

Analysis

The provision of drinking water in First Nations communities and Ontario municipalities: Insight into the emergence of water sharing arrangements[☆]B. James Deaton^{a,*}, Bethany Lipka^b^a McCain Family Chair in Food Security, Department of Food, Agricultural and Resource Economics, University of Guelph, Canada^b Project Coordinator and Research Associate, Department of Food, Agricultural and Resource Economics, University of Guelph, Canada

ARTICLE INFO

Keywords:

First Nations
Municipalities
Ontario
Canada
Drinking water
Water Sharing Arrangements (WSAs)
Interlocal
Institutions
Governance
Transaction costs

ABSTRACT

Some communities in Ontario procure potable water through water sharing arrangements (WSAs) with other neighbouring communities. This paper explores factors influencing First Nation and municipal participation in WSAs in Ontario. Specifically, we assess whether First Nations communities – many of which suffer persistently poor drinking water conditions – are less likely to be engaged in WSAs than municipalities. We assess this question by applying regression analyses to a unique data set characterizing 419 Ontario communities: 118 First Nations communities and 301 municipalities. Compared to Ontario municipalities, First Nations in Ontario have a lower rate of participation in WSAs. Our regression analyses suggest that community likelihood of WSA participation is strongly associated with factors like geography, regional wealth, and proximity to neighbouring communities with water supply.

“[A] gravel road [...] separates [Onieda Nation of the Thames] near London, Ont., from the neighbouring township of Southwold. On [Oneida’s] side of the road, virtually no one trusts the drinking water that flows from the Thames River to their homes. [...] On the other side of the gravel road, the township of Southwold draws its water from Lake Erie and is fed by a treatment system that received a \$176-million upgrade last year.”

–Keogh, Swyers, Hargreaves, Perkins and Cribb, 2019 (*Global News*)

1. Introduction

Since the 1960s, the federal government of Canada has undertaken initiatives aimed at fulfilling the fiduciary responsibility to ensure that individuals living in First Nations communities have access to drinking water that is of comparable quality to water provided to Canadians living in similarly situated municipalities (PBO, 2017). In 2015, Prime Minister Justin Trudeau committed to end long-term drinking water advisories on public

systems on reserves within five years if elected (Canadian Press, 2020). However, the federal government recently acknowledged that it will not be meeting this commitment, which to date has not been realized in any Canadian Province or Territory.¹ Approximately one-in-eight First Nations communities in Canada are under a boil water advisory at any given time, and these advisories are 2.5 times more frequent in First Nations communities than in non-First Nations communities (Bajjius and Patrick, 2019). First Nations communities also have a rate of water-borne infections that is 26 times higher than the Canadian national average. This issue is particularly pronounced in the province of Ontario, where 75% of active First Nations boil water advisories are located (ISC, 2020), and 46% of First Nations water and waste water systems² can be classified as “high risk” (Neegan Burnside, 2011). The 2006 *Report of the Expert Panel on Safe Drinking Water for First Nations* found that the core problem most First Nations stakeholders reported with respect to safe drinking water provision was inadequacy of resources; this includes a lack of funding for maintenance costs, and lengthy waiting times associated with the procurement of capital funding (Swain et al., 2006).

The quotation at the start of this paper reflects present concerns

[☆] This paper draws on research supported by the Social Sciences and Humanities Research Council of Canada (SSHRC).

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¹ While 108 long-term boil water advisories have been lifted since November of 2015, 51 long-term boil water advisories remain in effect across Canada at the time of writing (ISC, 2020).

² For the purpose of our study, and as defined by Neegan Burnside (2011), a First Nations water system is defined as consisting of assets funded by the federal government, and serving five or more residents or public facilities. Systems can range from a well servicing a Band office, to a trucked water hauling station, to a treatment facility with a piped water distribution network.

regarding drinking water quality in First Nations communities,³ and disparities between water quality on reserves and nearby municipalities. The quotation describes two neighbouring communities – one First Nation community, and one municipality – with very different water supply arrangements and quality outcomes. The First Nation community is self-supplied, and facing persistent water quality concerns. The municipality receives treated water from a large and recently upgraded treatment facility, through their participation in a regional water sharing network.⁴ Water sharing arrangements (WSAs) of this nature are common across Ontario, and many communities enter into these collaborative arrangements in order to coordinate the supply and quality of drinking water with their neighbours. This paper seeks to better understand WSAs by assessing key factors that influence the likelihood that communities – First Nations and municipalities – participate in these arrangements.

Alcantara and Nelles (2016) document the growing prevalence of interlocal, intergovernmental arrangements across Canada between First Nations and municipalities for a host of services (e.g., fire protection, trash collection, etc.), including WSAs. A WSA describes a situation where a community receives potable water through a demand-supply arrangement with a neighbouring community (bi-lateral) or communities (multi-lateral).⁵ WSAs are a subset of interlocal, intergovernmental arrangements, and can emerge between two or more municipalities, as well as municipalities and First Nations. In 2009/10 in Ontario, nearly 41% of municipalities and 10% of First Nations procured water (for at least one of their community's drinking water systems) through a WSA. Past research has found these arrangements to reduce the likelihood of boil water advisories for participating First Nations communities (Lipka and Deaton, 2015). While this past research establishes an inverse relationship between boil water advisories and WSAs, it is limited to First Nations communities only. Given the relative importance of WSAs as a means by which many communities procure drinking water across Ontario, and their association with improved water quality outcomes for First Nations, we aim to explore key factors associated with community engagement in these exchanges. We are particularly interested in whether First Nations are associated with a reduced probability of being engaged in WSAs compared to municipalities, after controlling for important community characteristics.

There are a number of reasons why WSAs may not emerge in certain contexts. Socio-economic characteristics and geographic factors – such as community remoteness – are important considerations for both First Nations and municipalities. WSAs between First Nations and municipalities might be further complicated by the complex historic and socio-cultural factors surrounding Indigenous⁶ settler relations in Canada. In some cases, these factors have resulted in contemporary interlocal conflicts.⁷ These conflicts will have shaped preferences for collaboration between First Nations and municipalities.

³ For an in-depth institutional analysis of water governance and management in Oneida Nation of the Thames, see Cave et al. (2013).

⁴ More information about this regional water sharing network is provided in Section 2, in our discussion of Figure 2.

⁵ To enhance the reader's understanding of WSAs, we provide a short discussion of specific WSAs in Appendices 1 and 2.

⁶ In the Canadian context, the term 'Indigenous peoples' refers to the original peoples of North America and their descendants. The term 'Aboriginal peoples' is also used by the Canadian government. The Canadian Constitution recognizes three groups of Aboriginal peoples: First Nations, Metis and Inuit (CIRNAC, 2017).

⁷ A review of the recent land conflict in Caledonia, Ontario (Barrera, 2020) provides contemporary evidence of one localized conflict – between Six Nations of the Grand River, and Haldimand County – that is longstanding and pre-dates Canadian confederation. The recent conflict surrounding the Sipekne'katik fishery in Nova Scotia is another example of a conflict between First Nations and settler communities that has spanned several decades (Levinson-King, 2020). For a more in-depth discussion of the pernicious history of colonialization and its effects on relations between Indigenous and non-Indigenous peoples in Canada, see Ramos (2007).

Another factor that might complicate the formation of WSAs between First Nations and municipalities are transaction costs. Generally speaking, transaction costs include the costs of gathering information, negotiating, and enforcing transactions. Past efforts by the federal government, such as the First Nations-Municipal Infrastructure Partnership Program, sought to reduce the transaction costs associated with collaborative arrangements for First Nations and municipalities interested in pursuing the joint provision of local services (FCM, 2011). Interestingly, this now defunct program placed a specific emphasis on supporting the emergence of WSAs between First Nations and municipalities. Indigenous Services Canada (ISC) continues to fund a First Nation-Municipal Community Economic Development Initiative, established in 2012 to support First Nations and their municipal neighbours interested in pursuing joint economic development opportunities (Council for the Advancement of Native Development Officers (cando) and FCM, n.d.; FCM, 2021).

