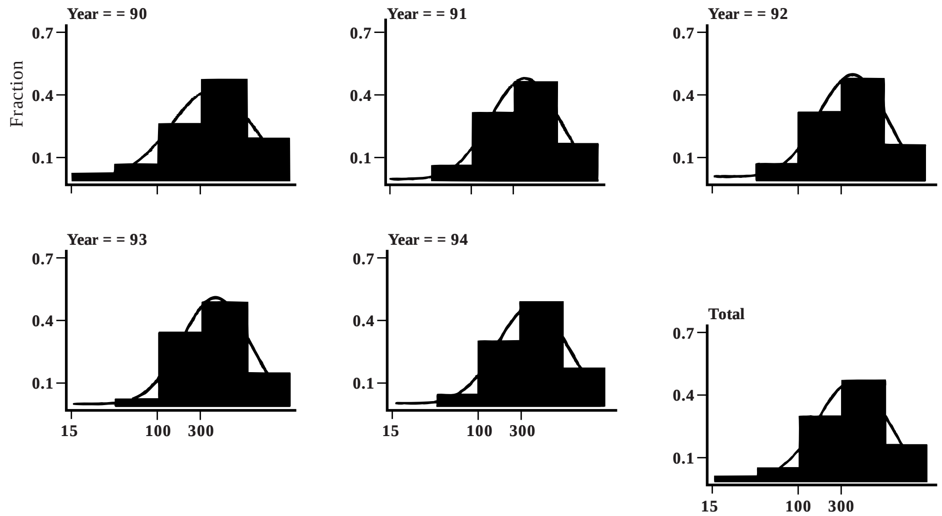
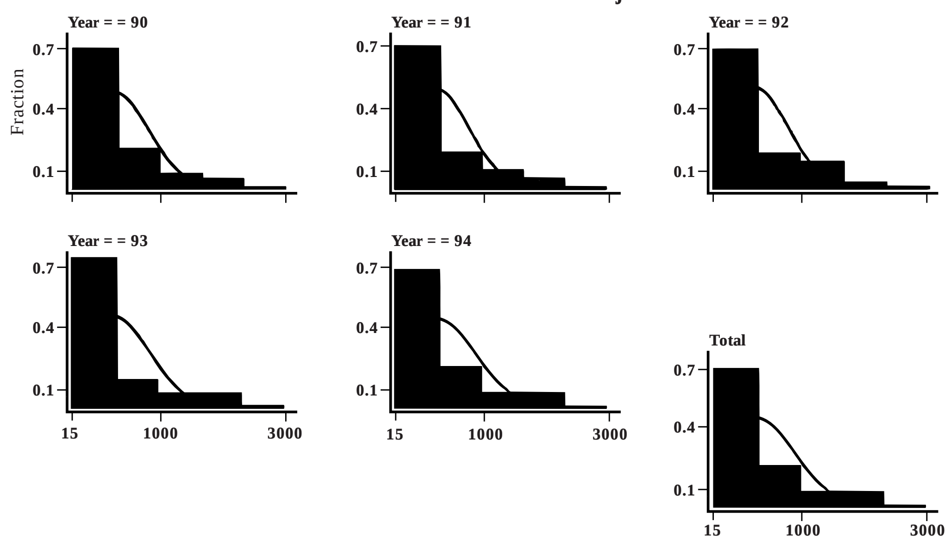


FIGURE 1b Real Construction Costs for Federal-Aid Projects: Normal Scale



potential endogeneity of variables based on the outcome-specific measures of the actual requirements imposed on individual projects.

The second issue arises with the formula funding of the federal-aid system. At one simple level, the cost sharing provides a bound on the added costs of federal environmental regulations. These statutes must add less to highway construction costs than the federal cost-sharing rates, otherwise the states would not participate. This insight is not especially informative as an upper bound estimate with a federal cost share of 80% of the construction costs. Nonetheless, it highlights a somewhat different issue. The features of specific projects will be adapted in other ways to maximize the federal cost share. New federal-aid project characteristics could then be expected to be related to the federal-aid construction costs. We avoided this potential endogeneity by including only the attributes of the each state's existing system. Moreover, FHWA statistical reports do not include specific information on the characteristics of new construction in each year.

