Indigenous Services Canada
Services aux Autochtones Canada

Approach for Adjusting Program Funding to Account for Remoteness of First Nations Communities

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Canada

1 Contents

Acronyms

a, b, c	Regression coefficients
AFN	Assembly of First Nations
ARIA+	Accessibility and Remoteness Index of Australia
BSF	Band Support Funding
CIB-OM	Infrastructure Operations and Maintenance
CIRNA	Crown-Indigenous Relations and Northern Affairs
CSD	Census Sub-divisions
EA	Environment Allowance
F&UD	Fuel and Utilities Differential
FVPP	Family Violence Prevention Program
GDP	Gross Domestic Product
INAC	Indian and Northern Affairs Canada
IPGHD	Isolated Post and Government Housing Directive
ISC	Indigenous Services Canada
LCD	Living Cost Differential
ln	Natural log
NJC	National Joint Council
PoC	Point of Comparison
R	Regression Correlation Coefficient
R^2	R-Squared, Regression Goodness-of-Fit Indicator
SCD	Shelter Cost Differential
SSRB	Spreadsheet Standards Review Board
x1	Remoteness Index (regression variable)
x2	Binary variable for Fly-in locations (regression dummy variable)
y	Cost Adjustment Factor
y1	Employment Allowance Factor
y2	Shipping Cost Factor

1.1 Executive Summary

Indigenous Services Canada (ISC) needs to examine options to offset the cost impact of remoteness for First Nations and to provide a rationale for additional funding for remote communities. ISC has tasked this to an internal Working Group that includes members drawn from Central Agencies as well as the Assembly of First Nations (AFN).

The current system of remoteness and environmental scaling factors in the Band Classification Manual (INAC, 2005) is not used consistently across programs nor are they documented in a way that permits a detailed review and periodical update. The purpose for this report is to develop a new Cost Adjustment Factor specific to each First Nation's level of remoteness. The location's new Cost Adjustment Factor can then be multiplied by the First Nation's base funding level to calculate the additional dollar amount required for remoteness.

The main text of the document provides background information about the issue. It also describes the data sources and methodology. Results and notes about future use and development are included. Annex A includes a more technical documentation of the model. Annex B contains all the background data used in the analysis.

Regression analysis is used to estimate a functional relationship between cost differentials in remote locations, their Remoteness Index, and whether a location has main road/ferry access or not. To achieve this, an Employment Allowance Factor is used as a proxy for labour cost differentials in remote areas. For this proxy, the analysis uses easily available data from the Isolated Posts and Government Housing Directive (IPGHD). Second Canada Post data are used to establish a Shipping Cost Factor that is used as a proxy for material cost differentials to remote areas. To determine the weighted average Cost Adjustment Factor for each location, Statistics Canada data on national Gross Domestic Product (GDP) by industry are used as split between services (currently 70% of GDP) and goods (currently 30% of GDP). The services share of GDP is used here as proxy for the labour share of base funding levels, while the goods share of GDP is used as a proxy for the material share.

This analysis establishes a method for estimating a single Cost Adjustment Factor. The additional amount required due to remoteness is calculated by multiplying the Cost Adjustment Factor to the base funding amount in each location:

- **Cost Adjustment Factor = 0.723 * Remoteness Index + 0.674 * Fly-in**

The following two examples illustrate the use of the Cost Adjustment Factor:

- First, assume that a First Nations location has base level funding of $2 million and its Remoteness Index is 0.8 and it is a Fly-in location.
  - Cost Adjustment Factor = 0.723 * 0.80 + 0.674 * 1 = 125%
  - Additional budget amount for remoteness = $2 million * 125% = $2.5 million
- Second, assume a First Nations location has base level funding of $2 million and its Remoteness Index is 0.6 and it is a Not-fly-in location.
  - Cost Adjustment Factor = 0.723 * 0.60 + 0.674 * 0 = 43%
  - Additional amount for remoteness = $2 million * 43% = $867,000

1.2 Introduction

Indigenous Services Canada (ISC) has examined options to take into account the financial impact of remoteness for First Nations and to provide a rationale for additional funding for remote communities. ISC has assigned this task to an internal Working Group that included members drawn from three Central Agencies as well as the Assembly of First Nations (AFN).

The current use of remoteness and environmental scaling factors comes from the Band Classification Manual (INAC, 2005). It is not, however, used consistently across programs nor is it subject to a detailed review and periodic update. The goal of this report is to develop a "Cost Adjustment Factor" that estimates each First Nation's level of remoteness. For each location, the new "Cost Adjustment Factor" is multiplied by the First Nation's base funding level to calculate the additional dollar amount required to accommodate the cost of remoteness.

