Consolidation as a Regulatory Compliance Strategy:Small Drinking Water Systems and the Safe Drinking Water Act

Min-Yang A. Lee and John B. Braden

Department of Agricultural and Consumer Economics
University of Illinois Urbana-Champaign
1301 W. Gregory Drive, Rm. 326, Urbana, IL 61801.
malee2@uiuc.edu

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Abstract

Despite extensive research and policy initiatives to increase the technical, financial, and managerial capacity of small drinking water systems, there has been little research focusing on understanding how consolidation can increase the overall capacity of the drinking water industry. Consolidation of water systems may be a mechanism that increases regulatory compliance by removing poorly performing systems from the industry and replacing inefficient management and/or capital. The US drinking water system is highly fragmented, with over 50,000 Community Water Systems (CWSs), of which the vast majority are classified as "small" by the US Environmental Protection Agency (EPA). A discrete choice model is employed to determine the characteristics shared by small water systems that are acquired. On average, these acquired firms are small, have frequent drinking water violations, are privately-owned, and purchase their water from another system. These results suggest that consolidation may have an important role to play in increasing overall industry compliance with the Safe Drinking Water Act (SDWA).

Key words: Community Water System, Drinking Water, Merger, Consolidation

JEL classification: Q25 , Q53

The Safe Drinking Water Act (SDWA) and it's subsequent amendments in 1986 and 1996 are the major regulations governing the US drinking water industry. The initial SDWA established regulations for 18 drinking water contaminants along with monitoring, reporting, and public notice requirements. The SDWA established three broad classes of drinking water systems, the largest of these classes, Community Water Systems (CWSs), provide drinking water year-round to a fixed customer base. The US drinking water industry is highly fragmented; there are over 50,000 CWSs in the US, over 90 percent of which serve fewer than 10,000 people and are classified as “small” by US Environmental Protection Agency (EPA).

This paper explores the causes of consolidation in the drinking water industry to determine if this type of institutional change can increase the overall capacity of the industry to comply with SDWA regulations. We examine recent mergers of Community Water Systems (CWSs) to determine the characteristics of water systems that are being acquired. Our economic model hypothesizes that acquired systems will have lower management skill, be small, and have relatively low costs of merger. We then estimate our model using data from EPA's Safe Drinking Water Information Systems (SDWIS) supplemented with merger data obtained from state primacy agencies. Our results suggest increasing that regulatory compliance is, in part, driving recent consolidation activity in the industry.

Under the SDWA, water quality and monitoring standards are set at the federal level; however, state-level primacy agencies are responsible for enforcement these regulations. Systems that do not meet the SDWA standards are subject to fines and other penalties from the primacy agencies.

The 1986 SDWA amendments mandated stringent water quality standards and included many regulations that were particularly burdensome for small water systems. Those amendments required EPA to set standards for 83 additional contaminants and set forth technology-based standards for treating contaminants (USEPA 1999). These standards-based regulations may have stifled technical innovation and reduced incentives for alternative means of compliance with regulations.

System performance and small water systems were particular foci of the 1996 SDWA amendments. EPA was directed to improve the technical, managerial, and financial (TMF) capacity of small drinking water systems. TMF capacity building was needed to keep pace with increasingly stringent requirements for drinking water quality. The challenge was especially great for small water systems, which account for a disproportionately large share of SDWA violations (USEPA 1999). The 1996 amendments mandated direct methods of improving compliance, including operator training and certification. EPA was also required to identify treatment technologies that are affordable for small water systems and grant technology "variances" (waivers) when no such technology is available. However, these variances are uncommon (Rubin 2001a). Additionally, the Drinking Water State Revolving

Fund (DWSRF) was established to assist small systems. Departing from traditional regulatory approaches, DWSRF funds may be used for consolidation of water systems in addition to funding infrastructure upgrades or sourcewater rehabilitation.

Indirect methods, such as system consolidation, may also help achieve higher compliance rates. Through consolidation, small systems might achieve economies of scale and improve their technical and financial performance. While researchers have studied potential efficiency gains from consolidation (Shih et al.), we are not aware of any research that has been examined the consolidation as a means to reduce the rate of SDWA violations.

