NETWORKED SUPPLY CHAINS: DESCRIBING THE COSTS OF LAKE MICHIGAN'S DRINKING WATER

JASON MICHNICK,[1] KATE ALBRECHT,[1] DEBORAH A. CARROLL,[1] AMANDA KASS,[2] AND BROOKE WETMORE[1]

[1] UNIVERSITY OF ILLINOIS CHICAGO
[2] DEPAUL UNIVERSITY

Most utilities supplying Lake Michigan water to Illinois residents rely on intergovernmental wholesale purchasing agreements. In this article, we describe this complex network of interconnected municipalities in northeastern Illinois — the Lake Michigan Drinking Water Network — and examine variation in residential water bills. We find a high degree of fragmentation is associated with substantial differences in what residents pay for their drinking water. Neither the type of purchasing agreement nor position within a supply chain explain such differences; however, there is less variation in residential water bills among municipalities with collective purchasing agreements. In addition, municipalities that self-produce their drinking water have the lowest rates.

INTRODUCTION

Despite Illinois comprising less than 4% of Lake Michigan's coastline, more than 60% of the people who rely on it as a primary source of drinking water are Illinois residents. With only a handful of municipalities having direct access, most water utilities serving the roughly 6.5 million Illinois residents consuming water from Lake Michigan rely on intergovernmental wholesale purchasing agreements to supply their systems. The result is a complex network of interconnected utilities creating multiple supply chains stretching more than 30 miles away from Lake Michigan's shores. This integrated network of drinking water providers appears to mimic a consolidated or regionalized water system in some ways but also remains highly fragmented. In this paper, we describe the nature of the networked supply chain of municipalities that rely on Lake Michigan as a source of drinking water in northeastern Illinois. We also examine the relationship between a municipality's position in a supply chain, its purchasing arrangement, its source of water, and its residential water bills.

This article provides an overview of the Lake Michigan Drinking Water Network (LMDWN), including the regulatory environment of this network. The LMDWN includes most municipalities in northeastern Illinois. In addition, we conduct a comparative analysis of residential water bills between municipalities in the LMDWN versus those relying on alternative sources (e.g., groundwater and non-Lake Michigan surface water). Last, we examine the different purchasing arrangements within the LMDWN to determine differences in residential water bills across communities and purchasing arrangements. This network structure of the wholesale market for drinking water is a critical component of municipal water systems that has not previously been studied. Given the complex context of drinking water supply and cost in northeastern Illinois, our article addresses two research questions: How do municipalities in the LMDWN navigate the wholesale drinking water network through purchasing arrangements? And what differences do we observe between regional supply chain structures and residential water bills?

Excluding producers, as of 2019, 93 of the municipalities (60%) purchased water through a direct purchasing agreement with their supplier. The remaining 67 municipalities (40%) created some form of cooperative arrangement, such as a water commission or joint action water agency (JAWA) for their drinking water supply. Through our analysis, we found only slight differences in the average water bills between these two purchasing approaches. However, municipalities acting as both producers and suppliers for the rest of the LMDWN had substantially lower water bills by comparison. This could indicate that producers are able to capture economies of scale through higher volumes of production and therefore benefit the most from a networked approach to a regional distribution network. We also found that despite supply chains with multiple points of resale having the potential for price markups along the way, a municipality's position within a supply chain was not associated with its overall residential bills.

WATER SYSTEM COSTS AND RATES

Existing research on the costs and management of drinking water systems around the world has found several factors that contribute to differences in residential water bills. The best rate-setting practices establish a price that reflects the true cost of providing drinking water to customers while maintaining long-term viability (Beecher & Shanaghan, 1999). The costs of drinking water systems can be divided into fixed costs, such as capital, and variable costs that include system inputs, labor, and administration (Beecher, 2011). Research has found that utilities invest four to five times more in capital than revenue generated, possibly due to utilities being subsidized by grants and low-interest revolving loan programs from higher levels of government (Thorsten et al., 2009). Moreover, a heavy reliance on variable costs can result in sudden rate shocks that are triggered by deferred maintenance or emergency repairs.

Statewide and regional comparisons of residential water bills in the United States have found a few other factors associated with system costs. First, the source of untreated water matters. Utilities using groundwater have lower rates due to it being less capital intensive to extract and treat (Hughes et al., 2006). However, not all utilities have access to a primary source of groundwater. Across the U.S., nearly a quarter of community water systems rely on purchased water for their supply (Beecher & Kalmbach, 2013). Evidence is mixed on whether this has a positive or negative impact on water bills. Beecher and Kalmbach's (2013) study of utilities across the Great Lakes region found that utilities purchasing wholesale water from another utility have lower residential bills, likely due to their ability to avoid capital expenses associated with extractions and treatment. Hughes et al. (2006) and Thorsten et al. (2009) found that in North Carolina, purchased water increases bills due to sellers' abilities to pass along capital costs to buyers.

Unanimous across these studies is that utility size is a determining factor of residential bills, with larger utilities charging lower rates by capturing economies of scale. Small utilities have higher rates of Environmental Protection Agency health violations (Shih et al., 2006), have less access to professional staff (Switzer et al., 2016), and pay higher interest rates on debt (Simonsen et al., 2001). Fragmentation of water systems within urban areas also results in disparities in fiscal capacity, preventing the redistribution of resources and adversely affecting lower income areas (Scott et al., 2018). Although consolidation is seen as an effective tool for overcoming these challenges and achieving economies of scale, there is evidence that not all strategies of consolidation are beneficial.