This report is organized in a number of Sections. Section 2 (Background) briefly highlights the background for this study. Section 3 (Model) discusses the model that was developed in calculating the cost adjustment factor. This includes a discussion of the data; potential functional relationships; validation of the results of these functional relationships including risk analysis using simulation. Section 4 (Closing Comments) offers some closing comments while Annex A includes a technical documentation of the model. Annex B contains all of the data used in the analysis.

2 Background

Remoteness is known to affect the buying power of communities that are not in proximity to a population center.[1] This report documents the analysis conducted for the ISC internal Working Group to determine if available data on remoteness can be related to available data on costs in a manner that calculates cost differentials for funding provided to First Nations for programs and services.

As part of establishing a new framework, approaches to measuring remoteness and applying an associated Cost Adjustment Factor in other jurisdictions have been researched and analyzed by the Working Group (ISC, August 2018). Some of the measures and approaches are listed below. Note that, the Community Remoteness Index, Northern and Remote Communities Infrastructure Index, and ARIA+ do not have Cost Adjustment Factors – only remoteness scores:

- A Statistics Canada measure of remoteness and accessibility devised in partnership with ISC (Community Remoteness Index);
- Isolated Posts as defined in the Isolated Posts and Government Directive Housing, maintained by the National Joint Council (NJC);
- The Ministry of Education in Ontario approach to adjust education funding for identifying characters of remote areas and rural locations;
- A Northern and Remote Communities Infrastructure Index that identifies characteristics of remoteness was devised for ISC/CIRNA; and
- The ARIA+ Remoteness Measure – used by the Government of Australia.

[1] A population centre refers to the Statistics Canada definition of an area with a population of at least 1,000 and a density of 400 or more people per square kilometre; the population centre defined by Statistics Canada are used in the computation (for a detailed definition see: *http://www12.statcan.gc.ca/census-recensement/2011/ref/dict/geo049a-eng.cfm*).

This research highlights some observable best practices for the development and application of a remoteness measure and associated Cost Adjustment Factors, including:

- Empirically based measure – Measure and associated concepts are founded in and can be validated by empirical research. This incorporates widely accepted concepts, such as: population, climate and road accessibility.
- Full geographic coverage – The measure has full geographic coverage of Canada, allowing for the measure to be used in various contexts, and not restricted to applying solely in the First Nations context.
- Availability and access to data – Data for the development of the measure are readily available and easy to access (i.e. from public sources, with little data manipulation required).
- Clearly defined criteria – The criteria used to define remoteness should be clearly defined for simplicity and ease in development and application and communication.
- Jurisdictional comparisons – Jurisdictional comparisons are possible, allowing for regional differences to be observed and for analysis to be conducted. Further, jurisdictional comparisons allow for targeted investments.
- Easily maintainable/updatable – The measure and the associated cost adjustment factors are easy to maintain and do not require extensive data mining, processing and analysis. Further, it is updated at regular intervals to ensure continued relevance in application (e.g. with the census cycle).
- Multi-party involvement – Multiple parties are responsible for the development / application / maintenance of the measure. It does not serve the policy objective of a single department.
- Continuous measure – A measure that captures remoteness with a continuous data set allows for degrees of remoteness to be observed between all communities and jurisdictions.
- Incorporates accessibility to services – The measure incorporates the concept of accessibility to services, such as health, retail, legal etc. This includes the concept of accessibility to the community via roads, rail, air, or ferry.

3 **Model**

The new Statistics Canada measure of remoteness, here referred to as the Remoteness Index, is used to estimate a functional relationship between remoteness and two cost factors as well as a weighted average between them. The two cost factors are used as proxies for different types of costs included in First Nations funds. One proxy is calculated using data from the Isolated Post and Government Housing Directive (IPGHD), which provides employment allowances to facilitate and retain government employees in selected remote locations. The second proxy is calculated using data from Canada Post on the shipping cost differentials to reach the same IPGHD remote locations.

A model has been designed to estimate functional relationships and to multiply the resulting Cost Adjustment Factors to First Nations base funding levels. The model is built in Microsoft Excel and follows guidelines from the Spreadsheet Standards Review Board (SSRB, 2016). It is also meant to guide any future updates whenever the source data are updated.

3.1 Data

Currently ISC uses remoteness factors (geographic and environmental) to adjust funding levels for programs and services. The remoteness indicators have been used by ISC since 1987 and require updating to ensure continued relevance.

In 2010, Statistics Canada in partnership with Indigenous and Northern Affairs Canada (INAC) initiated a review of INAC’s measures of community remoteness and environmental conditions. In March 2015, Statistics Canada provided a database of remoteness and environmental scores.

