Building Technical, Financial, and Managerial Capacity for Small Water Systems: The Role of Consolidation, Partnership, and Other Organizational Innovations

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Midwest Technology Assistance Center
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Building Technical, Financial, and Managerial Capacity for Small Water Systems: The Role of Consolidation, Partnership, and Other Organizational Innovations

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Goal: Assess the role of consolidation as a strategy for small community water system to achieve technical, managerial, and financial competency under the Safe Drinking Water Act.

Methodology: The research involved: (1) The development of a model of choice of regulatory compliance strategy in which water systems choose to continue independent operation or be acquired by another system. The model generates hypotheses about organizational responses to regulation. (2) Collection and analysis of federal and state data on trends in the consolidation and performance of water systems serving communities of less than 10,000 people and to test theoretical predictions about organizational response to regulation.

Findings:

1) Factors Affecting Organizational Change

The USEPA has devoted millions of dollars in recent years to programs aimed at strengthening the technical, managerial, and financial (TMF) capabilities of small systems. Concerns about small system capabilities are driven by differences in (SDWA) compliance rates – a higher percentage of smaller water systems have water quality and reporting violations under the Safe Drinking Water Act (SDWA) than do larger water systems (NRC, 1997). However, the best solutions may not always involve additional TMF investments. Sometimes it may make more sense to turn the systems over to new owners who are better able to run water systems lawfully and economically.

Problems of compliance with the SDWA can arise for many reasons. Some are attributable to limited customer bases producing lower revenues to cover fixed costs, lower bond ratings making borrowing more costly, and higher per-customer service costs. On average, the per-household cost of infrastructure of small systems is more than three times greater than that of systems serving more than 10,000 people (USEPA, 1999) Combining resources and administrative structures across small systems can reduce overhead while also gaining economies of scale. The resulting larger systems generally can afford greater technical sophistication and their bond issues to finance system improvements are more attractive in financial markets. Thus, encouraging small water system mergers and reorganizations can be an important strategy for improved compliance. However, there are a variety of theories about how such organizational changes come about.

A. Institutional Theories

There is a growing body of research examining the factors that most influence rapid organizational change, and what needs to be done within both the regulatory agencies and the water industry to encourage small systems to change. Some of these studies of organizational change are based on empirically testing what academics call neo-institutional theory while some are descriptive surveys of industry practices that attempt to identify the key factors associated with specific small water system changes (such as system consolidation). Development of a model to test organizational changes in small water systems might benefit from this research.

Examining how well neo-institutional theory explains dramatic organizational change seems the most abstract of these research efforts, but might be the most useful in validating what many small water system operators have already learned through their own experience. In explaining rapid organizational change, neo-institutional theory would look at organizational change from the perspective of the entire water supply industry, and propose that a water system's ability to drastically restructure its services would be influenced by three factors (Greenwood and Hining 1996): First, would be the degree that an organization is embedded in its institutional context (for example, be subject to industry and regulatory performance and operational expectations), second, the degree which different groups of organizations within the industry would have knowledge of what other groups within that industry are doing (especially in terms of practice innovations), and, third, the extent to which an individual organization would have both the ability and the willingness to change.

Although researchers have not examined small water systems to test the applicability of neo-institutional theory, they have looked at rural hospitals in order to explain why some rural hospitals have radically changed their services (become nursing homes or substance-abuse facilities, for example) even when rural health services are so tightly constrained by accreditation requirements and so heavily regulated by state agencies (D'Aunno, Succi and Alexander 2000). As predicted by the theory, these researchers found that regulations promoting organizational reliability and accountability (such as accreditation) or limiting market access (such as certificate of need laws) both inhibit organizational change, while state regulations intended to promote competition had no effect. In the tightly-regulated health industry, it was only when states specifically targeted interventions to promote change (for instance, by giving hospitals direct capital grants to convert) that rural hospitals were more likely to make radical change their services.

The rural hospital study also found that public facilities were less likely to change than private ones. Among the private hospitals, those belonging to larger multi-hospital systems were also more likely to change, suggesting that some of the radical changes may have been undertaken to better meet the needs of their corporate parents rather than in response to new government policies. This same entrepreneurial factors might help explain why local subsidiaries of large water companies might be more willing to innovate: for example, only a few years after New York City entered into an innovative agreement with the USEPA to work with local governments and farmers to buffer its up-state reservoirs as an alternative to filtration (NRC 2000), the Illinois-American Water Company's system in Alton, Illinois, negotiated a reduction in its return water sedimentation controls (and saved itself about $3 million) by entering into a similar stream-bank buffering agreement with a local land trust

The institutional framework of small water systems, like that of rural hospitals, tends to be tightly coupled, especially with respect to being subject to stringent regulatory oversight required under the Safe Drinking Water Act. Most state budgets are also currently constrained, suggesting that it is unlikely that state agencies would directly subsidize radical organizational change by giving small water systems direct grants to consolidate or regionalize their services. The theory would therefore predict that most small water system changes would be evolutionary and incremental, not revolutionary and dramatic, unless mandated industry-wide from the top-down. Regulatory mandates, such as management of disinfection by-products, require all water systems to modify their treatment processes rapidly, and therefore drive revolutionary industry-wide changes in tightly integrated institutional settings. In such a highly integrated industry as water supply provision, individual water systems, especially public systems, are much more likely to institute only minor changes to their organizational structures or operations in the absence of such mandates.

Despite these theoretical predictions of institutional inertia, some small water systems in fact do radically change their organizational structures. In a descriptive six-state survey of why small water system consolidate, the Cadmus Group (2002) found that political support, state goals promoting consolidation, and legislation mandating consolidation for troubled systems were all significant factors in promoting successful small water system consolidations. Other factors influencing consolidation were cooperation among state agencies, the creation of regional water plans by regional bodies, and the development of state processes to identify likely candidates for consolidation.

The Cadmus survey data tends to affirm neo-institutional theory. Since most of these factors lie outside the scope of both the water supply industry and their state regulatory agencies, there is little that the industry (and state regulators) can do to encourage small water systems to consolidate other than to disseminate information about successful consolidations to other small water systems. Their analysis only confirms that radical change in small water systems, such as consolidation, remains the exception rather than the rule.

B. Historical Theories

Despite institutional theory and recent water system surveys both suggesting that organizational change is relatively uncommon among small water systems, most water utilities in the U.S. actually underwent enormous transformation in the late 19th and early 20th centuries. Within just two or three decades, most urban water systems changed from being predominantly privately-owned to being predominantly publicly-owned. What makes this historical transformation relevant today is that, at the time they were initially municipalized, many of these private urban waterworks had service areas and customer bases similar in size to those served by many small water systems today.

Many economists and historians consider this historical shift of water systems to public ownership to be an anomaly. Most other municipal utilities (such as electricity, gas, and telecommunications) remained in private ownership, and most of those other types of utilities are still privately-owned up to this day. Scholars have struggled to explain this "institutional aberration" using sophisticated analyses of historical data to better understand why the ownership and management of so many water systems changed so significantly at the turn of the 20th Century. Four different factors have been proposed to explain this organizational transformation: public health concerns, public finance pressures, contractual conflicts between private providers and their customers, and corruption.

(i) Public Health and Safety.

One major responsibility of government is to protect citizens against danger. In the 19th Century, advances in medical knowledge led to huge changes in approaches to public health. Public health crises often sparked public outcries for municipal water services. A widely-cited example is the City of Chicago, which built its new water distribution and treatment facilities and initiated its project to reverse the flow of the Chicago River in order to flush sewage away from the City's water supply, Lake Michigan, after 80,000 citizens died of typhus in 1885 (O'Connell, 1976). Public concerns over fire risks also generated public dissatisfaction with private water companies. Privately-owned waterworks were thought by many local officials to make most of their water supply decisions only to generate short-term profits from residential water sales rather providing sufficient water to public hydrants for municipal fire protection (Anderson, 1988).