Consolidation can occur through the physical integration of water systems or through administrative consolidation (Shih et al., 2006). Administrative consolidation allows for one organization to oversee the management of functionally separated systems, but the potential gains are limited (Klien & Michaud, 2019). Consolidation through physical integration may yield more economies of scale but only if the underlying relationship between volume of water, size of the distribution area, and density of service connections is not adversely changed (Torres & Morrison Paul, 2006). Last, while Kim and Clark (1988) note that past engineering studies find nearly inexhaustible economies of scale in treatment, there is the potential for diseconomies of scale in the distribution of water as a result of a service area being too large relative to the number of customers or total volume of water being distributed.

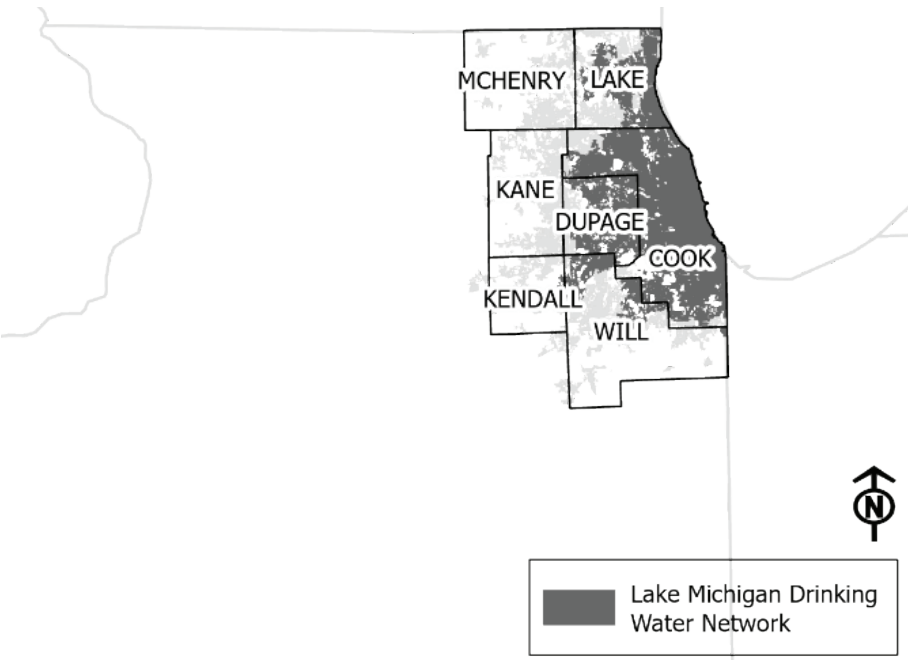
Although the LMDWN mimics a consolidated regional system, it is still highly fragmented, which has implications for how the benefits from economies of scale are distributed. Given that the structure of the LMDWN includes few producers (i.e., municipalities that pump water from Lake Michigan and treat it before distribution) and many purchasers, we believe it is possible for the savings created through economies of scale in treatment to be internalized by producers in order to maintain lower rates for their own constituents or redistributed to purchasers through different supply chain structures. The literature does not inform us how supply chain structures, especially the resale of wholesale water or a cooperative approach to wholesale purchasing and managing shared infrastructure, would influence the costs of a system. Intuitively, supply chains linked through multiple direct purchasing agreements between individual communities might have more opportunities for capital costs to be passed along. However, cooperative approaches that do not engage directly in production may also suffer from diseconomies of scale by linking distribution systems that have fundamentally different characteristics.

REGULATORY ENVIRONMENT OF LAKE MICHIGAN DRINKING WATER NETWORK

Northeastern Illinois encompasses Cook County (including the City of Chicago) and the six counties that surround Cook County: DuPage, Kane, Kendall, Lake, McHenry, and Will. Lake Michigan is a dominant resource for drinking water in the region, as seen in Figure 1, which highlights those municipalities relying on it as a primary source. Northeastern Illinois' relationship with Lake Michigan has an interesting history with several engineering marvels, including raising the grade of several city blocks to make room for a sewer system, digging a two-mile tunnel underneath the lake, and reversing the flow of the Chicago River by taking water from Lake Michigan and discharging it into the Mississippi River watershed (Cain, 2005). While these public works projects had positive impacts on the quantity and quality of drinking water available to residents of northeastern Illinois, negative impacts were felt elsewhere in the region. Downstream communities along the Mississippi River experienced worsened water quality, and states bordering Lake Michigan blamed declining lake water levels on the projects in Chicago. Both complaints resulted in lawsuits and years of negotiations. As a result of these legal conflicts, the U.S. Supreme Court issued a decree in 1967 (amended in 1980) that dictates the rules for Illinois' diversion of water from Lake Michigan (*Wisconsin v. Illinois*, 388 U.S. 426 (1967); *Wisconsin v. Illinois*, 449 U.S. 48 (1980)). The ruling stipulates that the State of Illinois is legally allowed to divert an average of 3,200 cubic feet of water per second from Lake Michigan, based on a 40-year running average, for all uses, including water for drinking and sanitary purposes, maintaining navigable waterways, and stormwater runoff that is unnaturally diverted from Lake Michigan's natural watershed.

FIGURE 1

MAP OF LMDWN COVERAGE IN NORTHEASTERN ILLINOIS



The Illinois Department of Natural Resources (IDNR) manages the diversion of Lake Michigan's waters. Through its Part 3730 Rules, IDNR provides the permits necessary to divert Lake Michigan water. Entities seeking a diversion permit must follow a lengthy review process and demonstrate that an alternative source, such as groundwater, is insufficient to meet the needs of the population served. If approved, the permit specifies the maximum volume of water that can be consumed by that entity. While IDNR is the authorizing agency for issuing permits to divert Lake Michigan water for domestic use and annually monitors the volume of water supplied to ensure the state is in legal compliance with the Supreme Court decree, IDNR does not regulate how utilities are managed, the rates charged, or how water is sold between permittees. Municipalities and water utilities have a high degree of autonomy to determine who they partner with for purchasing water and how those partnerships are established.

