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Connecting Our Communities: the Comparative Costs of Highway Construction

By Winter Lipscombe

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About the Author

Winter Lipscombe

Winter Lipscombe was born and raised in the community of Kenora, ON and was a past *Experience North* summer placement at Northern Policy Institute. She is in her final year at Mount Allison University, working towards an Honours Bachelor of Arts in International Relations with double minors in Economics and Political Science.

Winter has had experience working as a research assistant considering the impact of borders in a globalized world. Her past experiences have also included work with several First Nation organizations.

While she enjoys learning about nations abroad, she looks forward to researching the implications of policies closer to home and their unique implications on the North.

This research paper was prepared as part of Winter's summer 2017 placement with Northern Policy Institute. We are pleased to provide an opportunity for our new generation of thinkers to express their views to a public audience.

Disclaimer

The author's judgement was used to categorize highway projects and determine average costs of selected categories.

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Executive Summary

Minimal literature outlining the costs of building and maintaining highways in Canada exists, especially when examining the costs of highway infrastructure on a regional level. The most recent study examining the costs of building, maintenance, and rehabilitation of highways in Ontario was conducted by the Ontario Ministry of Transportation in 2011 with the Parametric Estimating Guide 2011. This report seeks to fill in gaps that the current literature leaves, through a comparison of maintenance costs for all five of Ontario's regions (Northwestern, Northeastern, Southern, Central, and Western), as well as the southern and northern regions of Manitoba.

With data provided through the Ontario Ministry of Transportation's (MTO) Registrations, Appraisal, and Qualifications (RAQs) database and the Manitoba Infrastructure and Transportation 2016 Archived Bid Database, we can take the total project cost and determine the average cost of a highway, per kilometre, in each region. The methodology used in this report is based off the model used by the Parametric Estimating Guide 2011, which uses the lowest three bids on a contract to determine the average cost – this approach reduces the impact of unusually low bids skewing results. The two variables analyzed in this report include the length of a project, and the remoteness of the project (distance to a population centre), as both variables are quantifiable with data provided by the MTO and Manitoba Infrastructure and Transportation.

Calculations determined that the average cost of highway per kilometre is higher in the northern regions of Manitoba and Ontario, while also concluding that the length of a project had a greater impact on cost than the remoteness of a project. In fact, remoteness of a project had minimal impact on the average cost. Overall, costs are influenced by a variety of factors, including: traffic flow, the number of other projects in the region, location of materials, and others. Each variable's impact changes across each project, meaning there is no set formula when determining the average cost of highway per kilometre.

While the average costs per kilometre are higher in each province's northern regions, we must not overlook the value in having sound transportation infrastructure. The highways that stretch across Ontario's northern regions provide significant economic impact – ensuring that the highways continue to meet their full economic and safety potential, Ontario must continue to invest in Ontario's northern transportation infrastructure.

Introduction

Have you ever driven down a highway riddled with potholes and wondered how it got to this state or why it has not been fixed? The short answer to these questions is the high price tag attached to building and maintaining highways. This commentary will explore this issue further, determining the per-kilometre construction costs of highways across the northern and southern regions of Manitoba and Ontario. It should be noted, however, there are several variables that influence construction costs, and the weight of these variables varies by region. Thus, there will be a focus on two variables in particular: the distance of a project from a population centre (remoteness) and the length of a project (kilometres).

Background

Aside from the Ministry of Energy, Northern Development and Mines' (MENDM) Northern Highways Programs and the Ministry of Transportation's (MTO) Southern Highways Programs, minimal research exists on the costs of Ontario's highways. Although the highways programs are important tools for understanding current and future investments in highway infrastructure, they fail to address the unique regional factors that can influence the cost of such projects. Furthermore, the highways programs illustrate the disproportionate investment in infrastructure across Ontario's southern and northern regions. The most recent undertaking analyzing the costs of highway construction, rehabilitation, and other projects was the MTO's Parametric Estimating Guide in 2011 (there was also an earlier version in 2007). Additionally, minimal literature exists regarding Manitoba's highway infrastructure. Most of it is contained in the Manitoba Infrastructure and Transportation's contract and tender section. This lack of information provides an opportunity to develop an increased understanding and awareness of the costs of highway construction, as well as the implications of the two variables (remoteness and length) that are the focus of this commentary.

The MTO and MENDM's Northern Ontario Multimodal Transportation Strategy (NOMTS) is an important step forward in understanding the transportation challenges that Ontario's northern regions face. As outlined in NOMTS (2016), Northern Ontario's highways provide a vital economic link to the rest of the country, yet there are serious issues that need to be resolved, specifically single-lane highways that offer minimal options for passing. As transportation flows continue to increase, Northern Ontario requires proper infrastructure to handle traffic efficiently and safely. A key step in implementing this infrastructure is to understand the associated development costs.

The MENDM's and MTO's Northern and Southern Highways Program 2016-2020 outlines the province's projected four-year goals. There are a number of projects underway and the MTO notes that each project is subject to change pending "funding, planning, design, environmental approval, property acquisition, and construction requirements" (MTO 2016, 2). As part of the program, Ontario is planning to invest $541 million on repairs and expansions of northern provincial highways and structures throughout 2016-17 (MENDM 2016, 2). Additionally, Ontario and the MENDM (2016) are planning to complete 71 lane kilometres of new highway and 551 centreline[1] kilometres of rehabilitated highway in the northern region. In Southern Ontario, the province will be investing $1.6 billion in repairs and expansions during 2016-17, totalling 330 lane kilometres of new highway and 346 centreline kilometres of rehabilitated highway (MTO 2016, 2). In order to better understand the MENDM's Northern Highways Program and MTO's Southern Highways Program, a breakdown of the various projects taking place in the northeast, northwest, central, and eastern parts of the province follows.

