Journal of Agricultural and Applied Economics, 42,1(February 2010):57–68

What Explains the Incidence of the Use of a Common Sediment Control on Lots with Houses Under Construction?

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To analyze compliance with one aspect of the regulation of stormwater discharge, we estimate a random-utility model of the probability that a builder uses a silt fence to control sediments on a lot with a house under construction in an urbanizing county of South Carolina. The probability increases if the builder is responsible to the subdivision's developer or if a homeowners association exists. The probability also increases as the cost to install a silt fence decreases or the number of houses under construction per built house in a subdivision increases. The results can help county officials target inspection to improve compliance.

Key Words: compliance with regulation, erosion and sediment control, filter fabric, management of stormwater runoff, random-utility model, silt fence, storm water pollution prevention plan

JEL Classifications: Q01, Q24, Q53, Q58

Background

Urbanization of land use is increasingly common in the United States. The area of developed land—urban, built-up, and rural transportation land—increased 47.4%, from 72.8 million acres to 107.3 million acres during 1982–2002 in the 48 contiguous states of the United States (NRCS, 2004). Land development apparently accelerated during 1982–2002 in the lower 48 states; the area of developed land increased 18.8% during 1982–1992 and then 24.0% during 1992–2002 (NRCS, 2004). Although land-use urbanization accompanies economic growth, the process of land-use conversion, particularly the removal of vegetation and disturbance of proportionally large areas of soil, can adversely affect aquatic environments.

In the United States, deposition of eroded sediments impaired 13.2% of assessed rivers and streams in 1998 (EPA, 2000) and 12.1% of assessed rivers and streams in 2000 (EPA,

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We are grateful to people at the Stormwater Division of Richland County Department of Public Works for their support and help with accessing data. John Cloyd, Richland County Assessor, provided information about dates of completion of house construction for seven properties. Shawn Loew and Kevin Pulis gathered preliminary data. Three of us received financial support for this research from the Natural Resource Conservation Service, USDA through Grant Agreement No. 69-4639-1-0010. Participants at a conference on Changing Land Use and the Environment in Greenwood, SC during February 2005 insightfully commented on preliminary results. Mary Ruth McRae and other attendees of a session at the 76th Annual Conference of the Southern Economic Association in Charleston, SC on November 20, 2006 also gave useful feedback. Kenneth Train and three anonymous reviewers made numerous helpful comments.

2002). Sedimentation also impaired nine percent of assessed lakes, reservoirs, and ponds in 2000 (EPA, 2002). Construction sites within developed land areas, urban stream banks without adequate vegetation, and undeveloped areas under development were important sources of these sediments (EPA, 2002).

The U.S. Environmental Protection Agency (EPA) regulates discharge of stormwater from construction sites. As required by 1987 amendments to the Clean Water Act (CWA), the EPA in November 1990 promulgated Phase I of a comprehensive national program to address stormwater discharges. Phase I requires construction operators to obtain coverage under a National Pollutant Discharge Elimination System (NPDES) permit for discharge of stormwater from sites where "large" construction activities occur, i.e., disturb at least five acres of land or disturb less than five acres but are parts of larger common plans or sales that disturb at least five acres (EPA, 2005, pp. 1–2, and 1997). These activities include grading, clearing, excavating, and other earth-moving processes. As required by the same amendments to the CWA, the EPA in December 1999 promulgated Phase II of the NPDES Stormwater Program. Phase II expanded the requirement of permit coverage to operators of sites where "small" construction activities occur, i.e., disturb at least one acre of land (EPA, 2005, pp. 1–2, A-2, and A-3). Regardless of Phase I or II, construction operators—the developer and all contractors—must develop and implement stormwater pollution prevention plans (SWPPPs) to obtain permit coverage from NPDES permitting authorities (EPA, 2005, p. 2; EPA, 1997; Sadler, 1998, pp. 17–18). Phases I and II also require counties, cities, and towns that operate municipal separate storm sewer systems (MS4s) to obtain coverage under an individual NPDES permit to discharge stormwater runoff from their conveyance system of drains, pipes, and ditches (EPA, 2009). The regulated municipalities must develop programs to control stormwater runoff from construction sites within their jurisdictions (EPA, 2009).

Stormwater pollution prevention plans must include locations and descriptions of erosion and sediment controls (ESCs) that must be installed prior to construction and maintained in a timely manner during construction until final stabilization of the site (Sadler, 1998, pp. 11–17 and 23). ESCs restrain "solid material, both mineral and organic, during a land disturbing activity to prevent its transport out of the disturbed area by means of air, water, gravity, or ice" (DHEC, 2003, Appendix A, p. 9). In these plans, one of the most frequently specified ESCs at construction sites is a silt fence, or filter fabric (Figure 1 and Paterson, 2000, p. 351).