Jaffe, Braden, and Lee review the economic and historical literature concerning mergers and reorganizations in the water industry. Public health concerns, public finance pressures, contractual conflicts, corruption, and transaction costs have all been theorized to provide the impetus to merger. Previous research suggests that privately- and publicly-owned firms may have different motives regarding consolidation. In a set of case studies of consolidation in the drinking water industry, Mann, Dreese, and Tucker found that high performing water systems were being acquired by privately-owned systems, while poorly performing systems were being acquired by municipalities. This finding suggest that private water systems are classical profit-maximizing firms while publicly-held water systems are partners of last resort for struggling water systems.

Currently, many of the largest CWSs are located in urban areas and owned by the municipal government. Federal and State governments also own and operate CWSs, such as those associated with prisons, while Native American tribes commonly own their own CWSs. All of these systems would be classified as publicly-owned [1]. Very small water systems are more likely than most to be privately-owned. Some of these systems serve a single residential complex and are often overseen by a homeowners association and have few, if any, full time employees. They also commonly coexist with a nearby larger, more efficient CWS.

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[1] Many of the remaining large water systems are owned by large firms. These may be publicly traded firms like Aqua American and Artesian Resources, or they may be privately held, like American Water. In either case, these are classified as privately-owned.

These small systems likely were built because developers found it less expensive to construct a stand-alone water system than to connect to an existing system. Operators of these systems may lack the expertise or infrastructure required to fully comply with the SDWA and the financial resources to expand their technical, managerial, and financial capacity.

Many privately-owned water systems, larger ones in particular, are regulated by a commerce or utility commission. Averch and Johnson note that firms facing rate-of-return regulation have an incentive to expand into new markets in order to raise their capital base. While this may explain some horizontal merger activity, regulators typically set post-merger water pricing very carefully in order to reduce this incentive. Regardless of the motivation for acquisition, consolidation is likely to help small systems achieve economies of scale. In this research, we focus on the firm's decision to be acquired or continue independent operations.

From an economic perspective, the production of drinking water is characterized by increasing returns to scale, while transmission through the distribution network displays decreasing returns to scale (Clark and Stevie). Optimal economic water system size requires a balance between the returns to scale in production and distribution. Large systems should be located near major population centers and smaller systems will serve outlying suburban and rural populations with smaller service regions. However, Rubin (2001b) finds that many small water systems are actually located in urban or metropolitan regions and may be located close enough to larger systems for consolidation to be feasible.

Small drinking water systems typically have relatively high costs of providing drinking water; the average small system's per-household infrastructure cost is three times larger than those of large systems (USEPA 1999). A small customer base yielding minimal operating revenues makes funding infrastructure improvements difficult. These infrastructure needs are large; a recent EPA study concluded that the entire drinking water industry faces a \$161B gap in anticipated operating expenses and a \$101B gap in anticipated capital expenses in the next 20 years (USEPA 2002). Small systems also have greater difficulty securing access to financing, although this has been mitigated to an extent by the establishment of the DWSRF. The National Drinking Water Advisory Council (NDWAC) has identified the lack of economies of scale for small CWSs as a factor contributing to unsustainability and encouraged state primacy agencies to use consolidation as a means to achieve these economies of scale (USEPA 2000).

Research on institutions in the water industry has historically focused not on merger, but on the relative efficiency of public and private firms (Feigenbaum and Teeples; Bhattacharyya, Parker, and Raffiee). However, merger and consolidation has recently become a research focus. Castillo et al. use GIS to analyze the feasibility of consolidation from a cost-of-interconnection perspective by identifying small systems in close proximity to larger systems. The costs of merger, either through physical interconnection or satellite management, were low enough for merger to be feasible for a large fraction of small water systems. However, Ottem, Jones, and Raucher find that the distance between small CWSs and a suitable merger partner ranged from approximately 5 miles for systems in metropolitan areas to over 11 miles for systems in rural areas. This finding raises the possibility that systems in rural areas are simply too far apart for merger to be cost effective. Raucher, Harrod, and Hagenstad note that while the potential benefits of consolidation include cost savings and increased regulatory compliance, costs include the physical costs of interconnection as well as a loss of local control. Shih et al. find that consolidation of very small water systems ($<$ 500 people served) with larger systems would result in nationwide efficiency savings of \$417-794 million per year. To date, we are aware of no study that examined actual mergers in order to determine if merger can be an effective compliance strategy.