Recent scholarship has disputed the presumed public health deficiencies of private waterworks. A 1999 study found that the transition of ownership did not bring about a significant reduction in water-borne disease outbreaks (Troesken, 1999). In addition, private companies more frequently used filtration. Nevertheless, the move to public ownership probably indicated a strong public demand for change and improvement and a prevailing sentiment that public ownership was more likely to produce results.

(ii) Municipal Expansion and Finance Pressures.

A second set of forces contributing to the municipalization of urban water supplies involves the rapid rate of municipal annexation that occurred in the late 19th and early 20th centuries. These municipal expansions greatly increased the service areas of urban waterworks, especially after modern indoor plumbing was introduced to residential dwellings in the late-19th Century and residents wanting these modern conveniences demanded that additional water service be provided to their homes. For example, when local improvement districts and private water companies were unwilling to expand their service areas to unincorporated areas to meet this new service demand, many suburban residents sought annexation to the City of Chicago as a means of connecting to its newly enhanced public water system (Keating, 1985).

Associated with this rapid rate of municipal annexation was the ability of publicly-owned and financed municipalities to tap financial resources that were unavailable to private water suppliers at the turn of the 20th Century (Cutler and Miller, 2005). After the development of modern bond markets, waterworks financed by private-investors simply could not raise capital as efficiently as municipalities could. Municipal bonds provided sophisticated municipalities with the financial resources needed to meet rising demand for potable water at a time when the costs of constructing modern water systems to serve entire urban populations were too large for private firms to assume.

The ability of government to enforce universal payment for services, and innovations in the bonding of public investments, undoubtedly increased the capacity of municipalities to take over and operate water supplies. Nevertheless, private water companies have historically offered safe and significant returns to shareholders, so poor performance and financial weakness are not the necessary results of private ownership (Grigg, 1988).

(iii) Contractual Conflicts.

At the turn of the 20th Century, franchise arrangements between cities and private water companies often required the companies to improve water treatment or expand their service areas without being able to increase their rates sufficiently to offset these additional expenditures. These fiscal limitations reduced dividends and thereby lowered the perceived value of their stock to their investors. This decline in stock values, in turn, enabled municipal officials to later acquire the private water systems at reduced prices either by purchase, franchise revocation, or through the exercise of eminent domain, or by simply building a public waterworks to undercut the private system (Troesken and Geddes, 2003). Moreover, the growing threats of public appropriation didn't provide private water companies with many incentives to expand their operations or improve their facilities. At the time, foregoing these improvements was a rational investment decision intended to bolster the private waterworks' short-term profits, but it was also a decision that, over the longer term, served to reduce the value of the systems, and the compensation received by the owners, when they were later expropriated and municipalized by public officials.

Contractual conflicts contributed to the simultaneous growth of state utility regulation, municipal ownership, and especially frequent litigation. These factors have been shown to correlate with later expropriation (Troesken and Geddes, 2003). Furthermore, the substantial metering costs commonly required of private waterworks by many municipal franchises created a quandary for privately-owned water utilities: Unit prices of water were often too low to justify spending by a privately-owned waterworks to install and read water meters, but failing to meter customers made it harder for the private waterworks to justify asking for increases fees. Therefore, many private water companies that couldn't adequately recover their metering costs had to rely on revenue transfers from government, further increasing the private utility's exposure to contractual conflict and appropriation (Masten, 2004).

(iv) Corruption.

A fourth factor at work in the wave of municipalization was corruption. Historical experience has demonstrated the need for regulation of privately-owned utilities by state utility commissions and through municipal franchise contracts. For example, studies of the emergence of municipal water systems in New York, Philadelphia, Boston and Baltimore in the early 19th Century show how public water boards and commissions were pitted against speculative private water companies, with the battle played out in the back-rooms of the state legislatures where service franchises were granted to private water systems (Blake, 1956). Corruption and back-room deals become a subtext of this historical narrative; in some cases, as in New York City, the private water companies were merely corporate shells through which wealthy investors engaged in banking and other financial enterprises unrelated to water supply provision. Scholars have cited this concern over corruption by private water suppliers, and the larger Progressive national reform movement at the end of the 19th Century which embraced the cause of utility regulation, as a significant contributor to municipal expropriation of private water companies (Troesken, 2005).

Many public water systems themselves later became instruments of urban machine politics, where patronage and politically-determined rate structures short-changed infrastructure maintenance (Troesken, 2005). A major reason that corruption theories remain so relevant in explaining institutional change is that water supply history might have come full circle, with the alleged operational inefficiencies and fiscal deficits of "corrupt" public water systems providing the justifications for the growing interest in water supply privatization in recent years (NRC, 2002).

C. Conclusions

What can small water systems learn from institutional theory and the four factors that shaped organizational change in the water industry? Neo-institutional analyses of hospital reorganizations suggest that privately-owned and managed health systems are more likely to change than publicly-owned ones. The underlying logic might also apply to water systems. Moreover, the theory suggests that change is more likely to be incremental than radical when an industry, such as water supply provision, is tightly coupled and its operations (and options) are constrained by regulatory and reporting requirements.

Times were certainly different at the turn of the last century, when the regulatory context (rampant corruption, open-ended and perpetual franchises, and lack of regulatory oversight) and capital markets differed so extensively from the institutional framework under which small water suppliers currently operate. But the fact that all of these historical theories consider safety, utility regulations, and financing as being key catalysts for change still makes these factors relevant today.

Health and safety concerns still account for most of the short-term pressures for change within the water industry. USEPA and states mandate and monitor water system compliance with new drinking water standards and other regulatory mandates. These include, for example, USEPA's copper, lead, arsenic, pathogen, disinfection by-product, and radionuclide rules, which are driving new investments in treatment technologies. The large costs of these investments are beyond the reach of many small water utilities and the communities they serve. For some, spreading the costs over a larger customer base through system expansion or consolidation with other systems is the most viable option.

The need to purchase advanced treatment technologies, in turn, raises many of the issues that private water systems faced in meeting new demand at the turn of the last century, when cities were rapidly growing and privately-owned utilities' access to capital was constrained. These capital needs are likely to grow, in any case, simply because of the need to replace old pipes as well as to expand service to meet new demand. On top of the water quality requirements, the American Water Works Association estimates that the industry has spent more than $2 billion in the past few years for water system security and emergency response planning prompted by the 2001 New York terrorist attack.

Water bonds are considered by most analysts to be a safe investment, but bond returns are still influenced by the size and scale of the water utility. It is usually easier for large water utilities to borrow money than smaller ones, because of their more sophisticated and larger administrative resources, and their bonds are often deemed safer investments because of their larger revenue streams. State revolving loan funds can theoretically offer smaller water systems capital at lower rates than could private bond markets, but the demand for these funds outstrips the supply and communities face long waits for improvements that often cannot be put off.

Finally, more stringent public oversight (both by state environmental protection agencies and by state public utility commissions) of water systems can influence institutional change. Public utility commissions have resolved most of the historic problems of corruption, but regulatory red-tape can also impede needed improvements, especially if it limits a small utility's ability to raise its water rates in order to pay for its growing treatment and operational costs, or denies its requests for expansion of its service area. Larger water systems simply have greater administrative capacity to handle the reporting and the paperwork generated in meeting state public utility regulations.