For Northeastern Ontario, the MENDM's (2016) highway program includes 11 four-lane widening projects on Highway 69 and one reconstruction on Highway 7182. Currently, five are underway with completion targets before or by 2020 and seven are in the planning phase with completion targets beyond 2020 (MENDM 2016, 7-9). Northwestern Ontario has eight four-lane widening projects, three of which are currently underway with five still in the planning phase (MENDM 2016, 10-13). All projects in the MENDM's (2016) highways program for Northwestern Ontario are on Highways 11/17 with target completions ranging from 2017 to beyond 2020.

Comparatively, Central Ontario has 28 projects, 10 of which are under way with 18 planned (MTO 2016, 10-15). The 10 projects under way are focused on lane widening, high-occupancy vehicle (HOV) lane expansions, and interchange improvements, with target completions from 2016 to beyond 2020 (MTO 2016, 10-15). Of the 18 planned projects, six to 10 focus on lane widening and HOV expansion, with target completions ranging from 2018 to beyond 2020 for all projects.

Eastern Ontario has seven projects – three are underway and four are planned – all with target completions ranging from 2016 to 2022 (MTO 2016, 16-18). Of these MTO (2016) highways program projects, five involve the addition of noise barriers and widening from six to eight-lanes along Highway 417 (p.16-18). By comparison, Western Ontario has the most projects out of the entire province with 34 – half of which are underway (MTO 2016, 19). All have target completions for 2019. The majority of the Western Ontario projects involve bridges, bridge improvements, culverts, and culvert rehabilitation (MTO 2016, 19).

As mentioned previously, the MTO and MENDM have developed the NOMTS alongside the Southern and Northern Ontario Highways Programs 2016-20. The NOMTS focuses on transportation infrastructure in Northern Ontario, including roads, winter roads, rail, airway, and waterways. It is particularly important as traffic flows are projected to increase over the next 25 years, necessitating the creation of new infrastructure by the province (MTO and MENDM 2017, 5). Additional reasons for further building include projected population increases in some Northern Ontario districts, namely Kenora, and if Northern

[1] Both centreline and lane kilometres are used to describe the length of a roadway. A centreline kilometre is the length of one kilometre of road, regardless of the number of traffic lanes. A lane kilometre is the number of lanes in one centreline kilometre of road. For example, for a road that is two lanes wide, there are two lane kilometres in one kilometre of road (Ministry of Transportation Contract Management: Estimating Office 2011, viii).

Ontario is able to successfully attract and retain the newcomers it needs (Cuddy and Moazzami 2017, 13, 15). In the following sections, the author will address key points from the NOMTS that are relevant to this commentary.

Section 1.4 of the Draft 2041 NOMTS outlines the four-lane widening or twinning of the Trans-Canada Highway, which is the creation of a parallel road, usually on an existing highway, to increase traffic capacity. To provide some background, highways 11 and 17 make up a significant portion of the Trans-Canada Highway, enabling transport of goods with an estimated value of $1.24 billion in 2012 (MTO and MENDM 2017, 21). These highways are mainly two lanes wide, which raises concerns that there could be road closures resulting from inclement weather or collisions. The NOMTS points to four areas where closures can be costly and risky:

1. Highway 11/17: Thunder Bay to Nipigon (103 KM)
2. Highway 11/17: Sistonens to Shabaqua (21 KM)
3. Highway 11/17: 2 kilometres past Highway 71 west (4 KM)
4. Highway 17: Manitoba border to Kenora (39 KM)

Portions of highway twinning are underway on the stretch from Thunder Bay to Nipigon, one of the areas identified in the NOMTS as having no alternative route in event of a closure (MENDM 2016, 5). In tandem with the NOMTS document addressing the issue of highway closures, the Northern Ontario Highways Program 2016-2020 also recognizes the risks involved in the above-mentioned areas. The Program includes plans for four-lane widening projects, including the stretch from the Manitoba border to Kenora, and it has launched studies of three of the four highways listed above (MENDM 2016, 5). Both the NOMTS and Northern Ontario Highways Program 2016-2020 collectively prioritize twinning to handle increasing traffic on these highways, thus demonstrating the importance of this undertaking.

Section 1.5 of the NOMTS notes that commercial traffic on highways in Northern Ontario, especially on highways west of Thunder Bay, will drive much of the forecasted traffic volume growth over the next 25 years (MTO and MENDM 2017, 22). The NOMTS (2017, 22) also notes that this poses difficulties for passenger vehicles following commercial trucks given that there are minimal passing lane opportunities, which necessitates increases in highway capacities. Overall, the focus of the NOMTS is areas of improvement, how to increase capacity, and the need to streamline transportation to meet the requirements of commercial and passenger use.

Given the number of current and planned projects, it is important to understand the costs and factors that go into constructing these highways.

Methodology

A methodology was created to better understand the financial implications of completing the projects highlighted in the NOMTS and Northern Highways Program Project.[2] As well, Manitoba was chosen as a comparator because the province is facing similar issues regarding population dispersion. As demonstrated in Appendices A and C, Northern Manitoba represents a large portion of the province's land, yet most of Manitoba's population is concentrated in the province's southern region. The northern region faces remoteness-related challenges as many communities are located up to thousands of kilometres away from large population centres.

The figures used in the analysis are based on information provided through the MTO's Registry, Appraisal, and Qualification System (RAQS) five-year contract tender history, as well as the Manitoba Infrastructure and Transportation's contract services bid results. The report uses 2016 contracts (in 2016 dollars) to determine cumulative average costs and cost ranges. It is important to note that the construction costs in this commentary only include work relating directly to highway improvements, including factors such as labour, equipment, and materials, thus following a similar approach to the Parametric Estimating Guide 2007 and the Parametric Estimating Guide 2011 created by the MTO.[3] The guides state that costs are comprised of:

"all grading costs, from major reconstruction to surface treatment, including geometric revisions, minor culverts and all associated minor items. Construction costs are considered to be the total of all contract items related to the improvement unless otherwise stated, but do not include any right-of way-costs associated with property acquisition - including purchasing, legal fees, costs of moving or altering utilities, or building removal unless part of the construction contract" (MTO 2007 and 2011, v-vi).