TABLE 3 The Determinants of Federal-Aid Versus State-Funded Expenditures on Highway Construction Costs (1994 dollars): Estimated Parameters and t-ratios from Random Effects Models[a]

Row	Dependent-variable: construct	Federal-aid construction cost	State-funded construction cost
1	lanemiles	.017***	-.027
		(2.86)	(-1.32)
2	miles	-.026**	.045
		(-2.45)	(1.26)
3	bridges (scaled by 1,000)	.026	-.010
		(1.34)	(-0.58)
4	eis	-.004*	-.003
		(-1.90)	(-0.43)
5	fhw_eis	.010	.011
		(1.17)	(0.44)
6	spec	.004*	.008
		(1.72)	(1.22)
7	npl	.009***	.002
		(3.05)	(0.18)
8	hist (scaled by 10)	.003***	.008**
		(3.18)	(2.01)
9	coastmi	.046**	.057
		(2.01)	(0.63)
10	fed/spec	-.039*	-.047
		(-1.81)	(-0.59)
11	farm	-.002	.015
		(-0.43)	(0.72)
12	intercept	11.845***	(8.95)***
		(90.59)	(14.55)
	θ	.726	.824
	R^2 within	.054	.027
	Between	.778	.091
	Overall	.727	.090
	Number of observations	238	235
	Hausman test	11.85	7.69
	(p-value)	(0.295)	(0.659)
	Breusch-Pagan test	209.38	186.84
	(p-value)	(0.000)	(0.000)

[a] The numbers in parentheses below the estimated parameters (rows 1–12) are the t-ratios for the null hypothesis of no association. Table 2 describes the sources of definitions of each variable in detail.

Key:
*** p-value of 0.01
** p-value of 0.05
* p-value of 0.10

We conducted a brief telephone survey of each state DOT. Twenty-five states provided some information for some of the years in our sample. The average new miles of federal-aid highway added in each state ranged from 88.1 miles (in 1990) to 61.2 miles (in 1994). It is not clear whether these new miles are reflected in each year's reports, because they relate to miles added during the year. Furthermore, they account for only about 0.5% of the existing system in the average state and thus are unlikely to be an important influence on treating existing mileage as an exogeneous control variable in our tests.

If environmental regulations impact highway construction costs, then we should expect, after controlling for the characteristics of each state's existing federal-aid roadway (and bridges), that the factors likely to increase the stringency of environmental regulations would raise construction costs. By contrast, measures hypothesized to be related to experience and to the resources available for facilitating inter-agency negotiations about the form of environmental regulations would reduce costs. The latter effect occurs because the costs due to delay are reduced. We tested this hypothesis by including measures that (in most cases) varied by state and year for the environmental resources likely to influence the stringency of regulations. These factors are hypothesized to be exogenous influences on the negotiated form of the regulations. We also included measures of the physical characteristics of resources in the state likely to be related to Coastal Zone Management Plans, private farmland, and measures of the level of activity (and experience) in preparing environmental impact statements under NEPA. The estimated parameters for these variables along with their t-statistics are given in row 4 through 11 of table 3.

The estimated coefficients measure the proportionate change in federal-aid construction costs with a change in the respective independent variable. Thus, increases in the count measures for federal endangered and threatened species with habitat in a state or of National Registry sites, all else being equal, increase federal-aid construction costs. Both are statistically significant with at least a 10% p-value. The greater the number of species and historic sites, all else being equal, the more likely they are to be affected by new highway projects in a state. Likewise, a state with a long coastline is likely to encounter issues with the provisions of the relevant Coastal Zone Management Plan important to highways. A large number of NPL hazardous waste sites could mean a greater chance of having to deal with one in a highway project. These factors are general indicators of the effects of increased environmental stringency on highway construction. The EIS for the Wilmington project referred to above illustrated how both of these types of effects can influence the strategy adopted in a project.

