Do Water Service Provision Contracts with Neighbouring Population Centres Reduce Drinking Water Risk on Canadian Reserves?

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Abstract

As of 2011, 39% of drinking water systems on Canadian First Nations' reserves could be classified as high risk, or unequipped to safely deal with the infiltration of a pollutant (Neegan Burnside 2011a). In recent years, some First Nations have contracted water services from neighboring population centres through 'Municipal Type Agreements', or 'MTAs'. Using a unique data set of 804 First Nation water systems, we explore both factors that influence participation in MTAs, and the effect of participation on the likelihood that a First Nation will be under a boil water advisory. Our empirical analysis consists of two probit models. The first model describes the likelihood that a MTA agreement will emerge between a First Nation and neighbouring population centre. The second estimates the likelihood that a First Nation will be under a boil water advisory. Our primary finding is that MTAs reduce the likelihood of a boil water advisory being in effect on a reserve. This is an important consideration when developing incentives or institutions that influence infrastructure collaboration between First Nations and Canadian population centres.

Key Words: First Nations, reserves, population centres (POPCTRs), Infrastructure Partnerships, Municipal Type Agreements (MTAs), Local Intergovernmental Cooperation, Contracts, Transaction Costs, Economies of Scale, Standards, Drinking Water Quality, Probit

Introduction

As of 2011, 39% of drinking water systems in Canadian First Nations' communities were identified as being "high risk", or ill equipped to deal with exposure to contamination (Neegan Burnside 2011a). The number of boil water advisories (BWAs) on reserves continues to rise. Many of those advisories can be classified as 'long-term' advisories, persisting for months or even years (Willsie, Patershank, Lydon-Hassen, Mimeault, Wu and Travis 2009; Polaris Institute 2008). The challenges of providing adequate drinking water services in rural areas are legion, and these challenges – finance, economies of scale, planning capacity, etc. – apply to both First Nations and non-First Nation population centres (POPCTRs). According to the 2012 'Canadian Infrastructure Report Card' published by the Canadian Federation of Municipalities (FCM 2012), 15.4% and 14.4% of Canadian drinking water systems are ranked "fair" and "very poor", respectively, for the condition of their pipes, plants, reservoirs and pumping stations. The estimated replacement cost for these insufficient drinking water systems is $25.9 billion, or $2082 per Canadian household.

In recent years, some reserves have sought partnerships with neighboring POPCTRs (and vice versa) to pursue mutually beneficial solutions to drinking water provision challenges[1]. These partnerships, classified as 'Municipal Type Agreements' (which we hereafter refer to as 'MTAs'), take the form of contracts between First Nations' bands and neighboring municipalities or townships. In these cases, a reserve purchases some negotiated quantity of treated drinking water from the neighboring community. This water is generally priced at average cost per unit[2], and the reserve remains responsible for all of the costs associated with distributing the purchased water to reserve households (including the construction and maintenance of any and all pipes on reserve lands, or the funding of delivery trucks in the case of trucked water distribution). The proportion of the population serviced by the MTA varies from all to only a portion of reserve households.

Aboriginal Affairs and Northern Development Canada (AANDC)[3], the FCM[4], and many

[1]Figure 2 of the Appendix provides a map with the locations of all of the water systems in my data set that are distributing water treated in a neighbouring POPCTR.

[2]The template for drinking water MTAs published by the FCM recommends pricing based on a fee that is equivalent to the rates established under the Municipal by-law regarding rates and regulations for the municipal partner (CIPP 2013). The majority of municipalities in Canada price according to average cost (Environment Canada 2013a), so it follows that the majority of reserves with MTAs likely fall under some type of average cost pricing structure.

[3]AANDC encourages MTAs in situations where they are the least cost alternative to other forms of service delivery (AANDC 2011; INAC 2009).

First Nations leaders support MTAs as one means of enhancing water quality on reserves. In their survey of 93 cooperative agreements (in a variety of service areas, including drinking water provision) between First Nations and POPCTRs in British Columbia, Nelles and Alcantara (2011) found these types of "jurisdictional agreements" to be on the rise, as "both First Nations and municipal governments have progressively recognized the mutual benefits of collaboration" (pp. 327). However, there is no empirical research examining the extent to which these MTAs actually enhance water quality. This paper remedies this gap, by empirically examining both the factors that influence the emergence of MTAs between First Nations and neighboring POPCTRs, and the extent to which MTAs reduce the likelihood of a boil water advisory (BWA) being present on a reserve.

Local intergovernmental cooperation has been gaining popularity in North America and Europe as a means of improving community service provision, particularly in remote rural areas, and economic research in this area has been increasing (Hawkins 2010; Kwon and Feiock 2010; LeRoux and Carr 2007; Morgan and Hirlinger 1991; Steiner 2003; Thurmaier and Wood 2002). The voluntary nature of these types of contracts appears to be prima facie evidence of mutual gains. The majority of research in this area is focused on explaining the emergence of these agreements, and does not extend to evaluating outcomes (with the exception of Steiner 2003), such as their impact on the quality of service provision. The importance of social capital between communities, community characteristics, and cost considerations are frequently emphasized as determining factors (Hawkins 2010; Kwon and Feiok 2010; Steiner 2003; Thurmaier and Wood 2002). Morgan and Hirlinger (1991) argue that many of the same forces driving contracting to the private sector also drive local intergovernmental service agreements, such as cost savings, fiscal pressures, and political influences. To date there have been no studies investigating factors influencing the emergence of MTAs between First Nations and POPCTRs, or the relationship between MTAs and drinking water quality on reserves.

Our empirical analysis of over 804 First Nation water systems provides a number of insights. Our primary findings are that proximity to POPCTRs increase the likelihood of a MTA agreement and that MTAs reduce BWAs on reserves. Population and population density on the

[4]FCM promotes MTAs through the ‘First Nations Municipal Community Infrastructure Partnership Plan’ (CIPP), which provides resources to First Nations and municipalities interested in forming MTAs. These resources include ‘toolkits’ containing case studies and agreement templates, as well as the facilitation of workshops to encourage cross-jurisdictional cooperation (FCM 2013).

reserve also influence the likelihood of a MTA agreement. One important observation, from a policy perspective, is that there are many First Nations in close proximity to POPCTRs that are not currently participating in a MTA. We explore this issue of proximity more fully in our results.

The remaining sections of this paper are organized as follows. First, we provide a background for understanding a key set of factors that may influence participation in MTAs. We focus our discussion on the costs of water provision and differences in the regulations and standards governing drinking water provision on First Nation reserves and within Canadian provinces. We then specify our regression approach to assess the likelihood that a First Nation will enter in to a MTA, and the effect of MTAs on the likelihood of a BWA being present on a reserve. The data section defines and reviews the variables we use in the regression approach. We then provide empirical results and conclusions that identify areas of future research and potential policy implications.

The Emergence of MTAs and Water Quality Outcomes

The emergence of a MTA is essentially a voluntary contract between a First Nation and POPCTR. Gibbons (2012; 2005; 1998) identifies four key elements regarding the incentives that underlay a voluntary contract and influence associated outcomes. First, the participants must agree to the contract. Second, the agent (i.e. the water provider in the POPCTR) must choose a set of actions (e.g. regarding the assessment of water quality, reporting requirements, etc.). The third component is to relate the agent actions to outcomes. The fourth component takes into consideration the effect of events unrelated to the agent (e.g., weather) that may also influence outcomes. In the remainder of this section we discuss two aspects of Gibbons' approach: (1) incentives that influence First Nations and POPCTRs to enter in to a voluntary contract and (2) differences in the institutional setting that may influence the set of actions chosen and subsequent outcomes. These differences may also be an incentive influencing the choice to enter in to a MTA.