In the spring of 2017, Statistics Canada in collaboration with INAC released the new Remoteness Index (Community Remoteness Index – referred to as the Remoteness Index in this report). This index incorporates best practices for measuring and accounting for remoteness funding (as identified in the Best Practices Report of August 2018). This is relevant to an ISC application because it is developed in close consultation with ISC Strategic Research Directorate and programs to address specific measurement needs of ISC programs. The new index is methodologically sound because it applies the widely accepted concept of gravity models, calculated via the summation of the sizes of population centres that can be reached by a community, divided by measure of proximity (travel costs) of each population centre to the community, for all centres within 150 minutes from the community with a separate airfare factor for fly-in communities. The new index has wide geographic coverage for more than 5,000 Census Sub-divisions (CSD) and can be used for comparisons with non-First Nations communities. See Figure 1. It is a continuous measure where the index for each community is normalized to a measure between 0 (not remote) and 1 (most remote). The index is readily available and easy to access and easily updated with each Census.

Figure 1: Statistics Canada's Remoteness Index

In the current analysis, two cost factors are used as proxies for different types of costs included in First Nations budgets. One proxy is for labour cost differentials between urban and remote areas. It is based on the Isolated Posts classification system (from the Isolated Post and Government Housing Directive - IPGHD) that establishes allowances for federal government employees who are working in remote communities. The Directive seeks to facilitate and retain staff who are supporting/delivering government programming in isolated areas through offsetting the higher costs associated with residing in approximately 300 Isolated Posts. This system incorporates several best practices. The system is evidence-based because it is compiled from survey information by a credible agency applying widely accepted concepts (National Joint Council, NJC). The measure covers a wide area of the country, which allows for the measure to be used in various contexts including non-First Nations communities. The data for developing the measure are readily available, easy to access, regularly updated, and do not require extensive data mining, processing and analysis by ISC. The criteria used to define costs are transparent and consistent over time, thus making it easy for its application and update.

A second proxy is needed because some funding is for the delivery of programs and services that are likely to have a large share of material and shipping costs. As a proxy for this, shipping cost data from Canada Post relative to urban shipping costs are linked to the new Remoteness Index. The data are standardized and can be collected consistently for all Isolated Posts in the dataset. The data are readily available online, easily updated and do not require extensive data mining, processing and analysis by ISC. More specific data would require considerable effort in developing and executing standardized surveys to collect data from representative First Nations.

Since these two proxies provide estimates of different cost differentials in remote areas, it is important that a weighted average Cost Adjustment Factor be developed for each location. Moreover, a single Cost Adjustment Factor is consistent with the department's goal of providing more grant and block funding to First Nations where the split between different funding categories is, by definition, unknown (i.e. the split between salaries, materials, travel, shipping etc. is not available).

By basing the Cost Adjustment Factor on these data sources, it accounts for the specific remoteness of each location. The factor can be applied to all communities because Statistics Canada's new Remoteness Index has national coverage. The additional amount required due to remoteness is calculated by multiplying the Cost Adjustment Factor to the base funding amount in each location.

These two cost differentials measures are merged as illustrated in Table A.1, by using location names, CSD numbers, and postal codes. In summary, the data are merged as follows:

- The Remoteness Index for all CSDs
    - Index values ranging from 0 to 1 with 1 as the most remote.
    - To account for the expected additional costs required with lack of year-round road/ferry access, locations that are classified by Statistics Canada as having "main road/ferry network" are considered to be "Not-fly-in" communities. All other locations are considered to be Fly-in communities in this analysis.[2]
- First, an Employment Allowance Factor is used as a proxy for labour cost differentials to remote areas:
    - Numerator - employment allowances for civil servants in Isolated Posts (IPGHD).
    - Denominator - the national median income for First Nations living on reserve ($20,337 per person per year from the 2016 census escalated to 2018 amounts to $21,518).[3]
- Second, a Shipping Cost Factor is used as a proxy for material cost differentials to remote areas from Point of Comparison (PoC) cities:
    - Numerator - Shipping Cost Differential = Cost of shipping a 10 kg package (10 inch cube) from PoC city to Isolated Post less Cost of shipping within PoC city.
    - Denominator - cost of standard Canada Post shipping of same package within each of the seven PoC cities.
- To determine the weighted average Cost Adjustment Factor for each location, Statistics Canada data on national Gross Domestic Product (GDP) by industry are used as split between services (currently 70% of GDP) and goods (currently 30% of GDP). The services share of GDP is used here as proxy for the labour share of base funding levels, while the goods share of GDP is used as a proxy for the material share.

[2] With the Statistics Canada Remoteness Index methodology, it is possible to compute a value for any CSD but if there is no resident population or road network, it becomes difficult to assign a reference point and the computation becomes uncertain. For this analysis, if a location is noted to have no population (according to 2016 census) it is considered "Fly-in" if its Remoteness Index is larger than 0.28 and "Not-fly-in" otherwise. This chosen cut-off point does not affect the Fly-in/Not-fly-in classification for any of the Isolated Posts. It only affects one First Nations location in the current analysis: Band #582 Skawahlook First Nation has no population and a Remoteness Index of 0.1761 – so it is set to be a Not-fly-in community.