Federal land relative to the count of the endangered species in a state, and a large number of EIS's prepared, may be factors that reduce costs. In the first case, federal land may serve as both a restriction on new highways and/or a potential source of habitat for the species affected by a project. In the case of the effects of the total number of EIS's prepared, the reduced costs may result from experience or the cost spreading that can arise when permanent staff are added to state agencies to meet similar mandates in other contexts. The farmland measure has a negative and insignificant effect on costs.

The column in table 3 reporting state-funded construction costs shows estimates of comparable roadway mileage and bridge measures corresponding to features of the state system. With the exception of the count of National Registry sites, none of these factors would be close to being statistically significant determinants of construction costs for roads funded completely by the state (these are not likely to be impacted as much by federal environmental regulations).

Overall, these statistical results are striking. Given the aggregate nature of the analysis as well as the proxy variables used to represent the potential for environmental factors differentially affecting federally funded projects in specific states, regulations could have had a marked influence *at the project level* and yet we might *not* have found significant factors influencing construction costs at the aggregate level. In situations where we must rely on judgment and proxy variables, however, there is an inevitable tendency to question statistical approximations. Three issues seem especially worthy of further consideration. First, it is widely recognized that states differ in their propensities to protect the environment. Would state-specific effects have changed the model? Second, wetlands' effects are the most commonly cited sources of increased environmental compliance cost (see Scodari 1997). We were unable to develop a reliable measure of wetland acreage by state over time. Most of the measures we considered either had incorrect signs, imposed significant restrictions on the available sample, or were highly correlated with other independent variables used to proxy the other resources. None were statistically significant determinants of federal-aid construction costs. In the presence of these data limitations, it is reasonable to ask whether there is any evidence supporting a wetlands effect? Finally, the catchall "omitted variable" concern plagues any effort to detect the effects of unobservable rules hypothesized to influence behavior.

The first and the last questions are partially answered with the Hausman and Breusch-Pagan (1980) test results. As noted earlier, the Hausman test indirectly compares a fixed-effects model (i.e., state-level dummy variables) with a random effects model. By testing the orthogonality of random effects to the independent variables we indirectly gauge whether omitted separate state-specific effects were important enough to cause a rejection in the null hypothesis. Neither the federal-aid nor the state-financed models reject the orthogonality hypothesis. Of course, it could well be the case that state effects were themselves not distinctive. The Breusch-Pagan test rejects this hypothesis. We can conclude based on this test that the variance in the state effect error is not zero for either model. Overall then, while we acknowledge that our model is incomplete, the results of these tests suggest that what may have been "left out" does not appear important enough to influence tests for specification errors and maintained assumptions that could change conclusions on the effects of federal environmental regulations.

The last issue—wetlands effects—is more complex. The only indirect measure we could construct to reflect wetland-related delay costs was the time to process Section 404 permits. The Wilmington, North Carolina, office of the Army Corps of Engineers provided records for over 1,300 permit applications for projects in North Carolina with decisions between 1994 and 1995. This included general and individual permits (see U.S. Army Corps of Engineers (1994); Kusler (1992); and Smith et al. (1998) for descriptions of the various types of permits). The Corps staff identified whether each permit was requested as part of a DOT project (i.e., DOT = 1, otherwise = 0). Our hypothesis is direct. Applications for Section 404 permits for transportation projects are, as a rule, more likely to involve other environmental impacts. Part of the reason for increased construction costs stems from the delay due to multiple, conflicting mandates of the environmental regulations facing highways. The states are required to develop a negotiated "balance" among environmental claims. Using this logic, we would expect DOT applications to take longer after controlling for other influences.