Voluntary contracting – which characterizes MTAs between a First Nation and POPCTR – requires that the net benefits to both parties are non-negative. Moreover, the net-benefits must be greater than (or equal to) a feasible alterative to either party (Coase 1960; Feiock 2007; Stigler 1989), and the contract must be enforceable (Masten 1999; Williamson 1979).

We expect the perceived mutual benefits of entering in to a MTA to be heavily influenced by proximity. That is, we expect that the closer a First Nation is to a POPCTR with the capacity to provide water, the more likely they are to enter in to a MTA. There are two reasons for this expectation. First, the costs of distributing water (by pipe or by truck) increase exponentially over distance. Diseconomies of scale in water distribution result from capital costs that increase with the construction of additional water mains, due to the costs of additional pipelines and connections, and the energy inputs required to transport water to consumers. Second, the transaction costs of coordinating a MTA are also likely to be influenced by proximity and familiarity between the First Nation and POPCTR.

We also expect on-reserve population and population density to influence the potential benefits of MTA participation for a First Nation. Economies of scale in drinking water treatment arise due to high initial capital construction costs relative to low operation and maintenance costs. Hence, from a treatment perspective, First Nations governing reserves with smaller populations may be more likely to seek out MTAs. However, as mentioned above, the extension of a water distribution network can result in high costs that may greatly offset economies of scale in water treatment. Factors that reduce water distribution costs (ex. shorter distances between the treatment source and serviced households, and a higher population density in the serviced area) may increase the likelihood of MTAs. Conversely, more dispersed reserve populations may disincentivize MTAs and result in the construction of small and concentrated on-reserve distribution networks (Boisvert and Schmit 1997; Kim and Clarke 1988).

POPCTRs may also benefit from MTAs. A POPCTR operating below the scale efficient level of water treatment output (the level of output where the minimum average cost per unit is achieved) can increase their volume of treated water to service a neighbouring reserve and take advantage of economies of scale. Importantly — from the perspective of POPCTRs — MTAs offer the option of increasing water treatment volume without having to expand distribution networks, as reserves remain responsible for water distribution on their own lands. This allows participating POPCTRs to capture all of the scale economies associated with increasing their output of treated water, without incurring any additional distribution costs.

Of course there remain meaningful transaction costs associated with entering in to a MTA. For a MTA to emerge, these potential benefits to both parties must outweigh the transaction costs associated with reaching an agreement. MTAs between First Nations and POPCTRs present specific challenges, as contracts between governments and across jurisdictional boundaries can be costly to negotiate. This is especially true in cases where a contract is being negotiated between governments that fall under very different political structures, as is the case with First Nation bands and Canadian townships and municipalities. These transaction costs may be reduced if there is a history of cooperation between the two parties, and existing social contacts between the two governments and community residents. In his study on inter-municipal cooperation and municipal mergers in Switzerland in the 1990s, Steiner (2003) found that intensive social contacts among inhabitants of both areas were essential. Hawkins (2010) also emphasizes the importance of "cooperative norms and trust" (pp. 253) in facilitating intergovernmental cooperation. On average, these relationships may be more likely to occur when First Nations and POPCTRs are in closer proximity.

Another important consideration, albeit more difficult to measure, is the political and social desire of First Nations and POPCTRs alike to maintain autonomy in the provision of key services like drinking water. In his study of U.S. municipal service provision contracts with external providers, Ferris (1986) emphasizes the importance to local officials of maintaining control over service provision and the perceived costs associated with losing that control. Ferris emphasizes that the perceived benefits of using an external service provider must be substantial in order for the costs associated with losing autonomy over vital services to be perceived as worthwhile. LeRoux and Carr (2007) also postulate that the appeal of cost savings is only as important as the perception of local governments as to the level of control over the service being contracted out. Therefore, the perceived benefits of a MTA must be significant enough that they outweigh the costs; and forfeiting control over drinking water provision may be a perceived component of the opportunity costs.

A key issue governing incentives to enter in to MTAs, and the associated water quality outcomes, is the institutional setting that influences and governs the actions of water service providers (i.e. treatment, testing, and reporting) and ultimately influences water quality. The Walkerton Inquiry emphasized the important role of institutions and regulatory oversight on determining individual actions affecting water quality outcomes (O'Connor 2002). In this regard, it is important to recognize that water provision in Canadian POPCTRs is guided by a set of provincial standards that do not apply to First Nation communities[5].

[5]Figure 2 of the Appendices outlines drinking water safety standards and guidelines for First Nation and non-First Nation communities in Canada.

Reserves fall into a jurisdictional gap with respect to drinking water quality standards. In Canada, drinking water safety and regulatory standards are set and enforced at the provincial level, and as such do not apply to First Nations' communities. This is because reserves are governed by the Indian Act, which is a piece of federal legislation (Department of Justice 1985); and Canada is the only OECD country that does not have enforceable national drinking water standards (Bakker and Cook 2011). Drinking water quality guidelines for reserves exist at the federal level under AANDC, but to date they are not enforceable (Auditor General of Canada 2005; Christensen 2011).[6] Water providers in POPCTRs are therefore held to a standard of quality and safety that water providers on reserves are not.

There are key distinctions between the issuance of BWAs on reserves and in POPCTRs that highlight differences in water quality standards and governing institutions. While provincial governments oversee water quality monitoring and mandate BWAs in Canadian POPCTRs, First Nations remain primarily responsible for water quality and BWA issuance on reserves. For example, in Ontario inspectors from the Provincial Ministry of the Environment ensure that water systems in POPCTRs are being properly sampled and monitored on a regular basis (Wellington-Dufferin-Guelph Public Health 2014); and if water quality does not meet provincial standards, the province ensures that a BWA is issued. In contrast, First Nations receive funding from Health Canada for the implementation of community-based water monitoring programs and the training of water quality monitors, or the hiring of an external monitor (Health Canada 2014). Health Canada recommends that a BWA be issued when water quality does not meet Federal guidelines, but monitoring measures and the decision to implement a BWA ultimately lies with the Band.

These differences in standards governing drinking water providers on reserves and in POPCTRs affect differences in drinking water outcomes. This may ensure greater water quality in situations where a reserve is supplied by water being treated in a neighbouring POPCTR.

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[6] A'Clean Drinking Water for First Nations Bill', bill S-8, is currently awaiting royal assent, which will hold reserve areas to a federal drinking water standard once it becomes law. The bill has faced significant resistance from First Nation groups who feel that it infringes on their jurisdiction (Christensen 2011), and will hold reserve areas to an unachievable water quality standard without providing bands with any additional resources (Chiefs of Ontario 2012). In 2006, a formal report published by an expert panel on safe drinking water for First Nation communities emphasized this issue of monitoring capacity, arguing that beyond setting standards and requirements, the most "critical element [in ensuring drinking water system safety] is the capacity of facilities and operations to meet the standards" (Swain, Louttit and Hrudey, pp.60).

Through a MTA, reserves are able to transfer the costs of monitoring water quality to the province, and are ensured that the water supplied to reserve households achieves the provincial standard. We explore this issue more fully by examining whether a reserve with a MTA is more or less likely to have a BWA in effect.