[3] 2016 Census data on earnings received from INAC. The salary escalation factors used are 1.23% from 2015 to 2016, 1.7% from 2016 to 2017, and 2% per year onwards based on Department of National Defence GL Account 01101. V1 INDETERMINATE CIVILIANS (PSEA).

Table A.1: Merging Data Sources with Each Other

Source	Name and Province	CSD	Postal Code	PoC City w Postal Code	Employment Allowances	Shipping Costs	Remoteness
Isolated Post (IPGHD, 2017)	Name, Province	Number	Postal Code	Name, Province, Postal Code	Levels, $ per person per year		
Canada Post	Name		Postal Code	Name, Province, Postal Code		$ PoC to location, $ within PoC	
Statistics Canada	Name	Number					Level: 15-0 Index: 0-1 Transport Infrastructure

Note: - IPGHD data are mapped using the Name and Province notation. Statistics Canada data are mapped using the CSD number.
- When analyzing 2016 Remoteness Index data, six locations must be excluded. Two locations are excluded because no CSD number was found (Pallant Creek, BC and Pitt, BC). Two other locations are excluded because they have no 2016 Remoteness Index data (Kangiqsujuaq, QC 2499888, and Lansdowne House, ON 3560081). Two island locations are excluded because their CSD number is the nearest urban area but their Isolated Posts ranking classifies them as remote (Sable Island, NS 1209034; Sand Point Island, ON 3547003).

Annex A discusses a number of considerations made while analyzing the numerators, denominators and weights. Each of the datasets are shown in Annex B: Data Table B.1 and B.2 list the Isolated Posts data from IPGHD. Data Table B.3 lists the shipping costs data collected for all Isolated Posts. Data Table B.4 shows the complete data set used in the analysis including Remoteness Index and level of transportation infrastructure.

3.2 Model Development

A spreadsheet model is designed to estimate a Cost Adjustment Factor for any location with a new Remoteness Index from Statistics Canada. The model is built in Microsoft Excel® and follows guidelines from the Spreadsheet Standards Review Board (SSRB, 2016).

As documented in Annex A, multiple functional relationships between the Remoteness Index and cost data are tested and validated using regression analysis. The starting point is a linear or exponential relationship where the cost factor which is referred to as y, is determined by an equation that has an intercept, a; a slope, b, that references the Remoteness Index, x1; and a coefficient, c, that is multiplied by a dummy variable, x2, which identifies whether the location is Fly-in or Not Fly-in. The following two equations are tested to derive relevant regression coefficients:

- Linear cost factor: $y = a + b * x1 + c * x2$
- Exponential cost factor: $\ln(y) = a + b * x1 + c * x2$

The validated and most statistically significant relationship is found to be linear without an intercept coefficient but with a dummy variable for Fly-in locations. It is valid to omit the intercept because it ensures that a location with zero remoteness also has a zero Cost Adjustment Factor. The preferred functional form is the same when estimating employment allowances as well as shipping cost.

To give a numerical flavour of the methodology, a calculation using the preferred functional relationship is shown in the following examples. Note how the weighted average can be calculated directly from the regression coefficients without calculating the two cost factors first:

- Employment Allowance Factor: $y1 = b1 * x1 + c1 * x2 = 0.600 * 0.80 + 0.382 * 1 = 86\%$

- Shipping Cost Factor: $y2 = b2 * x1 + c2 * x2 = 1.011 * 0.80 + 1.360 * 1 = 217\%$
- Cost Adjustment Factor: $y = 0.7 * y1 + 0.3 * y2 = 0.7 * 86\% + 0.3 * 217\% = 125\%$