Previous Research

In spite of regulations, silt fences and other commonly specified erosion and sediment controls (ESCs) are often not installed during construction of subdivisions. For example, silt fences were not installed in 33% of the instances that were specified in ESC plans for construction sites in North Carolina in 1989 (Paterson, 2000, p. 351). Sediment traps were not observed in 86% of the instances that were specified in ESC plans for construction sites in Greenville County, South Carolina in 2001 (Johns and Gillespie, 2003). Lack of required ESCs was particularly evident after the infrastructural phase of construction (Loew, Haselbach, and Meadows, 2004).

Researchers have extensively studied factors that explain whether farmers adopt certain management practices that conserve soil (e.g., Fuglie, 1999; Lynne, Shonkwiler, and Rola,

Figure 1. Use of a Silt Fence on a Residential Lot Under Construction in Study Area

1988; Paudel et al., 2008; Soule, Tegene, and Wiebe, 2000) and how government can promote conservation (e.g., Setia and Osborn, 1989) in the United States However, the use of erosion and sediment controls (ESCs) for nonagricultural activities that disturb land has not been well studied. In a seminal paper, Burby and Paterson (1993) analyzed, among other things, the effects of site characteristics, capacity and commitment of developers, and the enforcement system on the degree to which sediment traps were actually installed as specified in approved ESC plans at construction sites during the summer of 1989 in North Carolina. One important finding was that the frequency of inspections by regulators improved compliance (Burby and Paterson, 1993, p. 764). However, the dependent variable in their model of compliance was a percentage. In such models that are estimated with least-squares, predicted compliance can exceed 100% or fall below 0% and marginal effects of exogenous variables are unrealistically constant, even near 100% and 0% compliance.

Loew, Haselbach, and Meadows (2004) argued that installation of a silt fence on a lot during house construction appeared to be strongly and negatively related to a change before construction in the lot's ownership from the developer to an unaffiliated builder or future homeowner. Of course, the strength and significance of any possible effect of ownership change on the use of filter fabric should be estimated with a statistical model and one that also incorporates other possible determinants. In general, characteristics of the lot, house under construction, and subdivision in which the lot is located might affect the benefits and costs, both psychological and financial, to a builder of complying with the stormwater pollution prevention plan and, thus, using a silt fence.

Our purpose in this paper is to analyze the magnitude and significance of the effects of a number of these characteristics on promised silt-fence use. To this end, we substantially augment data from Loew, Haselbach, and Meadows (2004) and use the data to estimate a logit model of the probability that a builder uses filter fabric on a particular lot. Information about the relative importance of determinants of promised use of a silt fence can help government officials to focus inspection on certain types of lots, houses, or subdivisions during construction and, if necessary, revise regulation of dischargers of stormwater from residential construction sites.

Socio-Economic Model

Our theoretical model of silt-fence use is based on the following assumptions and facts. A builder cares about profits, his or her business reputation, and the neighborhood where he or she constructs a particular house.[1] The builder's monetary costs of silt-fence use are primarily those for installation. His expected financial costs of nonuse of silt fence are primarily the expected costs of cleanup and the expected value of any fine or additional bond payments. Soil that erodes from the builder's lot and becomes sediment on nearby lots, streets, and sidewalks can hurt the builder's reputation and neighborhood. Thus, if the builder uses a silt fence, his profits decrease by the cost of silt-fence installation but his reputation and the neighborhood's welfare remain intact. If the builder does not use a silt fence, he avoids the cost of installation but his expected profits decrease by the cost of any cleanup or penalty. Moreover, his reputation and the neighborhood's welfare decrease, to some extent, if he does not use a silt fence.

In formal terms, profits (π) of a builder decrease with the costs (C) of the use of a silt fence on a lot and with cleanup, fines, or other costs (F) for noncompliance. That is, $\pi(C, F)$ and $\pi_C < 0$ and $\pi_C < 0$ and $\pi_F < 0$. Costs of filter-fabric use depend positively on the lot's perimeter (L), i.e., $C(L) > 0$ and $C_L > 0$. Installation of a silt fence reduces, if not eliminates, off-site deposition of eroded soil, i.e., $X\langle C(L) > 0\rangle < X(C = 0)$. The off-site deposition of eroded soil from a lot increases with the disturbed area (A) within the lot, i.e., $X_A > 0$, and $X(A) \geq 0$.

[1] An anonymous reviewer pointed out the possible importance of other-regarding preferences, a subject of growing interest among economists (e.g., Cox, Friedman, and Gjerstad, 2007; Lynne, 2006).

The builder's reputation (R) can be bad, neutral, or good, i.e., $R(X, I, S) \in (-\infty, \infty)$. The reputation decreases with sediment that is eroded from the lot (X), i.e., $R_X < 0$, and increases with positive information of residents (I), i.e., $R_I > 0$. Increases in the degree to which the residents are socially connected (S) amplify the builder's reputation. That is, $R_S > 0$ if $R > 0$, $R_S = 0$ if $R = 0$, and $R_S < 0$ if $R < 0$.[2] Increases in the degree to which the residents are organized also amplify the negative marginal effect of off-site accumulated soil on reputation, i.e., $R_{SX} < 0$.