Determining Variables

Each project has unique requirements and circumstances that include new construction or rehabilitation of existing highways, the number of lanes (anywhere from two to ten), the number and types of structures, blasting/grading, property acquisitions, access or distance to aggregate sources, and the design and engineering. Thus, the MENDM or MTO do not have a set formula for estimating the cost of a highway. Indeed, there are many different variables to consider when determining the cost of highway construction. For example, larger projects, despite higher price tags, are often better priced per kilometre due to mobilization costs. The terrain of a region is also a factor because rock cuts, sensitive clays, and train or water crossings increase costs. Finally, distance from the construction sites may increase costs due to added transportation.

The following is a list of variables that would influence the cost of a highway based on information from MENDM and MTO, as well as from the Parametric Estimating Guides of 2007 and 2011:

- Location of the job, remoteness
- Distance from construction materials
- Cost of labour, availability of labour
- Cost of materials, cost of inflation, cost of fuel
- Length of project (total distance of the contract in kilometres)
- Number of other projects in the region, projects that carry over
- Specialty projects
- Areas with heavy traffic, traffic control, detours
- Terrain, environmental mitigation
- Completion time

This analysis will focus on examining two different variables: the remoteness of a project, which is defined as distance from a population centre, and the length of a project (distance of the contract in kilometres). The primary reason for choosing these variables is that both are quantifiable, with data collection and measurement that is less subjective. Variables that are

[2] All related data tables are rounded to the nearest thousand.
[3] Parametric estimating guide (2007) and (2011) can be found on the Ministry of Transportation Research Library online catalogue.

excluded from this report's analysis include, but are not limited to, terrain and environment, costs of fuel, and distances from inputs such as gravel pits. These exclusions are due to the subjective nature of data or the difficulty in obtaining the data required for concrete analysis. Averages and cost ranges are used to show cost per kilometre. Cost ranges will account for variations in cost across regions based on the above list of variables.

Determining Construction Costs

Construction costs in this report are based on resurfacing and grading of existing highways (which are considered road rehabilitation work under the Parametric Estimating Guides of 2007 and 2011) because comparable data pertaining to new highway construction and lane-widening projects in Manitoba and Ontario were lacking. As such, the total costs in this report for Ontario include grading, hot mix paving, drainage, and granular which are standard components to this type of project. Due to limitations in Ontario data, the costs of resurfacing and grading also include electrical work and structural rehabilitation (where multiple structures, Advanced Traffic Systems (ATMS), and illumination were present, the contract was omitted from the data to prevent artificial inflation of costs). The MTO's RAQS database does not provide a detailed unit breakdown, thus it was not possible to separate structural rehabilitation and electrical work from the contract. However, the average cost of a structure was taken by region and subtracted off the total project cost. This was done by averaging the total cost of all structure projects in the region that acted as a baseline cost for the region. When comparing project costs for a similar process in Manitoba, they include bituminous pavement, grading, aggregate, and base. No electrical or structural work is included in the average. The materials and process for Manitoba's highway projects are comparable to a process in Ontario and are in line with the materials and process outlined in the Parametric Estimating Guides of 2007 and 2011.

In order to calculate construction costs, an estimation method was used. As only contract bid data is available in Ontario, the calculations are based on projected costs of the bid and not the final project cost. For this reason, the three lowest bids are averaged to account for any anomalies in one company's projected cost and to provide the most reflective picture of costs associated with the project. Calculations based on the average of the three lowest bids has been a standard by the MTO when creating Parametric Estimating Guides. The following formula was used to determine average cost per kilometre:

$$\text{AvgCost (P)} = \frac{[(A+B+C)/\ 3]}{\text{Length of Project (KM)}}$$

The variables 'A', 'B', and 'C' represent the three lowest bids placed on a tender. In instances where there are fewer than three bids, only 'A' or 'A+B' will be used. AvgCost (P) represents the estimated average cost of the project per kilometre.

To calculate the total estimated dollar cost of all projects, the average cost of each project was multiplied by the total kilometre length of each project, and then combined:

Total Estimated Costs = Avg Cost (P1) * length (P1) + Avg Cost (P2) * length (P2) + AvgCost (P3) * Length (P3) + … Avg Cost (Pn) * Length (Pn)

Where AvgCost(P1), (P2), and (P3) represent the average costs of projects 1, 2, and 3, and length(P1), (P2) and (P3) represent the total length of those projects, in kilometres.

To calculate the total average cost per kilometre of all projects, a third formula was used:

$$\frac{\text{Total estimated costs}}{\text{Total KM length of all projects}}$$

The above calculation outlines the average cost to construct one centreline kilometre of highway in a specified region. The lowest average cost and the highest average cost of an individual contract awarded represent the cost range of constructing one kilometre of highway in a specified region. The same formula was used to calculate the provincial per kilometre average of Manitoba and Ontario to account for differences in the number of contracts in each region in the province.

Remoteness and Population Centres

The regions used for this project include Northern and Southern Manitoba, and Northwestern, Northeastern, Western, Eastern, and Central Ontario. Regions were classified according to the MTO and Manitoba Infrastructure and Transportation's existing boundary classifications. A map outlining the breakdown of Manitoba's regions can be found in Appendix A and a breakdown map for Ontario can be found in Appendix B. Population centres[4] were selected based on Statistics Canada Population Centres 2016 census data.[5]

For this report, population centres below 7,500, as per 2016 census data, have been excluded with one exception: Flin Flon, MB. Due to Flin Flon's geographical remoteness and mining industry, it acts as a regional hub (City of Flin Flon, N.D.). Population centres were used in place of cities for this report because the definition of a city in Manitoba requires an urban centre to have a population of 7,500 or more, whereas Ontario does not currently have a definition for a city (The Municipal Act 1996). Since there was no cohesive definition across both Manitoba and Ontario, the use of population centres with a population of over 7,500 ensures there is consistency in the comparison across both provinces.