Behavioral and Econometric Model

We present a simple model of the decision of a drinking water system to exit the business through merger. Because water systems are commonly owned by a municipal government, it may not be appropriate to assume profit maximization as their objective. Economists have long recognized that firms, regulated ones in particular, may not be maximizing profit, but rather revenues, expenses, or manager utility (Williamson; Edwards). Accordingly, we assume that owners of a water system are utility maximizers, and the decision-making process occurs in this framework. We maintain this basic economic assumption for the owners of all firms, public or private. In this framework, CWS owners are similar to consumers making decisions about purchases of durable goods and a Random Utility Model (RUM) of choice readily follows.

Owners of a CWS will choose to be acquired if the utility from acquisition is higher than that of continuing to operate independently. Mathematically, a CWS is acquired if:

$$U_A \geq U_{NA},$$

Where the subscript A denotes an acquired system and the subscripts NA denotes a non-acquired system. We make the standard assumption that utility can be decomposed into observed and unknown (to the analyst) components:

$$V_A + \varepsilon_A \geq V_{NA} + \varepsilon_{NA}$$

Under the assumption that these error terms are independently and normally distributed, the probability that a CWS is acquired can be written as:

$$(1) \qquad P(ACQUIRED) = P[V_A - V_{NA} \geq \varepsilon] = \Phi(X\beta)$$

where $\Phi(\cdot)$ is the cumulative normal distribution (Greene). The variable ACQUIRED takes on a value of 1 if the water system was acquired or 0 if it was not acquired.

Our behavioral model and previous research suggest several hypotheses about the systems most likely to be acquired. Systems that are too small to achieve economies of scale are likely to be acquired for a variety of reasons. These systems may be prone to economic losses and may be using merger to achieve economies of scale. Dewey notes that merger may be a means to transfer physical assets to a more successful firm. In this industry, merger may also be a way for small firms to exit the industry in an orderly manner. Systems with poor SDWA compliance records are also likely to use merger. Merger may be an effective way of attracting better management or upgrading some components of the water supply infrastructure.

Systems with low physical and political costs of completing a merger are more likely to be acquired. These costs should be especially small for CWSs that already purchase water from, and have an established connection to, a nearby system. Similarly, systems that are located closer to a potential partner presumably would incur lower costs of consolidation and be more likely to merge. Rural systems are likely to be located farther from an existing CWSs, reducing the potential for merger. However, these rural systems face lower unit costs of interconnections with fewer buildings, houses, and roads that make pipeline installation expensive. The net effect of ruralness is ambiguous. Compared to privately-owned CWSs, publicly-owned systems may confront a lengthy, expensive political process associated with transferring publicly-owned assets, and therefore be less likely to be acquired. These processes may also require hearings by the state commerce or utility commission, especially when a publicly-owned CWS is acquired by a privately-owned company.

Data

We gathered data on mergers of CWSs from six state primacy agencies in EPA regions 5 and 7: Illinois, Indiana, Iowa, Michigan, Missouri, and Nebraska. The primacy agencies keep data on mergers for different lengths of time; for example, records of merger activity in Illinois span 11 years, while records in Michigan cover only four years. We pool all of the observations across states and years. This information is combined with system characteristics data from EPA's Safe Drinking Water Information System (SDWIS) and county level demographic data from the US Census (Table 1). Mergers are rare events; only

430 of the 6,502 water systems (6.61 percent) were acquired during the period covered by our data.

Economists typically use financial ratios of profitability, debt, or cash flow as explanatory variables to study mergers of publicly-traded firms (Palepu; Espahbodi and Espahbodi). As a whole, these are thought to proxy of suitability for merger or relative strength of a firm. These ratios are unavailable for the drinking water industry, but other measures of merger suitability are available. The EPA's SDWIS database contains information on community water systems, including information on service connections, drinking water violations, ownership, and water source. Service connections (SVC) are the number of distinct billable connections that a water system serves. Systems with few service connections may be less able to achieve economies of scale and, therefore, less likely to achieve the technical, financial, and managerial skills necessary to provide drinking water. We hypothesize that these small systems are more likely to use merger to exit the drinking water industry.