CURRENT LAKE MICHIGAN DRINKING WATER NETWORK

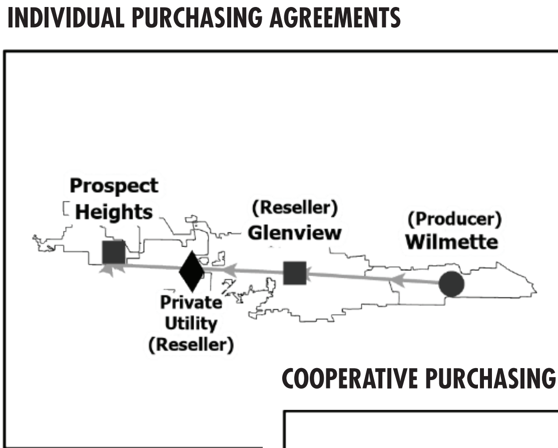
As of 2019, there were 172 municipalities in northeastern Illinois in the LMDWN relying on Lake Michigan for their drinking water supply. An additional eight municipalities (Antioch, Fox Lake, Joliet, Lake Zurich, Lockport, Long Grove, Old Mill Creek, and Shorewood) have also received permits from IDNR and are in various stages of planning or making capital improvements to connect with a supplier and switch their drinking water source to Lake Michigan. Among the 172 active municipalities, only 12 are engaged in directly pumping and treating water from Lake Michigan. These 12 municipalities serve as producers and suppliers for most of the region. The remaining 93% of municipalities rely on wholesale purchasing agreements for their water supply. These purchasing agreements are either directly with one of the 12 producers or with another entity that has purchased water from a producer and is reselling water. Resellers can be an individual municipality, commission or joint action water agency (JAWA), or a private utility company.

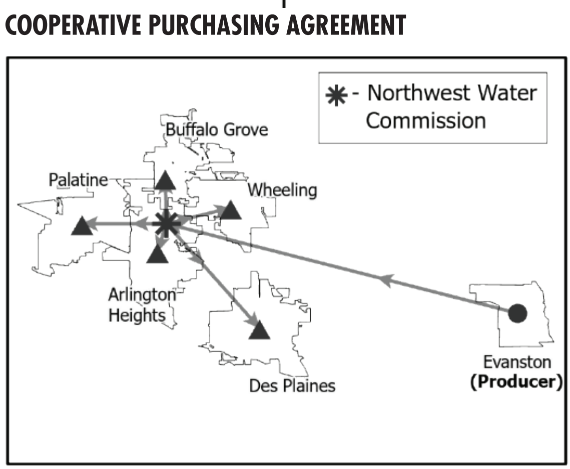
The relationships between producers and purchasers, including resellers, have created supply chains branching out across the region that take on various forms. While the purchasing agreements are unique for each relationship between buyers and sellers, they fundamentally fall into two categories. The first is an individual purchasing agreement between two entities: a single supplier and a single purchaser. Figure 2 provides an example of a linked supply chain that is connected through several individual purchasing agreements, whereby Wilmette produces finished water and sells it to Glenview, which sells to a private utility, which then sells water to Prospect Heights. In that example, there are three distinct purchasing agreements.

The second category involves cooperative arrangements whereby multiple municipalities come together to form a new joint entity such as a commission, JAWA, or single-purpose district. These joint entities engage in a single