Transaction costs are well known to be influenced by institutions (Coase, 1960; Williamson, 2010) and social capital (Fukuyama, 2001). As we discuss later in this paper, the institutions that emerged from the federal Indian Act (1985) and Ontario's Municipal Act (2001) are very different. We expect these differences to influence the relative transaction costs of WSA participation for First Nations and municipalities, and the subsequent relative likelihood of WSAs emerging. We develop this transaction costs argument because we have come to view it as important through our own work experiences with community water systems, discussions with communities, and past research. That said, our emphasis on the issue of transaction costs does not preclude other explanations. Indeed, as discussed in our results, geography, regional wealth, and distance to potential suppliers are found to be substantive considerations for both First Nations and municipalities.

This paper applies regression analysis to a novel data set uniquely assembled to allow for empirical comparisons of WSAs supplying First Nations and municipalities. Our data characterizes water supply in 419 communities in the province of Ontario: 118 First Nations communities, and 301 municipalities. In addition to exploring whether First Nations are less likely to be engaged in WSAs, we also examine the effect of key socio-economic and geographic community characteristics on the likelihood that a community will be engaged in a WSA. These factors include population density, proximity to neighbouring communities with water supply, and regional wealth. We place specific emphasis on assessing the role of northerness.⁸ This is an important consideration with respect to the issue of WSAs, as approximately 82% of First Nations communities in our data set are located in the northern regions of the province. Northern communities are particularly disadvantaged with respect to safe drinking water provision, due to their relative remoteness and the harsh climactic conditions they face (Côté and Fenn, 2014). There are also important differences between how municipalities are governed in northern Ontario and southern Ontario, that could impact the costs of engaging in interlocal exchanges like WSAs (MacKinnon, 2016; Southcott, 2013).

This paper is organized as follows. In Section 2 we provide background on WSAs in Ontario. We illustrate the prevalence of WSAs, and we provide a case example that further motivates the need for this study. In Section 3 we discuss the distinct institutional settings that municipalities and First Nations are situated within, with respect to the governance of interlocal exchanges like WSAs. And we introduce transaction costs as a potential explanation for possible differences in WSA engagement between First Nations and municipalities. In Section 4 we describe our empirical approach. We emphasize the important need to examine geographic considerations (in particular, northerness) and socio-economic considerations when assessing differences between First Nation and municipal

⁸ We define "northerness" based on a community's location within what FedNor (the Canadian Government's development agency for northern Ontario) classifies as a northern census division: <http://fednor.gc.ca/eic/site/fednor-fednor.nsf/eng/fn03338.html>.

engagement in WSAs. In [Section 5](#) we briefly describe the unique data set used in our analyses. In [Section 6](#) we provide summary data and regression results that we use to assess the relative likelihood that First Nations and similarly situated municipalities will be engaged in WSAs. In our final section, [Section 7](#), we summarize our central findings and identify a number of possible future research questions.

2. Background

[Fig. 1](#) illustrates the prevalence of WSAs in the province of Ontario during our study period: 2009–10.⁹ Each of the blue polygons highlighted on the map are census subdivisions (First Nations communities or Ontario municipalities) that were participating in a WSA during our study period.¹⁰ As we identify in the Introduction, the prevalence of WSAs is much lower for First Nations communities compared to municipalities during this time. Only 12 of the blue polygons highlighted on the map are First Nations communities, and a relatively small percentage (approximately 10%) of First Nations in Ontario participated in WSAs during our study period. This is the type of observation that motivates our empirical effort to assess whether First Nations are less likely to be engaged in WSAs after controlling for important socio-economic and geographic considerations. One important consideration that [Fig. 1](#) helps to illustrate is the role of northerness. The majority of First Nations communities in our data set (approximately 82%) are located in northern regions of Ontario – above the red line delineated on the map. In fact, the majority of Ontario communities located north of the 50th parallel are First Nations communities ([Southcott, 2013](#)). As the map illustrates, in this northern region both First Nations and municipalities are less likely to be engaged in WSAs.

[Fig. 2](#) provides a particular case example that further underscores the motivation for our study. This second figure identifies the extent of water sharing among municipalities surrounding the City of London, Ontario. Treated water is distributed to these municipalities through two regional water supply networks: the Lake Huron Primary Water Supply System, and the Elgin Area Primary Water Supply System. Situated in the centre of these two networks are three First Nations: Chippewas of the Thames First Nation, Munsee-Delaware Nation, and Oneida Nation of the Thames. Despite being situated within the catchment area of *both* of these regional water supply networks, and in spite of the potential cost savings and quality enhancements that water sharing may provide, these First Nations communities were not engaged in water sharing through these networks during our study period.

In summary, [Fig. 1](#) demonstrates the importance of WSAs as a primary means by which many communities across Ontario procure drinking water. Though, importantly, these arrangements are much less prevalent among First Nations communities, and in northern Ontario (where the majority of First Nations communities are located). [Fig. 2](#) provides an important case example that further motivates our analysis. However, neither figure allows us to adequately assess the key factors associated with community engagement in WSAs, or the extent to which First Nations are more or less likely than municipalities to be engaged in WSAs.

3. Institutional setting

One set of factors that influence the emergence of transactions, such as WSAs, are the costs of transacting.¹¹ Though we are unable to

measure these costs for WSAs directly in our empirical analyses, we expect that they are important considerations for both First Nations and municipalities. [Coase \(1960\)](#) and [Williamson \(2010\)](#) both emphasize the need to understand differences in governing institutions when assessing transaction costs. WSAs between municipalities may be enabled to a certain extent by supportive provincial governance systems. In contrast, WSAs between municipalities and First Nations must overcome significant historic and contemporary socio-economic, cultural and institutional differences. We use the remainder of this section to develop these points more fully. We focus specifically on illuminating key institutional differences between First Nations and municipalities in Ontario, with respect to the governance of interlocal exchanges.

Institutions influence the costs of transacting ([Coase, 1960](#)), and Ontario municipalities and First Nations are situated in very different institutional environments. Ontario municipalities are local governing units created by the Province, with rights and duties defined by provincial legislation. Institutional reforms in the late 1990s – largely driven by financial constraints faced by the Province at that time – led to a halving of the number of municipalities in Ontario through amalgamations. These reforms also led to a realignment of responsibilities between provincial and municipal governments, ultimately resulting in the downloading of a greater level of autonomy (and responsibility) to municipal governments ([Côté and Fenn, 2014](#)). The 2001 *Municipal Act*, which continues to govern Ontario municipalities today, awards municipalities the powers and capacities of “natural persons” within their spheres of jurisdiction (para. 9).¹² This includes the power to enter into contracts – with neighbouring municipalities, First Nations, or private entities – and to buy and sell goods ([Lidstone, 2004](#); *Municipal Act, 2001*, para. 20–21). The *Municipal Act (2001)* has also greatly reduced the costs of WSAs in some regions of the province, by requiring some jurisdictions to plan for and accommodate the water supply of others. For example, the Regional Municipality of York has exclusive jurisdiction over water treatment and storage for its member communities.¹³ Together, these governance reforms have prompted the emergence of many interlocal service provision arrangements across the Province of Ontario, including WSAs. This shift towards increased interlocal cooperation and the regionalization of services is in stark contrast to the provincial position pre-1990: that interlocal agreements were “time-consuming to negotiate, [could] foster dispute and [...] create confusion about accountability” ([Spicer, 2015](#)). Today, more than 90% of Ontario municipalities report having some form of shared services ([Côté and Fenn, 2014](#)).

With respect to WSAs, Ontario municipalities are endowed with the rights of “natural persons” (*Municipal Act, 2001*), while First Nations must operate within the constraints of the *Indian Act (1985)*.¹⁴ In many ways, the *Indian Act (1985)* conveys similar powers and duties to First Nations with respect to water provision that the *Municipal Act (2001)* conveys to Ontario municipalities: it provides that First Nation Bands¹⁵ have the right to govern water services through bylaws (*Indian Act, 1985*, para. 81(1)); and it provides that First Nations have the right to enter into WSAs with neighbouring First Nations, municipalities or third

⁹ The reasons for focusing our empirical analysis on this time period are detailed later in the paper in [Section 5](#).