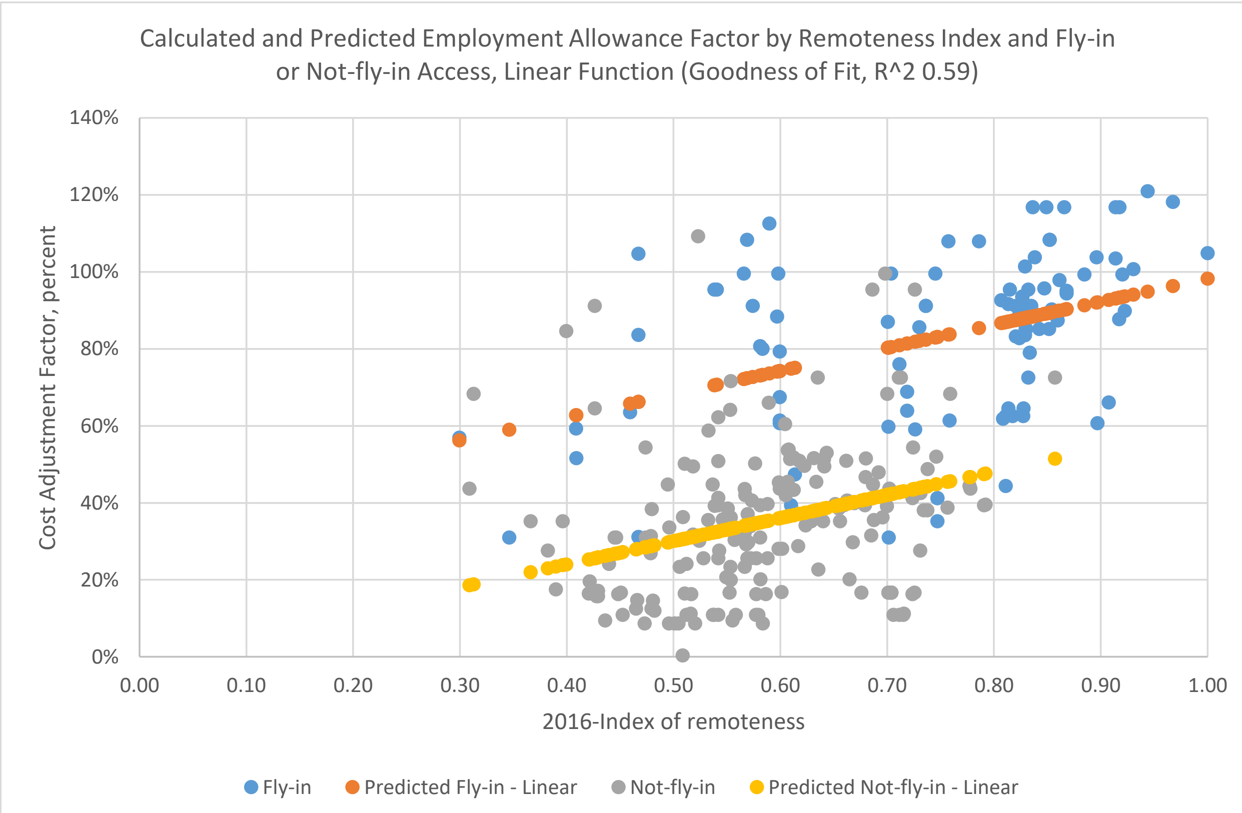
  or directly $\mathbf{y = 0.723 * x1 + 0.674 * x2 = 0.723 * 0.8 + 0.674 * 1 = 125\%}$

3.3 Results, Uncertainty and Risk

Figure 2 shows scatterplots of the data for employment allowance and shipping cost factors – with blue dots for Fly-in locations and grey dots for other locations. The predicted factors are those calculated using the chosen functional forms.

As can be expected from the scatterplots, the statistical goodness-of-fit as measured by the R^2 indicator is not 100%. The key regression results are reported in Table 2. For the Employment Allowance Factor, the goodness-of-fit (R^2) is 59%, meaning that the remaining 41% of the variance in the data is explained by something other than the Remoteness Index and the Fly-in dummy variable. The correlation coefficient is strong at 77%; however. Similarly the goodness-of-fit for the Shipping Cost Factor is 54% with the remaining 46% explained by variables that are not included in this analysis. This correlation coefficient is also strong at 74%.

Figure 2: Calculated and Predicted Employment Allowance- and Shipping Cost Factors by Remoteness Index and Fly-in or Road access.