The state of the neighborhood where the builder works can also be bad, neutral, or good, i.e., $N(X, S) \in (-\infty, \infty)$. The well-being of the neighborhood decreases with off-site accumulation of eroded soil, i.e., $N_X < 0$. An increase in the solidarity of residents of the subdivision where the builder works improves the welfare of the neighborhood, i.e., $N_S > 0$. Increases in off-site deposition of eroded soil from a lot reduce the marginal effects of a subdivision's social connectivity on the neighborhood's welfare, i.e., $N_{SX} < 0$.

Increases in off-site deposition of eroded soil from a lot with a house under construction or from all such lots per occupied house in a subdivision raise the probability that a resident is adversely affected by the sediment and, thus, complains to her neighbors, the builder, or regulatory authorities. Residents who are organized are also more likely to monitor a builder and complain about dirtied sidewalks, streets, or adjacent yards. If a builder works for a developer or is the developer, he is also more likely to clean up soil that erodes off the lot for lack of a silt fence. Thus, the probability (p) that a builder incurs financial costs for cleanup or fines (F) increases with off-site deposition of eroded soil from the lot (X), off-site deposition of eroded soil from all lots with houses under construction per household in the subdivision (H), the degree to which residents are organized (S), and the extent to which the builder is responsible to the developer (D). That is, $0 \leq p(D, H, S, X) \leq 1$, $p_D > 0$, $p_H > 0$, and $p_S > 0$, and $p_X > 0$. The probability of cleanup or penalty is zero if a silt fence is installed, i.e., $p\langle D, H, S, X(C > 0)\rangle = 0$.

The builder's utility depends positively on profits, business reputation, and the welfare of the neighborhood where he works, i.e., $U\langle \pi(C, F), R(X, I, S), N(X, S)\rangle$, $U_\pi > 0$, $U_R > 0$, and $U_N > 0$. The builder's expected utility of his **u**se of a silt fence, $E(U^u)$, is

$$E(U^u) = U\langle \pi(C(L) > 0, F = 0), R(X^u, I, S), N(X^u, S)\rangle,$$

in which $X^u \equiv X\langle C(L) > 0\rangle$.

The builder's expected utility of **n**onuse of a silt fence, $E(U^n)$, equals the sum of the expected utilities of nonuse when the builder does and does not pay for cleanup or penalties. That is,

$$E(U^n) = p(D, H, S, X^n) \cdot U\langle \pi(C = 0, F > 0), R(X^n, I, S), N(X^n, S)\rangle + \left(1 - p(D, H, S, X^n)\right) \cdot U\langle \pi(C = 0, F = 0), R(X^n, I, S), N(X^n, S)\rangle,$$

in which $X^n \equiv X\langle C = 0\rangle$. The builder's decision rule to use a silt fence is, in symbols, $E(U^u) > E(U^n)$ or, equivalently,

$$U\langle \pi(C(L) > 0, F = 0), R(X^u, I, S), N(X^u, S)\rangle - U\langle \pi(C = F = 0), R(X^n, I, S), N(X^n, S)\rangle > p\left(U\langle \pi(C = 0, F > 0), R(X^n, I, S), N(X^n, S)\rangle - U\langle \pi(C = F = 0), R(X^n, I, S), N(X^n, S)\rangle\right).$$

In words, the builder uses a silt fence if he prefers to protect his reputation and the neighborhood's well being but incur the costs of installation rather than incur the expected costs of cleanup or any penalty for non use.

Econometric Model and Procedures

To transform theory into an estimable model (e.g., Train, 2003), let $E(\tilde{U}_t^i) = \bar{\bar{U}}_t^i + \tilde{\upsilon}_t^i$, $i = u$ for **u**se or n for **n**on-use of silt fence and $t = 1, \ldots,$ or T for a particular lot with a house under construction. The term $\bar{\bar{U}}_t^i$ represents the deterministic and knowable mean, from the point of view of the researcher, of the expected utility of choice i on lot t. The term $\tilde{\upsilon}_t^i$ represents independently distributed random, but

[2] $R(X, I, S) = r(S)g(X, I)$, $r(S) > 0$, $r'(S) > 0$, and $g(X, I) \in (-\infty, \infty)$ is one specification of $R(X, I, S)$ in which an increase in S amplifies the builder's reputation.