Further, the reason behind the use of population centres rather than Census-Subdivisions (CSDs) is due to the fact that some CSDs have lower population densities, inferring that they may not be central areas for the construction industry. Using Population centres instead allows a greater probability of the construction industry being present within those centres which would act as an access point for highway construction.

Finally, regressions were run to see whether the distance from a population centre increased average cost per kilometre. Distance from a population centre, or remoteness of the project, was a factor outlined by the MTO and MENDM that could influence costs. Put simply, the closer the project, the lower the cost and the further the project, the higher the cost. The regions with included cities and towns plus populations can be found in Appendix C.

Limitations of the Data

One of the limitations of the methodology is that it does not account for smaller cities that act as hubs in areas that are more remote, such as Flin Flon and Thompson, Manitoba. Both are larger cities (relative to other regional communities) in Northern Manitoba, but there are 384 kilometres between them. To offset the sheer distance between these cities, an exception was made for Flin Flon in the population requirements. Given that Flin Flon is a mining community, a construction company would have more ready access to materials and labour there, thus eliminating travel costs. Similar small hubs exist in Northwestern and Northeastern Ontario, where communities are spread out due to geography and have smaller populations and population densities. However, these communities do not have the same kilometre distances as seen in Northern Manitoba.

To calculate the effect of remoteness on a project, the distance from the middle of the project to a population centre was taken and compared to the project cost. Calculating remoteness in the above manner is based on a Statistics Canada methodology, which measures remoteness as the relation to a central agglomeration (i.e., physical proximity to a central hub, such as a population centre) (Statistics Canada 2017). For this commentary, a central agglomeration is the population centre nearest a project (Statistics Canada 2017). The effect of remoteness was calculated using SPSS Model software and further illustrated in the commentary through Excel charts. To calculate the effects of project length, ranges of 0 to 14.9 kilometres, 15 to 29.9 kilometres, and 30 to 44.9 kilometres were selected. Projects were then sorted into the appropriate kilometre ranges, by region where applicable, and compared. In regions where data are unavailable, the graph is left blank. These intervals were selected as the better fit based on the data available, where smaller intervals may lead to additional gaps in instances where data were not available. To calculate the average cost, the following formula was used:

$$\frac{\text{Total dollar cost of all projects}}{\text{Total KM length of all projects}}$$

[4] Population centre is not synonymous with a city, therefore there will be differences between the 2016 population of a city compared to a population centre, which factors in population density.

[5] "Population centres are classified into three groups, depending on the size of their population:

1. Small population centres, with a population between 1,000 and 29,999
2. Medium population centres, with a population between 30,000 and 99,999
3. Large urban population centres, with a population of 100,000 or more.

Population is defined using population and population density data from the current census and is delineated using the dissemination block. The previous census counts provided in this table are the aggregation of the previous census population counts for the dissemination blocks that constitute the 2016 population centre" (Statistics Canada 2016).

The methodology for calculating the average costs follows a similar approach used by both Parametric Estimating Guides (2007 and 2011, v) that involves taking the lowest three bids on a tender to determine an average cost. This approach minimizes the potential that the winning bid is not an accurate reflection of costs. Remoteness was calculated following the process used by Statistics Canada. All factors and hypotheses are based on existing literature from the MTO, MENDM, and Parametric Estimating Guides (2007 and 2011).

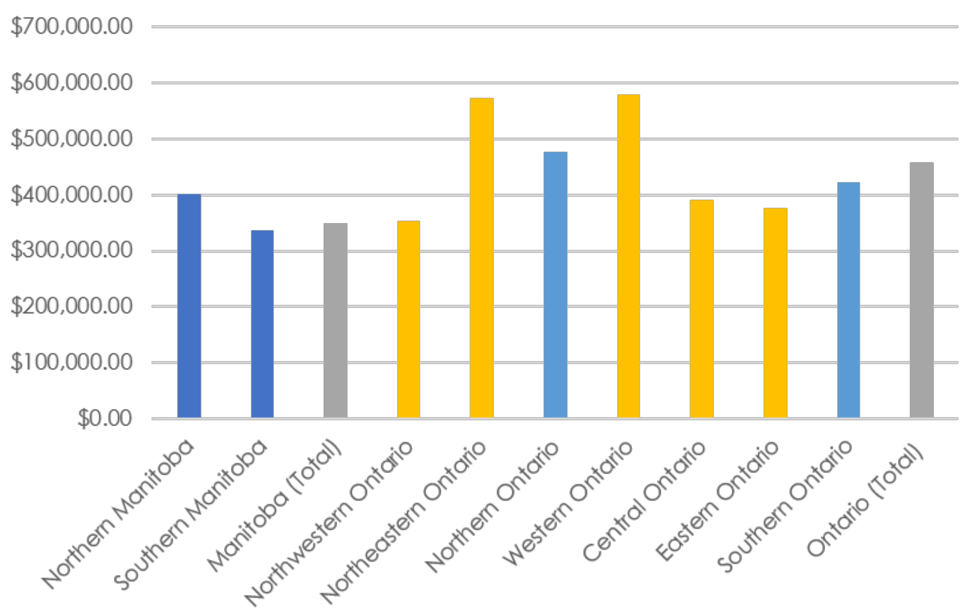
When using remoteness as a variable, there are a few factors which need to be considered and addressed before forming a concrete hypothesis for the variable. Using population centres fails to address the geographical realities of Northern Ontario and Manitoba, meaning that hubs that work in the southern regions may not be replicated farther north. Smaller towns and cities may also be acting as infrastructure hubs outside of the locations chosen in this commentary. In addition to this, the location of workers, materials, etc. may be located outside of population centres where storage is more readily available. Further research would benefit from basing remoteness on the project's distance from gravel pits and construction offices rather than larger population centres.