FIGURE 2

EXAMPLES OF SUPPLY CHAIN STRUCTURES IN THE LMDWN



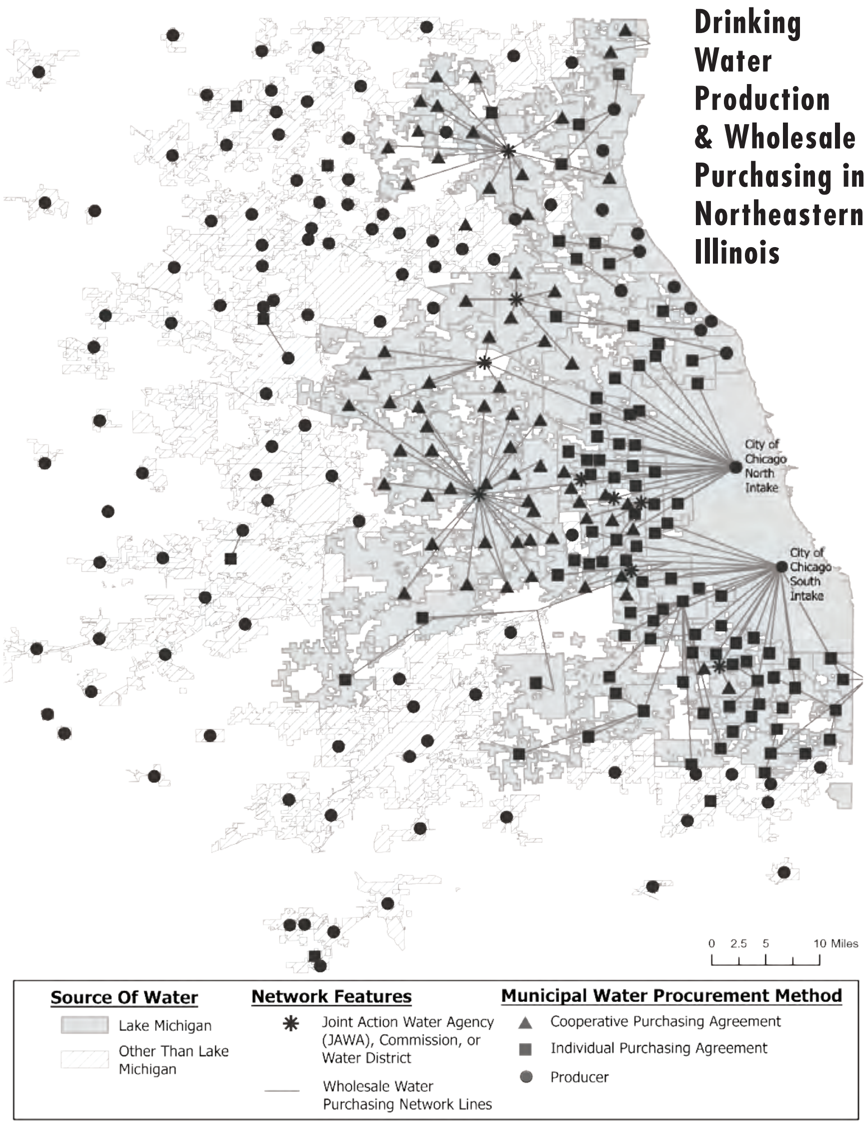


purchasing agreement on behalf of their members with a supplier, and then water is sold to their members at a specified wholesale rate. Figure 2 also provides an example of this arrangement where the Northwest Water Commission purchases water from Evanston and sells it to five municipalities (though Des Plaines is not a formal member of the commission). As of 2019, 93 municipalities purchased their water through an individual purchasing agreement, and 67 were part of some form of a cooperative arrangement.

Figure 3 provides a complete map of northeastern Illinois and identifies the purchasing connections between entities that make up the LMDWN. In the appendix, we describe the nature of these cooperative arrangements in more detail. These arrangements vary in that they receive the water they directly sell to municipalities from a variety of sources. Two of the cooperatives are also their own producers. Within northeastern Illinois, our research identified 10 unique cooperative arrangements that ranged in size from two members

FIGURE 3

MAP OF NORTHEASTERN ILLINOIS AND METHODS OF DRINKING WATER PROCUREMENT



Data Source: Illinois State Water Survey Municipal Water Use (2012). Data has been updated to reflect 2019 network configuration.

to 25 members (see appendix). In addition to varying in membership size, these cooperative arrangements are also distinct in their forms, membership rules, and roles. Broadly, the roles of these joint entities may include serving as a mechanism for wholesale purchasing and redistribution, managing shared infrastructure for supply and treatment, or acting as the administrator that directly bills customers across communities. Given the high capital costs to connect water systems, a cooperative approach allows for municipalities to engage in cofinancing and sharing the cost of infrastructure as well as potentially improving their wholesale rates through higher purchasing volumes. However, municipalities participating in cooperative arrangements also have costs associated with membership and reduced autonomy that are not present in direct purchasing agreements.

DATA SOURCES

To understand the potential differences between purchasing arrangements and positions within a supply chain and household water bills, we compiled a data set from multiple sources that allows us to detail the LMDWN and compare standardized monthly water bills. While the network of connected municipalities providing drinking water from Lake Michigan was a primary focus, we also analyzed municipalities relying on groundwater and non-Lake Michigan surface water as a useful comparison to understand the potential impacts for any communities that may be considering a switch to Lake Michigan as their primary source.

Residential water billing information in northeastern Illinois has been collected for multiple years through a partnership between the Chicago Metropolitan Agency for Planning and the Illinois-Indiana Sea Grant. These data sets include information on rate structures, base charges, and volumetric rates for municipalities across northeastern Illinois. There is substantial variation in the structure of water bills and billing periods across the region. For the purposes of our analysis, bills were standardized as the monthly charge for 5,000 gallons of consumption. This is a direct measure of the cost of drinking water consumption but does not include all water-related charges (e.g., additional taxes or fees) that residents might see on their water bill. Residential billing data were also supplemented with system information taken from the U.S. Environmental Protection Agency's Safe Drinking Water Information System and the Illinois State Water Survey (ISWS). The ISWS data also allow us to identify the purchasing connections and arrangements to analyze the network structure and position of each municipality in a supply chain. Our analysis covers the most recently available billing years of 2015, 2017, and 2019 and includes a total of 714 monthly water bills across 286 municipalities.

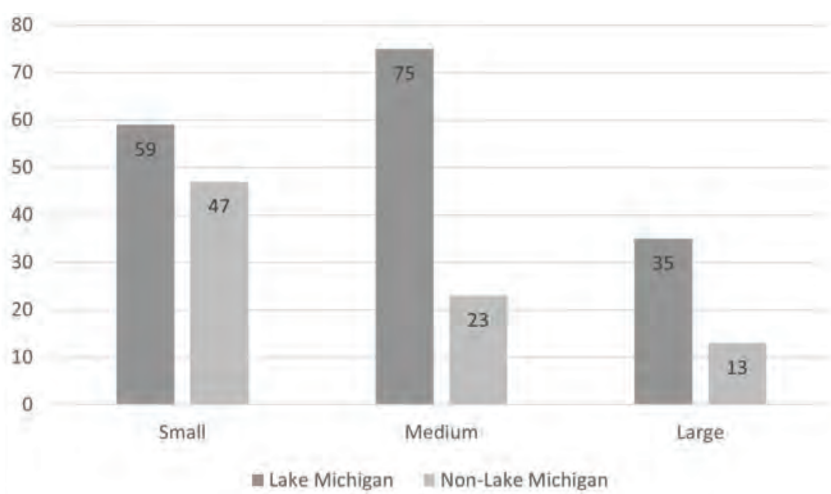
SIZE OF WATER UTILITIES

The Environmental Protection Agency considers water systems with fewer than 10,000 customers to be small utilities. This classification is further divided into subcategories with a cutoff point of 3,300 service connections, which we use to separate utilities below 10,000 into categories of small and medium. We consider any system serving more than 10,000 customers as large. As of 2019, the majority of municipalities in northeastern Illinois (61%) are now part of the LMDWN.