unobservable, factors that have, on average, no effect on the expected utility of choice i at lot t. Each term has a "~" because each must be subsequently transformed. Given the expected utilities, the probability in the researcher's mind that a builder uses a silt fence on a particular lot t is

$$P_t = \Pr\left(\tilde{\bar{U}}_t^u + \tilde{\upsilon}_t^u > \tilde{\bar{U}}_t^n + \tilde{\upsilon}_t^n\right) = \Pr\left(\tilde{\upsilon}_t^u - \tilde{\upsilon}_t^n > \tilde{\bar{U}}_t^n - \tilde{\bar{U}}_t^u\right)$$
$$= \Pr\left(\tilde{\upsilon}_t^n < \tilde{\bar{U}}_t^u - \tilde{\bar{U}}_t^n + \tilde{\upsilon}_t^u\right).$$

In light of the theory and available data, let $\tilde{\bar{U}}_t^i = \tilde{\beta}_1^i + C_t^i\tilde{\beta}_2 + Z_{3,t}\tilde{\beta}_3^i + \cdots + Z_{K,t}\tilde{\beta}_K^i$, in which $C_t^u > 0$ is the monetary cost of silt-fence installation and $C_t^n = 0$. $Z_{3,t}, \ldots, Z_{K,t}$ are K-2 lot, house, or subdivision variables that affect the amount of eroded soil that is deposited away from the lot and adversely affects residents, the builder's reputation, or the probability that the builder must incur costs for noncompliance. $\tilde{\beta}_1^i$ is a choice-specific constant that represents the nonzero mean effect of omitted variables on the expected utility of use or nonuse of a silt fence. $\tilde{\beta}_2$ is the marginal expected utility of money for installation of a silt fence. $\tilde{\beta}_3^i, \ldots,$ and $\tilde{\beta}_K^i$ are marginal effects of corresponding exogenous variables on the expected utility of the i-th choice.

Assume that $\tilde{\upsilon}_t^i$ is identically distributed so that $\mathrm{var}(\tilde{\upsilon}_t^i) = \sigma_1^2 \forall t$. Furthermore, assume that $\tilde{\upsilon}_t^i$ is an extreme-value random variable with variance $\sigma^2\pi^2/6 = \sigma_1^2$ (Train, 2003, p. 44). If $E(U_t^i) \equiv E(\tilde{U}_t^i)/\sigma$, $\beta_2 \equiv \tilde{\beta}_2/\sigma$, $\beta_k^i \equiv \tilde{\beta}_k^i/\sigma$ for $k \neq 2$, $\bar{U}_t^i \equiv \tilde{\bar{U}}_t^i/\sigma$, and $\upsilon_t^i \equiv \tilde{\upsilon}_t^i/\sigma$, then

$$E(U_t^i) = \bar{U}_t^i + \upsilon_t^i = \beta_1^i + C_t^i\beta_2 + Z_{3,t}\beta_3^i + \cdots + Z_{K,t}\beta_K^i + \upsilon_t^i.$$

Given that υ_t^i is extreme value but has a variance of $\pi^2/6$, which is customary (Train, 2003, p. 44), the probability that the builder uses a silt fence on lot t is logistic, namely $P_t = \frac{\exp(\bar{U}_t^u)}{\exp(\bar{U}_t^n) + \exp(\bar{U}_t^u)}$. If $\bar{U}_t \equiv \bar{U}_t^u - \bar{U}_t^n$ and $\beta_k \equiv \beta_k^u - \beta_k^n$ for $k \neq 2$, then $P_t = \frac{\exp(\bar{U}_t)}{1 + \exp(\bar{U}_t)}$, in which $\bar{U}_t = \beta_1 + C_{t_g}^u\beta_2 + Z_{3,t_g}\beta_3 + \cdots + Z_{K,t_g}\beta_K = \boldsymbol{\beta}'X_t$.

Let $y_t = 1$ for use or 0 for nonuse of a silt fence on lot t. The unconstrained likelihood function is $L = \prod_{t=1}^{T} (P_t)^{y_t}(1 - P_t)^{1-y_t}$. The vector $\boldsymbol{\beta}$ was estimated by the Newton-Raphson algorithm in the LOGIT procedure of STATA Version 9.2 to maximize L and obtain $\hat{P}_t \forall t$ (StataCorp, 2005). The estimator, $\hat{\boldsymbol{\beta}}$, is consistent, asymptotically efficient, and asymptotically normally distributed (Greene, 2003, pp. 476–480). A robust and consistent estimator of the asymptotic variance-covariance of $\hat{\boldsymbol{\beta}}$ is $\left(\sum_{t=1}^{T} \hat{P}_t(1-\hat{P}_t)X_t X_t'\right)^{-1} \left(\sum_{t=1}^{T} (Y_t - \hat{P}_t)^2 X_t X_t'\right) \left(\sum_{t=1}^{T} \hat{P}_t(1-\hat{P}_t)X_t X_t'\right)^{-1} = est.asy.V(\hat{\boldsymbol{\beta}})$ (Train, 2003, pp. 204–205).[3]