Similarly, growing state EPA oversight over treatment options and effectiveness, as mandated by USEPA regulations, creates a larger administrative, testing, and reporting burden for all water systems. Larger systems, with their larger staffs, are better able to manage these burdens than smaller systems – it is no accident that most reported violations occur with smaller systems, and that most of these violations involve missing a required report or failure to submit required test data on time. So, in the same way that some scholars believe that contractual conflicts on the state and municipal level drove urban water system changes in ownership in the 19th and 20th centuries, state and federal conflicts may still create incentives for water systems to change their scale or operations in the 21st Century.

2) Development of a Model to Assess How Regulatory Compliance Affects Institutional Organization

Informed by the preceding review of organizational change theories, we have developed an economic and behavioral model that explores driving forces of organizational innovation for small water systems subject to the requirements of the Safe Drinking Water Act. This section describes the model and tests its implications using data for small public water supply systems in six Midwestern states.

A. Why Firms Merge

Basic economic reasoning suggests that a firm will go out of business and exit an industry if it cannot make a profit. However, drinking water systems may not operate with a profit motive. Government-owned systems can be subsidized by taxpayers and may be viewed as important sources of employment or symbols of local prosperity. Other small systems are tied to specific residential developments and can also be cross-subsidized.

Two complementary economic explanations of merger and acquisition place perspective around consolidation in the drinking water industry. One line of thinking holds that mergers are a mechanism to transfer assets from underperforming firms to successful ones (Dewey, 1961; Tremblay, 1988). The other maintains that mergers are transactions in the market for corporate control, where management teams compete for the right to manage productive assets (Jensen, 1983). These two points of view converge in our model of acquisition as a means to both match poorly performing systems with better management and to take advantages of economies of scale.

In our model, a drinking water system gives its owner a stream of benefits (or losses) from continuing to provide water. This includes current and future economic profits in the traditional sense, as well as penalties due to SDWA violations. In a less traditional sense, these benefits also includes ”psychic" benefits from providing water, such as pride in operating a water system, fulfillment of a perceived mission to provide a public service, or the extra employment that a water system brings to the community. There can also be psychic costs; a small, underperforming water system could be a major cause of stress due to regulatory pressures and public criticism. These psychic costs typically do not enter into a profit-loss statement. A traditional for-profit firm does not consider these psychic costs and benefits, but a small owner-operated or municipally-owned system may take some of these psychic costs into account.

When a systems stops independent operation via merger, it incurs transactions costs. These include costs of connecting infrastructure, regulatory costs, and restructuring costs. These transactions costs also include any transfers paid to or from the acquiring firm as well as political costs from relinquishing control. In the case of municipally owned water systems, transferring publicly owned assets to a private company may be a long, expensive political process. A water system will be acquired if makes the current owner better off, that is, if the capitalized value of the profits is smaller than the transactions costs.

Our behavioral model generates the following hypotheses:

1. Small systems that cannot achieve economies of scale are likely to be acquired.
2. Systems that frequently violate the SDWA have lower TFM capacity and are more likely to be acquired.
3. Publicly-owned systems have higher political costs of merger and are less likely to be acquired.
4. Systems that currently purchase water have lower transactions costs of completing a merger and are more likely to be acquired.
5. Systems in resource-limited areas are likely to use merger as a way to exit the industry.

In order to test and verify our behavioral model, we use a probit model to predict the probability of a water system being acquired. This type of econometric model has been commonly used to analyze factors influencing municipalization of drinking water systems (Troesken, 2003), plant exit in the meatpacking industry (Anderson: 1998), and mergers of publicly traded firms (Palepu: 1986). We estimate two models; the first model is for the entire sample but contains not spatial data. For the second model, we augment a portion of our dataset with some simple GIS data.

B. Data Used

We gathered data on mergers of CWSs from primacy agencies in USEPA Regions 5 and 7. Six of the eleven state primacy agencies in these regions track consolidation and were able to supply data. These data were then combined with system characteristics data contained in USEPA's Safe Drinking Water Information System (SDWIS) database, and county-level demographic data from the US Census and the Economic Research Service (ERS) of the U.S. Department of Agriculture. There are 6,502 observations of small water systems, of which 430 (6.61%) were acquired (ACQUIRED). Because the collection of merger data is not standardized, the primacy agencies have data for varying periods of time. For example, data on mergers span 11 years in Illinois, but only four years in Michigan. In our statistical analysis, we control for this variability between states using a series of dummy variables. A state-by-state summary of drinking water systems is presented in Table 1.

Data from SDWIS includes information on service connections, number and type of drinking water violations, ownership, and water source. A summary of the data and associated hypotheses are presented in Table 2. Service connections (SVC) are simply the number of connections that a water system serves. Systems that are acquired tend to be smaller than systems that are not acquired.

Table 1: Distribution of Community Water Systems by Acquisition Status

State	Full Sample	Acquired	Not Acquired	Observation Period
IA	1032	211	821	1994-2004
IL	1528	75	1453	1995-2004
IN	753	62	691	1996-2004
MO	1308	18	1290	2000-2004
MI	1303	40	1263	2001-2004
NE	578	24	554	1997-2004

Table 2: Descriptive Statistics for Community Water Systems and Hypothesized Effect on Merger Probabilities

Variable	Units	Full Sample	Acquired	Not-Acquired	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	0.73	(+) Lower management capacity
PUBLIC	percentage	62.1%	30.1%	64.3%	(-) Higher transaction costs
PURCHASE	percentage	18.4%	40.2%	16.9%	(+)lower interconnection costs
DENSVC	Connections /mile	67	96	65	(+) Nearby merger partners
INCOME	$10,000s	3.95	4.20	3.93	(-) Resource limitations
GROWTH	percentage	9.54	8.65	9.6	(-) Resource limitations
METRO	percentage	44.4%	56.6%	43.5%	(-) Resource limitations (-) High unit costs of merger
DIST	miles	6.786	3.296	7.187	(-) Lower connection costs
MSA	percentage	27.2%	33.1%	26.5%	(-) High unit costs of merger

Drinking water violations are classified by USEPA into two categories: monitoring/reporting violations and quality violations. Monitoring and reporting violations (MONITOR) include failure to adequately test drinking water, file a consumer confidence report, or a public note of drinking water quality. Quality violations (QUALITY) include treatment type violations and maximum contaminant level violations. Both types of violations are reported as the average number of violations by a system per year. We use SDWA violations, particularly monitoring and reporting violations, as indicators of underperforming management. Water quality violations may be indicative of underperforming management, inadequate capital investment, or both.

Drinking water systems were categorized as public (PUBLIC) if they are owned by a federal, state, or local government. Before accounting for any merger activity, 62.1% of drinking water systems in our sample were publicly owned. Publicly owned water systems may have lower costs of capital, a perceived mandate to provide water, and high transactions costs of merger due to political reasons. Therefore, we expect publicly owned water systems to be less frequently acquired.

Small water systems that purchase water from another system account for 18.4% of the water systems in the sample. Because these systems are already physically connected to, and accustomed to working with, another system, we hypothesize that systems that they are more likely to merge.

We expect that by rural water systems will be more likely to exit the industry through consolidation because they are more likely to face adverse demographic trends, such as declining populations or static income levels. We use a modification of the ERS rural-urban continuum codes to control for how rural the service areas of water systems are, aggregated at the county level. Counties are metropolitan if they are part of a metropolitan area of 250,000 persons or more (METRO); otherwise they are classified as non-metropolitan. Following the NRC (1997), we expect systems located outside of these metropolitan areas to be more likely to merger in order to comply with SDWA regulations. However, in metropolitan areas, we believe that the per-unit costs of connecting water infrastructure is likely to be higher than in rural areas; this also implies that systems outside metropolitan areas will have lower transactions costs of mergers and therefore be more likely to merge.