While SDWIS reports SDWA violations in fine detail, we have aggregated those violations into two categories: monitoring/reporting violations and quality violations. Monitoring and reporting violations (MONIT) include failure to adequately test drinking water, file a consumer confidence report, or notify the public of a drinking water quality violation. This may be particularly indicative of managerial underperformance. Quality violations (QUAL) include treatment-type violations and maximum contaminant level violations. They may reflect low technical capacity or infrastructure problems. The USEPA reports the number of violations by a system per year, without reporting information on the severity of the violations. In our analysis, we use the average number of violations committed by a water system per year. We view both types of SDWA violations as generally indicative of low technical, financial, and managerial capacity. We hypothesize that CWSs with more violations of either type are more likely to be acquired than systems with good compliance records. By allowing both types of violation to enter our econometric model separately, we can test for the relative importance of their effect on the probability of merger. Prior to any merger activity, 62.1 percent of small drinking water systems were publicly-owned, while the remaining 37.9 percent were privately-owned. We expect that the political costs of merger are higher, and therefore the likelihood of merger is less, for publicly-owned systems due to the political process required to transfer ownership of publicly-owned assets. We hypothesize that publicly-owned CWSs are less likely to be acquired.

Water systems that purchase water, and therefore have already connected to another system, have lower transactions costs of completing a merger. Approximately 18 percent of the water systems in our sample purchase water (PURCHASE) from another system. We hypothesize that these systems are more likely to be acquired.

We construct two proxy variables to measure the costs of interconnection. Castillo et al. used GIS to identify water systems in close proximity, they then used these distances to calculate costs of interconnection based on per-mile infrastructure costs, allowing the per-mile costs to vary between rural and urban areas. Unfortunately, detailed spatial data are unavailable due to security concerns. We instead use the density of service connections per square mile in each county (DENSITY) as a proxy for the cost of a system merger. In densely-populated counties, the water supply network is more extensive, which would presumably decrease the distances between systems, and therefore the transactions costs of completing a merger. However, in those counties, the per-unit costs of constructing pipelines may also be higher due to an increase in the density of obstacles posed by a more urban environment.

The National Research Council maintains that small systems in rural areas face difficult demographic pressures, including decreasing populations, lower incomes, and higher rates of poverty. Rural systems faced with resource limitations may use merger to comply with SDWA regulations. However, as Rubin (2001b) and Ottem, Jones, and Raucher find that consolidation may be be unaffordable for small rural systems and overall use of merger by small systems is unknown. In order to capture this effect, we include an indicator derived from the Economic Research Service's Rural-Urban continuum. Although the ERS categorizes counties on a nine-point scale, counties were aggregated into metropolitan and non-metropolitan counties. The variable (METRO) takes on the value of 1 if the county is a metropolitan county and 0 otherwise. The inclusion of this variable together with a term interacting METRO with DENSITY introduces controls for the likely physical costs of merger.

We use two county-level demographic variables from the 1990 US Census that were identified by the NRC as affecting the viability of small water systems: median income (CTYINC) and growth rate(CTYGRO). The latter variable is calculated as the percent increase or decrease in population between 1990 and 2000. Systems in areas with low income and negative growth rates face greater resource limitations and are more likely to be candidates for acquisition. Dummy variables are used to control for variations in state-level policies as well as variations in the observation period.

Summary statistics along with hypothesis generated by our model are presented in Table 2. A simple correlation matrix of the independent variables is presented in Table 3. Some of the independent variables, particularly the county level demographic variables are moderately collinear. There is also moderate correlation between PUBLIC and SVC; very large water systems tend to be government-owned. Econometrically, this will reduce the precision of the estimates and increase estimated standard errors.