Figure 4 illustrates the sizes of utilities within the LMDWN compared with municipalities outside of the LMDWN. The LMDWN is primarily made up of medium-sized utilities serving 3,301–10,000 customers while municipalities outside of the LMDWN have mostly small systems with fewer than 3,300 customers. This is important because although municipalities within the LMDWN are physically connected, they remain functionally fragmented in their management and fall within the size classifications (fewer than 10,000 customers) that the literature suggests often suffer from the challenges of small utilities.

FIGURE 4

DISTRIBUTION OF UTILITY SIZE ACROSS NORTHEASTERN ILLINOIS



RESIDENTIAL WATER BILLS BY SOURCE

Past research on residential water bills also informs us that surface water — like Lake Michigan — is more expensive to treat compared with groundwater. Table 1 provides a comparison of the average monthly water bills by utility size and source. We found that residents within the LMDWN were paying much higher bills — 41% higher on average — for the same amount of water across all utility sizes and years. While this finding of surface water being associated with higher residential bills is similar to other rate studies, the difference we found was much higher than the 10% or less difference between source types found in other regional and statewide comparisons (Beecher & Kalmbach, 2013; Hughes et al., 2006; Thorsten et al., 2009). The statistically significant difference in average bills between communities in the LMDWN and those outside of it may indicate that the networked approach within the region is less efficient or more inequitable in the distribution of shared costs across integrated systems.

TABLE 1

COMPARISON OF AVERAGE MONTHLY BILLS BY UTILITY SIZE AND SOURCE

YEAR	LAKE MICHIGAN			NON-LAKE MICHIGAN			MEAN VALUES BY YEAR
	SMALL	MEDIUM	LARGE	SMALL	MEDIUM	LARGE	
2015	$38.94	$35.86	$30.83	$26.89	$26.65	$24.12	$33.34
2017	$44.08	$44.05	$38.17	$29.49	$31.38	$25.10	$39.05
2019	$49.82	$46.70	$39.92	$33.98	$32.93	$32.19	$42.32
Mean Values by Source	$42.17			$29.77			

RESIDENTIAL WATER BILLS BY PURCHASING ARRANGEMENTS

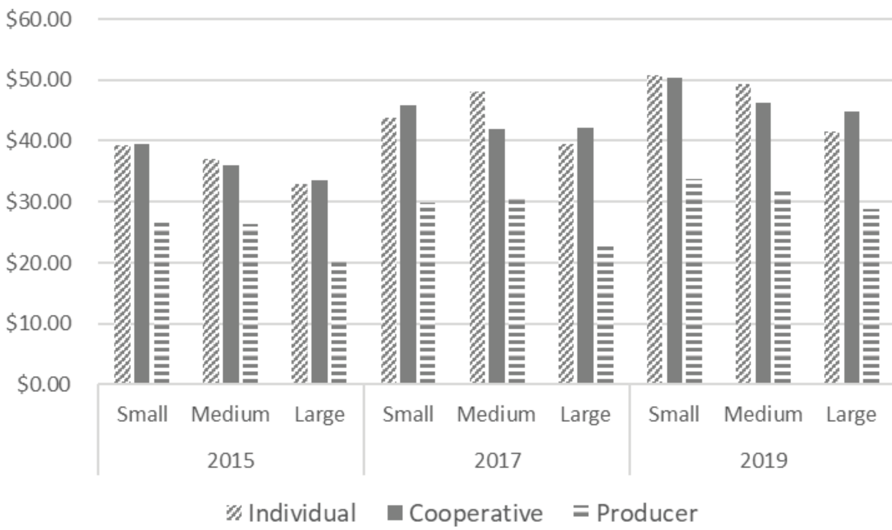
While source type can explain some of the higher residential bills for the LMDWN municipalities, it is unlikely to explain the total difference. Previous research is mixed on whether utilities purchasing water had higher or lower rates, though these studies do not differentiate between purchasing arrangement types to determine if there are any advantages between an individual or cooperative approach. However, by using the ISWS data and analyzing the purchasing links between municipalities, we were able to categorize each utility by their purchasing arrangement. Municipalities that directly purchased wholesale water from another municipality or a private utility were categorized as individual purchasing agreements. Municipalities that purchased water from or were served by a commission, JAWA, or special district were categorized as cooperative arrangements.