Equation (3) reports our estimated model for delay (days to process and obtain a final decision for a Section 404 permit using the North Carolina sample). The model is estimated as a random effects specification comparable to the description in equation (1). Here each county is treated as the source of the random effect error. Equation (3) reports the estimates. The database does not allow other features of the application to be identified. The numbers in parentheses are the t-ratios for the model and test the null hypothesis of the association.

$$\text{Processing time} = \underset{(17.14)}{119.08} + \underset{(5.84)}{215.06}\ \text{DOT} \quad (3)$$

R^2

within .136
between .259
overall .160

Hausman $\chi^2(1) = 1.84$
p-value = 0.175
Breusch-Pagan $\chi^2(1) = 7.79$
p-value = 0.005

The estimates are consistent with our expectations. DOT projects on average take 215 days longer to obtain a permit. The Hausman and Breusch-Pagan tests are also consistent with using this simple approach to control for other effects. Thus, to the extent delay adds to compliance costs for environmental regulations and North Carolina's experience is representative, the available data confirm the informal record suggesting that the permitting process associated with wetlands takes more time for transportation projects. This would be consistent with the interactions we outlined, and imply wetlands regulations are part of the environmental compliance cost picture.

CONCLUSIONS AND IMPLICATIONS

This paper statistically compares construction expenditures for highways that address federal environmental regulations to approximate a natural experiment and, in the process, to evaluate whether those regulations impose significant compliance costs on highway construction and repair. The federal-aid system is subject to over 20 different statutes. In addition, states using Federal-Aid Highway Program funding may encounter subsets of the nearly 30 different federal agencies with some oversight responsibilities for the environmental resources covered by these statutes. We have argued the resulting system is one that has public agencies negotiating with other public agencies about the exact nature of compliance on multiple environmental mandates.[14] Our statistical analyses suggest that environmental regulations appear to increase construction expenditures for federal-aid highways. Only the wetlands' effects could not be specifically linked to our cost measures. Permit-level data for one state appears to confirm that when highway projects require Section 404 permits, this factor alone seems to increase permitting delays. Of course, it is also important to note that we do not know much more about these applications and as a result have treated other sources of heterogeneity as random.

There are a number of serious qualifications to these findings. Two are especially important. The federal-aid highway system and the state road systems are quite different. The state road system is likely to be more heterogeneous, with some roadways providing transportation comparable to that of the federal-aid system and others that do not. Thus, one should expect that the construction requirements will be different irrespective of the effects of federal environmental regulations. This implies that direct comparisons of the estimated parameters from the models using the two construction expenditure measures would be inappropriate. As a result, our test considered only the statistical significance and sign of the estimated effects for the proxy variables reflecting the regulations.

Second, and equally important, we do not have direct measures of the stringency of the environmental regulations. Instead, we have variables that reflect the amounts of resources in each state that may be associated with increases in the likelihood that some environmental regulations would apply to projects in that state. This is not the same as knowing that specific projects were affected by the regulations due to specific federal statutes. In short, we are testing our hypothesis using "weak signals" of the influence of the requirements imposed by environmental mandates with "noisy" records of their outcomes for costs.

An optimist reading our results will find the significant effects under these circumstances a clear reflection of the impacts of the regulatory process. This reasoning would suggest that the odds are "stacked against" finding anything. Moreover, our "experiment" implies we should observe influences on federal-aid construction costs and *not* find the associations for state-financed construction costs. The twofold requirement would seem to reduce the chances of nonsense correlations "explaining" the

---

[14] New legislation authorizing federal funding for highways recognizes these complications and their effect on compliance costs in its provisions calling for "environmental streamlining" (Section 1309). The legislation encourages development of an integrated decisionmaking process to coordinate permitting and to encourage early consideration of environmental impacts. It encourages the Secretary of DOT to enter into Memoranda of Agreement (MOAs) with the agencies responsible for receiving the environmental documents under NEPA or for conducting other environmental reviews, analyses, opinions, or issuing licenses, permits, or approvals related to highway projects. The expectation is that MOAs will lead to cooperatively determined time periods for reviews and integrated reviews. The Secretary is also given authority to close the record. But this authority to issue a record of decision, closing the record when another agency fails to meet an agreed upon deadline, is limited to matters pending before the Secretary. If projects require a Section 404 permit the Secretary may not restrict the Corps' review with respect to that permit.

The legislation also includes provisions that allow the additional costs associated with this streamlined process to be considered eligible project expenses under the Federal-Aid Highway Program. They are, however, only for federal agencies meeting the deadlines for environmental reviews when these new deadlines are less than the customary time allowed for the reviews.