Findings

Overall Average Cost per Kilometre by Region

The overall average costs for all regions in Manitoba and Ontario are outlined in Figure 1. These costs do not account for additional variables such as length of a project (km) or distance from a population centre.

Figure 1: Average cost per Kilometre in Manitoba and Ontario, 2016



Sources: Manitoba Infrastructure and Transportation Bid Results, 2016; Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System five-year Contract History Database, 2016

Manitoba's northern region is more expensive per kilometre than the southern region by more than $60,000 per kilometre. As well, depending on the variables analyzed (remoteness and the length of a project (km)), costs fluctuate across each region. As noted in Figure 2, average costs of highway construction in both Manitoba's and Ontario's northern regions are higher. Yet in Northern Manitoba, the cost ranges are smaller than its southern counterpart, demonstrating there is less fluctuation across pricing in Manitoba's northern region.

In Figure 1, Northwestern Ontario had the lowest cost per kilometre of all Ontario's regions, with a comparative difference of more than $200,000 per kilometre to that of Northeastern Ontario. Both regions fall on opposite sides of the provincial average by approximately $100,000 each way. When comparing both provinces, Manitoba boasts lower average costs by more than $100,000 per kilometre. Similarly, Manitoba's southern and northern regions are lower than all of Ontario.

Figure 2: Cost Ranges and Number of Contracts in Manitoba and Ontario

Region	Range	Number of Contracts
Northern Manitoba	$324,000-$632,000	3
Southern Manitoba	$201,000-$988,000	8
Manitoba (all)	$201,000-$988,000	11
Northwestern Ontario	$253,000-$426,000	7
Northeastern Ontario	$276,000-$879,000	11
Central Ontario	$337,000-$486,000	3
Western Ontario	$455,000-$703,000	4
Eastern Ontario	$171,000-$618,000	8
Northern Ontario	$253,000-$879,000	18
Southern Ontario	$171,000-$703,000	15
Ontario (all)	$171,000-$879,000	33

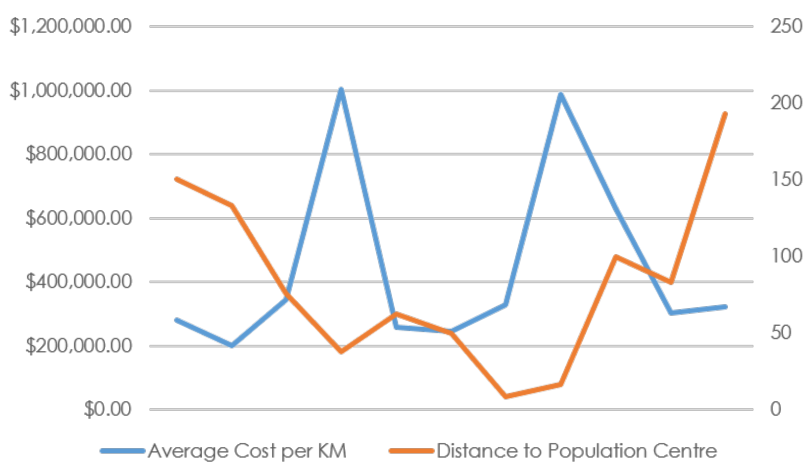
Sources: Manitoba Infrastructure and Transportation Bid Results, 2016; Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System 5-year Contract History Database, 2016

Remoteness

Evidence from the regressions suggest that the distance of a project from a population centre is statistically insignificant on the impact on the overall cost per kilometre. There are two primary issues with the results from the regressions: a lack of data points to base a solid analysis and weak R values. Based on the model used in this commentary, not enough data observations are present to form a conclusive case for the variable. Further, the resulting R-Square values suggest that the impact of remoteness is statistically insignificant (The values of which can be found in Appendices D through H). Future research would benefit from long-term data collection on cost in each region over a few years which would increase the number of observations available. Overall, evidence from the regressions, illustrated in Excel charts as well, contradicts the hypothesis that increasing remoteness and distance from a population centre correlates to increasing construction costs.

Figure 3 reveals that the average cost per kilometre in Manitoba is lower if the project is more than 45 kilometres away from an urban centre, with costs for seven out of eight projects under $400,000 per kilometre. In the case of Manitoba, the relationship of population centre to the project may be overshadowed by the project length in terms of kilometres. The two most expensive projects were two kilometres (just under $890,000) and 11.6 kilometres (just over $1 million) in length.

Figure 3: Relationship between Cost and Remoteness, Manitoba



Source: Manitoba Infrastructure and Transportation Bid Result (2016)

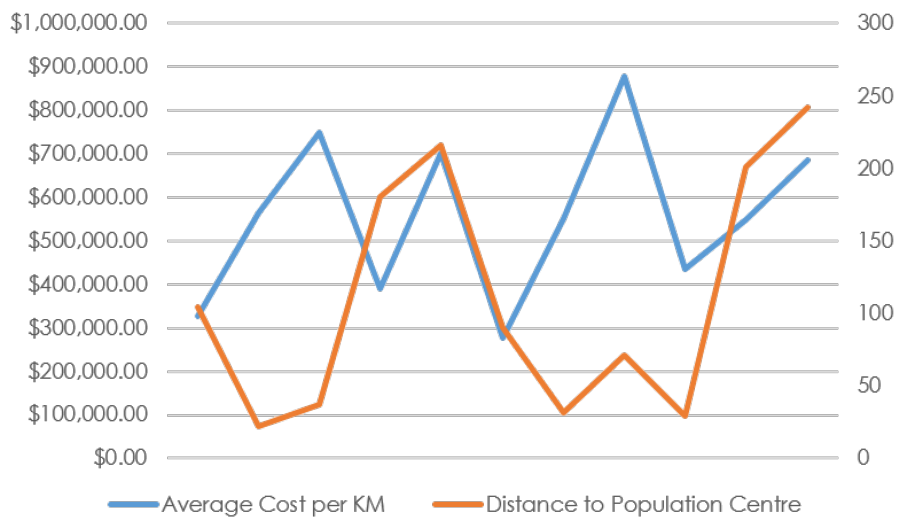
[6] Data from linear regressions for Northern Ontario can be found in Appendix G and data from linear regressions for Southern Ontario can be found in Appendix H

In Northwestern Ontario, R-Square value is 10.8 and comparatively in Northeastern Ontario, R-Square value comes in at 0.4. In other words, the impact is minimal. Figures 4 and 5 graph the two variables together to assess the relationship between cost per kilometre and the remoteness of a project.