The scaled R^2, or $1 - \left(\frac{\ln L_u}{\ln L_c}\right)^{-(2/N)\ln L_c}$, is a relatively new and intuitively interpretable measure of the goodness of fit of dichotomous dependent variables (Estrella, 1998, p. 198). In this formula "L_c" refers to the maximized value of the **c**onstrained likelihood function in which K-1 parameters, all except the constant, are fixed at 0 and "L_u" refers to the maximized value of L, the **u**nconstrained likelihood. Let $\boldsymbol{b}$ be the $K \times 1$ vector of parameter estimates and $\boldsymbol{R} = [\mathbf{0}\ \mathbf{I}_{K\text{-}1}]$ be a K-1 $\times$ K matrix. A Wald statistic, $W = \boldsymbol{b}'\boldsymbol{R}'\left[R \cdot est.asy.V(\hat{\boldsymbol{\beta}}) \cdot R'\right]^{-1}\boldsymbol{Rb}$, is used to test whether at least one exogenous variable, other than the intercept, affects the probability of silt-fence use. Given the null hypothesis that nothing but the constant matters, this statistic is asymptotically distributed as a Chi-square random variable with K-1 degrees of freedom (Greene, 2003, p. 487).

Data Sources and Variables

Information about the presence of silt fences comes from an ocular census during September 2003 of all, namely 184, single-family lots with houses under construction in 14 subdivisions in Richland County (Loew, Haselbach, and Meadows, 2004). The mean size of the surveyed lots in a subdivision ranged from 0.075 to 0.75 of an acre. The mean sales price of surveyed lots with the eventually constructed houses ranged from \$79,599 to \$463,290. A predominantly

[3] Possible correlation across lots within a subdivision is one justification for estimation of robust standard errors (Train, 2009).

Table 1. Descriptive Statistics (n = 184) for Silt-Fence Use, Lots, Houses, and Subdivisions

VARIABLE	Mean	Std. Dev.	Minimum	Maximum
SILTFENCE (= 1 if silt fence was used on a lot with a house under construction)	0.272	0.446	0	1
RESDEVEL (= 1 if the builder of the house under construction in a subdivision was the developer or an affiliate of the developer)[a]	0.185	0.389	0	1
COSTSF (dollar cost of installation of silt fence on the lot)[b]	233	63.4	85.5	559
HFLOORSPS (100 ft^2 of heated floor space per story of the house under construction)[b]	14.1	3.20	8.21	18.6
HOA (= 1 if the lot was in a subdivision with a home owners association)	0.554	0.498	0	1
UNCONPBH (number of houses under construction per built house in the subdivision)	0.260	0.236	0.0260	1.13
SUBDAGE (years since the first house in the subdivision was built)	3.91	3.05	0.345	13.8

[a] This variable equals the proportion of lots that were owned by an affiliate of the developer for 18 of the 184 lots.
[b] These variables equal the mean installation cost and heated floor space per story of houses under construction in the subdivision where each lot was located for 112 of the 184 lots.
Sources: Loew, Haselbach, and Meadows (2004) and the Assessor's Office (2008).

urban area in central South Carolina, Richland County had 320,779 people, 756.41 sq. miles of land, and, thus, a population density of 424 people per sq. mile in 2000 (Census Bureau, 2009a).

Although county-approved storm water pollution prevention plans indicated silt fences were required at all 184 lots, they were observed at only 50 lots. SILTFENCE, the dependent variable of our logit model, equals one if a lot with a house under construction had any required silt fence and zero if it did not (Table 1). Loew, Haselbach, and Meadows (2004) recorded only the subdivision's name, but not a lot number or street address, to identify the 184 observations.

To ascertain which specific lots were most likely observed in the ocular census, we first used maps and online aerial photographs from the Assessor's Office (2008) of Richland County to determine the names of all streets within each of the subdivisions. We then examined the online record of each address and requested through email any missing information from the Assessor's Office to determine the date when, if ever, each lot in a subdivision was listed as "improved" for the first time and the year when, if ever, a house was built on the lot. We then noted the address of each lot that was listed as "improved" for the first time at least one week after the date of the ocular survey and put the addresses that met this criterion in chronological order from the earliest to the latest date of the listing. We listed houses that were under construction at least a week, instead of one day, after the survey to allow for lags between completion of construction and official recognition of it and because construction of a house can appear to be finished from the outside even though minor tasks have not been finished on the inside. Finally, we selected the number of the chronologically ordered addresses equal to the number of lots that were counted in the survey as having had houses under construction.[4]

The Assessor's Office's (2008) online records for the selected addresses were used to create the independent variables of the model. For example, RESDEVEL, an empirical counterpart of *D* in the theoretical model,

[4] For example, if 20 lots with houses under construction were observed in a particular subdivision, we selected the 20 addresses of lots that had been listed as "improved" for the first time closest to the eighth day after the ocular census.

equals one for a lot if the lot's owner during construction of the house was the developer of the subdivision where the lot was located and, thus, the builder worked for or was the developer. In two of the 14 subdivisions, all lots with houses under construction—a total of 31—were still owned by the developer. In contrast, RESDEVEL equals zero for a lot if the lot's owner during construction was not the developer but, instead, was an independent construction company or the future home owner(s). In other words, RESDEVEL equals zero for a lot if the builder was not the developer and either constructed the house for sale or under contract with the future homeowner. In 11 of the 14 surveyed subdivisions all lots with houses under construction—a total of 135—were not owned by the developer or an obvious affiliate.