¹⁰ WSAs were identified for our study period using data from [Neegan Burnside \(2011\)](#) and various municipal sources and contacts. We discuss our data and sources in greater detail in [Section 5](#) and [Appendix 3](#).

¹¹ A WSA is a transaction, and transactions are the central unit of observation for the classic institutional economist ([Williamson, 2010](#); [Commons, 1961](#)). In our study, “transaction costs” describe the costs of organizing, negotiating, and enforcing WSAs.

¹² The *Municipal Act* states: “[m]unicipalities are created by the Province of Ontario to be responsible and accountable governments with respect to matters within their jurisdiction and each municipality is given powers and duties under this Act and many other Acts for the purpose of providing good government with respect to those matters” (2006, c. 32, Sched. A, s. 2). [Côté and Fenn \(2014\)](#) detail the history and evolution of the *Municipal Act*, and municipal governance strategies.

¹³ The Regional Municipality of York is comprised of the following lower tier municipalities: Town of Aurora, Town of East Gwillimbury, Town of Georgina, Township of King, City of Markham, Town of Newmarket, City of Richmond Hill, City of Vaughan, and Town of Whitchurch-Stouffville (*Regional Municipality of York Act, 1990*).

¹⁴ See [Joseph \(2018\)](#) for an overview of the *Indian Act (2001)*.

¹⁵ Under the *Indian Act*, the First Nations Band is the basic governmental unit. Each Band is governed by an elected Chief and Council ([Imai, 1999](#)).

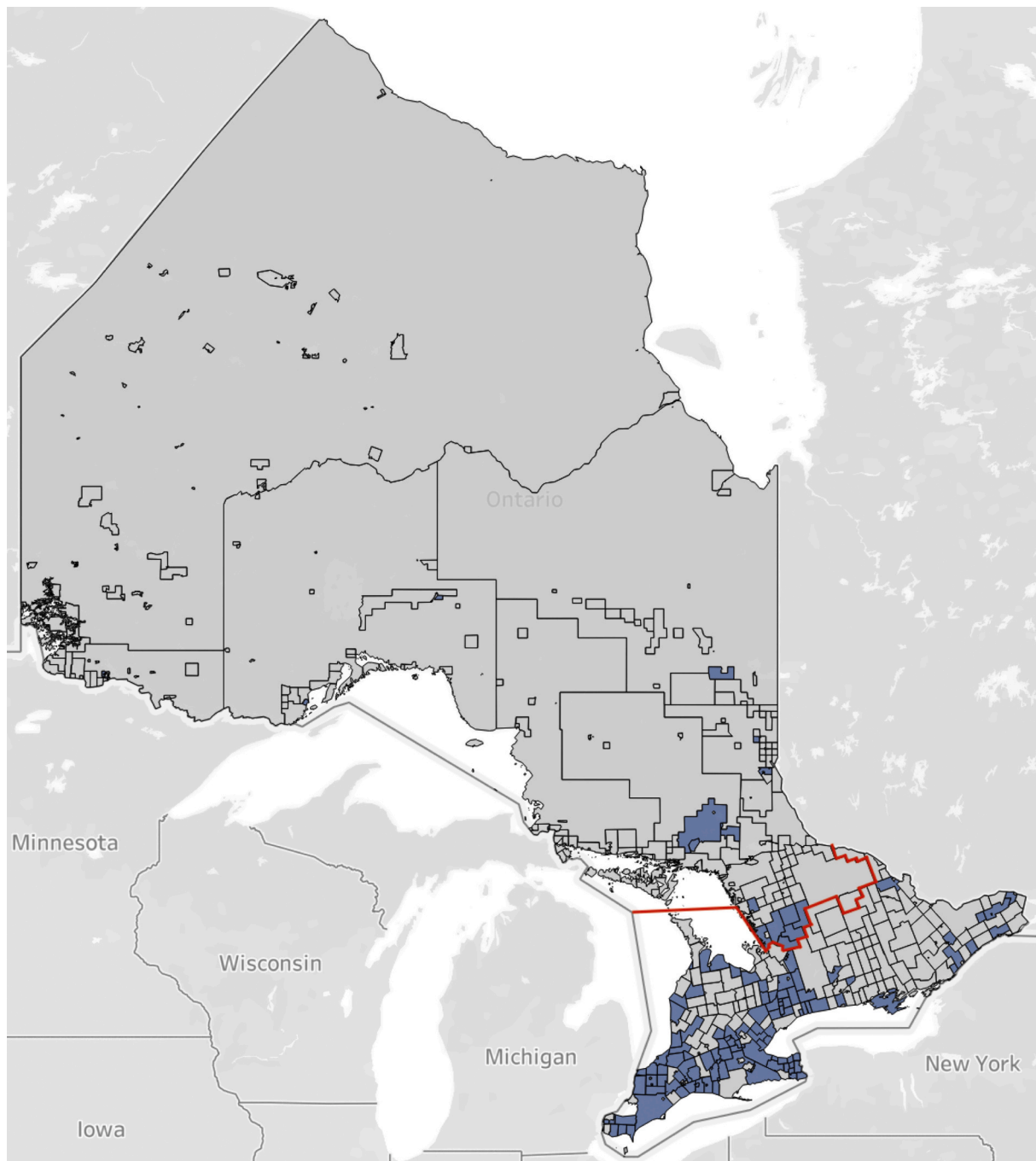


Fig. 1. First Nations communities and Ontario municipalities (census subdivisions) engaged in water sharing arrangements (WSAs) – 2009-10.

parties (FCM, 2011; Indian Act, 1985, para. 2(3) (b)).¹⁶ However, while the federally imposed Band governance system has some similarities to municipal governance with respect to water services, First Nations communities are still “embedded in unique political and legal relationships quite different from what municipalities enjoy” (Alcantara et al., 2020). Notably, unlike municipalities, First Nations do not have the

autonomy to enter into WSAs without federal oversight. In order to continue to receive funding for water services, a First Nation must present a feasibility study to the federal government demonstrating that the desired WSA is the community’s least cost servicing option (CIRNAC/ISC, 2011).¹⁷ These institutional differences might contribute to significant transaction costs for First Nations seeking to participate in WSAs. Additionally, while Ontario municipalities are “creatures” of the

¹⁶ Under the Indian Act, a First Nations Band council would gain the authority to enter into a WSA on behalf of the Band through a resolution, passed at a meeting where the majority of Band councillors were present (FCM, 2011). Importantly, First Nations governance structures can vary considerably across communities, and outside of the constraints of the Indian Act a First Nations government may have additional community-level requirements for authorizing such an agreement (e.g., community vote or consensus).

¹⁷ This feasibility study would need to demonstrate that such an arrangement is the least cost option for the First Nations community, based on a life cycle costing analysis – normally conducted for a 20 year period – of all practical available servicing options (CIRNAC/ISC, 2011). The Canadian Federation of Municipalities (FCM, 2011) recommends the costs of water sharing be split between potential partners, proportional to populations or expected benefits.