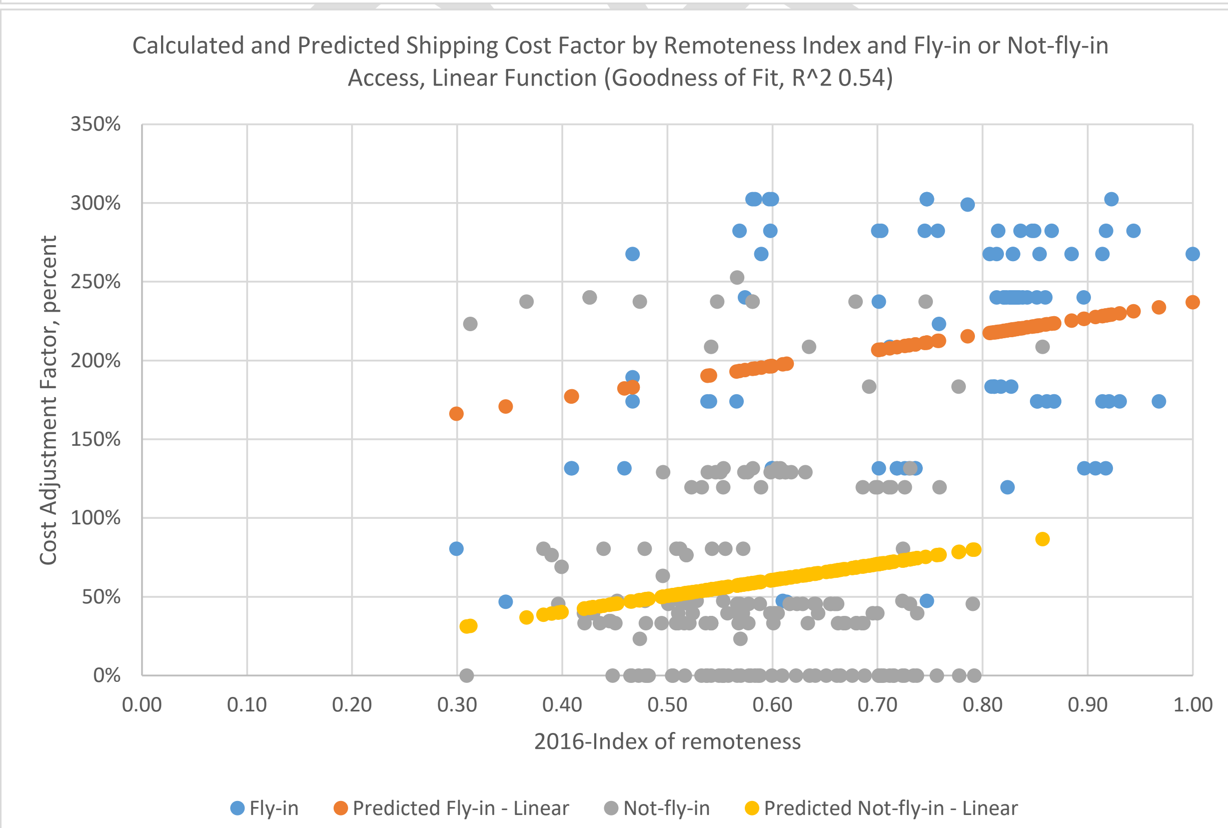


Table 2: Final Regression Functions for Cost Factors.

	Employment Allowance Factor	Shipping Cost Factor
Degrees of Freedom	276	276
Correlation (R) - see note	0.77	0.74
Goodness-of-fit (R^2) - see note	0.59	0.54
b	0.600	1.011
c	0.382	1.360
standard error, b	0.024	0.082
standard error, c	0.027	0.092
95% confidence interval, b	0.600 -/+ 0.048	1.011 -/+ 0.162
95% confidence interval, c	0.382 -/+ 0.053	1.360 -/+ 0.181
t-stat, b	24.74	12.27
t-stat, c	14.06	14.75
p-value, b	5.33E-72	6.50E-28
p-value, c	3.03E-34	1.07E-36
Significant at 5% level	b and c	b and c
Function	y1 = 0.600 * x1 + 0.382 * x2	y2 = 1.011 * x1 + 1.360 * x2
Weighted Average	y = (0.7 * b1 + 0.3 * b2) * x1 + (0.7 * c1 + 0.3 * c2) * x2 y = 0.723 * x1 + 0.674 * x2	

Note: - Linear regression function: y= b*x1 + c*x2. x1: Remoteness Index, x2: Fly-in = 1 ; Not-fly-in = 0
- p-values <0.05 indicates that the estimated value is significantly different from zero.
- Note that the correlation coefficient (R) and goodness-of-fit (r^2) indicators are not valid in models where the intercept is set to zero. The R and R^2 indicators reported here are those calculated on the model before forcing the intercept to zero.

This analysis establishes a method for estimating a single Cost Adjustment Factor. An assumed weight between the Employment Allowance and Shipping Cost Factors is taken from the services versus goods split in Canada's GDP – currently at 70% versus 30%. The Cost Adjustment Factor can be calculated directly which is derived from the weighted average of the two factors as shown in the formula below. A range of examples for different Remoteness Indices are shown in Table 3. Note that, the current Isolated Posts dataset does not cover all possible Remoteness Indices from 0 to 1. The formula should therefore not be extrapolated to all locations even if it is theoretically possible. The results are not valid for Remoteness Index below 0.3 because IPGHD-negotiations with NJC has so far not classified any of those locations as Isolated Posts in need of allowances for remoteness. This is indicated by "na" notations in Table 3. The additional amount required due to remoteness is calculated by multiplying the Cost Adjustment Factor to the base funding amount in each location.

- **Cost Adjustment Factor = 0.723 * Remoteness Index + 0.674 * Fly-in**
  From:
- Cost Adjustment Factor = 0.7 * Employment Allowance Factor + 0.3 * Shipping Cost Factor

Two calculation examples of how to use the Cost Adjustment Factor:

- A First Nations location has base level funding of $2 million. Its Remoteness Index is 0.8 and it is a Fly-in location.
    - Cost Adjustment Factor = 0.723 * 0.80 + 0.674 * 1 = 125%
    - Additional budget amount for remoteness = $2 million * 125% = $2.5 million
- A First Nations location has base level funding of $2 million. Its Remoteness Index is 0.6 and it is a Not-fly-in location.
    - Cost Adjustment Factor = 0.723 * 0.60 + 0.674 * 0 = 43%
    - Additional amount for remoteness = $2 million * 43% = $867,000

Table 3: Examples: Use Regression function to calculate Cost Adjustment Factors

	Cost Adjustment Factor	
Remoteness Index	Not-fly-in	Fly-in
0.00	na	na
0.30	22%	89%
0.40	29%	96%
0.60	43%	111%
0.80	58%	125%
1.00	72%	140%

Note: - Best regression function fit – Linear with Fly-in dummy variable: 0.723 * Remoteness Index + 0.674 * Fly-in
- na – calculation not applicable because source data do not cover locations with Remoteness Index below 0.3.