The probit model estimation uses our full sample with the DENSITY and METRO variables. The basic estimating equation is:

$$\begin{aligned} P[ACQUIRED] = \Phi[&\beta_1 SVC + \beta_2 SVC^2 + \beta_3 QUAL + \beta_4 QUAL^2 + \beta_5 MONIT \\ &+ \beta_6 MONIT^2 + \beta_7 PUBLIC + \beta_8 PURCHASE + \beta_9 DENSITY \\ &+ \beta_{10} DENSITY^2 + \beta_{11} METRO + \beta_{12} METRO \times DENSITY \\ &+ \beta_{13} METRO \times DENSITY^2 + \beta_{12} INCOME + \beta_{13} GROWTH + \gamma \vec{Z}], \end{aligned} \tag{2}$$

where $\vec{Z}$ is a vector of dummy variables that are used to control for the state in which a CWS is located. Because there is no underlying structural model of merger on which to base the estimation, we estimate four alternative model specifications. These specifications are formulated by adding, dropping, or transforming variables in order to capture non-linear effects of these variables on the probability of a system being acquired.

Results

Estimation results are presented in Table 4. The first specification includes squared terms for SVC, DENSITY, QUAL, and MONIT to account for possible non-linear effects. The second alternative omits those squared terms. The third alternative uses the natural logarithm of SVC and DENSITY to account for possible nonlinear effects in those variables, while maintaining the squared terms of QUAL and MONIT. The fourth alternative is nested inside the third specification and omits the squared terms for QUAL and MONIT. All specification include state dummy variables. While that group of variables is statistically significant, variation in state policies and the differing periods of observation complicate the interpretation of those coefficients. All reported significance levels are constructed using standard errors robust to arbitrary heteroskedasticity.

The four models have similar goodness-of-fit measures. Based on McFadden's Likelihood Ratio Index , models 3 and 4 are preferred. Model 4 is preferable using the Akaike Information Criteria (AIC), classical hypothesis testing, and parsimony as model selection guidelines. However, there is little theoretical guidance to choose between specifications.

In table 5, we present results of joint coefficient tests for the 4 models. For models 1 and 3, we fail to reject the joint hypothesis that the QUAL^2 and MONIT^2 coefficients are both zero. However, many CWSs have no violations of either type, so these two variables are highly correlated with the QUAL and MONIT variables. This results in large standard errors and may cause the statistical insignificance.

Despite the individual insignificance of the DENSITY^2 and METROxDENSITY^2 variables, they have joint explanatory power in model 1. We also find that DENSITY, DENSITY^2, METROxDENSITY, and METROxDENSITY^2 have joint explanatory power in the same model.

Marginal effects for continuous variables are calculated by differentiating equation (1) with respect to x_i to produce:

$$(3) \qquad \frac{\partial P(ACQUIRED = 1)}{\partial x_i} = \phi(X\beta)\frac{\partial X\beta}{\partial x_i}$$

where ϕ is the normal probability distribution function. Following Train, we calculate marginal effect though sample enumeration; equation (3) is then evaluated for all observations. Because the marginal effects are distributed non-normally, the medians of the marginal effects are reported and significance is determined directly from the population confidence intervals. For continuous variables, these can be interpreted as the change in the probability of merger that results from a small change in the dependent variable. Marginal effects for dummy variables cannot be calculated as above; instead discrete effects are calculated from equation (1) as:

$$(4) \qquad \Phi(XB)|_{x_j=1} - \Phi(XB)|_{x_j=0}$$

Discrete effects are the change in probability of merger that results from a change in value of the variable from 0 to 1. These values are also calculated using the sample enumeration procedure above. Marginal and discrete effects from our estimation are presented in Table 6.

Interpretation

We focus on the results of our preferred specification, model 4; however, the qualitative results are robust across the specifications, with the exception of the QUAL, QUAL^2, MONIT, and MONIT^2 coefficients as discussed above. While the model should not be used to predict whether specific systems will be acquired, generalizations about the industry can be made. The lack of an underlying theoretical model of merger dictates caution, in the interpretation of the marginal effects. In general, the signs and significance of the coefficients support many of our hypotheses.