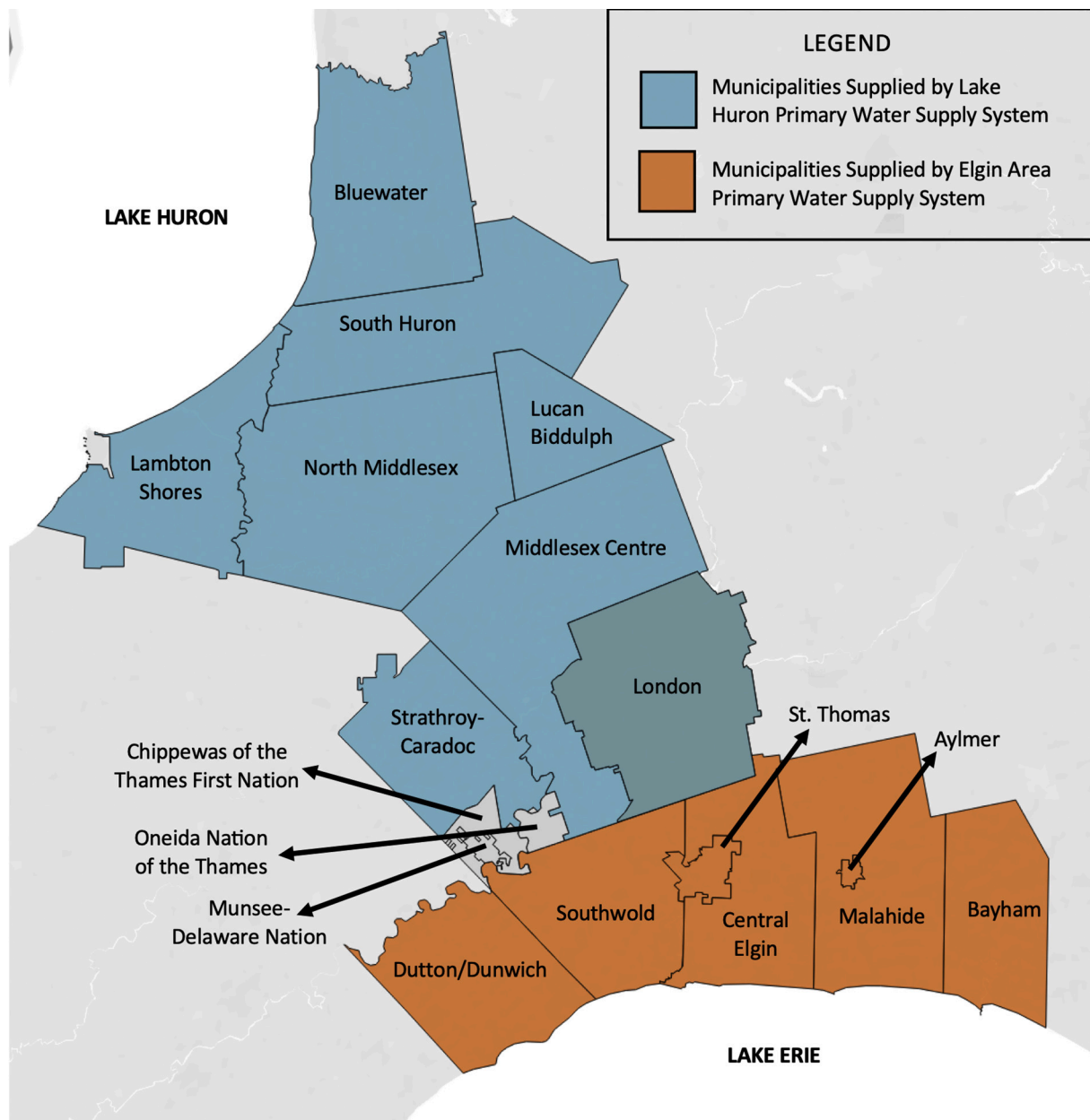


Fig. 2. Lake Huron and Elgin Area Primary Water Supply Systems.

Provincial government and emerged through a historically similar process, First Nations are much more culturally and socio-politically diverse. In this regard, familiarity and similarity among municipalities may reduce the transaction costs associated with negotiating inter-municipal WSAs.

Geography is another potentially significant factor influencing the transaction costs associated with WSAs for both First Nations and municipalities. Specifically, whether a community is located in southern or northern Ontario may have a significant influence on the costs of these exchanges. In southern Ontario, Counties and Regional Municipalities provide coordination of some community services¹⁸ for local

¹⁸ For regional municipalities, these services include: arterial roads, transit, policing, water and sewer, waste disposal, region land use planning and development, and health and social services (AMO, 2021). For counties, these services are generally limited to arterial roads, county land use planning, and health and social services.

municipalities. The *Municipal Act* (2001) defines the respective spheres of jurisdiction over the coordination and provision of different community services – including water services – for local municipalities and their Counties or Regions. In northern Ontario, there is a lack of similar regional-level coordination and municipal governance. The majority of northern Ontario is divided into Districts (a geographical unit equivalent of Counties and Regions) that function as territorial boundaries only, and do not serve any municipal purpose (AMO, 2021). As a result, there is a lack of regional municipal coordination in the north, and the “economies of scale and governance sophistication evident in southern Ontario are often lacking [in northern Ontario]” (MacKinnon, 2016, pp. 6; Southcott, 2013). These differences in municipal governance between northern and southern Ontario are so significant, that a 2016 report of the *Northern Policy Institute* recommended that the provincial and federal government treat northern Ontario “as though it were a separate province for the purposes of economic and statistical analysis” (MacKinnon, 2016; pp. 4).

In summary, there are important differences in the institutions governing First Nations and Ontario municipalities. We expect these

differences to increase the transaction costs of WSAs between First Nations and municipalities, relative to the transaction costs of inter-municipal WSAs. We also expect that communities located in northern Ontario – notably, where the majority (approximately 82%) of First Nations in our data set are located – to face higher transaction costs of WSAs due to a lack of regional governance. In the next section, we outline our empirical approach. Our approach allows us to assess a number of factors influencing community participation in WSAs. In particular, we assess whether First Nations are less likely than municipalities to participate in WSAs, and whether communities in northern Ontario are less likely to engage in WSAs.

4. Empirical approach

We estimate the following regression using a linear probability model¹⁹:

$$P(\text{WSA} = 1|X) = \beta_0 + \beta_1 FN + \beta_2 \text{North} + \beta_3 \ln PD + \beta_4 \ln \text{Dist} + \beta_5 \ln \text{Inc} + \beta_6 \text{Elev} + \varepsilon, \quad (1)$$

where $P(\text{WSA})$ is the probability that a community is engaged in a WSA, conditioned on a host of covariates (X). These variables are defined more formally in Appendix 3.

Our two key variables of interest, FN and North , are categorical variables defined as follows: $FN = 1$ if the community is a First Nations community, and 0 otherwise; and $\text{North} = 1$ if the community is located in Northern Ontario, and 0 otherwise. As discussed in the previous section, in the context of transaction costs we expect that First Nations are less likely than municipalities to be engaged in WSAs.²⁰ Hence, we expect $\beta_1 < 0$. And as previously noted, in comparison to municipalities First Nations communities are disproportionately located in the north, with approximately 82% of First Nations communities in our data set being in [FedNor \(2017\)](#) classified northern census divisions. There are well known differences between northern Ontario and southern Ontario communities in terms of the costs and challenges associated with establishing and maintaining piped water infrastructure – factors such as community size, topography, temperature variability, and remoteness.²¹ And as discussed in the previous section, there are important differences in regional municipal governance between northern and southern Ontario that may increase the costs of interlocal cooperation in the north. For these reasons, we also expect $\beta_2 < 0$: i.e., being located in northern Ontario is expected to reduce the likelihood that a community will be engaged in a WSA.

The remaining variables are continuous, and capture other key community characteristics.²² The variable $\ln PD$ is the natural log of a measure of community population density, in 100s of persons per square kilometer. Regions with higher population densities are expected to benefit from economies of scale in water treatment and lower water distribution costs that support the emergence of WSAs. We expect $\ln PD$ to have a

positive association with WSAs. The natural log of the distance to the closest potential water supplier (measured in kilometers to the nearest neighbouring community with active water infrastructure), $\ln \text{Dist}$, may also be an important consideration. Diseconomies of scale in water distribution make it cost prohibitive to transport piped water over great distances, so as this distance increases we expect the likelihood of a WSA to decline. Hence, we expect $\ln \text{Dist}$ to be negatively associated with WSAs. We have also included the natural log of the median income of the census division that each community is situated within (measured in \$1000s per person), $\ln \text{Inc}$. This variable serves as an indicator of regional wealth²³ and is expected to be positively associated with WSAs, as we expect wealthier regions to have greater capacity for interlocal exchange. Elevation (measured in 10s of meters above sea level), Elev , can influence the cost of maintaining water distribution infrastructure, as higher elevations are associated with greater temperature variability.²⁴ The relationship between soil temperature variation – specifically, temperature drops and water main breaks – is well documented ([Rajani and Kleiner, 2001](#); [Rajani et al., 1996](#); [Yafei and Hung, 2011](#)). We expect Elev to be negatively associated with WSAs. Epsilon, ε , represents the residual term.