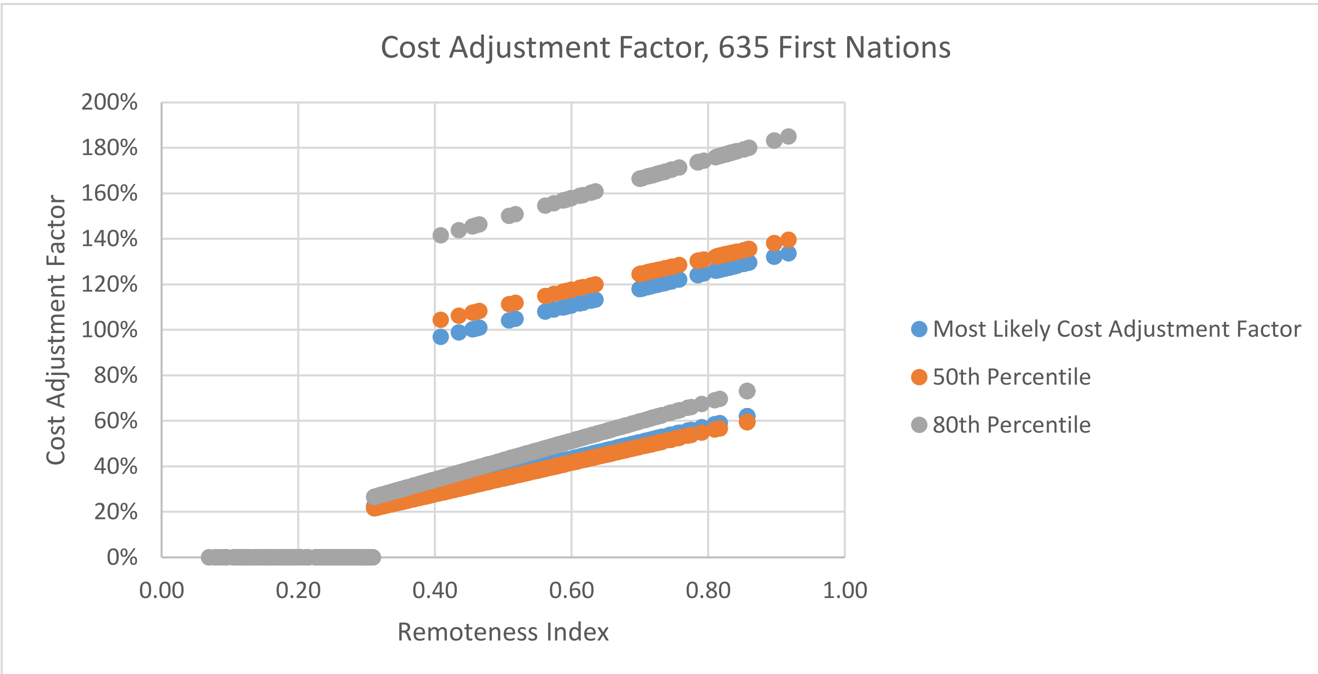
Because the nature of different funding programs and the future shift toward grant and block funding, there will always be uncertainty about the actual split between labour and material costs and therefore which weights that should be used between them. The median income estimate used as a denominator in the Employment Allowance Factor is uncertain. And finally, the estimated regression coefficients that are used to calculate the Cost Adjustment Factors in this analysis are also uncertain as long as the regression model fit is not 100%.

To measure the impact on the result from model uncertainties, one could run the model multiple times with different assumptions for these uncertain factors. To standardize and automate this type of risk analysis, a commonly used method is to run a Monte Carlo simulation. By defining the possible ranges that the uncertain assumptions can take, rather than just their current most-likely values, the simulation method generates results for a selected number of model iterations (for example 50,000 times). Without simulation, the model result is one Cost Adjustment Factor per location. With simulation, the model result is a probability distribution for the Cost Adjustment Factor in each location. This distribution provides us with a range and probability of all possible values for the Cost Adjustment Factor given the model assumptions. Based on an assessment of the overall uncertainty and to allow for measurable risk, the user can apply a Cost Adjustment Factor that differs from the most likely estimate.