Ultimately, the effect of MTA participation on drinking water quality outcomes on reserves is jointly determined by the actions taken by the POPCTR water service provider, and other uncontrollable factors. These factors include reserve proximity to potentially polluting resource and industrial sites, which could result in the pollution of groundwater sources or pollution infiltration into water distribution networks through water main breaches. Reserves located in climactic zones with high degrees of temperature variation face risks associated with the freezing and thawing of pipes, which can result in damaged pipelines that are costly to repair, and likely to introduce pollution into the water supply (Rajani and Kleiner 2011). Our model, described below, controls for such geographic and climactic variables that may influence a water system's exposure to risk (in addition to other water system characteristics with potential risk implications), in order to isolate the effect of MTA participation on drinking water quality on reserves.

Empirical Model

Our empirical approach consists of two probit models. The first model identifies factors affecting the emergence of MTAs, focusing on characteristics of First Nations and POPCTRs that may influence their decisions to participate. We are most interested in community characteristics that are expected to influence the costs of MTA participation, namely: the distance between the two communities and their populations, and reserve population density. The second model is used to evaluate the effect of MTA participation on the probability of a BWA being present on a reserve, controlling for other factors that may influence a reserve's susceptibility to drinking water risk.

Our first model, used to assess the probability that a First Nation is a participant in a MTA, can be represented as follows:

$$P(MTA = 1|X_M) = \Phi(\alpha_0 + \alpha_1 lnDISTRP + D_r'\beta + D_p'\gamma + \alpha_2 CDY + PROV_i'\delta) \qquad [1]$$

Where $P(MTA = 1|X_M)$ is the probability that a First Nation is participating in a MTA with a neighbouring POPCTR. The variable *MTA* is equal to 1 in the case where a reserve has an existing MTA with a neighbouring POPCTR, and 0 otherwise. And X_M is a vector of explanatory variables included in the analysis. Of key interest is the variable $lnDISTRP$, which is the natural log of the distance between each reserve and its closest proximal POPCTR (representing either the existing or potential MTA partner), which is expected to have a negative and significant marginal effect. That is, as the distance between a reserve and its closest proximal POPCTR increases, the likelihood of a MTA emerging is expected to decrease.

D_r' and D_p' are vectors of the following characteristics for each reserve and POPCTR: surface area (in square kilometres), population (in hundreds of people) and population density (in hundreds of people per square kilometer). We expect the population variables for both communities to have a significant and negative marginal effect, indicating that reserves and POPCTRs with smaller populations will be more likely to pursue MTAs to take advantage of economies of scale in drinking water treatment. This incentive may be less compelling as reserves or POPCTRs increase in population size.

The variable *CDY* captures the median income in the census division surrounding each reserve. This variable is included to account for the potential effect of regional economic prosperity on the likelihood of inter-local cooperation. Finally, $PROV_i'$ is a vector of dummy variables indicating the provincial jurisdiction that each water system falls within. It is included to account for potential institutional differences across provinces, or differences in the characteristics of reserves and POPCTRs themselves that may vary across provinces, that may affect the likelihood of MTAs emerging.

Our second model estimates the probability that a water system is under a BWA, and can be represented as follows:

$$P(BWA = 1|X_B) = \Phi(\mu_0 + \mu_1 MTA + ID_s'\pi + WSC'\varphi + \mu_3 lnDISTRRI + TP_c'\omega) \qquad [4]$$

Where $P(BWA = 1|X_B)$ represents the probability that a BWA is in effect on a reserve. The variable *BWA* is equal to 1 in cases where a BWA is in effect, and zero otherwise. And X_B is a vector of explanatory variables included in model. The key variable of interest is the variable *MTA*, which is identical to the dependent variable in equation 1. We expect this variable to have a negative and significant marginal effect, indicating that participation in a MTA reduces the probability of a reserve being under a BWA.

In the model we control for a number of other potentially influential covariates. ID_s' is a vector of two dummy variables, indicating when a reserve water system is independent (ie. non-

MTA) and serviced by groundwater, or groundwater under the direct influence of surface water (GUDI). This was to account for differences in the types of risk that groundwater and GUDI sources are exposed to (with the omitted variable being surface water sources). WSC' is a vector of water system characteristics that may influence risk susceptibility, including: system age (in years), the maximum daily volume of the system (in hundreds of cubic metres per day, to capture system scale), and the percentage of households serviced by trucked and piped water (to capture differences in piped and trucked distribution risk exposure; specifically, risk exposure for piped distribution networks from pollution infiltration into water mains). The variable *lnDISTRRI* captures the natural log of the distance from each water system to the closest potentially polluting resource or industrial site. Finally, TP_C' is a vector of climate variables – ten year average temperature range, and ten year average total annual precipitation – that may influence a water system's exposure to contamination (ie. through freezing and thawing, pipe soil interactions, and excessive rainfall infiltration into water mains).

In our study, a key empirical challenge is to identify whether a MTA reduces the likelihood of a BWA being present on a reserve. An endogeneity issue emerges if the variables *BWA* and *MTA* are determined simultaneously. In other words, if the decision to enter in to a MTA is partly a function of a BWA, then the MTA variable will be endogenous. Monfardini and Radice (2006) outline an approach to assess this endogeneity concern. The first step is to estimate both models simultaneously using a recursive bivariate probit model. This enables one to examine the correlation between the error terms of the two models, conditional on the other covariates. STATA 12.1 provides a Wald test to assess whether the correlation between the error terms is statistically significant, with the null hypothesis in this test being that the error terms are not correlated. If the error terms are found to be correlated, a bivariate probit estimation approach is needed. Alternatively, a failure to reject the null indicates that the models should be estimated independently as separate probit models. In our analysis, we fail to reject the null, indicating that the error terms in our two models are not significantly correlated. As a result, two separate probit models are used. The results of our Wald test are discussed more fully in the results section.

Data

The empirical model is applied to data gathered from 4 key sources: the 'Report on First Nation Water and Wastewater Systems', the 2006 Canadian Census, resource and industrial site data published by DMTI Spatial Inc, and Environment Canada climate data. All data included in the analysis is summarized in Table 1.

The Neegan Burnside report (2011a) provides key information on BWAs, as well as water system characteristics. First Nations with water systems were surveyed between 2009 and 2010, providing data on 804 water systems located on 691 reserves (multiple water systems are located on some reserves), in all Canadian provinces and the Yukon (the Northwest Territories and Nunavut were excluded from the study).[7] Of the 587 First Nations in Canada, 571 participated in the study (with 4 First Nations choosing not to participate, and 12 First Nations with no active infrastructure on reserve). Of the participating First Nations, 560 were serviced by water systems while the remaining 11 are serviced solely by individual wells. All active water systems in participating First Nations were surveyed[8]. Surveyors visited each water system to collect information on construction and design, day-to-day operations, and system risk, among other variables. This report identifies when water is purchased from a neighboring POPCTR through a MTA, and also identifies cases where a BWA is in effect on a reserve, providing both dependent variables used in the analysis. Approximately nineteen percent of the water systems in our data set are distributing water purchased from a neighbouring POPCTR (ie. have an existing MTA), and approximately twenty eight percent have an existing BWA. It is worth noting that of the nineteen percent of MTA participant water systems, less than three percent have an existing BWA, indicating that the vast majority of BWAs are on reserves with non-MTA (ie. independent) water systems.