Figure 4: Relationship between Cost and Remoteness, Northwestern Ontario

Source: Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System

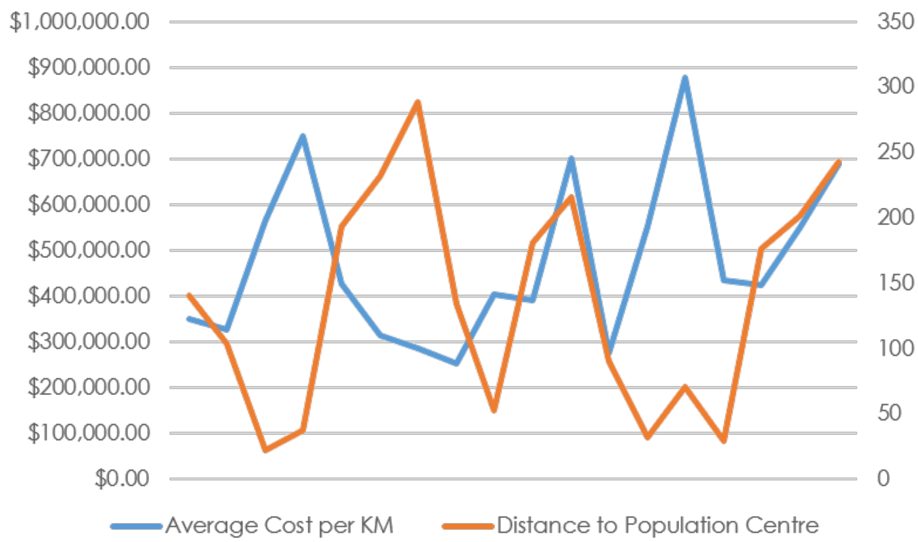
Figure 5: Relationship between Cost and Remoteness, Northeastern Ontario



Source: Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System

As demonstrated in Figure 6, Northern Ontario's data fluctuate greatly, with high costs in intervals that were either the closest or farthest from the population centre.

Figure 6: Relationship between Cost and Remoteness, Northern Ontario



Source: Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System

For Southern Ontario, a similar trend to Northern Ontario is demonstrated with the distance to a population centre having no significant impact on the cost. A similar pattern of fluctuation to Northeastern Ontario can also be noticed.

Figure 7: Relationship between Cost and Remoteness, Southern Ontario

Source: Ministry of Transportation Ontario Registry, Appraisal, and Qualifications System

Overall, the distance from a population centre has no statistically significant impact on the overall project per kilometre, with only a few projects where cost and remoteness meet. This conclusion may be the result of smaller population centres that act as a hub instead of a larger population centre. It could also be the result of materials being stored at a location outside of a population centre (e.g., gravel pits, storage centres).

Length of a project (km)

The second variable to be analyzed was the influence of the length of a project on the overall cost per kilometre. Evidence, based on the calculations in this commentary suggests that costs are more likely to be driven by the length of a project.

When looking at the data from Manitoba in Table 1, the average cost per kilometre decreases in tandem with the project length. It is worth noting that in the 0 to 14.9-kilometre interval, the average cost per kilometre is $500,000 greater in Southern Manitoba than in other areas of the province. By contrast, for the 15 to 29.9-kilometre interval, the price decreases for Southern Manitoba, making it more economically priced. There are two much smaller but expensive projects at the 0 to 14.9-kilometre interval, which may have artificially influenced the average costs.

Table 1: Relationship between Cost and Length of a Project, Manitoba (from lowest to highest average cost per KM)

Region (MB)	Average cost per KM	Range	Number of Contracts
0-14.9 KM			
Northern	$453,000	$324,000-$632,000	2
Province	$650,000	$324,000-$1,005,000	4
Southern	$1,003,000	$988,000-$1,005,000	2
15-29.9 KM			
Southern	$276,000	$201,000-$347,000	5
Province	$283,000	$201,000-$347,000	6
Northern	$329,000	$329,000	1
30-44.9 KM			
Southern	$260,000	$260,000	1
Province	$260,000	$260,000	1
Northern	N/A	N/A	0

Source: Manitoba Infrastructure and Transportation Bid Results, 2016

In Table 2, the average cost per kilometre in Ontario decreases as the project length increases. However, in the 30 to 44.9-kilometre interval in Table 2, the average costs increase, making it the highest per kilometre. Northeastern Ontario proved to be an outlying case in that increasing length of a project increased the cost per kilometre. In Northwestern Ontario, cost begins to decrease as the project length increases, but then spikes in the 30 to 44.9-kilometre interval. In the higher intervals, it is important to note there are fewer projects occurring, meaning that one contract has the potential to skew results. Fewer bids on a tender means there is less competition on the contract, allowing the company to set its own prices that could potentially be inflated. The variable also fails to consider the project's terrain or underlying factors, which may have driven up the costs instead of the project's length.