5. Data

To our knowledge, this is the first data set ever assembled to allow for empirical comparisons of water services and WSAs in First Nations communities and Ontario municipalities. Table A.3 in Appendix 3 details each variable included in our empirical analysis and provides source information. In the remainder of this section, we provide an overview of our key data sources and data methods.

The cross-sectional data for municipal and First Nations water systems (821 total) are from 2009/10. For reasons of data availability (detailed further below), these are the only years for which sufficiently detailed data could be obtained for water systems servicing First Nations communities to allow for comparison to municipalities. We have observed that many communities have multiple water systems servicing different portions of their community. For the purpose of our assessment of factors influencing community engagement in WSAs, we aggregate our water system level data to the community level. Hence, a First Nations community or municipality is identified as participating in a WSA if any one of its water systems receives drinking water from a neighbouring community.

Once aggregated, our data set characterizes water supply in 419 communities in the province of Ontario – 301 municipalities and 118 First Nations communities. Our data are limited to communities with existing water infrastructure during the study period. All communities in our data set are either completely independently supplied (i.e., by a stand-alone water system, or systems), or engaged in a WSA for all or a portion of their water supply. We define a WSA as any arrangement where a community (municipality or First Nation) receives all or a portion of its water supply from another community. These exchanges can take different forms. Some communities may receive treated water directly from a neighbour, by connecting to that neighbour's piped distribution network. Other communities – like those depicted in [Fig. 2](#) – are parties to regional WSAs, where water treatment infrastructure is collectively owned and managed. As discussed in [Section 3](#), some intermunicipal WSAs are imposed by the province of Ontario, via extra-

¹⁹ The results are qualitatively similar to results obtained using a probit model. We provide probit model results in Appendix 4, Table A4.1.

²⁰ Given the transaction costs argument we advanced in the previous section, we expect the sign to be negative; that said, as discussed, we recognize that there are additional reasons for expecting this effect to be negative.

²¹ We found positive and significant (at the 1% level) correlations between our measure of northerness and community elevation (0.31), remoteness (0.31), and temperature variability (0.82). Elevation was measured in 10s of meters above sea level, remoteness was measured in distance to the closest neighbouring census subdivision (in km), and temperature variability was measured in 10 year average temperature range (in degrees Celsius) as captured by the closest available weather station.

²² The first three of these continuous variables – the population density, distance and income measures – have been logged. To allow for comparison, we provide results for the regression run on untransformed variables in Appendix 4, Table A4.2.

²³ Community-level income data could only be obtained from the census for 47% of the First Nations in our data set. For this reason, we are not able to capture community-level income in our analysis. However, it is important to note that significant disparities exist between on and off-reserve incomes. As of the most recent census (2016), the median individual on-reserve income was approximately half of the national median individual income (\$18,445 compared to \$34,204) ([Statistics Canada, 2017, 2018](#)).

²⁴ In our dataset, the correlation between elevation (in 10s of meters above sea level) and a variable capturing ten year average temperature range for each community is 0.32, at a 1% significance level.

jurisdictional ownership and coordination of water infrastructure.²⁵ For our purposes, communities are identified as *not* being engaged in a WSA only when they are completely self-reliant with respect to water supply.

Water system information was collected from two key sources: the Neegan Burnside (2011) *Survey of First Nation Water and Wastewater Systems*, and the 2009/10 *Chief Drinking Water Inspector's Report (CDWIR)* for Ontario (Stager, 2011). The Neegan Burnside report is based on the results of the only Canada-wide inspection of First Nations water systems to ever take place, which was conducted between 2009 and 2010. Our analysis is limited to this time period, due to this limitation on the availability of First Nations water system data. The Neegan Burnside report provides detailed water system information for First Nations communities, but a similar level of detail is lacking from the Ontario 2009/10 *CDWIR* for municipalities. For this reason, we have collected supplementary documents from each municipality in our data set to develop comparable municipal water system details for our study period. These documents include (but are not limited to): Drinking Water Quality Management System (QMS) Operational Plans,²⁶ Annual Water System Reports,²⁷ and Annual MOE (now MOECP) Water System Inspection Reports.²⁸ In 30 cases (9.96% of municipalities) where no relevant documentation was available, a municipal contact was used to confirm the water system information we required to identify if sharing was taking place.²⁹

Community characteristics were collected from FedNor (2017), the Canadian Census (Statistics Canada, 2019a, 2019b), and Natural Resources Canada (Natural Resources Canada, 2018). Communities were classified as being within or outside of northern Ontario based on FedNor's classification of northern communities. 2006 Census Community Profiles were used to gather community population densities (at the

census subdivision level) and regional median incomes (at the census division level).³⁰ Proximity to the closest neighbouring community (census subdivision) with water infrastructure was calculated for each community in our data set using 2006 census boundary files and GIS software. Community elevations were calculated using 2006 census boundary files, Natural Resources Canada's CanVec³¹ database, and GIS software.

6. Results

Fig. 3 illustrates the prevalence of water sharing in Ontario – for First Nations and municipalities. The comparison presented in the first (left-most) panel of Fig. 3 includes all communities in our data set, and indicates that approximately 32% of those communities are engaged in a WSA. The second (middle) panel provides a naïve comparison of the prevalence of WSAs in First Nations communities and municipalities – one that does not take into account community characteristics, such as geographic location. This naïve comparison reveals a 41% prevalence of WSAs for municipalities, and only a 10% prevalence of WSAs for First Nations communities. When controlling for geographic considerations – i.e., whether a community is located in northern or southern Ontario – this comparison changes significantly. The third (right-most) panel of the figure provides a north versus south comparison that reveals significant geographic differences in the prevalence of WSAs for both First Nations communities and municipalities. In northern Ontario, 7% of First Nations communities are engaged in WSAs compared to 14% of municipalities. This contrasts with southern Ontario, where 24% of First Nations communities are engaged in WSAs compared to 50% of municipalities. The ratio of the percentage of First Nations communities to the percentage of municipalities engaged in WSAs is approximately 1:2 in both northern and southern Ontario. And, both First Nations and municipalities have a smaller percentage of WSAs in northern Ontario. Importantly, First Nations communities and municipalities are not distributed evenly across the province – 82% of First Nations communities in our data set are located in northern Ontario, compared to only 28% of municipalities. Because First Nations communities are disproportionately located in northern Ontario, there is a high correlation between the *FN* variable and the *North* variable (a correlation of 0.48).

As discussed in the previous section, we control for other factors in addition to northern Ontario that are expected to influence the likelihood of community engagement in a WSA. These are defined in detail in Appendix 3, Table A3. Table 1 provides summary data for WSAs and each variable we examine in our regressions – for the complete data set, and separately for First Nations communities and municipalities. Table 2 provides the key regression results for two different models: Model 1 and Model 2. Both of these models are first run on our complete data set (Ontario), and then run on northern and southern subsets of our data. Model 1 regresses WSA on a single explanatory variable: *FN*. Model 2 includes the full set of covariates specified in Eq. 1. A comparison of these two models helps to assess the effects of northerness and our additional covariates.

As expected, in all of the regressions the sign of the estimated effect of the *FN* variable indicates a negative association between WSAs and First Nations communities, relative to municipalities. Both models indicate that the magnitude of this effect is stronger in southern Ontario than in northern Ontario. In Model 2, which includes the full suite of covariates depicted in Eq. 1, First Nations in southern Ontario are 18 percentage points less likely than municipalities to be engaged in a WSA. From a statistical significance standpoint, comparisons between Models

²⁵ For example, treatment infrastructure servicing the Town of Newmarket is owned and managed by the Regional Municipality of York. As cited earlier in Section 3, the Regional Municipality of York has exclusive jurisdiction over water treatment and storage for all of its member communities. Similar provincially imposed extra-jurisdictional ownership and coordination of water treatment and/or distribution infrastructure is established in the *Municipal Act* (2001) for all Regional Municipalities, the District of Muskoka, and Oxford County (other Counties, United Counties, and northern Districts are excluded from these arrangements).

²⁶ The *Safe Drinking Water Act* (2002) requires municipalities to produce, and regularly review and revise, a QMS Operational plan for their water utilities. These plans contain system descriptions including owner, operator and supply information. Most of these plans were originally published before or during our study period (2009/2010), but many had since been revised. For revised plans, revision records would often allow us to confirm the information needed for our study period. However, these plans were often difficult to obtain and occasionally incomplete or missing a detailed revision history, requiring the use of additional sources.