The negative sign of the ln(SVC) coefficient indicate that small systems are more likely to be acquired than larger systems. All other things equal, a water systems with 100 additional service connections is 0.6 percent less likely to be acquired than a smaller one. This supports our hypothesis that mergers are occurring in order to achieve economies of scale; however, the relative size of this effect is small.

Monitoring and quality violations both increase the probability of merger, although the effects of each type of violation are statistically different. A small water system with 1 monitoring violation per year is approximately 0.2 percent more likely to be acquired than a system with no violations of this type. The effect is more pronounced for systems with drinking water quality violations; a system with 1 quality violation per year is 1.4 percent more likely to be acquired than a system with no quality violations. These results supports our hypothesis that merger is being used as a compliance mechanism by water systems with lower capability to provide safe drinking water. Both types of violations may indicate poorly performing management; however drinking water quality violations seem to provide a larger impetus for merger than monitoring violations. These systems may be using merger to upgrade management capacity, technical capability, or both. It is important to note that monitoring and quality violations are possibly endogenous to the model. CWSs can be thought of as making capital expenditure decisions concurrently with decisions about whether to be acquired. Rational owners that foresee or anticipate that their CWS will be acquired will spend less on capital, possibly resulting in more frequent SDWA violations. This effect may be mitigated to a certain extent by the averaging of SDWA violations across years; it is less likely that small CWSs are anticipating merger many years into the future. However, to the extent that this does occur, the coefficients estimated are biased upwards and should be interpreted cautiously.

Systems that already have interconnected infrastructure are able to complete a merger at lower cost that systems that must pay for expensive infrastructure to finalize a merger. Water systems that purchase water are 14.6 percent more likely to be acquired than systems that had no preexisting connection to another system. The transactions costs of completing a merger are likely to be much lower when the two systems have already physically connected and experienced working together. The merger and acquisition process can be viewed as a continuum, with independent operation on one end and full integration on the other. By outsourcing their production processes, while continuing to perform distribution and administrative operations, water systems that purchase water are located in the middle of this continuum. The choice to fully integrate with their water wholesaler is an obvious next step. This result also suggests that encouraging water systems to purchase water may eventually facilitate integration through merger.

Publicly-owned firms are less likely to be acquired, possibly due to the high political costs involved with selling government assets.Our results imply that publicly-owned water systems are approximately 6 percent less likely to be acquired than privately-owned water systems. The costs of transferring ownership of public assets may be higher in terms of political capital and bureaucratic costs, making mergers of municipal and government-owned water systems less attractive. As Raucher, Harrod, and Hagenstad note, the loss of local control over water supply is a very real cost of consolidation in this industry.

Rural systems are less likely to be acquired, which seems to support Rubin and Ottem, Jones, and Raucher's findings that rural systems are too dispersed for consolidation to be cost effective. However, the discrete effect of METRO is not statistically different from zero, suggesting that systems in rural areas are neither being acquired more or less frequently than systems in more urban areas.

The effect of service connection density on merger is small. The lnDENSITY coefficient is insignificant, which implies that density and distance are not important in explaining merger in rural systems. However, the interaction term between METRO and lnDENSITY reveals that , an increase in system density decreases merger probability for CWSs located in metropolitan areas. An increase in the service connection density by 10 connections per square mile increases the probability of merger by 0.2 percent in spite of increases in merger costs due to location in a metropolitan area. However, this result is not robust across specifications and should be treated with skepticism. Both the non-robustness and lack of significance may be due to the imprecision of these proxy variables. In particular, these variables are aggregated at the county level; and take on the same values for all CWSs in a county. Furthermore, they are proxy variables for costs, and may perform poorly.

Finally, systems located in counties with higher incomes are more likely to be acquired. This implies that small systems in more resource-constrained areas are not using merger as a mechanism to improve water quality, which is an unanticipated result. This variable also is aggregated at the county level and may suffer from the previously described imprecision.

Conclusions

The problem of ensuring safe reliable public supplies of water in systems serving small populations has received considerable regulatory attention in the past two decades. However, most of the focus has been on technical solutions. The question of organizational change in response to increasingly demanding drinking water regulations has received minimal attention in the economic literature. Our results indicate some support for the theory that merger and acquisition can improve the regulatory compliance of small water systems, serving to upgrade services and improve system performance.