In the remaining subdivision, the builders of 15 of the 18 houses under construction owned the lots and were not affiliated with the developer. However, the construction company of the three other houses was an affiliate of the developer. Three of the 18 lots also had silt fences. Were the three lots with silt fences among the 15 that were owned by unaffiliated builders, or exactly the three that were owned by the developer's affiliate, or owned by a mixture of independent and affiliated builders? This question cannot be answered for lack of addresses to identify the three lots with silt fences. As a result, RESDEVEL for each lot equals 1/6 (= 3/18), which is the proportion of the surveyed houses that were being built by the developer's affiliate.

Online information about the perimeter of each lot was collected to estimate the cost of silt-fence installation (Assessor's Office, 2008). Assume that a builder installed or would have installed filter fabric on one-half of a lot's perimeter. Expenses for 3 ft. high polypropylene filter fabric, labor to install it, overhead, and profit were \$0.76 and \$1.30 per linear foot under ideal and adverse conditions in Columbia, South Carolina in January 2004 (Murphy, 2005, p. 37; Waier, 2003 p. 53). COSTSF, C in the theoretical model, equals one-half the perimeter of the lot with a house under construction multiplied by \$1.03, the mean expense per linear foot of silt-fence installation (Table 1).

HFLOORSPS, the final lot-specific variable, equals the ratio of the heated floor space (100 ft^2) to the number of stories of the house under construction on a particular lot (Table 1). Also created with online information from the Assessor's Office (2008), HFLOORSPS empirically approximates the theoretical variable A, the disturbed area within a lot under improvement.

An individual value for installation costs and heated floor space per story was accurately matched with a one or zero for the presence of a silt fence on 72 lots in five subdivisions because the surveyed lots in each of these subdivisions either all had silt fences or all lacked them. However, an individual value for COSTSF and HFLOORSPS could not be accurately matched with a value of SILTFENCE for the other 112 lots because each of the nine subdivisions where these lots were located had some lots with and some lots without silt fences. In lieu of an accurate method to match individual values, COSTSF equals, for each of these 112 lots, the mean cost of silt-fence installation on lots under improvement in the subdivision where the lot was located. For the same reason, HFLOORSPS equals, for each of the 112 lots, the mean of the ratios of heated floor space to the number of stories of the houses under construction in the subdivision where the lot was located.

Civil penalties for violation of the NPDES Stormwater Program and South Carolina's Sediment, Erosion, and Flood Control Program could have amounted to as much as \$10,000 and \$1,000 per day in late 2003 (DHEC, 2001). However, there is no evidence that a builder was penalized for noncompliance with the stormwater pollution prevention plan in Richland County during late 2003. Recall that the probability of a fine is part of the probability that a builder incurs financial costs for nonuse of a silt fence, or $p(D, H, S, X^n)$ in the theoretical model. A minor reason why the probability of a fine approached zero was that inspectors typically allowed a builder to solve a problem before penalizing him or her for noncompliance. A major reason why the probability of a fine approached zero for nonuse of a silt fence was that county officials usually did not inspect a subdivision after the infrastructural phase of development.

What might explain why county officials rarely inspected when houses were under construction? Richland County had only seven stormwater managers who had authority to inspect construction sites for compliance with SWPPPs and at most three of them could issue tickets (Valavala, 2006). The county issued 2,951 permits in 2003 and an estimated 3,340 permits in 2004 to build new privately-owned residential units, 2,896 and 3,246 of which were single-family units (Census Bureau, 2009b). If houses and other residential buildings took, on average, one year to complete, these officials had approximately 3,000 residential lots to inspect per year. The same officials also had to review and approve erosion and sediment control plans and other aspects of the SWPPPs in advance for each construction site, residential and commercial too.