Table 2: Relationship between Cost and Length of a Project, Ontario (from lowest to highest average cost per KM)

Region (ON)	Average cost per KM	Range	Number of Contracts
0-14.9 KM			
Northwestern	$349,000	$349,000	1
Eastern	$425,000	$170,000-$618,000	7
Province	$483,000	$170,000-$749,000	16
Central	$486,000	$486,000	1
Northeastern	$545,000	$328,000-$749,000	3
Western	$579,000	$455,000-$702,000	4
15-29.9 KM			
Eastern	$205,000	$205,000	1
Northwestern	$332,000	$253,000-$426,000	5
Province	$429,000	$205,000-$879,000	13
Central	$474,000	$474,000	1
Northeastern	$555,000	$276,000-$879,000	6
Western	N/A	N/A	0
30-44.9 KM			
Northwestern	$425,000	$425,000	1
Province	$548,000	$548,000	3
Northeastern	$620,000	$550,000-$687,000	2
Western	N/A	N/A	0
Central	N/A	N/A	0
Eastern	N/A	N/A	0
45-59.9 KM			
Central	$337,000	$337,000	1
Province	$337,000	$337,000	1
Northwestern	N/A	N/A	0
Northeastern	N/A	N/A	0
Western	N/A	N/A	0
Eastern	N/A	N/A	0

Generally, the data suggest that the length of a project impacts average costs more than the project's distance from a population centre. Across all regions in Manitoba and Ontario, price generally decreases as the project length increases. The jump in cost seen in Ontario's northern regions alludes to a cap where increasing length begins to exceed marginal returns. Increasing costs are a result of the much larger projects requiring additional time and resources to complete as well as reduced competition on contracts. The decreasing costs in the 15 to 29.9-kilometre range in both provinces are a result of projects where there are lower mobilization and material costs creating a sweet spot, so to speak.

Conclusion

The purpose of this commentary was to determine the average cost per kilometre of highway construction across Manitoba and Ontario, while analyzing how two variables – a project's distance from a population centre and the length of contract in kilometres – will affect those costs. The commentary found that there is not one specific variable that can be pointed to for determining a cost; the variables that influence cost vary across each project and region. Both the variables studied in this commentary, as well as the ones mentioned but not analyzed, are just as important to consider when determining a project's cost. Given that each variable uniquely influences each project with varying degrees, there is no concrete formula to determining a project's cost. As discussed in the methodology, this commentary does not directly measure the impacts of traffic flow, location of construction materials or offices, additional regional projects or specialty projects, and other costs such as materials used, labour, and fuel. In certain regions, it can be inferred that variables such as traffic flow in Southern Ontario or the need to blast through rock in Northwestern Ontario would impact costs of highways.

For future research, it would be worth exploring additional data to better determine the relationship between cost per kilometre and distance from a population centre. The relationship between locations of gravel pits and associated materials when compared to the project locations, rather than (or in conjunction with) population centres should also be explored. Additionally, research could explore whether heavier traffic flows, increased needs for detours or traffic control, and other add-ons such as illumination and ATMs could have a greater influence on costs in Southern Ontario.

Overall, the research suggests that the cost of highways in the northern regions of both Manitoba and Ontario are, on average, more expensive than their southern counterparts. While costs per kilometre may be higher in Northern Ontario, improving highway infrastructure is important from a safety standpoint, as well as for crucial economic and social benefits. Echoing sentiments from the NOMTS, there are several key areas where Ontario should direct its attention:

1. Twinning of the highways at identified key areas where transportation flows can be impacted due to lane closures (e.g., accidents, weather) and where there are safety risks (e.g., minimal areas for passing). Highway closures pose safety and economic concerns for travellers.

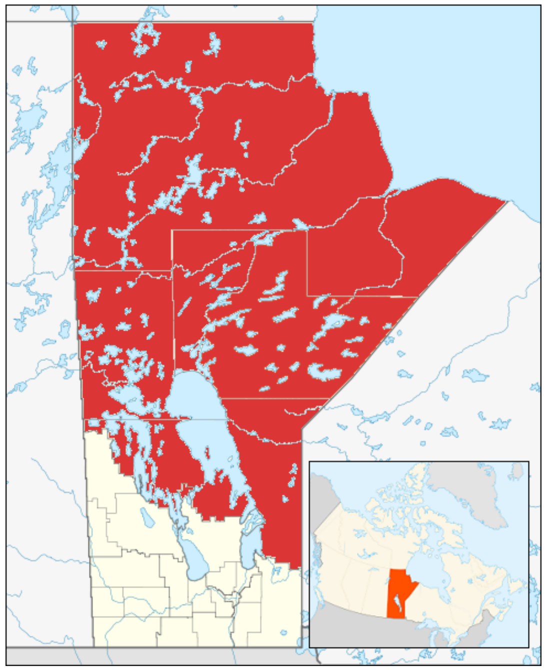
2. Maintaining a project's length between 15 and 30 kilometres where there appears to be the best value per kilometre. By ensuring a greater valuation per kilometre, infrastructure dollars can be further invested.

As discussed earlier in the commentary, $1.24 billion in goods are transported along Northern Ontario's highways (MTO and MENDM 2017, 21). Events decreasing the flows of traffic result in costly delays, and these events could be minimized through improved transportation infrastructure. Understanding the underlying costs of infrastructure enables us to better allocate resources and is the first step in making such improvements. Ultimately, an investment in Northern Ontario's highway infrastructure is an investment in Northern Ontario's economy.




Appendices

Appendix A



Source: "Northern Region, Manitoba." Wikipedia.com. Accessed November 8, 2018. Available online at: https://en.wikipedia.org/wiki/Northern_Region,_Manitoba.

The area in red represents Northern Manitoba, while Southern Manitoba is left uncoloured.

Appendix B

Source: "Contracts By Regional Map." RAQSB/Ontario Ministry of Transportation. Accessed November 8, 2018. Last modified November 8, 2018. Available online at: https://www.raqsb.mto.gov.on.ca/login/raqs.nsf/English/Text/ViewRegionalMap?OpenForm.