Figure 5 provides the average monthly bill by utility size and purchasing arrangement for each year of data. We also included the average bills of municipalities that are producers in the LMDWN in Figure 5 to determine if there were any systematic differences. First, when comparing municipalities that were in a cooperative arrangement or individual purchasing agreement, our research showed there was a slight advantage for medium-sized utilities to enter cooperative purchasing arrangements. For small and large utilities, in contrast, the average monthly bills were very similar between the two purchasing arrangements, and these average bills were slightly less for the individual purchasing group than municipalities in a cooperative arrangement, though the differences were marginal. Second, we found that across utility size, municipalities within the LMDWN that are producers maintain lower average residential bills compared with municipalities that are in a cooperative arrangement or individual purchasing agreement. While underlying characteristics of producer utilities might explain some of this difference, it may indicate that producers are disproportionately passing along the capital costs of treatment in their wholesale rates or that these producers are capturing most of the benefits of economies of scale in production. The higher bills for purchasers are also likely due to substantial capital expenses associated with infrastructure needed to pipe water from Lake Michigan to the outlying suburbs.

While these average bills do not necessarily reflect cost savings to residents, the advantages of cooperative purchasing agreements may be found elsewhere. One possible advantage is that a cooperative approach allows multiple communities to co-finance infrastructure projects. Small municipalities might also receive lower borrowing costs through a cooperative arrangement. There may also be intrinsic advantages to a cooperative arrangement such as better information around rate-setting and transparency in the negotiation process between members. By comparison, it may be harder for purchasers in an individual purchasing agreement to know the true cost of providing water at a wholesale rate, especially in instances where sellers are not producers and are acting as a reseller.

FIGURE 5

COMPARISON OF AVERAGE MONTHLY BILLS FOR LAKE MICHIGAN DRINKING WATER NETWORK, GROUPED BY UTILITY SIZE

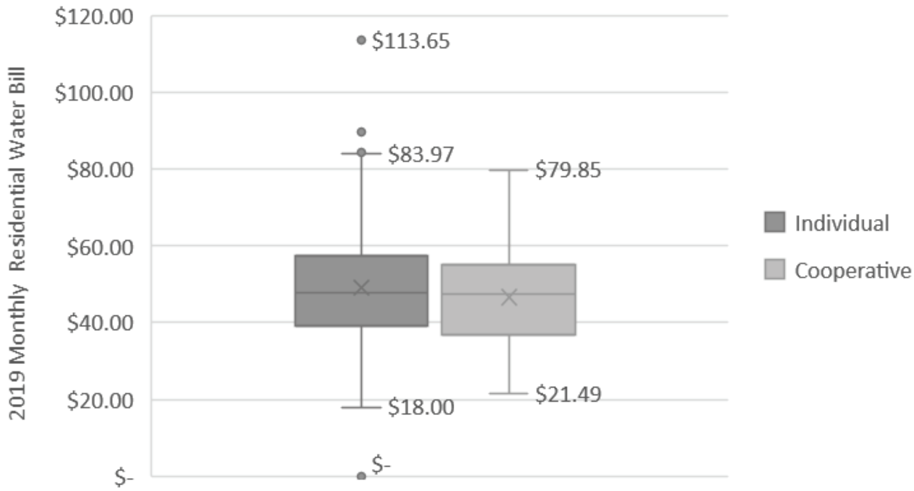


Note: T-test comparisons of rates across utility size, year, and production/purchasing categories are statistically significant with the exception of small utilities in the individual and cooperative purchasing categories in 2015.

If a cooperative approach to purchasing water offers buyers with more information than an individual approach, we would expect there to be less variation in bills for communities that are part of a cooperative arrangement. The box plots in Figure 6 illustrate the distribution of water bills by purchasing type for 2019. As can be seen, the range of water bills for cooperative arrangements (between $21.49 and $79.85) was smaller than that for individual purchasing arrangements (between $18 and $83.97), although this difference is quite small. More importantly, however, there were no outliers for cooperative arrangements like we saw for individual agreements (e.g., $113.65). This might suggest that cooperative purchasing arrangements improve information in the rate-setting process or that the rules and norms among members result in more equitable distribution of residential water bills across those communities.

FIGURE 6

DISTRIBUTION OF 2019 MONTHLY WATER BILLS BY PURCHASING TYPE



SUPPLY CHAIN POSITION AND WATER BILLS

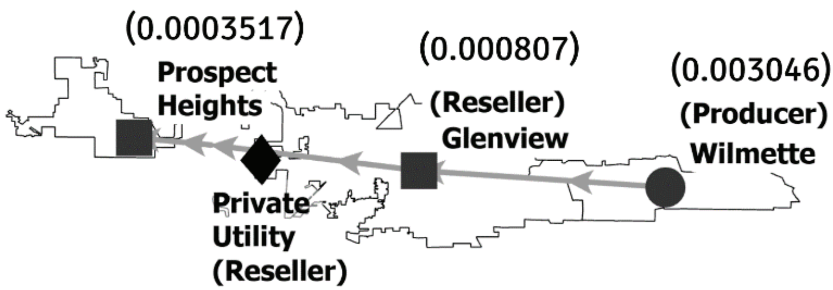
To analyze differences in the position of a municipality in a supply chain, in addition to the type of purchasing arrangement and residential water bills, we used a network analysis approach to measure and compare each municipality's position within the LMDWN. Network analysis has become an increasingly popular tool to study intergovernmental cooperation and public service networks (LeRoux & Carr, 2007; LeRoux et al., 2010). Several statistics are available to measure overall network structures and the individual position of an actor within a network. For purposes of our analysis, we used the statistical measurement of pagerank centrality. Pagerank centrality measures an individual actor's influence within a network by comparing the number of direct connections that are subsequently linked to it. In the context of the LMDWN, pagerank centrality provides a subtle measurement of both the position of an individual municipality's position in a supply chain but also how many other municipalities in that supply chain depend on them for their water supply.