Because we lack data on the costs of potential interconnections, we construct a variable that represents physical interconnection costs. We use the number of service connections per square mile per county (DENSVC) as a proxy for the cost of a system merger. In densely populated counties, the water supply network is likely to be more extensive, which would decrease the transactions costs of merger because there is a greater chance that two separate networks will be closer to each other. However, in those counties, the higher densities may increase per-unit costs of constructing pipelines. To account for this, we use also interact the METRO and DENSVC terms. In order to control for resource limitations on small water systems, we include data from the 1990 Census for population growth rate (GROWTH) and median income (INCOME). Both of these measures are aggregated at the county level.

For two states, Iowa and Illinois, we are able to incorporate spatial data into our analysis. The spatial data supplied by the drinking water agencies in those two states were incomplete, so gaps in location information were supplemented by water system addresses that were geocoded using ArcGIS. In this two-state subsample, to proxy for transactions costs, we construct a variable equal to the distance between the address of record of a water system and that of its nearest neighbor (DIST). Also using ArcGIS, water systems located inside a Metropolitan Statistical Area (MSA), as defined by the US Census, were identified. We expect the MSA variable to function similarly to the METRO variable in the larger sample. Interaction terms between MSA and DIST are included to control for the possibility of different unit costs of interconnecting two water systems across metropolitan and non-metropolitan areas.

C. Results

Overall, the results are support our hypotheses concerning the factors that promote merge activity. We report results first for the six-state sample, then for the two-state subsample where geographic data are available to enhance the analysis.

(i) Six-state sample with no spatial data

Looking at the full sample (which does not include spatial data), Table 3 shows the effects that marginal changes in system characteristics will have on the probability of a merger. For continuous variables, this is the change in probability of merger that results from a unit change in the independent variables. For discrete variables, these are the change in probability that results from a change of the independent variable from 0 to 1 (Greene, 2003). In interpreting these effects, it is useful to note that six percent of the firms were observed to have merged. Therefore, with no other information about the characteristics of a system, we would estimate that it has a six percent chance of being acquired.

The results indicate that small systems are more likely to be acquired than large systems; however, this effect is relatively small. To be precise, an additional 10 service connections lowers the probability that a system will be acquired by 0.6 percent. While this effect is small in magnitude, it does support the theory that small systems are choosing to be acquired.

The model also indicates that water systems with frequent SDWA violations are more likely to be acquired. Water systems that average one quality violation per year are approximately 1.4 percent more likely to be acquired than systems that do not violate the SDWA. Similarly, water systems with one monitoring violation per year are approximately 0.2 percent more likely to be acquired than systems with no SDWA violations.

Publicly-owned water systems are approximately 6.5 percent less likely to be acquired that privately owned water systems. This is consistent with high political costs of transferring ownership of public assets, which would discourage merger activity.

As expected, water systems that purchase water are more likely to be acquired than systems that do not purchase water. Water systems that purchase water are 14.6 percent more likely to be acquired than systems than systems that were producing their own water. Clearly, the transactions costs of completing a merger are much lower when the two systems have already connected, and the relatively large effect found here reflects these reduced transactions costs.

Table 3: Marginal and Discrete Effects Calculated After Estimating a Probit Model with and Without Spatial Data

Variable	**No Spatial Data**	**Spatial Data**
SVC	$-6.1\text{x}10^{-5}$ ***	$-5.25*10^{-5}$ ***
QUAL	0.0136***	-0.040
MONIT	0.0021***	0.0045***
PUBLIC[a]	-0.0646**	-0.048***
PURCHASE[a]	0.1456**	0.142**
DENSITY	$2.10 \text{ x } 10^{-4}$***	-
METRO[a]	-0.001	-
INCOME	$6.78 \text{ x } 10^{-3}$***	-
GROWTH	-	0.0013***
DISTANCE	-	$1.81 \text{ x } 10^{-4}$
MSA[a]	-	-0.0096***

** - Significant at 5% level
*** - Significant at 1% level
[a] – Indicates a discrete effect; the effect of changing the value of a discrete variable from 0 to 1.

County-level water system density increases the probability of an acquisition slightly. An increase in the service connection density by 10 connections per square mile increases the probability of merger by approximately 0.21 percent. This result is consistent with a hypothesis of our model: an increase in system density implies smaller distances separating distribution networks. The costs of physically interconnecting two water systems would therefore be less expensive.

Finally, water systems in metropolitan areas are approximately 0.1 percent less likely to be acquired than systems in non-metropolitan counties. This result seems to support the NRC's hypothesis that rural systems face more intense demographic pressures. These systems may be using merger as a mechanism to relieve those pressures.

ii) Findings with spatial data

We follow the analysis of Castillo, *et al.* (1997); however, instead of constructing prices of merger, we use the distance between a water system and it's nearest neighbor (DIST) as a proxy variable. Also using ArcGIS, water systems located inside a Metropolitan Statistical Area (MSA), as defined by the US Census, are identified. We expect the MSA variable to function similarly to the METRO variable; unit-costs of merger may be higher due to physical construction costs in a densely populated area. Interaction terms between MSA and DIST are included to control for the possibility of different unit costs of interconnecting two water systems across metropolitan and non-metropolitan areas.

When spatial data are included and our model is re-estimated, we find similar results. Again, the effect of size is relatively small; an additional 10 service connections lowers the probability that a system will be acquired by just 0.5 percent. Water systems with one monitoring violation per year are approximately 0.45 percent more likely to be acquired than systems with no monitoring violations. However the model finds that drinking-water quality violations have no statistically significant impact on the frequency of merger. These findings imply that regulatory pressures may differ for quality versus monitoring violations, with the latter being more consequential for subsequent decisions about system management.

With the spatially-explicit subsample, publicly owned water systems are approximately 4.8 percent less likely to be acquired that privately owned water systems. Water systems that purchase water are 14.2 percent more likely to be acquired than systems that were producing their own water. Curiously, distance to the nearest neighboring water system has no impact on the probability of a water system to be acquired. However, this unexpected finding may result from imprecise geocoding and the fact that distances between addresses of record may imperfectly represent distances between the pipelines of adjacent systems. Finally, water systems in metropolitan statistical areas (MSA) are approximately 0.1 percent less likely to be acquired than systems in non-metropolitan counties.

D. Discussion and Conclusions

This type of model should not be used to predict whether a specific system will be acquired. It is best suited to understand how changes in firm characteristics or policy might affect merger activity. We also do not attempt to understand the internal decision making process of the acquiring firm. These systems may be motivated to increase their capital base, capture profits due to increase returns to scale, or be required to acquire small systems by regulators. Finally, we also do not attempt to explain other types of organizational innovation, including the formation of drinking water collectives/cooperatives or the decision to begin purchasing water.

Our results support the theory that merger and acquisition is a method of improving corporate governance. Anecdotally, operators of many small water systems lack the technical, financial, and managerial resources to provide reliable, safe drinking water. Some of those operators are either unwilling or unable to acquire the requisite skills. Future and current profits/losses as well as transactions costs play a role in determining if water systems will remain independent or choose to be acquired. Our findings confirm that merger may be a means to exit the industry, increase the skill level of operators, and avoid future expenses associated with investment in (human and physical) capital.