²⁷ The *Safe Drinking Water Act*, (2002) requires municipalities to make annual water system reports, including system descriptions and quality information, publicly available for residents to access. Municipalities usually provide these reports on their website, making them fairly easy to obtain. However, municipalities often do not archive previous years' reports for as long as we required, making 2009/10 reports difficult to obtain in many cases. As a result, they often needed to be supplemented with additional sources.

²⁸ MOE (now MOECP) water system inspection reports are provided to municipalities on an annual basis. These reports, when available, provide all of the information needed to characterize a municipality's water system for our purposes. However, it was not always possible to obtain these reports, as not all municipalities make them available to the public.

²⁹ In cases where a municipality was unable to provide any of the requested documents due to a lack of availability or capacity, we sought a knowledgeable contact who could confirm our key variables of interest by phone or email, by responding to the following questions: 1) who owned your municipality's water system in 2009/10?; 2) in 2009/10, was any water sharing taking place through this system with any neighbouring municipality or First Nation?

³⁰ The 2006 census was used because this was the most recent census as of our study period.

³¹ CanVec is a database of digital topographic data produced by Natural Resources Canada. For more information see: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/CanVec_en.pdf.

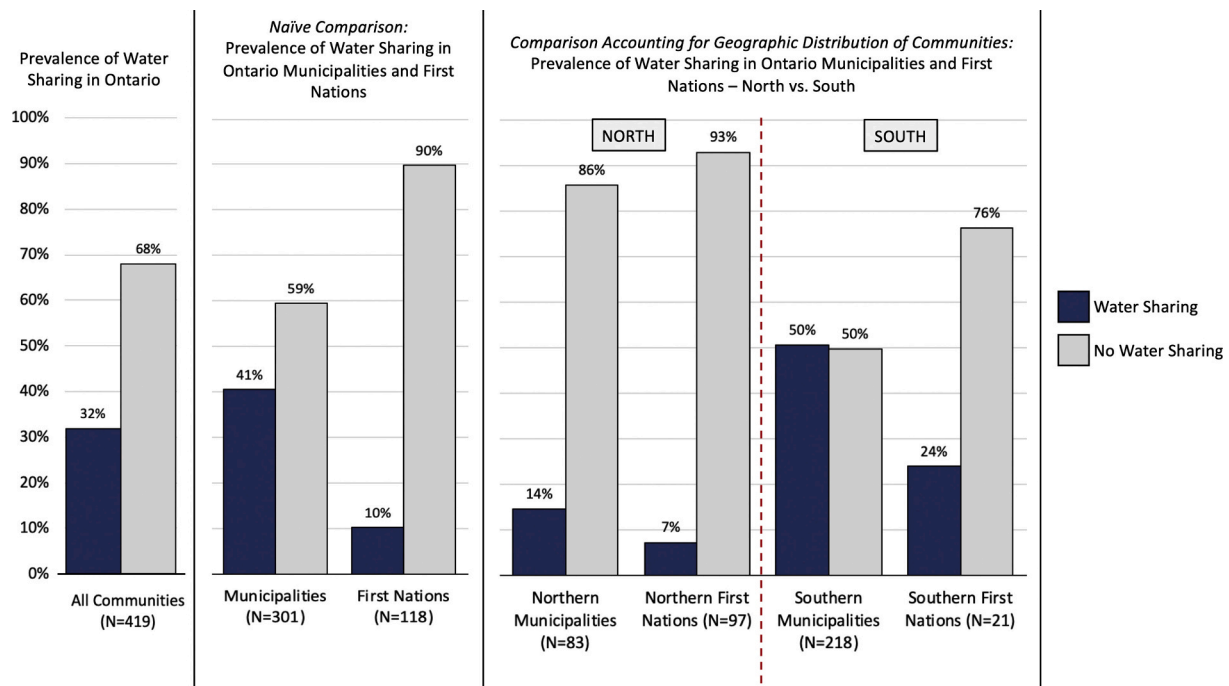


Fig. 3. Prevalence of water sharing in Ontario.

Table 1

Sample summary statistics – All communities, First Nations communities and municipalities.

Variable	All Communities (N = 411)			First Nation Communities (N = 110 ^b)			Municipalities (N = 301)		
	Mean (Std. Dev.)	Min	Max	Mean (Std. Dev.)	Min	Max	Mean (Std. Dev.)	Min	Max
WSA	0.324 (0.468)	0	1	0.100 (0.301)	0	1	0.405 (0.492)	0	1
North Ontario (North)	0.428 (0.495)	0	1	0.845 ^b (0.363)	0	1	0.276 (0.448)	0	1
Population Density (PD)	1.90 (4.08)	0.003	39.72	0.401 (0.769)	0.004	4.12	2.45 (4.63)	0.003	39.72
Distance to Closest Neighbour with a Water System (Dist)	11.14 (17.05)	0.132	178.42	23.15 (26.72)	0.465	178.42	6.76 (8.10)	0.132	68.28
Census Division Median Income (Inc)	25.80 (2.60)	19.89	35.43	24.54 (2.13)	19.89	32.01	26.26 (2.61)	19.89	35.43
Elevation (Elev)	25.06 (9.07)	1	49	27.63 (7.92)	1	45	24.11 (9.29)	1	49

^{a,b} The full suite of community characteristics summarized here, and included in Model 2 below (the fully specified model), were only available for 110 of the 118 First Nations communities in our dataset. This difference explains why, for example, 82% of First Nations are located in the north in our full data set, but 84% of First Nations are located in the north in the subset of the data presented here.

1 and 2 underscore the sensitivity of these results to the inclusion of additional covariates. In Model 2, which includes all covariates, the *FN* variable is not statistically significant at the 10% level in any of the three data sets (i.e., Ontario, northern Ontario or southern Ontario). That said,

in the southern Ontario subset the *FN* variable approaches statistical significance at the 10% level, with a *p*-value of 0.112.

Fig. 4 provides another means to evaluate the estimated effects for the *FN* variable in Models 1 and 2 across the three data sets. In this

Table 2

OLS regression results^a – Models 1 and 2.

		Variable ^b	Ontario	Northern Ontario	Southern Ontario
Model 1: <i>FN</i> Variable Only		<i>First Nation (FN)</i>	−0.304*** (0.040)	−0.072 (0.047)	−0.266*** (0.099)
		<i>R</i> ²	0.086	0.014	0.023
		<i>N</i>	419	180	239
Model 2: Full Suite of Covariates		<i>First Nation (FN)</i>	−0.056 (0.049)	−0.039 (0.050)	−0.183 ^c (0.115)
		<i>Northern Ontario (North)</i>	−0.130** (0.060)	–	–
		<i>Population Density (lnPD)</i>	−0.001 (0.012)	−0.010 (0.011)	0.007 (0.020)
		<i>Distance to Closest Neighbour with a Water System (lnDist)</i>	−0.078*** (0.019)	−0.035* (0.020)	−0.146*** (0.041)
		<i>Census Division Median Income (lnInc)</i>	1.313*** (0.231)	0.836*** (0.300)	1.402*** (0.363)
		<i>Elevation (Elev)</i>	−0.003 (0.003)	−0.001 (0.002)	−0.003 (0.004)
		<i>R</i> ²	0.2532	0.0716	0.1591
		<i>N</i>	411	176	235

^a Standard errors in parentheses. Significance level of result: *** 1% significance level; ** 5% significance level; * 10% significance level.

^b Dependent variable is WSA (0 = community has no WSA, 1 = community has a WSA).

^c *p*-value is 0.112.