We find that systems with frequent SDWA violations are more likely to be acquired. This may indicate that small systems are using merger as a tool to improve performance. However, even when controlling for their proximity to neighboring systems, small systems in areas with slow population growth (or declines) and lower incomes are not using this type of institutional change as a compliance strategy. This result suggests that local ownership may be relatively more important in the life of low-income and demographically stagnant communities than is the case in more affluent or populous areas. It may also suggest that potential merger partners shy away from systems serving such communities.

According to the USEPA, large capital improvements to drinking water infrastructure will be necessary in the coming years (USEPA 2002). Merger may be a cost-effective means at upgrading the capital stock of the industry if acquired firms are using merger to discontinue reliance on old, depreciated capital.

Quality and monitoring violations increase the probability of a merger by different amounts, and the marginal effect of quality violations is approximately five times larger than the effect for monitoring violations. This may reflect the relative costs of the two different types of violations. It may also reflect the relative ease of fixing monitoring problems compared to the capital intensive requirements associated with the same water quality compliance issues. The fact that smaller systems are more likely to merge is consistent with motivations to realize economies of scale. Some small residential or commercial systems may be divesting themselves of a non-core business enterprise.

We find that systems with lower costs of completing a merger are more likely to be acquired. Public ownership, and it bureaucratic and political costs, makes merger less likely, while an existing physical connection makes merger more likely. Furthermore, CWSs located in wealthier areas are more likely to use merger, perhaps because these systems have the resources to pay for a merger. Decreasing those transactions costs or increasing the ability of a small water system to pay for a merger could have the effect of encouraging mergers. This could be accomplished directly through financial transfers and low-cost financing of merger costs or indirectly through modifying existing regulations.

There has been substantial effort to increase the capacity of small water systems directly, through operator training, subsidized loans, and technology variances. Most of the gains from those activities may have been realized. Comparatively less effort has focused on merger as an institutional change and there may still be sizable gains to be realized from relatively small investments in merger-encouraging policies. Policies that lowering the political, regulatory, and physical costs of mergers, may be an effective means to increase SDWA compliance. In particular, allocating Drinking Water State Revolving Funds (DWSRF) to finance mergers may be an effective use of funds. Additionally, purchasing water seems to be an intermediate step in the consolidation process. Encouraging systems to purchase water may be an effective policy if EPA cannot encourage consolidation more directly.

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Table 1. Community Water Systems by State

State	Full Sample	Acquired	Not Acquired	Observation Period
IA	1,032	211	821	1994-2004
IL	1,528	75	1,453	1995-2004
IN	753	62	691	1996-2004
MO	1,308	18	1,290	2000-2004
MI	1,303	40	1,263	2001-2004
NE	578	24	554	1997-2004

Table 2. Descriptive Statistics and Hypothesized Effects on Merger Probability

Variable	Units	Full Sample (n=6502)	Acquired (n=430)	Not-Acquired (n=6072)	Hypothesized Effect
SVC	connections	474	173	495	(-) Economies of Scale
QUAL	avg. violations/yr	0.167	0.208	0.164	(+) Lower management capacity
MONIT	avg. violations/yr	0.845	2.463	0.730	(+) Lower management capacity
PUBLIC	(%)	62.1%	30.1%	64.3%	(-) Higher political Costs
PURCHASE	(%)	18.4%	40.2%	16.9%	(+) Lower interconnection costs
DENSITY	connections/mile^2	67.0	96.1	65.0	(+)Nearby merger partners (-) Higher unit costs of merger
CTYINC	($10,000s)	3.95	4.20	3.93	(-) Resource limitations
CTYGRO	(%)	9.54%	8.65%	9.60%	(-) Resource limitations
METRO	(%)	44.4%	56.6%	43.5%	(-) Resource limitations