Poorly performing systems, those with drinking water quality or monitoring violations, are more likely to be acquired than highly performing systems. Furthermore, patterns of merger and acquisition activity in the drinking water systems indicate that transactions costs are likely to play a large role in affecting mergers in the industry. While encouraging consolidation is not a declared policy of EPA, inducing organizational changes may be an alternative means to raise the management skill of drinking water system operators. Encouraging small systems to form rural cooperatives or purchase water from a neighboring system might also be effective policies.

We also find some evidence that smaller systems have a higher probability of acquisition. This is consistent with the hypothesis that acquired water systems may be merging to achieve economies of scale. However, this is by no means conclusive evidence. It may also suggest that systems that are non-core components of a larger business (such as systems serving residential or commercial property developments) are essentially being spun-off or sold to a company or agency for which water supply is a core enterprise.

3. Dissemination

(1) M-Y.A. Lee, "Consolidation as a Compliance Mechanism: "Small Drinking Water Systems and the Safe Drinking Water Act." Presented to the Illinois Water Conference, Urbana, IL October 2006; also, presented to the Illinois Economics Association, October 2006.

(2) M. Jaffe, J.B. Braden, and M-Y. A. Lee. "The Why and Wherefore of Water System Mergers." *On Tap,* National Drinking Water Clearinghouse, West Virginia University (Forthcoming).

(3) M-Y. A. Lee and John B. Braden. "Consolidation as a Compliance Mechanism: "Small Drinking Water Systems and the Safe Drinking Water Act." Draft is provided in Appendix B of this report. The paper is in revision for submission to a peer-refereed journal.

(4) The paper noted in (3) was accepted for presentation to the University Council on Water Resources (UCOWR), July 2007, in Boise, Idaho, and to the American Agricultural Economics Association, July 2007, in Portland, Oregon.

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Appendix A

The Why and Wherefore of Water System Mergers

Martin Jaffe,[*] John Braden[**] and Min-Yang Lee[***]

The USEPA has devoted millions of dollars in recent years to programs aimed at strengthening the technical, managerial, and financial (TMF) capabilities of small systems. These concerns about strengthening small system capabilities are driven by differences in Safe Drinking Water Act (SDWA) compliance rates – a higher percentage of smaller water systems have water quality and reporting violations under the SDWA than do larger water systems. However, solutions are not always found in additional TMF investments. Sometimes it makes more sense to turn the systems over to new owners.

Compliance problems arise for many reasons. Some are attributable to limited customer bases. Fewer customers usually mean lower revenues to cover fixed costs, lower bond ratings making borrowing more costly, and higher per-customer service costs. In such cases, encouraging underperforming systems to combine resources and administrative structures can reduce overhead while also gaining economies of scale. Larger system generally can afford greater technical sophistication. They also have greater attractiveness in bond markets. Thus, encouraging small water system mergers and reorganizations can be an important strategy for improved compliance.

There is relatively little research available on factors that precipitate mergers or reorganizations of small water systems. USEPA (2002) identified some general factors associated with successful water system consolidation, including stakeholder support, policies and legislation, and the existence of regional water organizations. Historical analysis suggests other possibilities in the drinking water industry, and careful statistical analysis provides insight into their importance.

Most water utilities in the U.S. underwent enormous transformation in the late 19th and early 20th centuries. Within a period of just two or three decades, most urban water systems changed from being predominantly privately-owned to being

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predominantly publicly-owned. This historical transformation is relevant today because, at the time they were initially acquired and municipalized, many of these private urban waterworks had service areas and customer bases similar in size to those served by many small water systems today. Furthermore, many of these municipalized systems were also perceived as underperforming in meeting the water quality and quantity demands of their eras.

Five different factors have been proposed by historians and economists to explain this historical organizational transformation: public health concerns, public finance pressures, contractual conflicts between private providers and their customers, corruption, and transaction costs. Each of these may also influence contemporary small water system acquisitions and mergers.

Public Health and Safety

In the 19th Century, public health crises often sparked public outcries for municipal water services. For example, the City of Chicago built its new water distribution and treatment facilities and initiated its project to reverse the flow of the Chicago River to protect its Lake Michigan water supplies after 80,000 citizens died of typhus in 1885. Public concerns over fire risks also generated public dissatisfaction with private water companies. As York University economist Letty Anderson (1988) noted, many also thought that privately-owned waterworks made most of their water supply decisions only to generate short-term profits from residential water sales rather providing sufficient water to public hydrants for municipal fire protection.

Recent studies dispute the presumed public health deficiencies of private waterworks, including one by University of Pittsburgh economic historian Werner Troesken (1999) which found that the transition of ownership did not bring about a significant reduction in water-borne disease outbreaks. In addition, private companies more frequently used filtration. Nevertheless, the move to public ownership probably indicated a strong public demand for change and improvement and a prevailing sentiment that public ownership was more likely to produce results.

Municipal Finance Pressures

A second set of forces contributing to the municipalization of urban water supplies involves the rapid rate of municipal annexation in the late 19th and early 20th centuries. These municipal expansions greatly increased the service areas of urban waterworks, especially after modern indoor plumbing was introduced to residential dwellings in the late-19th Century. Residents wanting these modern conveniences demanded that additional water service. For example, Ann Durkin Keating (1985), a history professor at North Central College in Illinois, noted that many suburban residents sought annexation to the City of Chicago as a means of connecting to its newly enhanced public water system when local improvement districts and private water companies were unwilling to expand their service areas to unincorporated areas.

According to Harvard economist David Cutler and Grant Miller (2005), then a graduate student in health economics at Harvard, this rapid rate of municipal annexation was associated with the ability of publicly-owned and financed municipalities to tap financial resources that were unavailable to private water suppliers. After the development of modern bond markets, private-investor and special-assessment financed waterworks simply could not raise capital as efficiently as municipalities could. Bonds provided sophisticated municipalities with the financial resources needed to meet rising demand for potable water at a time when the costs of constructing modern water systems to serve entire urban populations were too large for private firms to assume.

The ability of government to enforce universal payment for services, and innovations in the bonding of public investments, undoubtedly increased the capacity of municipalities to take over and operate water supplies. Nevertheless, private water companies have historically offered safe and significant returns to shareholders, so poor performance and financial weaknesses are not necessary results of private ownership.

Contractual Conflicts

At the turn of the 20th Century, franchise arrangements between cities and private water companies often required the companies to improve water treatment or expand their service areas without being able to increase their rates sufficiently to offset these additional expenditures. These fiscal limitations reduced dividends and thereby lowered the perceived value of their stock to their investors. This decline in stock values, in turn, enabled municipal officials to later acquire the private water systems at reduced prices either by purchase, franchise revocation, or through the exercise of eminent domain, or by simply building a public waterworks to undercut the private system. Moreover, the growing threats of public appropriation removed economic incentives for private water companies to expand their operations or improve their facilities. Foregoing these improvements was a rational investment decision intended to bolster the private waterworks' short-term profits; however, this inaction further reduced both the long-term value of the systems and the compensation received by the owners, when they were later expropriated and municipalized by public officials.

Contractual conflicts contributed to the simultaneous growth of state utility regulation, municipal ownership, and especially frequent litigation. Werner Troesken and Cornell University economist R. Rick Geddes (2003) correlated these factors with later expropriation, also noting that the substantial metering costs commonly required of private waterworks by many municipal franchises created a quandary for privately-owned water utilities: Unit prices of water were often too low to justify a privately-owned waterworks to spend money to install and read water meters, while failing to meter customers made it harder for the private waterworks to justify asking for increases in their usage charges and connection fees. Further, as noted by Scott Masten (2004), a professor of Business Economics and Public Policy at the University of Michigan, many private water companies that couldn't adequately recover their metering fees had to rely on revenue transfers from government, further increasing the private utility's exposure to contractual conflict and appropriation.