Data from the 2006 census "Aboriginal Population Profiles" is used to characterize each reserve in the data set, classifying them by key socioeconomic characteristics: surface area, population, and population density (Statistics Canada 2010a). These same characteristics are used to classify POPCTRs that were paired to each reserve based on closest proximity, through the use of GIS software and census boundary files (Statistics Canada 2007a; Statistics Canada 2007b), and the 2006 census GeoSearch tool (Statistics Canada 2010b). The mean distance from a reserve to its closest neighbouring POPCTR was 64 kilometres for the overall sample, but only 33 kilometres in cases where a MTA was present. This contrast motivates our hypothesis that

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[7] See https://www.aadnc-aandc.gc.ca/eng/1313770257504/1313770328745#chp1_1 for additional detail on the Neegun Burnside sampling.

[8] A water system is broadly defined as consisting of assets funded by Indian Affairs and Northern Development Canada, serving five or more residents or public facilities (Neegan Burnside 2011b).

MTAs are less likely to emerge as the distance between reserves and POPCTRs increases, due to the significant costs associated with expanding water distribution networks across large distances. Also included in the MTA participation model is a measure of the median income in the surrounding census division, to control for the potential effect of regional economic prosperity on the likelihood of interlocal cooperation. This variable was also taken from the 2006 census.

To account for external factors influencing drinking water risk exposure, reserve proximities to the closest resource or industrial site (ex. mining areas, dumping sites, auto wreckers, oil and gas operations, etc.) are included in the BWA model. This data was obtained using GIS software, with reserve longitude and latitude coordinates and resource and industrial shapefiles published by DMTI Spatial Inc (2012). Climate variables are also included in the BWA model to account for the effect of climactic variation on a water system's exposure to risk. This data was taken from the Environment Canada weather stations in closest proximity to each reserve (Environment Canada 2014). Ten year average temperature range (with temperature range defined as the difference between annual maximum and annual minimum temperatures) is included to account for the effect of extreme temperature variation on a water system’s susceptibility to risk: i.e., through the freezing and thawing of pipes, and changes to pipe-soil interactions. Also included is a measure of ten year average total annual precipitation for each reserve, to account for the potential for pollution to enter a system through rainwater infiltration into groundwater sources or water mains.

Results

Full results of the empirical analyses are presented in Tables 2 and 3 of the Appendix. Here we present key findings from each model. Overall, our findings from both models support our empirical hypotheses. We find that reserves in closer proximity to POPCTRs are more likely to participate in MTAs, and MTA participation does reduce the likelihood of BWAs on reserves.

As discussed above, both models were first run simultaneously as a recursive bivariate probit model, in order to test for a potential endogeneity issue that may emerge due to the joint determination of our two dependent variables. This joint estimation method provided a maximum likelihood estimate of the correlation between the error terms of the two model equations, as well as a Wald test of this correlation to determine if it was significantly different from zero. Under the Wald test, the maximum likelihood estimate of the correlation is compared to the proposed value (which is zero, under the null hypothesis), with the difference assumed to be approximately normally distributed. The square of this difference between the maximum likelihood estimate and the proposed value is then compared to a chi-square distribution. Our estimated correlation was -0.56, but with a p-value of 0.38. Therefore, we failed to reject the null hypothesis that the error terms were not significantly correlated, which indicates that there is not an endogenieity issue, and joint estimation of the two models is not required. Thus both models were run as independent probit models, and those results are presented here.

Data limitations result in a decrease in the sample size of both the MTA participation model and the BWA model. In the MTA participation model, the distance variable was only available for 758 of the 804 drinking water systems. Additionally, reserve demographic data was only available for 764 water systems, and reserve area data was available for only 789 water systems. The census division median income data was only available for 714 water systems, and was not available for any water systems in the Yukon; therefore, the inclusion of this variable eliminated all water systems in the Yukon from this model. These small limitations in each of these explanatory variables compounded to a total drop in the number of observations from 804 water systems to 673.

In the BWA model, the dependent variable (indicating if a BWA was in effect at the time of the survey) was not available for any water systems in the Atlantic Provinces, eliminating them from the analysis. This reduced the sample size from 804 water systems to 769). The key limiting explanatory variable was the measure of maximum daily volume of each system, which was only available for 606 water systems. These two data limitations were largely responsible for a reduction in sample size from 804 water systems to 470 water systems in this model.

MTA Participation Model

The distance between each reserve and its closest proximal POPCTR was found to have a negative and statistically significant effect on the probability of a reserve participating in a MTA. Specifically, the marginal effect can be interpreted to indicate that a 1 kilometre increase in the distance between a reserve and proximal POPCTR decreases the probability of a MTA emerging by approximately 0.1[9]. This supports our hypothesis that reserves and POPCTRs in closer proximity will be more likely to participate in a MTA, as water distribution networks are costly to expand across large distances.

[9]See Woolridge (2002), pp. 459 for additional details on interpretation of marginal effects.

Reserve population was found to have a negative effect on the probability of MTA participation, as anticipated. This supports the hypothesis that reserves with smaller populations will be more likely to pursue MTAs, as they are unable to achieve economies of scale in drinking water treatment independently. The marginal effect indicates that a decrease in reserve population by 100 persons increases the probability of MTA participation by approximately 1%. The variable capturing reserve population density was also found to have a positive and significant effect on the probability of MTA participation, supporting the hypothesis that reserves with larger population densities will be better able to meet the costs of constructing and servicing a single drinking water distribution network from a single treatment source. The marginal effect indicates that an increase in reserve population density by 100 persons per square kilometer increases the probability of MTA participation by approximately 4%.

POPCTR population was found to have a negative and significant effect on the probability of MTA participation. This supports the hypothesis that POPCTRs with smaller populations are more likely to pursue MTAs to expand their treatment output and take advantage of economies of scale. However, the marginal effect indicates that an increase in POPCTR population by 100 persons decreases the probability of MTA participation by only 0.01%, which is not very economically significant. In contrast, POPCTR population density was also found to be significant, with a marginal effect that indicates that as POPCTR population density increases by 100 persons per square kilometre, the probability of a MTA emerging increases by approximately 1.3%. This result may reflect that POPCTRs with larger population densities are more likely to have a large centralized water distribution network in place (as opposed to independent well water service, or a very small water distribution system), and therefore are more likely to be in a position to service a neighbouring reserve.

Another interesting finding is that reserves located in Alberta and Manitoba were found to be 36% and 20% more likely to participate in MTAs, compared to reserves located in Ontario. This indicates that these provinces may have institutional characteristics that make the negotiation of MTAs less costly within their jurisdictions; or that there may be characteristics unique to First Nations in these provinces that make MTA participation more likely. For example, reserves and POPCTRs located in certain areas of the province of Alberta may face higher costs of drinking water treatment due to exposure to oilsands activities, which may encourage MTAs.

BWA Model

Participation in a MTA was found to have a negative and statistically significant effect on the probability of a BWA being present on a reserve. The estimated marginal effect was fairly large, at -0.1448, at a 5% significance level. This can be interpreted to indicate that reserves distributing water treated in a neighbouring POPCTR are 14.5% less likely to be under a BWA than reserves distributing water treated on-reserve, at an independent treatment facility drawing from a surface water source. This supports the hypothesis that reserves distributing water treated in a neighbouring POPCTR are less likely to be under a BWA.