Richland County was also required to have and had an individual NPDES permit to discharge runoff from its medium-sized municipal separate storm sewer system. As a consequence, the same officials were required to develop and implement programs that addressed the following issues, in addition to management of runoff from sites during construction: 1) control of runoff from sites after construction; 2) management of roadway runoff; 3) detection and elimination of illicit discharges; 4) regulation of sites that engaged in industrial activity other than construction; 5) application of pesticides, herbicides, and fertilizers on urban landscapes; 6) impacts on water quality of flood control; 7) discharges and runoff from landfills, wastewater treatment plants, and other municipally owned operations; 8) impacts on water quality of treatment, storage, or disposal of hazardous wastes; and 9) public education and outreach (DHEC, 2005). These regulatory demands on the time of Richland County's stormwater officials help to explain why the expected value of a penalty for nonuse of a silt fence was close to zero during late 2003.

The Assessor's Office (2008) was also the source of information about characteristics of the subdivisions in which the surveyed lots were located. HOA equals one for all lots with houses under construction, 102 of them, in the nine subdivisions that had a home owners association (Table 1). A subdivision had a home owners association if property tax records indicated that an association owned a pool, clubhouse, pond, or common area. Each of the fourteen subdivisions was also visited in August 2005 to check for the presence of a home owners association. HOA is a measure of variable S in the theoretical model, the social connectivity within a neighborhood.

For each surveyed lot in a subdivision, UNCONPBH is the number of houses under construction per house already built in the subdivision. For each surveyed lot there were, on average, four houses already built. UNCONPBH is variable H in the theoretical model.

SUBDAGE equals the number of years from the day that the first house in the subdivision was listed as improved for the first time in the Assessor's records to the particular day in September 2003 when the ocular survey was conducted. Thus, SUBDAGE is, for each lot with a house under construction in a particular subdivision, the subdivision's age. SUBDAGE ranged from three months to almost 14 years and is a proxy for variable I in the theoretical model.

Results

Three preliminary specifications of the model were estimated to test for heteroskedastic random errors across groups of subdivisions. Statistical evidence indicated no group-wise heteroskedasticity.[5] Parameter estimates, robust standard errors, z-statistics, p values, and sample-mean marginal and discrete effects of the variables in the homoskedastic model are presented in Table 2. The scaled R^2 is 0.545; the model "explains" 54.5% of the information about SILTFENCE. Furthermore, 87.5% of the estimated probabilities of silt-fence use on a particular lot either exceed 0.5 for lots where a builder actually used a silt fence or are less than 0.5 for lots where he did not. The p-value

[5] These preliminary results are available upon request from the senior author.

Table 2. Logit Model of the Probability of the Use of Silt Fence on a Residential Lot

VARIABLE	Parameter Estimate	Robust Standard Error	z-statistic	Two-sided p-value	Mean of Marginal or Discrete Effects[a]
CONSTANT	−6.234	2.126	−2.93	0.003	
RESDEVEL	3.488	1.057	3.30	0.001	0.498
COSTSF	−0.010	0.006	−1.70	0.090	−0.000898
HFLOORSPS	0.129	0.101	1.29	0.198	0.0119
HOA	2.940	0.991	2.97	0.003	0.271
UNCONPBH	5.234	1.633	3.20	0.001	0.479
SUBDAGE	0.329	0.116	2.83	0.005	0.030

[a] The marginal effect of the k-th continuous variable on the estimated probability of silt-fence use on the t-th lot is $\frac{\partial \hat{P}_t}{\partial X_{t,k}} = \hat{\beta}_k \hat{P}_t(1 - \hat{P}_t)$. The discrete effect of the k-th dummy variable on the estimated probability of use at the t-th lot is $\hat{P}_{kt} - \hat{P}_{-kt} = \frac{\exp(X'_{-kt}\ \hat{\beta}_{-k} + \hat{\beta}_k)}{1 + \exp(X'_{-kt}\ \hat{\beta}_{-k} + \hat{\beta}_k)} - \frac{\exp(X'_{-kt}\ \hat{\beta}_{-k})}{1 + \exp(X'_{-kt}\ \hat{\beta}_{-k})}$.

The natural log of the (pseudo) likelihood function is −54.94439.

associated with the Wald statistic of 65.53 for the test of nonzero slopes is less than 0.001. Hence, the logit model predicts the probability better than the sample proportion does.

The estimated parameters of the three lot-specific variables have expected signs and the positive or negative effects of the variables statistically matter at various levels of significance (Table 2). The probability that a builder uses a silt fence on a lot with a house under construction is 49.8 percentage points higher, on average, if the builder is affiliated with or is the developer. The probability approximately decreases 0.898 percentage points, on average, for a \$10 increase in the cost of silt-fence installation. The evidence for a positive effect of HFLOORSPS exists if $\alpha = 0.10$. In particular, the probability of use approximately increases 1.19 percentage points, on average, for a 100 ft^2 increase in the heated floor space per story of the house under construction.

The three characteristics of the residential development are also statistically significant (Table 2). The probability that a builder uses filter fabric on a lot is 27.1 percentage points higher, on average, in a subdivision with a home owners association than in a subdivision without one. The probability increases about 4.79 percentage points, on average, if the number of houses under construction per house already built in a subdivision increases by 10 hundredths, say from 0.50 to 0.60. The probability is 3.01 percentage points higher in a subdivision that is one year older.