When analyzing the 10 cooperative arrangements in the LMDWN, we found two were directly engaged in production (the Central Lake County JAWA and the Lake County Public Water District), and the other eight were purchasing directly from a producer. As a result, nearly all members of these cooperative arrangements were in the same position in a supply chain as purchasers from their respective commission or JAWA. Therefore, our analysis of how an individual municipality's position within a supply chain was limited to the 93 municipalities engaged in individual purchasing agreements and where rate data were available for 2019. These linked supply chains included different numbers of connected systems as well as municipalities that served as juncture points that split supply lines.

Figure 7 provides a simple example of the differences in pagerank centrality based on the position of a municipality in its supply chain. In theory, if a seller is able to effectively pass along capital costs to a buyer, a higher pagerank centrality for the seller would be associated with lower residential water bills. Alternatively, municipalities that were at critical points of connecting multiple supply chains in the LMDWN may also have had higher capital and administrative costs that may or may not have been effectively passed along to buyers.

FIGURE 7

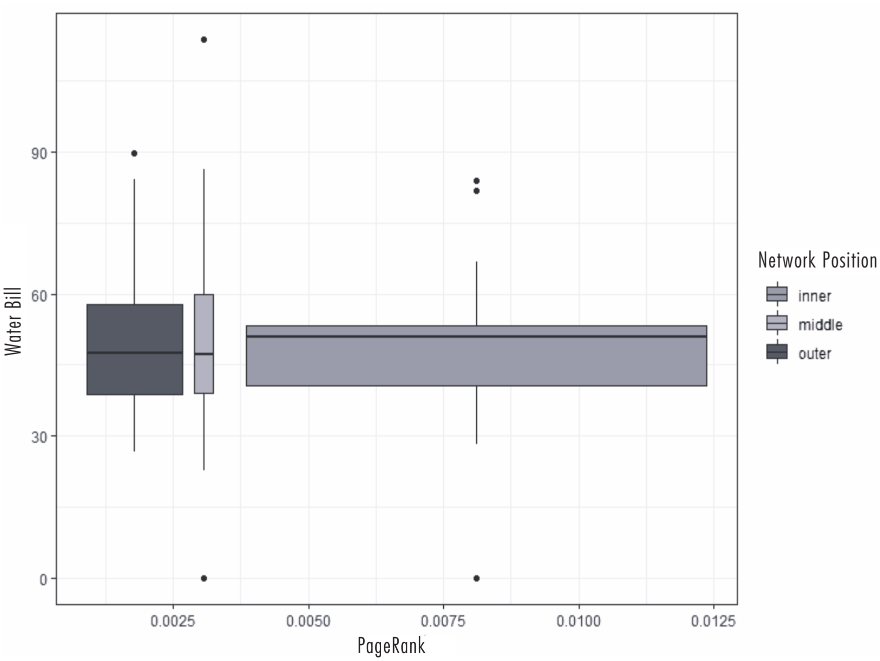
PAGERANK CENTRALITY CALCULATIONS FOR LINKED SUPPLY CHAIN



To test for systematic differences in a supply chain position, we ran a correlation test between pagerank centrality and standardized water bills. The results were not statistically significant. To further test for potential differences in pagerank, we grouped municipalities into three categories of pagerank (based on their similar positions in a linked supply chain); labeled them as inner, middle, or outer network position; and then compared the distributions of their average water bills, as shown in Figure 8. While there appears to be some differences in the average rates, an analysis of variance indicated no statistically significant difference between bills in these categories. As such, our findings indicate that the position within a supply chain does not impact residential water bills for municipalities within the LMDWN.

FIGURE 8

COMPARISON OF PAGERANK AND WATER BILLS BY SUPPLY CHAIN POSITION



CONCLUSION

The LMDWN is an excellent example of municipal governments relying on intergovernmental cooperation to provide a critical public service. Although the 172 communities in northeastern Illinois are connected in a single network to share a common resource, the high degree of fragmentation results in substantial differences in the amounts that residents across the region pay for their drinking water. Our analysis of the differences between supply chain structures within the LMDWN and residential water bills found that while a networked approach to a regional water system may create some economies of scale, the largest benefactors are producers that supply the majority of municipalities in the LMDWN. Most likely, these municipalities benefit the most from economies of scale in production that are not redistributed through wholesale rates. We also determined that a buyer's approach to the wholesale market for purchasing drinking water and its position within a supply chain do not exhibit meaningful differences in residential water bills. However, municipalities that take a collective approach have less variation in their residential water bills. This may indicate that subregional cooperative arrangements in managing supply chains and purchasing agreements could have an impact on improving equitable water rates across the region.

We acknowledge that the management of water systems and the rate-setting process are more complex than our analysis here is intended to explain. Future research might consider the development of a regression model to allow for isolation of variables of interest while holding others constant and to allow for the inclusion of other cost control factors, which might be useful for inferential predictions of likely future trends. Additional future research can also examine the processes of decision-making and rate-setting within cooperative arrangements to better understand whether those arrangements have similar dynamics regarding economies of scale for customers. The contribution of our analysis is to highlight the importance of public managers', policymakers', and stakeholders' understanding that more than 6.5 million people rely on a complex network of interdependent utilities for their drinking water. If groundwater resources continue to be depleted, the LMDWN will continue to grow. While Lake Michigan is part of the world's largest body of freshwater, the amount of water that can be diverted for drinking water is restricted. To maintain equitable access for all current and future residents of the region, it is important for policymakers to engage with the LMDWN and work to improve efficiencies in the production and distribution of clean drinking water.

Jason Michnick is a PhD student in the College of Urban Planning and Public Affairs at the University of Illinois Chicago. His research interests focus on the intersection of public service networks and public budgeting and finance, with an emphasis on environmental governance and regional sustainability.