Additional results for control variables in this model shed light on other factors affecting drinking water risk, namely source water, system scale, and temperature variation. The dummy variable indicating when a reserve is serviced by an independent water system drawing from a groundwater source was found to have a negative and statistically significant effect on the likelihood of a reserve being under a BWA. The marginal effect indicates that reserves with independent systems serviced by groundwater are approximately 8% less likely to have a BWA in effect than reserves with independent systems drawing from surface water. This likely reflects the fact that reserves drawing from groundwater sources face less exposure to drinking water risk than those drawing from surface water sources or GUDI sources, as groundwater sources are not as susceptible to pollution (ie. from rainfall runoff, or other forms of point and non-point source pollution).

The variable capturing the maximum daily volume of each water system (in hundreds of cubic metres per day) was found to have a negative and significant effect on the probability of a BWA being present on a reserve. This finding indicates that water systems treating larger volumes of water are less prone to quality concerns. This may reflect the fact that larger water systems are more efficient, being able to take advantage of economies of scale in treatment, and are therefore less likely to have water quality issues. The marginal effect indicates that an increase in maximum daily volume by 100 cubic metres per day decreases the likelihood of a BWA by approximately 1%.

The variable capturing ten-year average temperature range was found to have a positive and statistically significant effect on the probability of a BWA being in effect on a reserve. The marginal effect can be interpreted to indicate that a 10°C change in ten-year average temperature range increases the likelihood of a BWA being in effect on a reserve by approximately 9%. This likely reflects the effect of high temperature variance on a drinking water system's exposure to risk, through damages caused by the freezing and thawing of pipes and changes to pipe soil interactions that can heighten the potential for pollution to infiltrated water mains.

Sensitivity

As a sensitivity analysis, two additional variables describing water system characteristics in each POPCTR were included in the MTA participation model: the number of treatment plants, and groundwater reliance (measured as the percentage of the POPCTR population serviced from a groundwater source). This data was obtained from the Water Pricing and Usage Reports published by Environment Canada for 2009 (Environment Canada 2013b). These variables were included only as a sensitivity due to their limited availability; data on the number of treatment plants was only available for 431 water systems, and data on groundwater reliance was only available for 607 water systems. These additional variables were not found to be significant, and key findings remain consistent with their inclusion. This was in spite of a large reduction in sample size, from 673 observations to only 372. One notable change is that the variables capturing the surface areas of both the reserve and the POPCTR became significant with positive marginal effects, and the variable capturing the population density of the POPCTR lost its significance. Also, the marginal effect of the distance variable was reduced (from 0.10 to 0.06). It is not possible to determine if these changes were due to the inclusion of these additional variables, or simple the result of the significant reduction in observations.

Additionally, a First Nation Band education variable (the percentage of the Band population over 15 years of age without a highschool diploma) was included as a sensitivity in both the MTA participation model and the BWA model. This variable was calculated using band population data from the AANDC report "Registered Indian Population by Sex and Residence" (AANDC 2007), and education data taken from individual 2006 Aboriginal population profiles for each Band included in the data set (Statistics Canada 2010a). As with the additional POPCTR water system characteristics, this variable was only included as a sensitivity in both models due to data limitations (it was only available for 413 water systems in the data set) that resulted in significant reductions in sample size. With its inclusion, the MTA participation model fell from 673 observations to 369 observations, and the BWA model fell from 470 observations to 263 observations. This additional variable was not found to be significant in either model. In the MTA participation model, the changes resulting from the inclusion of this variable were very similar to the changes that resulted from the inclusion of the additional POPCTR water system characteristics; and it was also impossible to discern if these changes were due to the inclusion of the education variable, or the reduction in sample size. With the inclusion of the education variable in the BWA model, only the MTA participation variable remained statistically significant (and with a slight increase in the marginal effect). We are therefore confident that this finding is robust. And as with the MTA participation model, it is unclear whether the loss in significance of the other estimates was due to the inclusion of the variable itself, or the significant sample size reduction.

Discussion

While MTAs have been gaining popularity in recent years, the study of service provision contracts between reserves and POPCTRs is largely non-existent to date. This study contributes to a growing economic literature on inter-local cooperation for service provision. This research is novel, in that it investigates a context in which these service contracts are emerging between two very different local governments within different jurisdictions. Much of the literature on inter-local service provision contracts stresses the importance of homogeneity between contracting communities, as a factor in reducing the transaction costs of negotiation (Feiock 2007; Shrestha 2005). The fact that MTAs continue to emerge between First Nations and POPCTRs that are very political and culturally heterogeneous appears to be strong evidence of mutual gains.

The results of this study highlight some key factors influencing the emergence of MTAs. First, reserves in closer proximity to POPCTRs are much more likely to participate in MTAs. Due to the significant costs associated with transporting water across large distances, MTAs are not feasible if reserves are geographically isolated. Also, reserves with smaller populations and larger population densities are more likely to participate in MTAs. This is likely because reserves with smaller populations cannot take advantage of economies of scale in drinking water treatment due to an insufficient level of demand, and pursue MTAs to avoid the high capital costs associated with water treatment facility construction and (or) maintenance. And reserves with larger population densities face lower per capita costs associated with having a large centralized water distribution network from a single source in a neighbouring POPCTR, and are therefore more likely to pursue MTAs.

Our findings also indicate that POPCTRs with large population densities are more likely to pursue MTAs. This likely reflects the fact that POPCTRs with larger population densities will be more likely to have a large centralized drinking water distribution network in place (as opposed to having all or the majority of their community population serviced by independent wells, or a small distribution network for a small portion of their service area), that can potentially be expanded to service a neighbouring reserve.

Provincial jurisdiction also appears to play a role in motivating MTA emergence, as our findings indicate that MTAs are more likely to emerge in the Provinces of Alberta and Manitoba, compared to the province of Ontario. This may reflect institutional characteristics of these provincial jurisdictions that make the negotiation of MTAs less costly, or characteristics of reserves or POCPTRs unique to these Provinces that make MTAs more likely to emerge. For example, as Figure 1 demonstrates, many of the MTAs in Alberta are located around oilsands activities; and exposure to those types of environmental pollution may make MTAs more likely to emerge as a means for neighbouring communities to share on water treatment costs.

Our results also illuminate the potential role of MTAs for improving water quality on reserves. We find that participation in a MTA does have a statistically significant effect on reducing the likelihood of a BWA being in effect on a reserve. This finding lends support to the promotion of MTAs as one potential solution to drinking water provision challenges, and drinking water safety concerns on reserves. AANDC's current position on MTAs is that they should be encouraged in situations where they are the least cost alternative to independent service provision. AANDC provides funding support to Bands with MTAs in these cases (AANDC 2011; INAC 2009), and also provides funding to the FCM's First Nation—Municipal Infrastructure Partnership Program, which seeks to encourage these agreements by providing resources to potential partners that help to reduce transaction costs (FCM 2013).