Discussion

The results are broadly consistent with the socio-economic model. For example, as the mean financial costs of installation increase, the builder is less likely to use a silt fence because the costs of use increase relative to costs of nonuse. In contrast, the degree to which costs of the erosion and sediment control requirements added to total development costs did not affect the degree to which promised sediment traps were installed in North Carolina in 1989 (Burby and Paterson, 1993).

Monetary costs of installation tend to increase with lot size. In particular, the size of a lot with a house under construction is positively, strongly, and significantly correlated with the cost of silt-fence installation on the lot ($r = 0.948$, $t = 40.4$) and also with the heated floor space per story ($r = 0.531$, $t = 8.46$). As a result, lot size was insignificant as an explanatory variable in preliminary versions and excluded in the final version of the model.

If the builder works for the developer who still owns a particular lot, he is more likely to be responsible to and monitored by the developer. If the builder is the developer who still owns the lot, he is more likely to remember his financial responsibility for noncompliance with the storm water pollution prevention plan (SWPPP). However, if a builder purchases the lot from a developer or is hired by a future homeowner, the builder might not file a separate SWPPP or be aware of the original one and, in either case, is less likely to be monitored by the developer.

As the mean heated floor space per story of a house under construction increases, the amount of disturbed soil from the lot tends to increase because surface areas of foundations grow with floor space. If the amount of disturbed soil per lot increases, the potential amount of eroded sediments on sidewalks, streets, and adjacent yards increases and so do potential damages to a builder's reputation and the neighborhood, both the residents and physical environment. If these expected costs of nonuse increase, *ceteris paribus*, the builder is more likely to use a silt fence.

Residents are usually more organized and might have a greater financial and emotional stake in a neighborhood if there is a home owners association. An increase in the number of lots with houses under construction per built and, typically, per occupied house in a subdivision implies an increase in the likelihood that a resident would experience adverse impacts of soil that would erode onto sidewalks, streets, or adjacent yards. A resident whose social connectivity or experience of potential damage grows would be more likely to complain to her neighbors, inspectors, and a builder who would otherwise not install a silt fence. As a result, the builder's awareness of his potential damage to the neighborhood and expected loss of reputation would likely be greater in a subdivision where a home owners association exists or relatively many houses are under construction per resident. In response, the builder would be more likely to install a silt fence.

An increase in the age of a subdivision implies two possible changes that affect silt-fence use. First, the social connectivity of neighbors might increase because residents get to know each other over time. As residents get to know each other over time, they might be less likely to tolerate eroded soil that would accumulate on surrounding roads, nearby sidewalks, and adjacent yards. Second, a developer and future homeowners learn about builders' reputations as time passes in the subdivision. The more reputable the builder, the more environmentally and socially responsible he might be and the more likely he would comply with this aspect of the SWPPP.

Implications for Research and Policy

The socio-economic model undoubtedly simplifies the reality of a builder's use of a silt fence on a lot with a house under construction. Nonetheless, the empirical results are consistent with even simpler models in which the builder considers the effects of silt-fence use on his profits and reputation or his profits and the neighborhood where he works. In either case, our results suggest that, in addition to a builder's relationship with government inspectors (Burby and Paterson, 1993), his relationships with the developer and neighborhood and the relationships among neighbors matter for compliance. Identification and measurement of reliable predictors of how much a builder cares about the neighborhood where he works, independent of his other motives, is important for future research.

The empirical model only partially explains the incidence of silt-fence use and was estimated with data about characteristics of lots and subdivisions in only one fast-growing, urban county of one southeastern state. Whether a developer's sale of a lot to an independent builder or future homeowner reduces the probability of silt-fence use and whether the presence of a home owners association in a subdivision or the age of the subdivision increase this probability in other counties in South Carolina and other states are important, yet-unanswered questions. Also, information about costs of silt-fence installation on a particular lot and the heated floor space per story of the house under construction should be linked with information about the use of a silt fence on the property for all, not just some, lots in future samples. During 2006 Richland County's stormwater officials became certified as SWPPP inspectors and code enforcement officers (Valavala, 2006). Whether the probability of silt-fence use has increased as a result of extra training or the on-site power to issue tickets are other questions with policy relevance.

Our results enable us to suggest that government officials could improve builder compliance with SWPPPs in this county and possibly other similar ones if they target inspections. In particular, inspectors should target subdivisions where the developer has already sold unimproved lots or no home owners association exists. Inspectors should also focus on subdivisions where costs of silt-fence use would be relatively high because lots are relatively large. Compliance could also improve if officials inspect subdivisions where a relatively small number of houses are under construction per occupied house or most residents are newcomers.

[Received July 2007; Accepted September 2009.]

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