These details clearly suggest Congress received the informal messages about time delays and compliance costs arising from lack of coordination in the environmental reviews. Nonetheless, to the extent the delays are inevitable, given the conflicting "absolute" mandates, the reauthorized legislation provides no guidance on how a hierarchy of the mandates is to be established.

constant findings for both cases. The pessimist will, by contrast, conclude the experiment is not ideal and our results could equally well reflect a number of omitted variables. State roads are subject to state-level environmental regulations and can, under some conditions, also encounter the federal mandates. Because each construction measure aggregates over several projects, this line of argument would suggest both measures could be influenced by the federal environmental statutes.

We side with the optimistic perspective, but do so cautiously. The primary reason for our acceptance of this perspective is that other independent evidence (e.g., General Accounting Office reports and the ratings of DOT environmental officials (see Smith et al. 1997) confirm the specific sources isolated in the statistical analysis as the most important effects of environmental regulations for highways.

Further progress in evaluating how the environmental mandates impose federal-aid highway impact costs will require a detailed study of individual projects—either reconstructing ex post the adjustments made to accommodate the relevant environmental requirements, or estimating ex ante what appears to be their likely consequences for a specific set of projects. This would be a very significant research effort.

Before undertaking such an effort, it is important to consider why environmental regulations have received so much attention. The regulations seem to be increasing delays and costs, but we do not know whether the modifications to what was best practice in the planning, design, and construction (or repair) of highways are worth at least the added costs. To address this question requires consideration of the net benefits of environmental modifications. While including benefits involves another significant set of complexities, it is important to recognize that the present process is not "neutral" on what these benefits might be. Decisions to set priorities among the absolute mandates associated with each environmental regulation implicitly assign values to the environmental changes that are avoided (or not avoided) by the modifications made to the construction and repair practices for roadways. There is currently no effort to include economic measures of what people would want from these decisions. Thus, even if the benefit estimates are approximate they are likely to help the negotiations of the alternatives. TEA-21 recognizes the need for early coordination and integrated reviews. It does not, however, provide guidance on how to prioritize conflicting environmental mandates. Benefit analysis would offer one way to help set these priorities.

ACKNOWLEDGMENTS

This research was supported under grant no. 46-0003-01 from the Center for Transportation and the Environment, North Carolina State University. A number of individuals contributed to this research by providing us information, data, comments and reactions to the preliminary findings. Thanks are due to John Fisher, Winston Harrington, David Harrison, Wayne Kobler, Thomas D. Larson, Barney O'Quinn, Bill Phillips, Phyllis Ramel, Charles Thompson, and Wayne Wright. Thanks are also due to participants in seminars at UCLA, the NBER Public Economics 1997 Summer Workshop, FHWA and three anonymous referees for comments, and especially to research assistants who helped in assembling literature and developing or coding the survey and other data used for this research, including Rachel Cleetus, Chris Dockins, Nancy Graham, Martin Heintzelman, Brent McLamb, and Donald Rayno. Alice Bowser, Kris McGee, and Kelly DeMarchis prepared and edited numerous drafts of this manuscript. The views presented are the authors' and not those of these individuals or the sponsoring organization.

REFERENCES

Baltagi, B.H. 1995. *Econometric Analysis of Panel Data.* New York, NY: John Wiley & Sons.

Baltagi, B.H. and Q. Li. 1990. A Lagrange Multiplier Test for the Error Components Model with Incomplete Panels. *Econometric Reviews* 9, no. 1:103–107.

Breusch, T. and A. Pagan. 1980. The LM Test and Its Application to Model Specification in Econometrics. *Review of Economic Studies* 47:239–254. January.

Carlin, A., F. Scodari, and D.H. Garner. 1992. Environmental Investments: The Costs of Cleaning Up. *Environment* 34:12–20, 38–44. March.

Freeman, A.M. III. 1978. Air and Water Pollution Policy. *Current Issues in U.S. Environmental Policy.* Edited by Paul R. Portney. Baltimore, MD: Johns Hopkins University Press.