To date, there are many reserves that lie within a feasible distance to a potential MTA partner, that do not have an existing MTA agreement. Of the 654 independent water systems in our data set, 307 are located on reserves that are within 32.59 kilometres of a neighbouring POPCTR, which is the mean distance between reserves and POPCTRs for the subset of reserves participating in MTAs[10]. In Ontario alone (which contains only 12 reserves with MTAs) 48 reserves fall within a suitable geographic distance of a potential MTA partner, but do not have an

[10]This distance is significantly greater than the distance that the FCM considers to be feasible for MTAs (5 kilometres). However, this mean distance includes trucked distribution in addition to piped distribution, and trucked distribution is feasible across larger distances. The number of water systems on non-MTA participating reserves that fall with the FCMs 'feasible' distance for a piped water MTA is only 34.

existing agreement[11]. Figure 3 of the Appendix shows the locations of these reserves, as well as the locations of all reserves in Ontario with existing MTAs. Some of these potential partnerships may have failed to arise due to constraints faced by the POPCTR (such as already strained water service infrastructure, or finite drinking water sources), or a hesitance on the part of a First Nation Band to relinquish control over an essential service to an outside party. However, in many of these cases, prohibitively high transaction costs may be preventing a mutually beneficial MTA from emerging. These costs can arise due to low social capital between the communities, high costs of negotiating across jurisdictions, and difference in political preferences between communities and among community leaders.

There is a large untapped potential in the area of inter-local cooperation between First Nations and neighbouring POPCTRs. This is true not only for drinking water provision, but for other areas of community service provision as well. Our findings provide evidence to suggest that there may be significant welfare gains associated with increasing funding to initiatives that help to encourage this inter-local cooperation between First Nations and POPCTRs, and aid in reducing the costs associated with facilitating this cooperation. However, in many small and remote First Nation communities MTAs are simply not a feasible method of drinking water service provision. This is due to the unavailability of a potential MTA partners, or population densities that are so low that piped or trucked water distribution systems are not feasible. There is a need to investigate alternative methods of improving drinking water provision and drinking water safety in these communities. Research investigating the feasibility of drinking water treatment and storage technology that can be used at the household level on these reserves is an important next step. The Centre for Affordable Water and Sanitation Technology, for example, provides a variety of resources and training on household water treatment and storage in developing countries (CAWST 2011). There is a need for an assessment of the feasibility of the use of these types of technologies, and others, on the smallest and most remote reserves.

Conclusion

This study aimed to identify factors influencing the emergence of MTAs between reserves and their neighbouring POPCTRs, and to determine if these MTAs have a significant effect on reducing the probability of BWAs being present on reserves. Specifically, we evaluated the

[11]Determined by taking the maximum distance between a reserve and POPCT in a case where a MTA was in place (13 kilometres).

effect of the surface area, population, and population density of reserves and their neighbouring POPCTRs, and their geographic proximities, on the probability of the emergence of a MTA. We then evaluated the effect of MTAs on the probability of a BWA being in effect on a reserve, while controlling for other factors that may affect a drinking water system's exposure to risk. Our results indicate that when reserves and POPCTRs are in closer proximity to each other, a MTA is more likely to emerge. Our results also indicate that reserves with smaller populations and larger population densities are more likely to participate in MTAs; and that POPCTRs with larger population densities are more likely to participate in MTAs. MTAs are also more likely to emerge in the Provinces of Alberta and Manitoba, compared to the province of Ontario. Controlling for other factors influencing drinking water risk, we find that MTAs significantly reduce the probability of a BWA being in effect on a reserve.

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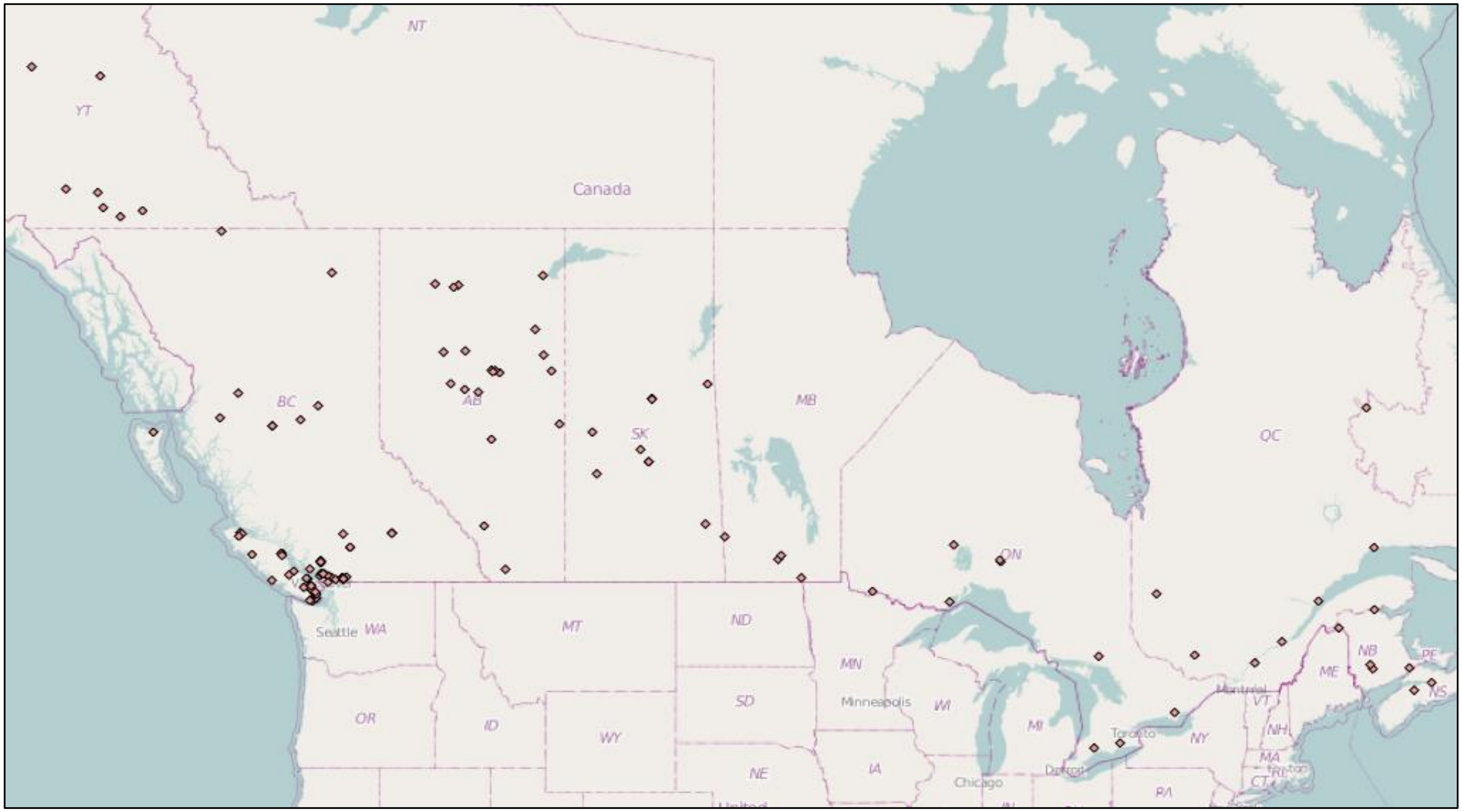
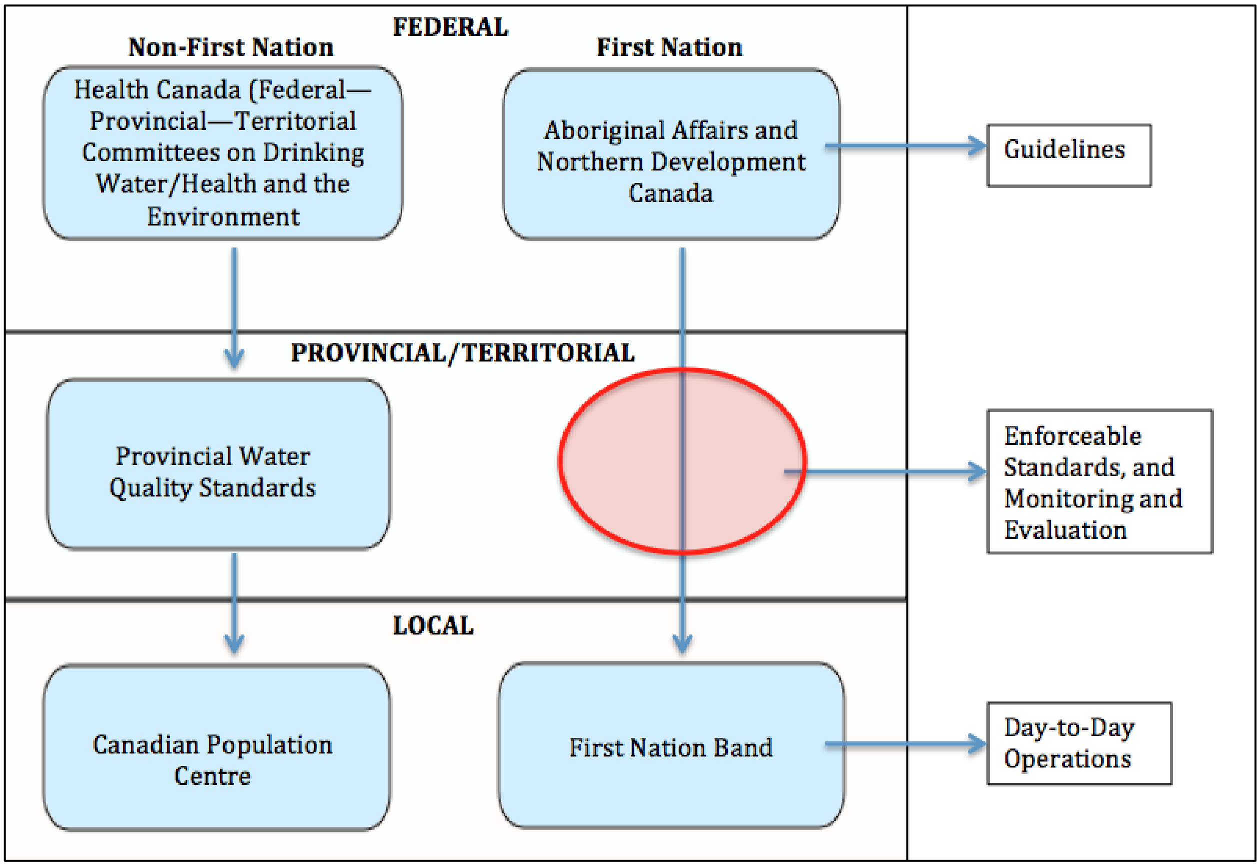
Figure 1: Locations of MTA-Participant Reserve Water Systems