Corruption

History has amply demonstrated the need for regulation of privately-owned utilities by state utility commissions and through municipal franchise contracts. For example, Syracuse University historian Nelson Blake's classic book examining the emergence of municipal water systems in New York, Philadelphia, Boston and Baltimore in the early 19th Century showed how public water boards and commissions were pitted against speculative private water companies, with the battle played out in the back-rooms of the state legislatures that granted lucrative service franchises to private water systems.

Corruption and back-room deals become a subtext of Blake's historical narrative; in some cases, as in New York City's, the private water companies were merely corporate shells through which wealthy investors engaged in banking and other financial enterprises unrelated to water supply provision. Werner Troesken (2005) later cited this concern over corruption by private water suppliers, and the larger Progressive national reform movement at the end of the 19th Century which embraced the cause of utility regulation, as a significant contributor to municipal expropriation of private water companies.

Troesken also ironically notes that many public water systems themselves became instruments of urban machine politics, where patronage and politically-determined rate structures filled the pockets of the well-connected while infrastructure maintenance was short-changed. A major reason that corruption theories remain so relevant in explaining institutional change is that water supply history might have come full circle, with the alleged operational inefficiencies and fiscal deficits of "corrupt" public water systems providing the justifications for the growing interest in water supply privatization today.

Transaction Costs

A recent statistical study of Midwestern water system mergers by Min-Yang Lee (2006), a University of Illinois researcher, examined how the costs of reorganization affect the probability of merger. Lee found that the two factors having the greatest influence on the transaction costs of water system mergers are the system's form of ownership and the extent which the water system is already interconnected with an adjacent system. Publicly-owned water systems were six percent less likely to be acquired than privately-owned ones. This finding suggests that the transfer of public assets is fraught with greater political complexity and higher bureaucratic costs than transfer of privately held assets. Water systems that purchased water were 13 percent more likely to be acquired than systems that were not already interconnected to an adjacent system. The existence of an operating relationship between two water systems almost surely reduces the costs of further system integration through merger.

Lee also found that small water systems located within wealthier metropolitan areas were also slightly more likely than average to be acquired. Even though urban systems are theoretically more expensive to acquire than water systems in more rural locations due to land costs and the number of parties interested in the transaction, their greater density of service connections also implies a relatively high ratio of operating income to fixed costs. This could offset some of the higher transaction costs. An increase in the service connection density by ten connections per square mile was found by Lee to increase the probability of merger by 0.08 to 0.2 percent.

Encouraging Small System Mergers

Times were certainly different at the turn of the last century, when the regulatory context (rampant corruption, open-ended and perpetual franchises, and lack of regulatory oversight) and capital markets differed so extensively from the institutional framework under which small water suppliers currently operate. But the ongoing importance of safety, utility regulations, and financing makes these factors relevant today.

Health and safety concerns still account for most of the short-term pressures for change within the water industry. Public disclosure requirements expose systems to increased public scrutiny. USEPA and states mandate and monitor water system compliance with new drinking water standards and other regulatory mandates. These include, for example, USEPA's copper, lead, arsenic, microbe, disinfection by-product, and radionuclide rules, which are driving new investments in treatment technologies. Since these investments are expensive, many small water utilities can most economically treat meet these new demands by spreading their water filtration and treatment costs over a larger customer base, rather than continually raising their water rates. This creates an incentive for institutional change, especially through water system expansion or consolidation.

The need to purchase advanced treatment technologies, in turn, raises many of the issues that private water systems faced in meeting new demand at the turn of the last century, when cities were rapidly growing and privately-owned utilities' access to capital was constrained. These capital needs are likely to grow, in any case, simply because of the need to replace old pipes, expand service to meet new demand, and comply with post-9/11 security needs. Water service bonds are considered by most analysts to be a safe investment, but bond returns are still influenced by the size and scale of the water utility. It's still often easier and cheaper for larger water utilities to borrow money than smaller ones because of their larger revenue streams., State revolving loan funds can theoretically offer smaller water systems capital at lower rates than could private bond markets, but since the demand for these funds outstrips supply, access to that capital can involve a long wait on a state priority list.

More stringent public oversight (by state environmental agencies and public utility commissions) of water systems can influence institutional change. Public utility commissions have resolved most of the historic problems of corruption, but regulatory red-tape can also impede needed improvements, especially if it limits a small utility's ability to raise its water rates in order to pay for its growing treatment and operational costs, or denies its requests for expansion of its service area. Larger water systems with their larger staffs simply have greater administrative capacity to handle the reporting and the paperwork generated in meeting state public utility regulations as well as SDWA mandates. So, in the same way that some scholars believe that contractual conflicts on the state and municipal level drove urban water system changes in ownership in the 19th and 20th centuries, state and federal conflicts may still create incentives for water systems to change their scale or operations in the 21st Century.

Finally, reducing the transaction costs of acquisition could be a useful strategy to encourage mergers between water systems so that they can realize better economies of scale and thus achieve higher rates of regulatory compliance. Lee's statistical analyses of water system mergers in the Midwest reinforce current beliefs that merger can be an effective way for smaller water systems with SDWA violations to achieve regulatory compliance. The fact that smaller water systems and water systems with SDWA violations are both more likely to be acquired gives some credence to those beliefs.

However, this same analysis shows that small water systems in rural counties with lower incomes and low or declining growth rates are apparently not using merger as a compliance strategy, despite their higher rates of SDWA violations. So if regulators and policy-makers want to encourage mergers as one way to shift more capital and resources to troubled small rural water systems, adopting policies to reduce the transaction costs of merger make a lot of sense. Because water systems that purchase water often are acquired by the system that they purchase water from, adopting state and federal policies that encourage the transfer or sale of water between adjacent rural systems is likely to be the most helpful approach to reducing some of these costs.

Other strategies can also be considered. Either offsetting high transaction costs with direct grants or loans, or deregulating the merger process (especially if water systems are treated public utilities) will certainly encourage more mergers. Reducing some of the political burdens on transfers of publicly-owned systems (by removing requirements for public referenda, for instance) might also reduce some of these costs, making mergers a more effective strategy for dealing with SDWA violations by small water systems.

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Appendix B

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

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Executive Summary:

This paper explores the role that consolidation can play in increasing the capacity of small water systems to provide safe, affordable drinking water. We develop a simple model to explain water system acquisition; systems continue to operate if the profits (current and future) are greater than the net gains from being acquired (transfer payment minus transactions costs). Using data from the Safe Drinking Water Information Systems (SDWIS), state primacy agencies, USDA, and US Census, we test our model. We find that small systems with frequent Safe Drinking Water Act (SDWA) violations are likely to be acquired. We also find that systems that purchase water and are privately owned are more likely to be acquired than systems that produce their own water and are government owned. Together, we interpret these findings as evidence that water systems in are using merger as a compliance mechanism.

Introduction

Following the Safe Drinking Water Act (SDWA) amendments of 1996, there has been considerable effort by government, research institutions, and the private sector to increase the technical, financial, and managerial (TFM) capacity of small drinking water systems to deliver safe, affordable drinking water. With this goal in mind, legislators included operator certification requirements, Drinking Water State Revolving Fund (DWSRF) loans, and small system technology variances as part of those amendments. By comparison, there has been little effort directed towards understanding how organizational innovation can improve the capacity of small water systems to comply with regulations. We explore the role that consolidation can play in increasing the capacity of small water systems to provide safe, affordable drinking water.