Appendix C

Region	Geographic Name	Population
Northern Manitoba	Thompson	12,878
	Flin Flon	4,791
Southern Manitoba	Winnipeg	711,925
	Brandon	48,324
	Steinbach	14,753
	Winkler	14,311
	Portage La Prairie	12,949
	Selkirk	9,839
	Dauphin	8,095
	Morden	7,907
Northwestern Ontario	Thunder Bay	93,952
	Kenora	10,687
Northeastern Ontario	Sudbury	88,054
	Sault Ste. Marie	66,313
	North Bay	50,396
	Timmins	29,331
	Valley East	17,451
	Elliot Lake	10,498
	Bracebridge	9,232
Western Ontario	Kitchener	470,015
	London	383,437
	Windsor	287,069
	Guelph	132,397
	Brantford	98,179
	Sarnia	72,125
	Chatham	43,550
	St. Thomas	41,813

Region	Geographic Name	Population
Western Ontario (continued)	Woodstock	40,404
	Leamington	32,991
	Stratford	31,053
	Owen Sound	22,032
	Tilsonburg	15,594
	Strathroy	14,401
	Amherstburg	13,910
	New Hamburg	13,595
	Ingersoll	12,587
	Paris	12,310
	Elmira	10,161
	Wallaceburg	10,098
	Calcedonia	9,674
	Kincardine	8,315
	Port Elgin	7,862
	Alymer	7,621
	Goderich	7,536
	Listowel	7,530
Eastern Ontario	Ottawa-Gatineau	989,567
	Kingston	117,660
	Kanata	117,304
	Peterborough	82,094
	Belleville	67,666
	Cornwall	45,723
	Brockville	21,854
	Lindsay	20,713
	Cobourg	19,031

Region	Geographic Name	Population
Eastern Ontario (continued)	Pembroke	15,940
	Petawawa	13,701
	Port Hope	12,587
	Rockland	12,302
	Carleton Place	11,936
	Hawkesbury	11,715
	Arnprior	10,426
	Smith's Falls	8,885
	Renfrew	8,152
Central Ontario	Toronto	5,429,525
	Hamilton	693,645
	Oshawa	308,875
	St. Catharines - Niagara Falls	229,246
	Barrie	145,614
	Milton	101,715
	Welland-Pelham	62,388
	Georgetown	42,123
	Bowmanville	39,371
	Stouffville	32,634
	Orillia	31,128
	Orangeville	30,734
	Bradford	29,862
	Keswick - Elmhurst Branch	26,757
	Bolton	26,738
	Midland	24,353
	Innisfill	23,992
	Fergus	20,767
	Collingwood	20,102

Region	Geographic Name	Population
Central Ontario (continued)	Alliston	18,809
	Wasaga Beach	17,808
	Port Colborne	15,037
	Fort Erie	14,621
	Simcoe	13,922
	Angus Borden CFB-BFC	12,640
	Beamsville	11,834
	Uxbridge	11,832
	Acton	9,462
	Port Perry	9,453
	New Castle	9,167
	Binbrook	8,794
	Crystal Beach	8,524
	Shelburne	8,126

Source: Statistics Canada, Population and Dwelling Count Highlight Tables, 2016 Census

http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Table.cfm?Lang=Eng&T=801&S=47&O=A

Appendix D

Manitoba Linear Regression Data

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Distance[b]	-	Enter

[a] Dependent Variable: Cost
[b] All requested variables entered

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.445[a]	.198	.109	$277,006.41105

[a] Predictors: (Constant), Distance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	170756209794.021	1	170756209794.021	2.225	.170[b]
	Residual	690592965865.562	9	76732551762.840		
	Total	861349175659.584	10			

[a] Dependent Variable: Cost
[b] Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	635790.568	151520.732		4.196	.002
	Distance	-2273.325	1523.923	-.445	-1.492	.170

[a] Dependent Variable: Cost

Appendix E

Northwestern Ontario Linear Regression Data

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Distance[b]	-	Enter

[a] Dependent Variable: Cost
[b] All requested variables entered

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.329[a]	.108	-.070	$71,902.80234

[a] Predictors: (Constant), Distance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3140010858.131	1	3140010858.131	.607	.471[b]
	Residual	25850064918.954	5	5170012983.791		
	Total	28990075777.084	6			

[a] Dependent Variable: Cost
[b] Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	403481.098	72901.398	170756209794.021	5.535	.003
	Distance	-303.130	388.964	76732551762.840	-.779	.471

[a] Dependent Variable: Cost

Appendix F

Northeastern Ontario Linear Regression Data

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Distance[b]	-	Enter

[a] Dependent Variable: Cost
[b] All requested variables entered

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.064[a]	.004	-.107	$197,388.81620

[a] Predictors: (Constant), Distance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1421050182.795	1	1421050182.795	.036	.853[b]
	Residual	350661102860.014	9	38962344762.224		
	Total	352082153042.808	10			

[a] Dependent Variable: Cost
[b] Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	539600.916	102413.418		5.269	.001
	Distance	142.842	747.951	.064	.191	.853

[a] Dependent Variable: Cost

Appendix G

Northern Ontario Linear Regression Data

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Distance[b]	-	Enter

[a] Dependent Variable: Cost
[b] All requested variables entered

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.212[a]	.045	-.015	$182,891.90644

[a] Predictors: (Constant), Distance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25226316948.821	1	25226316948.821	.754	.398[b]
	Residual	535191191074.452	16	33449449442.153		
	Total	560417508023.273	17			

[a] Dependent Variable: Cost
[b] Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	537988.652	83495.166		6.443	.000
	Distance	-457.508	526.825	-.212	-.868	.398

[a] Dependent Variable: Cost

Appendix H

Southern Ontario Regression Data

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Distance[b]	-	Enter

[a] Dependent Variable: Cost
[b] All requested variables entered

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.109[a]	.012	-.064	$170,165.17220

[a] Predictors: (Constant), Distance

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4553687823.887	1	4553687823.887	.157	.698[b]
	Residual	376430415793.445	13	28956185830.265		
	Total	380984103617.332	14			

[a] Dependent Variable: Cost
[b] Predictors: (Constant), Distance

Coefficients[a]

Model		Unstandardized B	Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	398858.539	74635.442		5.344	.000
	Distance	715.266	1803.669	.109	.397	.698

[a] Dependent Variable: Cost

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