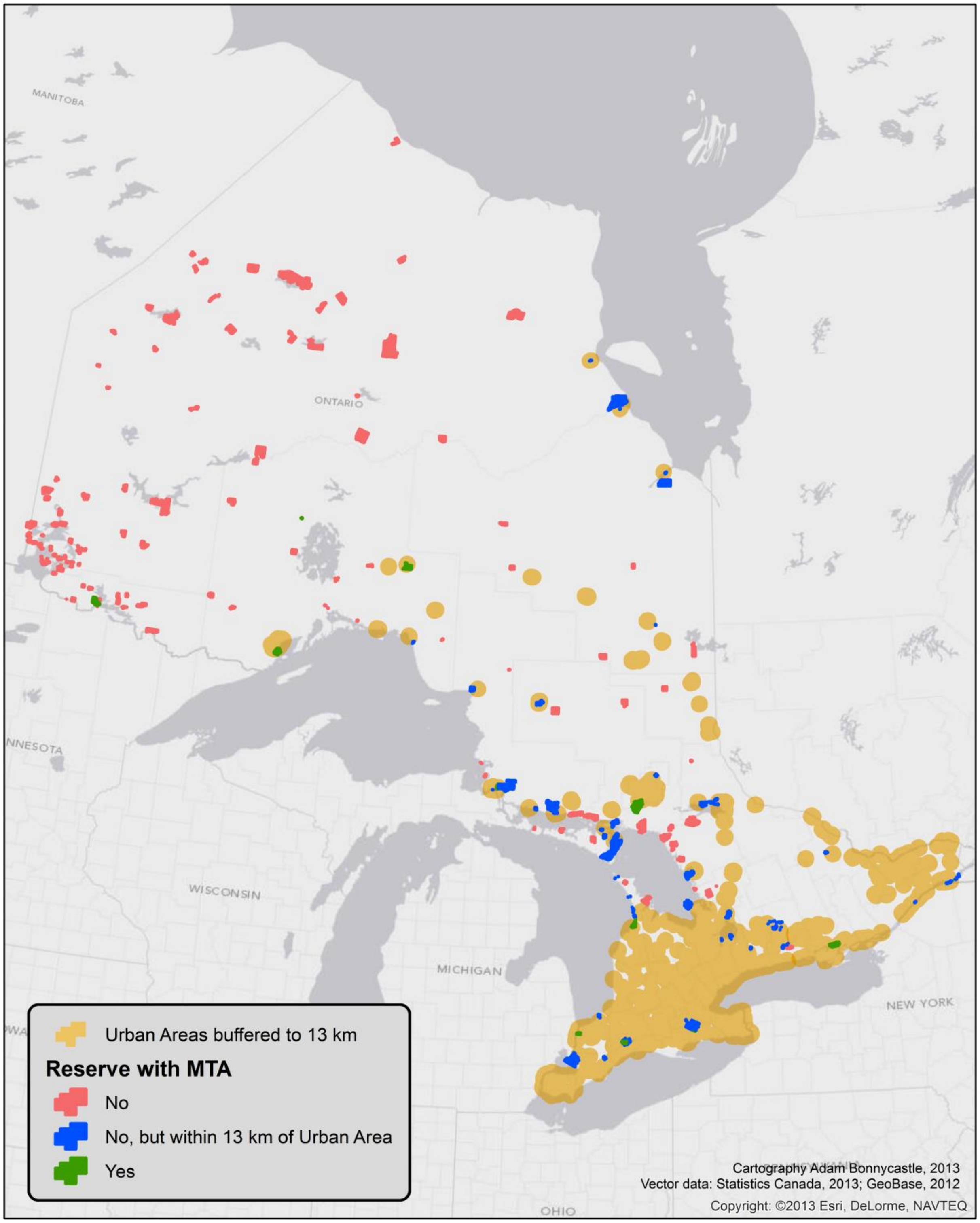
Source: Figure produced by the authors. Water systems were identified in Neegan and Burnside (2011), and plotted by longitude and latitude coordinates using Cartographica (GIS software).

Figure 2: Governance of Drinking Water Safety in First Nation and non-First Nation Communities in Canada



Source: Author.

Figure 3: First Nation Reserves in Ontario (MTA Participants and Non-Participants) and Their Proximities to Urban Areas



Source: Author and data references contained in figure.