There are over 50,000 CWSs in the US, more than 90% of them are serve fewer than 10,000 people and thus are classified as small by USEPA. Compared to larger water systems, these small systems have higher per-customer infrastructure costs, are not able to take advantage of economies of scale and are more likely to violate SDWA regulations (USEPA:1999).

Basic economic reasoning suggests that a firm will go out of business and exit an industry if it cannot make a profit. However, drinking water systems may not operate with a profit motive. Government-owned systems can be subsidized by taxpayers and may be viewed as important sources of employment or symbols of local prosperity.

Other small systems are tied to specific residential developments and can also be cross-subsidized.

Small water systems, which are often rural, face demographic challenges in complying with the regulations of the SDWA. According to the National Research Council, rural systems face difficult demographic pressures, such as decreasing populations and lower median incomes, that can make full-cost recovery difficult (1997).

Merger is a possible organizational change by which systems can exit the industry in an orderly fashion. We operate under a simple economic model to explain water system consolidation. Then, examining recent data on water system consolidation, we find evidence that systems are more likely to merge if they currently purchase water from another system, have frequent drinking water violations, are privately-owned, or are small. Inclusion of basic spatial data for a subsample of water systems leads to similar results. Our results suggest that consolidation may be an effective way of increasing the compliance with the SDWA, therefore the overall quality of the US drinking water supply.

Why Firms Merge

Two complementary economic explanations of merger and acquisition place perspective around consolidation in the drinking water industry. One line of thinking holds that mergers are a mechanism to transfer assets from underperforming firms to successful ones (Dewey, 1961; Tremblay, 1988). The other maintains that mergers are transactions in the market for corporate control, where management teams compete for the right to manage productive assets (Jensen, 1983). These two points of view converge in our view of acquisition as a means to both match poorly performing systems with better management and to take advantages of economies of scale.

In our model, a drinking water system gives its owner a stream of benefits (or losses) from continuing to provide water. This includes current and future economic profits in the traditional sense, as well as penalties due to SDWA violations. In a less traditional sense, these benefits also includes any ``psychic'' benefits from providing water, which could include a pride in operating a water system, fulfillment of a perceived a mission to provide drinking water, or the extra employment that a water system brings to the community. There can also be psychic costs; a small, underperforming water system could be a major cause of stress for a non-professional owner. These psychic costs typically do not enter into a profit-loss statement. A traditional for-profit firm does not consider these psychic costs and benefits, but a small owner-operated or municipally-owned system may take some of these psychic costs into account.

When a systems stops independent operation via merger, it incurs transactions costs. These include costs of connecting infrastructure, regulatory costs, and restructuring costs. These transactions costs also include any transfers paid to or from the acquiring firm as well as political costs from relinquishing control. In the case of municipally owned water systems, transferring publicly owned assets to a private company may be a long, expensive political process. A water system will be acquired if makes the current owner better off, that is, if the capitalized value of the profits is smaller than the transactions costs.

Our behavioral model generates the following hypotheses:

1. Small systems that cannot achieve economies of scale are likely to be acquired.
2. Systems that frequently violate the SDWA have lower TFM capacity and are more likely to be acquired.
3. Publicly-owned systems have high political costs of merger and are less likely to be acquired.
4. Systems that currently purchase water have lower transactions costs of completing a merger and are more likely to be acquired.
5. Systems in resource-limited areas are likely to use merger as a way to exit the industry.

In order to test and verify our behavioral model, we use a probit model to predict the probability of a water system being acquired. This type of econometric model has been commonly used to analyze factors influencing municipalization of drinking water systems (Troesken, 2003), plant exit in the meatpacking industry (Anderson:1998), and mergers of publicly traded firms (Palepu,1986). We estimate two models; the first model is for the entire sample but contains not spatial data. For the second model, we augment a portion of our dataset with some simple GIS data.

Data Used

We gathered data on mergers of CWSs from primacy agencies in EPA Regions 5 and 7. Six of the eleven primacy agencies in these regions track consolidation and were able to supply us with data. These data are then combined with system characteristics data contained in EPA's Safe Drinking Water Information System (SDWIS) database, and county-level demographic data from the US Census and ERS division of USDA. There are 6,502 observations of small water systems, of which 430 (6.61%) were acquired (ACQUIRED). Because the collection of merger data is not standardized, the primacy agencies have data for varying periods of time. Data on merger occurrence spans 11 years in Illinois, but only 4 years in Michigan. In our statistical analysis, we control for this variability using a series of dummy variables. A state-by-state summary of drinking water systems is presented in Table 1.

Data from SDWIS includes information on service connections, number and type of drinking water violations, ownership, and water source. A summary of the data and associated hypotheses are presented in Table 2.

Service connections (SVC) are simply the number of connections that a water system serves. We hypothesize that systems that are acquired will be smaller than systems that are not acquired.

Drinking water violations are classified into two categories: monitoring/reporting violations and quality violations. Monitoring and reporting violations (MONITOR) include failure to adequately test drinking water, file a consumer confidence report, or a public note of drinking water quality. Quality violations (QUALITY) include treatment type violations and maximum contaminant level violations. Both types of violations are reported as the average number of violations by a system per year. We hypothesize that SDWA violations, particularly monitoring and reporting violations, indicate underperforming management. Water quality violations may be indicative of underperforming management, inadequate capital investment, or both.

Drinking water systems were categorized as public (PUBLIC) if they are owned by a federal, state, or local government. Before accounting for any merger activity, 62.1% of drinking water systems in this sample were publicly owned. Publicly owned water systems may have lower costs of capital, a perceived mandate to provide water, and high transactions costs of merger due to political reasons. Therefore, we expect publicly owned water systems to be less frequently acquired.

Small water systems that purchase water from another system account for 18.4% of the water systems in the sample. Because these systems have already connected with another system we hypothesize that systems that purchase water are more likely to merge.

We expect that the demographic pressures faced by rural water systems will cause them to desire to exit, when possible. We use a modification of the ERS rural-urban continuum codes to control for ruralness at the county level. Counties are metropolitan if they are in a metropolitan area of 250,000 persons or more (METRO), otherwise they are classified as non-metropolitan. Following the NRC (1997) hypothesis, we expect systems located outside of these metropolitan areas to be more likely to merger in order to comply with SDWA regulations. Furthermore, in metropolitan areas, we believe that the per-unit costs of connecting water infrastructure is likely to be higher than in rural areas; this also implies that systems outside metropolitan areas will have lower transactions costs of mergers and therefore be more likely to merge.

Because we lack data on costs of potential interconnection, we construct a variable to represent interconnection costs. We use the number of service connections per square mile per county (DENSVC) as a proxy for the cost of a system merger. In densely populated counties, the water supply network is more extensive, which would decrease transactions costs of merging because two separate networks may be closer to each other. However, in those counties, the per-unit costs of constructing pipelines may also be higher, due to those higher population densities. To account for this, we also interact the METRO and DENSVC terms.

In order to control for resource limitations on small water systems, we include data from the 1990 Census for population growth rate (GROWTH) and median income (INCOME). Both of these measures are aggregated at the county level.

For two states, Iowa and Illinois, we are able to incorporate spatial data into our analysis. The spatial data supplied by drinking water agencies in those two states was incomplete, so gaps in location information were supplemented by geocoding addresses using ArcGIS. We follow the analysis of Castillo, *et al* (1997); however, instead of constructing prices of merger, we use the distance between a water system and it's nearest neighbor (DIST) as an explanatory variable. Also using ArcGIS, water systems located inside a Metropolitan Statistical Area as defined by the US Census, are identified (MSA). We expect the MSA variable to function similarly to the METRO variable; unit-costs of merger may be higher due to physical construction costs in a densely populated area. Interaction terms between MSA and DIST are included to control for the possibility of different unit costs of interconnecting two water systems across metropolitan and non-metropolitan areas.