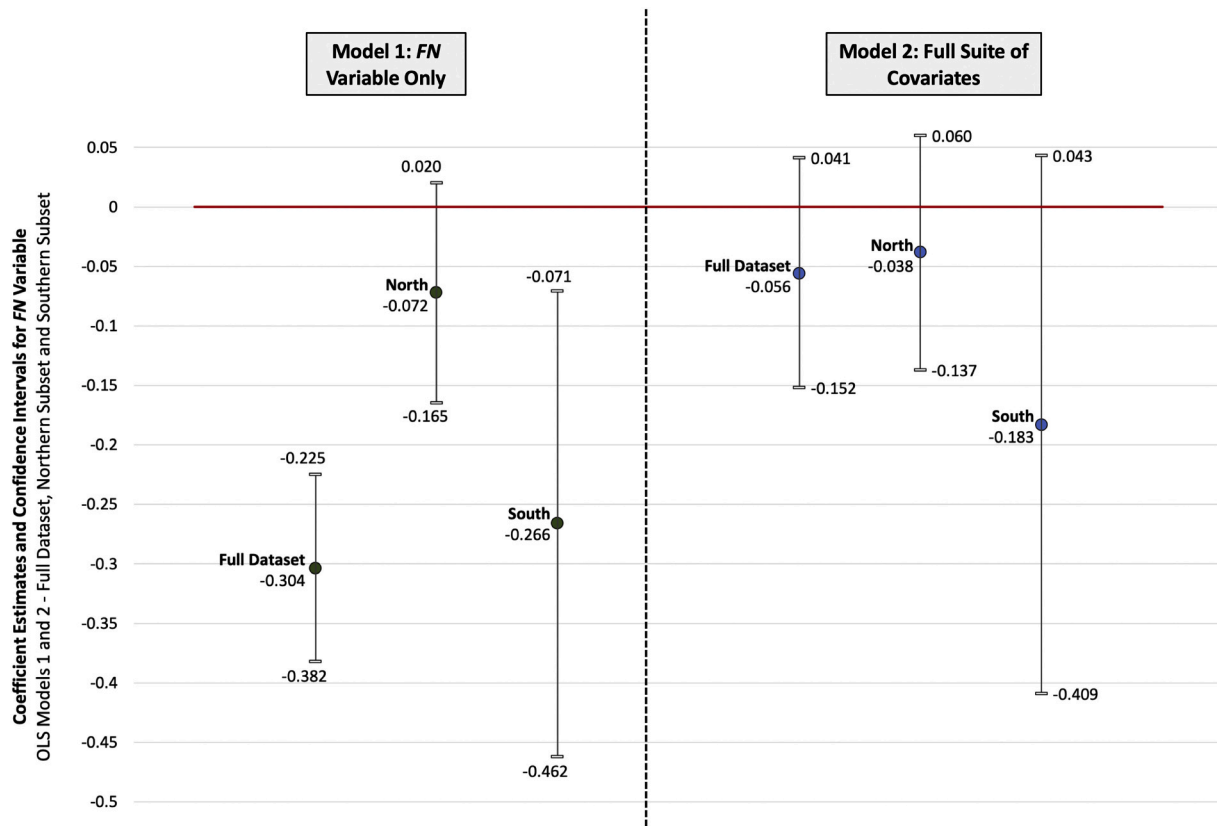


Fig. 4. Estimated coefficients for *FN* in Models 1 and 2 with confidence intervals.

figure, we illustrate these estimates with their 95% confidence intervals, which suggest a consistent negative association between *FN* and WSAs. The negative association between *FN* and WSAs is consistent with the expectation that First Nations – after controlling for important factors – might be less likely to be participating in WSAs. However, we note that the statistical significance of these results are less robust than many of the other covariates.

The results from Model 2 indicate that additional covariates have a significant effect on the likelihood of community participation in a WSA. When Model 2 is applied to the complete data set, communities located in northern Ontario are found to be 13 percentage points less likely to be participating in a WSA than communities located in southern Ontario. This result is statistically significant at the 5% level. As discussed earlier, this northern effect is especially important because the majority of First Nations communities (82%) in our data set are located in northern Ontario.

Across all three data sets – Ontario, northern Ontario, and southern

Ontario – there is a consistently negative and significant association between distance to the closest neighbouring community with a water system and the likelihood of a WSA. In southern Ontario, for example, a 10 percentage point increase in this distance is associated with a 1.5 percentage point decrease in the likelihood of WSA participation (compared to an estimated 0.4 percentage point decrease in northern Ontario, and an estimated 0.8 percentage point decrease for the province overall). There is also a consistently positive and significant association between regional wealth and the likelihood of WSA in Model 2. In southern Ontario, a 10 percentage point increase in census division median income (which is measured in \$1000s) increases the likelihood of WSA by 14 percentage points (compared to an estimated 8.4 percentage point increase in northern Ontario, and an estimated 13 percentage point increase for the province overall). Neither of the remaining variables – i.e., population density and elevation – are robust with respect to their effects or statistical significance.

Table 3 provides the standardized coefficients for Model 2 run on the

Table 3

Model 2 OLS regression results: complete data set – unstandardized and standardized coefficients^a.

Variables ^b	Unstandardized Coefficient	Robust Std. Error	Standardized Coefficient	t	P > t	95% Confidence Interval	
First Nation (<i>FN</i>)	-0.056	0.049	-0.053	-1.13	0.258	-0.152	0.041
Northern Ontario(<i>North</i>)	-0.130**	0.059	-0.138**	-2.18	0.030	-0.247	-0.013
Population Density (<i>lnPD</i>)	-0.001	0.012	-0.003	-0.06	0.953	-0.024	0.022
Distance to Closest Neighbour With a Water System (<i>lnDist</i>)	-0.078***	0.019	-0.190***	-4.16	0.000	-0.115	-0.041
Census Division Median Income (<i>lnInc</i>)	1.313***	0.231	0.280***	5.68	0.000	0.859	1.768
Elevation (<i>Elev</i>)	-0.003	0.003	0.049	-1.00	0.316	-0.008	0.002
R ²	0.2532						
N	411						

^a Significance level of result: *** 1% significance level; ** 5% significance level; * 10% significance level.

^b Dependent variable is WSA (0 = community has no WSA, 1 = community has a WSA).

complete data set for all of Ontario. These standardized coefficients provide the effect of a one standard deviation change in the explanatory variable on the probability of a community participating in a WSA, and they allow us to better assess the relative strength of the covariates. For comparison purposes, this table features the unstandardized regression coefficients from Table 2 as well. The standardized coefficients in Table 3 underscore the relative importance of distance to neighbouring communities with water systems (*lnDist*) and regional wealth (*lnInc*), compared to the other covariates. The regional wealth variable in particular appears to have the largest positive association with the probability that a community will be participating in a WSA, compared to the standardized coefficients of the other covariates.

7. Conclusions and future research

In our data set, First Nations are associated with a reduced likelihood of participation in WSAs relative to municipalities. This result is not robust from a statistical significance perspective. Potential future studies could strengthen the statistical test by incorporating data from additional regions thereby expanding the number of observations. We find that communities located in remote, low-income regions of Ontario — especially those located in northern Ontario — are less likely to be engaged in WSAs. These factors had a statistically significant influence on WSA participation for all communities, but notably they are significantly correlated with First Nations communities. Northernness is an especially important consideration, as 82% of First Nations communities in our data set are located in northern Ontario.

We believe the issue of WSAs is deserving of continued research. We are unaware of other studies, outside of the few identified in our manuscript, that provide careful empirical documentation and assessment of these relationships. A number of important questions abound. How do our results for Ontario compare to other Canadian provinces and other regions of the world? Is the north versus south divide that we have identified present in other geographic contexts within Canada and beyond? Do WSAs have a similar effect on drinking water quality for municipalities and First Nations? Can we better identify the opportunities for, and constraints to, feasible and mutually beneficial exchanges between First Nations and municipalities? Answers to these questions require both quantitative and qualitative approaches. While this paper begins to address this area of research by the former method, we hope we have identified a suite of considerations to support the latter.

Our results suggest that characteristics of communities — such as the relative wealth of their surrounding region, and their proximity to neighbours with water systems — are important factors influencing WSA engagement. Once these characteristics are taken into account,

differences in WSA engagement between First Nations and municipalities become less pronounced. That said, our findings remain problematic for First Nations because they are disproportionately located in northern Ontario, and are more likely than their municipal counterparts to be located in remote and low-income regions.