Table 3. Correlation Coefficients of Independent Variables

	SVC	QUAL	MONIT	PUBLIC	PURCHASE	DENSITY	INCOME	GROWTH	METRO
SVC	1								
QUALITY	-0.0323	1							
MONITOR	-0.0642	0.0666	1						
PUBLIC	0.3555	0.001	-0.126	1					
PURCHASE	0.1063	-0.09	-0.0771	0.2096	1				
DENSITY	0.1029	-0.0205	0.0199	-0.0749	0.1656	1			
INCOME	0.0199	-0.0416	0.0739	-0.21	-0.0272	0.3753	1		
GROWTH	-0.066	0.0107	0.0379	-0.292	-0.1235	0.0214	0.3823	1	
METRO	0.0427	-0.0214	0.0501	-0.1788	0.0469	0.3392	0.5425	0.2047	1

Table 4. Probit Estimation Results

Variable	Model (1)	Model (2)	Model(3)	Model(4)
Water System Characteristics				
SVC	-9.42×10^{-4} ***	-9.34×10^{-4} ***		
SVC^2	1.57×10^{-7} ***	1.56×10^{-7} ***		
ln(SVC)			-.219 ***	-0.220 ***
QUAL	0.097	0.234 ***	0.106	0.251 ***
QUAL^2	0.031		0.0341	
MONIT	0.051 ***	0.039 ***	0.0499 ***	0.0382 ***
MONIT^2	-2.87×10^{-4}		-2.82×10^{-4}	
Merger Costs				
PUBLIC	-0.654 ***	-0.669 ***	-0.547 ***	-0.540 ***
PURCHASE	1.123 ***	1.091 ***	1.066 ***	1.063 ***
DENSITY	0.0010	0.0022 ***		
DENSITY^2	2.38×10^{-6}			
ln(DENSITY)			0.067	0.067
METRO	-0.026	0.168 **	-0.340 *	-0.348 *
METROxDENSITY	2.91×10^{-3}	-0.0019 ***		
METROxDENSITY^2	-5.65×10^{-6}			
METROxln(DENSITY)			0.109 *	0.109 *
County level Demographics				
INCOME	0.0029	0.169 ***	0.121 ***	0.125 **
GROWTH	0.0061			
Estimation Diagnostics				
n	6,501	6,501	6,502	6,502
AIC	2,223	2,258	2,187	2,188
Log-Likelihood	-1,090	-1,113	-1,077	-1,079
McFadden's LRI	0.31	0.30	0.32	0.32

Note: Significance levels : $*$: 10% $**$: 5% $***$: 1% .

n varies because perfectly predicted observations are dropped during estimation.

Table 5. Coefficient Tests for Probit Models

H_0 (null hypothesis):	Model (1)	Model (2)	Model (3)	Model (4)
$QUAL^2=0$				
$MONIT^2=0$	0.367		0.344	
$DENSITY^2=0$				
$METROxDENSITY^2=0$	0.000			
DENSITY=0				
$DENSITY^2=0$				
METROxDENSITY=0				
$METROxDENSITY^2=0$	0.000			
QUAL=MONIT	0.724	0.005	0.678	0.003

Note: All reported p-values are for χ^2 tests with appropriate degrees of freedom.

Table 6. Marginal Effects for Probit Estimation

Variable	Model (1)	Model (2)	Model(3)	Model(4)
Water System Characteristics				
SVC	-4.82×10^{-5} **	-4.82×10^{-5} **	-6.13×10^{-5} ***	-6.1×10^{-5} ***
QUAL	0.0064	0.0055 ***	0.0068	0.0136 ***
MONIT	0.0028	0.0028 ***	0.0027	2.07×10^{-3} ***
Merger Costs				
PUBLIC	-.0620 **	-.0603 **	-0.064 **	-0.0646 **
PURCHASE	0.146 **	0.141 **	0.145 **	0.1456 **
DENSITY	8.24×10^{-5}	7.78×10^{-5} ***	2.08×10^{-4}	2.10×10^{-4} ***
METRO	0.0010	0.0010	-7.36×10^{-4}	-0.001
County level Demographics				
INCOME	1.61×10^{-4}	1.61×10^{-4} ***	6.54×10^{-3}	6.78×10^{-3} ***
GROWTH	3.28×10^{-4}			

Note: Significance levels : $*$: 10% $**$: 5% $***$: 1% .

[a]- Discrete effect for a change from 0 to 1 (Greene)).