Results

Overall, our results support our hypotheses concerning the factors that promote merger activity. We report results first for the six-state sample, then for the two state sample where geographic information is available to enhance the analysis.

In Table 3, we show the effects that marginal changes in system characteristics will have on the probability of a merger. For continuous variables, this is the change in probability of a merger that results from a unit change in the independent variables. For discrete variables, these are the change in probability that results from a change from of the independent variable 0 to 1 (Greene, 2003). In interpreting these effects, it is useful to note that 6 percent of the firms were observed to have merged. Therefore, with no other information about the characteristics of a system, we estimate that it has a 6 percent chance of being acquired.

Six-State sample with no Spatial Data

The results indicate that small water systems are more likely to be acquired than large systems; however, this effect is relatively small. To be precise, an additional 10 service connections lowers the probability that a system will be acquired by just 0.6 percent. While this effect is small in magnitude, it does support our theory that small systems are choosing to be acquired. However, we note that systems that are larger tend to be publicly-owned; statistically, this results in larger standard errors for those coefficients, but does not bias the coefficients themselves.

We also find evidence that water systems with frequent SDWA violations are more likely to be acquired. An increase of 1 quality violation per year results in an increase of acquisition probability by 1.4 percent. Similarly, an additional 1 monitoring violation per year increases acquisition probability by approximately 0.2 percent.

We find that publicly owned water systems are approximately 6.5 percent less likely to be acquired that privately owned water systems. The political costs of transferring ownership of public assets may be high, which would discourage merger activity.

As expected, water systems that purchase water are more likely to be acquired than systems that do not purchase water. Water systems that purchase water are 14.6

percent more likely to be acquired than systems than systems that were producing their own water. Clearly, the transactions costs of completing a merger are much lower when the two systems have already connected, and the relatively large effect found here reflects these reduced transactions costs.

County-level water system density increases the probability of an acquisition slightly. An increase in the service connection density by 10 connections per square mile increases the probability of merger by approximately 0.21 percent. This result is consistent with a hypothesis of our model: an increase in system density implies smaller distances separating distribution networks. The costs of physically interconnecting two water systems would be lower in those areas.

Finally, we note that water systems in metropolitan areas are approximately 0.1 percent less likely to be acquired than systems in non-metropolitan counties. This result seems to support the NRC's hypothesis that rural systems face more intense demographic pressures. These systems may be using merger as a mechanism to relieve those pressures.

Two-State subsample with Spatial Data

When spatial data is included and our model is re-estimated, we find similar results. Again, the effect of size is relatively small; an additional 10 service connections lowers the probability that a system will be acquired by just 0.5 percent.

Water systems with 1 monitoring violation per year are approximately 0.45 percent more likely to be acquired than systems with no monitoring violations. However with this model, we find that drinking-water quality violations have no statistically significant impact on the probability of merger. These findings imply that regulatory pressures may differ for quality versus monitoring violations, with the latter being more consequential for subsequent decisions about system management.

Publicly owned water systems are approximately 4.8 percent less likely to be acquired that privately owned water systems. Water systems that purchase water are 14.2 percent more likely to be acquired than systems than systems that were producing their own water.

Curiously, distance to the nearest neighboring water system has no impact on the probability of a water system to be acquired. However, this unexpected finding may be a result of poor quality data due imprecise geocoding.

Finally, water systems in a metropolitan statistical area (MSA) are approximately 0.1 percent less likely to be acquired than systems in non-metropolitan counties.

Conclusions

Although it is tempting, this type of model should not be used to predict whether a specific system will be acquired. It is best suited to understand how changes in firm characteristics or policy might affect merger activity in general. We do not attempt to understand the decision making process of the acquiring firm. These systems may be motivated to increase their capital base, capture profits due to increase returns to scale, or be required to acquire small systems by regulators. We also do not attempt to explain other types of organizational innovation, including the formation of drinking water collectives or cooperatives or the decision to begin purchasing water.

Our results support the theory that merger and acquisition is a method of improving corporate governance. Anecdotally, operators of many small water systems lack the technical, financial, and managerial resources to provide reliable, safe drinking water. Some of those operators are either unwilling or unable to acquire the requisite skills. Future and current profits/losses as well as transactions costs play a role in determining if water systems will remain independent or choose to be acquired. Our findings confirm that merger may be a means to exit the industry, increase the skill level of operators, and avoid future expenses associated with investment in (human and physical) capital.

Poorly performing systems, those with drinking water quality or monitoring violations, are more likely to be acquired than highly performing systems. Furthermore, patterns of merger and acquisition activity in the drinking water systems indicate that transactions costs play a large role in affecting mergers in the industry. While encouraging consolidation is not currently a declared policy of USEPA, inducing organizational changes may be an alternative means to raise the management skill of drinking water system operators. Encouraging small systems to form rural cooperatives or purchase water from a neighboring system might also be effective policies.

We also find some evidence that acquired water systems may be merging to achieve economies of scale; smaller systems have a higher probability of acquisition. However, this is by no means conclusive evidence. It may suggest that systems that are non-core components of a larger business (residential or commercial property) are essentially being spun-off or sold to an existing company.

Table 1: Distribution of Community Water Systems by Acquisition Status.

State	Full Sample	Acquired	Not Acquired	Observation Period
IA	1032	211	821	1994-2004
IL	1528	75	1453	1995-2004
IN	753	62	691	1996-2004
MO	1308	18	1290	2000-2004
MI	1303	40	1263	2001-2004
NE	578	24	554	1997-2004

Table 2: Descriptive Statistics for Community Water Systems and Hypothesized Effect on Merger Probabilities.

Variable	Units	Full Sample	Acquired	Not-Acquired	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	0.73	(+) Lower management capacity
PUBLIC	percentage	62.1%	30.1%	64.3%	(-) Higher transaction costs
PURCHASE	percentage	18.4%	40.2%	16.9%	(+)lower interconnection costs
DENSVC	connections/mile	67	96	65	(+) Nearby merger partners
INCOME	$10,000s	3.95	4.20	3.93	(-) Resource limitations
GROWTH	percentage	9.54	8.65	9.6	(-) Resource limitations
METRO	percentage	44.4%	56.6%	43.5%	(-) Resource limitations (-) High unit costs of merger
DIST	miles	6.786	3.296	7.187	(-) Lower connection costs
MSA	percentage	27.2%	33.1%	26.5%	(-) High unit costs of merger

Table 3: Marginal and Discrete Effects Calculated After Estimating a Probit Model with/without Spatial Data

	No Spatial Data	Spatial Data
SVC	-6.1x10^-5***	-5.25*10^-5 ***
QUAL	0.0136***	-0.040
MONIT	0.0021***	0.0045 ***
PUBLIC[a]	-0.0646 **	-0.048 ***
PURCHASE[a]	0.1456 **	0.142 **
DENSITY	2.10 x 10^-4 ***	-
METRO[a]	-0.001	-
INCOME	6.78 x 10^-3 ***	-
GROWTH	-	0.0013 ***
DISTANCE	-	1.81 x 10^-4
MSA[a]	-	-0.0096***

** - Significant at 5% level
*** - Significant at 1% level
[a] – Indicates a discrete effect; the effect of changing the value of a discrete variable from 0 to 1.

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