From a practical standpoint, we suggest that ongoing empirical and qualitative research in this area will benefit from the careful assessment of institutions, or “rules”, undergirding the emergence of WSAs. Consider the specific situation described in the quotation at the start of this paper. In that situation, a First Nations community is experiencing desultory drinking water conditions, yet they are surrounded by municipalities enjoying much better water quality. An important policy-based research question follows: is there a policy innovation that would potentially motivate an improved outcome? As a thought experiment, suppose a rule were to be put in place that required nearby municipalities to provide water to First Nations communities, if requested by the First Nation. Such a rule might set in motion a host of municipal planning decisions that would not only ensure the development of adequate water capacity, but would greatly lessen the burden of negotiation for First Nations should they choose to pursue the option.

The range of potential policy changes to be considered are beyond the scope of this paper. That said, we believe there is an ongoing need to better understand effective coordination between communities with respect to drinking water provision. In this regard, our research can be complemented by qualitative research that helps to identify the constraints to, and reasons for, the emergence of WSAs in different contexts. In addition, our empirical approach provides a basis for ongoing quantitative efforts, and the development of similar data sets in other regions.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors thank two anonymous reviewers for their suggestions and insightful comments. The authors also thank Sheri Longboat, Chris Alcantara, Barry Hill and David Vince for their comments on an early presentation of the paper. We greatly appreciate the data gathering efforts of Edwige Tia, Elsie Richmond, and Jamie Naylor. That said, the authors are responsible for all errors and any opinions expressed in this paper. This paper draws on research supported by the Social Sciences and Humanities Research Council of Canada.

Appendix 1. WSA between the Mohawks of the Bay of Quinte First Nation and the Town of Deseronto

The Mohawks of the Bay of Quinte (MBQ) First Nation and the Town of Deseronto are geographic neighbours on the Bay of Quinte in Southeastern Ontario. These communities each have their own independent water utilities, but have also been collaborating to share the costs of their water and sewer services since 1985 (MOU, 2000). Their most recent agreement was signed in November of 2000, on a twenty-five year term. Under the terms of their current agreement, MBQ functions as a large client of Deseronto's water utility, purchasing treated water from their water treatment plant. MBQ is responsible for all costs associated with maintenance of pipe infrastructure channeling water on to reserve properties, both on and off reserve, and must obtain permission from the Town of Deseronto for all new hookups. Water is metered from two locations at the border of the reserve, and based on the quantity of water from those meter readings, the MBQ Band is charged monthly for the community's usage. MBQ is allotted a set portion of Deseronto's water treatment plant capacity, based on their past usage, and must pay for any excess. The price charged is determined as the total quantity of water used divided by the total cost of provision. The Town of Deseronto does not profit from this agreement, and the per unit price charged to the MBQ Band is the same as the price charged to Town residents. MBQ maintains its own independent water treatment facility to service their airport and a small number of residential consumers (Neegan Burnside, 2011), and the remainder of the community is supplied by individual wells (First Nations Engineering Services Ltd, 2014). However, as of 2012 approximately 80% of individual wells within the community were determined to be unsafe, and 222 homes (approximately 19% of all households) experienced water shortages throughout the year. The mutual benefit of this agreement is that it allows the Town of Deseronto, a relatively small community, to spread the cost of treatment among a larger number of users (i.e. achieving economies of scale), and it gives MBQ an additional cost-effective source of water when their groundwater sources have been historically constrained and plagued by quality issues. As of the most recently available data, 257 MBQ households (approximately 22% of total households) were

receiving treated water through this water sharing arrangement (Neegan Burnside, 2011).

Appendix 2. WSA between the City of Guelph and the Township of Guelph Eramosa

The City of Guelph and the Township of Guelph Eramosa are neighbouring municipalities in Southern Ontario, situated approximately 100 km west of the City of Toronto. Guelph is a single tier municipality, and the Township of Guelph Eramosa is a lower tier within Wellington County. Since 1980, the two communities have had a WSA that made the City of Guelph the supplier and operating authority for the Class 1 (small municipal residential) water distribution system that services the Gazer Mooney subdivision in the Township of Guelph Eramosa (Guelph City Council, 2019). This small system services 72 residential parcels. The City of Guelph agreed to provide and monitor water meters on each service connection in Gazer Mooney, to the same level of maintenance provided within the City of Guelph, and was granted the right to enter Guelph/Eramosa township as needed for any maintenance, repairs and operational purposes. The City of Guelph also provides billing and collection services for the subdivision. Effectively, the Gazer Mooney subdivision is treated as an extension of the City of Guelph's drinking water system. The Township remains responsible for system licensing, and financial planning for the system.

Appendix 3. Details of dataset (data and code available by authors here: <https://doi.org/10.5683/SP2/TTHJVN>)

Table A3: Detailed variable descriptions with data sources.

Water System Characteristics		
Variable	Description	Source
Water Supply		
WSA	Identifies communities that receive at least some portion of their water supply through some form of water sharing arrangement (WSA).	Neegan Burnside (2011), Stager (2011)
Demographic		
FN	Identifies First Nation communities.	Statistics Canada (2019b)
PD	Population density of community (census subdivision) in 100s of persons per square kilometer, as reported in the 2006 Canadian census.	Statistics Canada (2019b)
Inc	Census Division median income in 2005, in \$1000s, as reported by the 2006 Canadian Census.	Statistics Canada (2019b)
Geographic		
North	Identifies communities located in Northern Ontario Census Divisions, as defined by FedNor (the government of Canada's economic development organization for Northern Ontario).	FedNor (2017)
Elev	Community (census subdivision) elevation measured at community centroid, in 10s of meters relative to mean sea level.	Natural Resources Canada (2018), Statistics Canada (2019a)
Dist	Distance to the closest neighbouring census subdivision with water infrastructure, measured as distance from community boundary to neighbour centroid (kilometers).	Neegan Burnside (2011), Stager (2011), Statistics Canada (2019a)

Appendix 4. Additional regression results

Table A4.1: Model 2 probit regression results – Average marginal effects reported^a.

Variable ^b	Ontario	Northern Ontario	Southern Ontario
First Nation (<i>FN</i>)	−0.094 (0.059)	−0.043 (0.047)	−0.198 (0.122)
Northern Ontario (<i>North</i>)	−0.120** (0.060)	–	–
Population Density (<i>lnPD</i>)	−0.002 (0.012)	−0.011 (0.011)	0.009 (0.019)
Distance to Closest Neighbour with a Water System (<i>lnDist</i>)	−0.080*** (0.021)	−0.032* (0.018)	−0.144*** (0.040)
Census Division Median Income (<i>lnInc</i>)	1.272*** (0.246)	0.841*** (0.300)	1.442*** (0.395)
Elevation (<i>Elev</i>)	−0.003 (0.002)	−0.001 (0.003)	−0.003 (0.004)
Pseudo R ²	0.2362	0.1112	0.1262
N	411	176	235

^a Standard errors in parentheses. Significance level of result: *** 1% significance level; ** 5% significance level; * 10% significance level.

^b Dependent variable is WSA (0 = community has no WSA, 1 = community has a WSA).

Table A4.2: Model 2 OLS regression results – Untransformed variables^a.

Variable ^b	Ontario	Northern Ontario	Southern Ontario
First Nation (<i>FN</i>)	−0.088* (0.049)	−0.060 (0.051)	−0.161 (0.120)
Northern Ontario (<i>North</i>)	−0.145** (0.059)	–	–
Population Density (<i>PD</i>)	−0.008 (0.005)	−0.038*** (0.013)	−0.006 (0.006)
Distance to Closest Neighbour with a Water System (<i>Dist</i>)	−0.003*** (0.001)	−0.001* (0.001)	−0.018** (0.008)
Census Division Median Income (<i>Inc</i>)	0.054*** (0.009)	0.035*** (0.013)	0.055*** (0.012)
Elevation (<i>Elev</i>)	−0.003 (0.003)	−0.002 (0.002)	−0.005 (0.004)
R ²	0.2371	0.0774	0.1496
N	411	176	235

^a Standard errors in parentheses. Significance level of result: *** 1% significance level; ** 5% significance level; * 10% significance level.

^b Dependent variable is WSA (0 = community has no WSA, 1 = community has a WSA).

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