Table 1: Summary Statistics for Variables Included in Empirical Analysis

Variable	Obs	Mean	Std. Dev.	Minimum	Maximum
Dependent Variables					
MTA Participation	804	0.1866	0.3898	0	1
BWA in Effect	769	0.2809	0.4497	0	1
Explanatory Variables					
Natural Log of Distance From Reserve to Closest Proximal Population Centre	758	3.2766	1.338	-1.971314	6.181
Reserve Area (100s of kms)	789	0.5199	1.296	0.0002	14.139
Reserve Population (100s)	764	5.676	7.325	0.05	51.71
Reserve Population Density (100s of persons/km^2)	764	1.0398	2.6770	0.001	33.589
POPCTR Area (100s km^2)	763	1.0054	2.7435	0.005	12.066
POPCTR Population (100s)	763	1344.92	4421.81	10.09	19532.52
POPCTR Population Density (100s of persons/km^2)	763	6.3062	3.9413	1.0117	22.16
Median Income in Surrounding Census Division	714	23020.37	4358.671	9822	42806
Reserve Independent Water System – Groundwater Source (Dummy)	804	0.4664	0.4992	0	1
Reserve Independent Water System – Groundwater Source Under the Direct Influence of Surface Water (Dummy)	804	0.0560	0.2300	0	1
Percentage of Reserve Households Supplied By Piped Water (100s)	801	86.836	28.754	0	100
Percentage of Reserve Households Supplied By Trucked Water (100s)	801	11.666	26.722	0	100
Maximum Daily Volume of Water System Servicing Reserve (100s of metres cubed per day)	606	4.7793	13.1379	0.005	250
Age of Water System Servicing Reserve	756	19.0992	10.735	1	82
Natural Log of Distance To Closest Resource or Industrial Site (m)	779	5.9234	1.6851	0.2465	9.3468
Ten Year Average Temperature Range (10s of Degrees Celsius)	707	4.014	0.9464	1.415	5.414

Ten Year Average Annual Total Precipitation (10s of centimetres)	706	7.209	4.3218	2.0268	32.971
Yukon Territory (Dummy	804	0.0210	0.1703	0	1
British Columbia (Dummy)	804	0.3607	0.4805	0	1
Alberta (Dummy)	804	0.1020	0.3028	0	1
Saskatchewan (Dummy)	804	0.1281	0.3344	0	1
Manitoba (Dummy)	804	0.0920	0.2893	0	1
Quebec (Dummy)	804	0.0485	0.2150	0	1
Atlantic Canada (Dummy)	804	0.0435	0.2042	0	1
Variables Included in Sensitivity Analysis					
Municipal Water System Characteristics					
Percentage of Total Municipal Water Sources Coming From Groundwater	431	32.128	43.5210	0	100
Number of Water Treatment Plants	607	1.132	1.2424	0	9
Education					
Percentage of First Nation Band Population Without a Highschool Diploma	413	59.687	15.8274	23.2558	97.826

Table 2: Probit Results – MTA Participation Model

Log pseudolikelihood = -229.358 **Pseudo R^2 = 0.2900** **N = 673**	Marginal Effect (dF/dx)	Robust Std. Error	Z	P>|z|	x-bar	95% Confidence Interval	
Natural Log of Distance Between Reserve and POPCTR (kilometres)	-0.0923	0.0130	-6.38	0.000***	3.2307	-0.1178	-0.0668
Reserve Population (100s)	-0.0109	0.0033	-3.23	0.001***	5.3951	-0.0174	-0.0044
Reserve Area (100s of kilometres)	0.0206	0.0195	1.05	0.292	0.4902	-0.0175	0.0587
Reserve Population Density (100s of persons/km^2)	0.0382	0.0090	4.63	0.000***	1.0907	0.0206	0.0559
POPCTR Population (100s)	-0.0001	0.0000	-1.81	0.070*	1466.91	-0.0001	4.9e-06
POPCTR Area (100s of kilometres)	0.0776	0.0521	1.49	0.135	1.0749	-0.0246	0.1797
POPCTR Population Density (100s of persons/km^2)	0.0129	0.0047	2.76	0.006***	6.3948	0.0037	0.0221
Census Division Median Income	6.07e-06	4.16e-06	1.44	0.151	22913	-2.1e-06	0.0000
Reserve Located in British Columbia	0.0155	0.0453	0.34	0.730	0.3982	-0.0732	0.1043
Reserve Located in Alberta	0.3605	0.0971	4.38	0.000***	0.0996	0.1702	0.5507
Reserve Located in Saskatchewan	0.0435	0.0698	0.67	0.503	0.1426	-0.0933	0.1802
Reserve Located in Manitoba	0.2019	0.1230	1.97	0.049**	0.0832	-0.0392	0.4429
Reserve Located in Quebec	0.0298	0.0910	0.32	0.751	0.0446	-0.1661	0.2257
Reserves Located in Atlantic Canada	-0.0482	0.0638	-0.65	0.518	0.0431	-0.1732	0.0769
Obs. P	0.1857						
Pred. P	0.1280	(at x-bar)					

Wald $chi^2(14)$ = 94.21
Prob > chi^2 = 0.0000

Z and P>|z| correspond to the test of the underlying coefficient being 0.
Statistical significance at the 1% (***), 5% (**), and 10% (*) levels.

Table 3: Probit Estimation Results – BWA Model

Log pseudolikelihood = -266.678 **Pseudo R^2 = 0.0538** **N = 470**	Marginal Effect (dF/dx)	Robust Std. Error	Z	P>|z|	x-bar	95% Confidence Interval	
MTA Participation	-0.1448	0.0592	-2.04	0.042**	0.1213	-0.2608	-0.0289
Reserve Independent Water System – Groundwater Source (Dummy)	-0.0803	0.0472	-1.68	0.093*	0.4617	-0.1727	0.0122
Reserve Independent Water System – Groundwater Source Under the Direct Influence of Surface Water (Dummy)	0.0627	0.0942	0.69	0.488	0.0638	-0.1218	0.2473
Percentage of Reserve Households Supplied by Piped Water (100s)	-0.0003	0.0019	-0.15	0.878	86.116	-0.0041	0.0035
Percentage of Reserve Households Supplied By Trucked Water (100s)	-0.0022	0.0021	-1.08	0.281	12.820	-0.0063	0.0018
Maximum Daily Volume of Water System (100s of cubic metres per day)	-0.0100	0.0052	-1.87	0.062*	5.0048	-0.0203	0.0002
Age of Water System Servicing Reserve (years)	0.0023	0.0023	0.98	0.325	17.981	-0.0023	0.0068
Natural Log of Distance To Closest Resource or Industrial Site (metres)	0.0124	0.0177	0.70	0.485	6.138	-0.0223	0.0471
10 Year Average Temperature Range (10s of degrees Celsius)	0.0882	0.0332	2.63	0.008***	4.157	0.0232	0.1533
10 Year Average Annual Total Precipitation (100s of milliliters)	0.0012	0.0068	0.17	0.864	6.884	-0.0122	0.0145
Obs. P	0.2872						
Pred. P	0.2660	(at x-bar)					

Wald $chi^2(10)$ = 24.85
Prob > chi^2 = 0.0056

Z and P>|z| correspond to the test of the underlying coefficient being 0.
Statistical significance at the 1% (***), 5% (**), and 10% (*) levels.