Kate Albrecht is an Assistant Professor in the Department of Public Policy, Management, and Analytics at the University of Illinois Chicago. Her primary focus as a public management scholar is on networks and collaborative governance arrangements in multi-sector settings. Her current research focuses on costs and benefits of interlocal agreements for service delivery, as well as

the complexity of water system governance planning and implementation. Her most recent research has been funded by the Illinois Innovation Network, and she is an affiliated research faculty with the UIC Government Finance Research Center and the UIC Great Cities Institute.

Deborah A. Carroll is Director of the Government Finance Research Center (GFRC) at the University of Illinois Chicago. Her research focuses on financial management and fiscal policy issues of state and local governments, particularly related to taxation, revenue diversification and stability, and urban economic development. With more than 60 publications and 15 grant-funded white papers and technical reports, she has been invited to share her research and expertise with academic and practitioner audiences across the U.S. and in several other counties. Dr. Carroll also serves as Editor-in-Chief of the Journal of Public and Nonprofit Affairs and previously worked as a budget and policy analyst for the City of Milwaukee, Wisconsin.

Amanda Kass is an Assistant Professor in the School of Public Service at DePaul University. Her research interests include public finance, public pensions, housing markets, and urban governance, particularly at the local scale.

Brooke Wetmore is a graduate student in the College of Urban Planning and Public Affairs at the University of Illinois Chicago's Master's in Public Administration degree program with a concentration in local government management. She has professional experience in community development nonprofits and small business development.

REFERENCES

Beecher, J. A. (2011, November 1). Primer on water pricing. *Institute of Public Utilities, Michigan State University.*

Beecher, J. A., & Kalmbach, J. A. (2013). Structure, regulation, and pricing of water in the United States: A study of the Great Lakes region. *Utilities Policy*, 24, 32-47. https://doi.org/10.1016/j.jup.2012.08.002

Beecher, J. A., & Shanaghan, P. E. (1999). Sustainable water pricing. *Journal of Contemporary Water Research and Education*, 114(1), 4. https://opensiuc.lib.siu.edu/jcwre/vol114/iss1/4/Cain, L. (2005). Sanitation in Chicago: A strategy for a lakefront metropolis. *Chicago Historical Society.* http://www.encyclopedia.chicagohistory.org/pages/300017.html

Chicago Metropolitan Agency for Planning (2020). Northeastern Illinois water and sewer utility rate data, 2009–2019 [Data set]. Illinois-Indiana Sea Grant.

Hughes, J., Eskaf, S., Thorsten, R., Barnes, G. A., Mandel, L. M., & Franklin, O. (2006, November). *Multi-level financial analysis of residential water and wastewater rates and rate-setting practices in North Carolina* (Report 389). Water Resources Research Institute of the University of North Carolina.

Kim, H. Y., & Clark, R. M. (1988). Economies of scale and scope in water supply. *Regional Science and Urban Economics*, 18(4), 479-502. https://doi.org/10.1016/0166-0462(88)90022-1

Klien, M., & Michaud, D. (2019). Water utility consolidation: Are economies of scale realized? *Utilities Policy*, 61(3), 100972. https://doi.org/10.1016/j.jup.2019.100972

LeRoux, K., Brandenburger, P. W., & Pandey, S. K. (2010, March/April). Interlocal service cooperation in U.S. cities: A social network explanation. *Public Administration Review*, 70(2), 268-278. https://doi.org/10.1111/j.1540-6210.2010.02133.x

LeRoux, K., & Carr, J. B. (2007). Explaining local government cooperation on public works: Evidence from Michigan. *Public Works Management & Policy*, 12(1), 344-358. https://doi.org/10.1177/1087724X0730258

Scott, T. A., Moldogaziev, T., & Greer, R. A. (2018). Drink what you can pay for: Financing infrastructure in a fragmented water system. *Urban Studies*, 55(13), 2821-2837. https://doi.org/10.1177/0042098017729092

Shih, J-S., Harrington, W., Pizer, W. A., & Gillingham, K. (2006, September). Economies of scale in community water systems. *Journal American Water Works Association*, 98(9), 100-108. https://doi.org/10.1002/j.1551-8833.2006.tb07757.x

Simonsen, B., Robbins, M. D., & Helgerson, L. (2001, November/December). The influence of jurisdiction size and sale type on municipal bond interest rates: An empirical analysis. *Public Administration Review*, 61(6), 709-717. https://doi.org/10.1111/0033-3352.00141

Switzer, D., Teodoro, M. P., & Karasik, S. (2016, August). The human capital resource challenge: Recognizing and overcoming small utility workforce obstacles. *Journal American Water Works Association*, 108(8), E416-E424. https://www.jstor.org/stable/90004194

Thorsten, R. E., Eskaf, S., & Hughes, J. (2009). Cost plus: Estimating real determinants of water and sewer bills. *Public Works Management & Policy*, 13(3), 224-238. https://doi.org/10.1177/1087724X08324302

Torres, M., & Morrison Paul, C. J. (2006, January). Driving forces for consolidation or fragmentation of the U.S. water utility industry: A cost function approach with endogenous output. *Journal of Urban Economics*, 59(1), 104-120. https://doi.org/10.1016/j.jue.2005.09.003

Wisconsin v. Illinois, 388 U.S. 426 (1967). Cornell Law School Legal Information Institute. https://www.law.cornell.edu/supremecourt/text/388/426

Wisconsin v. Illinois, 449 U.S. 48 (1980). U.S. Reports via Library of Congress. https://www.loc.gov/item/usrep449048/