Gray, W.B. 1987. The Cost of Regulation: OSHA, EPA and the Productivity Slowdown. *American Economic Review* 77, no. 5:998–1006.

Gray, W.B. and R.J. Shadbegian. 1994. Pollution Abatement Costs, Regulation and Plant-Level Productivity, discussion paper. U.S. Department of Commerce, Center for Economic Studies.

Hausman, J.A. 1978. Specification Tests in Econometrics. *Econometrica* 46:1251–1271. November.

Hazilla, M. and R.J. Kopp. 1990. Social Cost of Environmental Quality Regulation: A General Equilibrium Analysis. *Journal of Political Economy* 98, no. 4:853–873.

Jaffee, A.B., S.R. Peterson, P.R. Portney, and R.N. Stavins. 1995. Environmental Regulations and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us? *Journal of Economic Literature* 33: 132–163.

Jorgenson, D.W. and P.J. Wilcoxen. 1990. Environmental Regulation and U.S. Economic Growth. *Rand Journal of Economics* 21, no. 2:314–340.

Kusler, J. 1992. Wetlands Delineation: An Issue of Science or Politics? *Environment* 34:7–11, 29–37.

Kussy, E.V.A. 1996. Surface Transportation and Administrative Law: Growing Up Together in the 20th Century. *Transportation Research Record, No. 1527 Planning and Administration; Transportation Law.* Washington, DC: National Academy Press.

Moffitt, R. 1991. Program Evaluation with Nonexperimental Data. *Evaluation Review* 15:291–314. June.

Morgenstern, R.D., W.A. Pizer, and J.S. Shih. 1998. The Costs of Environmental Protection, discussion paper 98-36, Quality of the Environment. Resources for the Future. May.

National Research Council (NRC), Committee on Characterization of Wetlands. 1995. *Wetlands: Characteristics and Boundaries.* Washington, DC: National Academy Press.

Novick, J.B. 1995. Summary of Wisconsin Department of Transportation analysis of environmental compliance costs, private correspondence. 16 May.

Scodari, P.F. 1997. *Measuring the Benefits of Federal Wetland Program*. Washington, DC: Environmental Law Institute.

Smith, V.K. and R. von Haefen. 1996. Legislative Sources of Environmental Regulations and Past Efforts To Measure Their Costs, unpublished working paper. Center for Environmental and Resource Economics, Duke University. September.

Smith, V. K., R. von Haefen, and M. Heintzelman. 1997. Environmental Compliance Costs for Highways, Center for Environmental and Resource Economics Research Note, No. 1–97. Duke University. August.

Smith, V.K. and R. von Haefen and W. Zhu. 1998. Environmental Compliance Costs Where Rubber Meets the Road, unpublished revised working paper. Center for Environmental and Resource Economics, Duke University. June.

Tarrer, A.R. 1993. Impacts of Environmental, Health and Safety Regulations on Highway Maintenance, final report prepared for National Cooperative Highway Research Program, Transportation Research Board. Department of Chemical Engineering, Auburn University. May.

U.S. Army Corps of Engineers, New England Division. 1994. Guide to Permit Applications.

U.S. Department of Transportation (USDOT), Federal Highway Administration. 1991. Smith Creek Parkway and Downtown Spur Wilmington, North Hanover County, North Carolina, State Project No. 8.22 50101, U-92 Federal Project No. M-5851(2), Administrative Action, Final Supplemental Environmental Impact State. 15 July.

____. 1994. Mon/Fayette Transportation Project From I-68 in Monogalia County, West Virginia to SR43 (formerly the Chadville Demonstration Project) in Fayette County, Pennsylvania, Final Environmental Impact Settlement/ Section 4(f) Evaluation, Section 404 Permit Application. July 14.

U.S. General Accounting Office (USGAO). 1994. *Highway Planning: Agencies are Attempting To Expedite Environmental Reviews, But Barriers Remain*, report to the Chairman, Subcommittee on Transportation, Committee on Appropriations, U.S. House of Representatives, GAO/RCED-94-211. Washington, DC. August.