Figure 3 shows the Cost Adjustment Factors for different locations with the simulation results illustrated by their 50th and 80th percentiles. A closer inspection of the detailed data behind the figure shows, for example, that a Fly-in location with a Remoteness Index of 0.7 has a Cost Adjustment Factor of 118% which increases to 124% for the 50th percentile. If the location has a base level funding of $1 million, the expected adjustment for remoteness would be $1.18 million or $1.24 million. By comparison, a Not-fly-in location with a Remoteness Index 0.60 has an expected Cost Adjustment Factor of 43% (close to the 50th percentile), which increases to 53% at the 80th percentile. If this location has a base level funding of $1 million, the expected adjustment for remoteness would be $430,000 or $530,000 for 80% certainty. The increases required to reach the higher percentiles are larger in Fly-in locations because of the larger differences between the two underlying cost factors (the two proxies for employment allowance and shipping).

Figure 3: Weighted Average Cost Adjustment Factor

expected vs 50th and 80th percentile, 635 First Nations.



Note: - Results from Monte Carlo Simulation with Latin Hypercube sampling and 50,000 iterations and initial seed of 67247 (random number to ensure same result each time simulation is run).
- See Figure A.7 for detailed distribution assumptions.

4 Closing Comments

The model documented in this report combines easily accessible data from existing sources to estimate a function that establishes a Cost Adjustment Factor for any location that has a Remoteness Index value. The additional amount required due to remoteness is calculated by multiplying the Cost Adjustment Factor to the base funding amount. The estimated function is statistically significant, validated to not be over-fitted, and provides expected values that appear plausible compared to the very limited number of available comparable sources. Further comparisons should be done to validate the results when more comparable studies are identified and data are available.

- To estimate a Cost Adjustment Factor for any given location, it is necessary that a location's CSD number is known so that its Remoteness Index and transport infrastructure classification (i.e. whether it has main road/ferry access or not) can be identified.
- While the Cost Adjustment Factors are statistically significant and show strong correlations, possibly they should not be applied to the total funding amount. Other factors not covered by

the Remoteness Index and the Fly-in dummy variable explain some of the cost differences between urban and remote areas. More data are needed to explore this.

- Results may underestimate the required cost adjustment if background data already include adjustments for remoteness.
- The shipping Cost Factor is based on simplified assumptions and data, although collecting more relevant data from a cross section of First Nations would be costly to achieve a standardized and comparable measurement. If more data were collected, it would have to replace both the Isolated Posts and shipping costs data.
- While it is theoretically possible, extrapolation to the less remote locations (Remoteness Index below 0.3) should be avoided because IPGHD in the NJC has thus far not classified any of those locations as Isolated Posts in need of allowances for remoteness.

Annex A: Technical Documentation of the Model.

The new Statistics Canada measure of remoteness, here referred to as the Remoteness Index, is used to estimate a functional relationship between remoteness and two cost factors as well as a weighted average between them. The two cost factors are used as proxies for different types of costs included in First Nations budgets. One proxy is calculated using data from the Isolated Post and Government Housing Directive (IPGHD), which provides employment allowances to facilitate and retain government employees in selected remote locations. The second proxy is calculated using data from Canada Post on the shipping cost differentials to reach the same IPGHD remote locations.

A model has been designed to estimate functional relationships and to multiply the resulting Cost Adjustment Factors to First Nations base funding levels. The model is built in Microsoft Excel and follows guidelines from the Spreadsheet Standards Review Board (SSRB, 2016). This Annex documents the process of how the model was designed and validated. This is also meant to guide any future updates when the source data are updated. The model design process includes:

1. Preparing the data
2. Exploring potential functional relationships
3. Validating the selected functional relationship
4. Results and validation
5. Risk analysis using simulation
6. Closing comments

A.1. Preparing the data

The new Statistics Canada Remoteness Index ranks all Census Subdivisions (CSDs) in Canada between 0 and 1, where 1 is most remote (Alasia et al., 2017)[4]. The complete dataset for all 5,162 CSDs in Canada based on the 2016 census is included in the Excel model and the geographical coverage is shown in Figure A.1. The data include the CSD, name, population, transportation infrastructure classification, and Remoteness Index for each location. Each CSD is classified by one of four levels of transportation infrastructure: main road/ferry network; combination of air, train, winter road, charter boat and/or seasonal ferry; air only; or no population. To account for the expected additional cost required with lack of year-round road or ferry access, locations that are classified as having “main road/ferry network” are considered to be “Not-fly-in” communities. All other locations are considered to be Fly-in communities. An exception is made for locations with no population. With the Statistics Canada Remoteness Index methodology, it is possible to compute a value for any CSD but if there is no resident population or road network, it becomes difficult to assign a reference point and the computation becomes difficult. For this analysis, if a location is noted to have no population it is considered “Fly-in” if its Remoteness Index is more than 0.28[5]; “Not-fly-in” otherwise. This chosen cut-

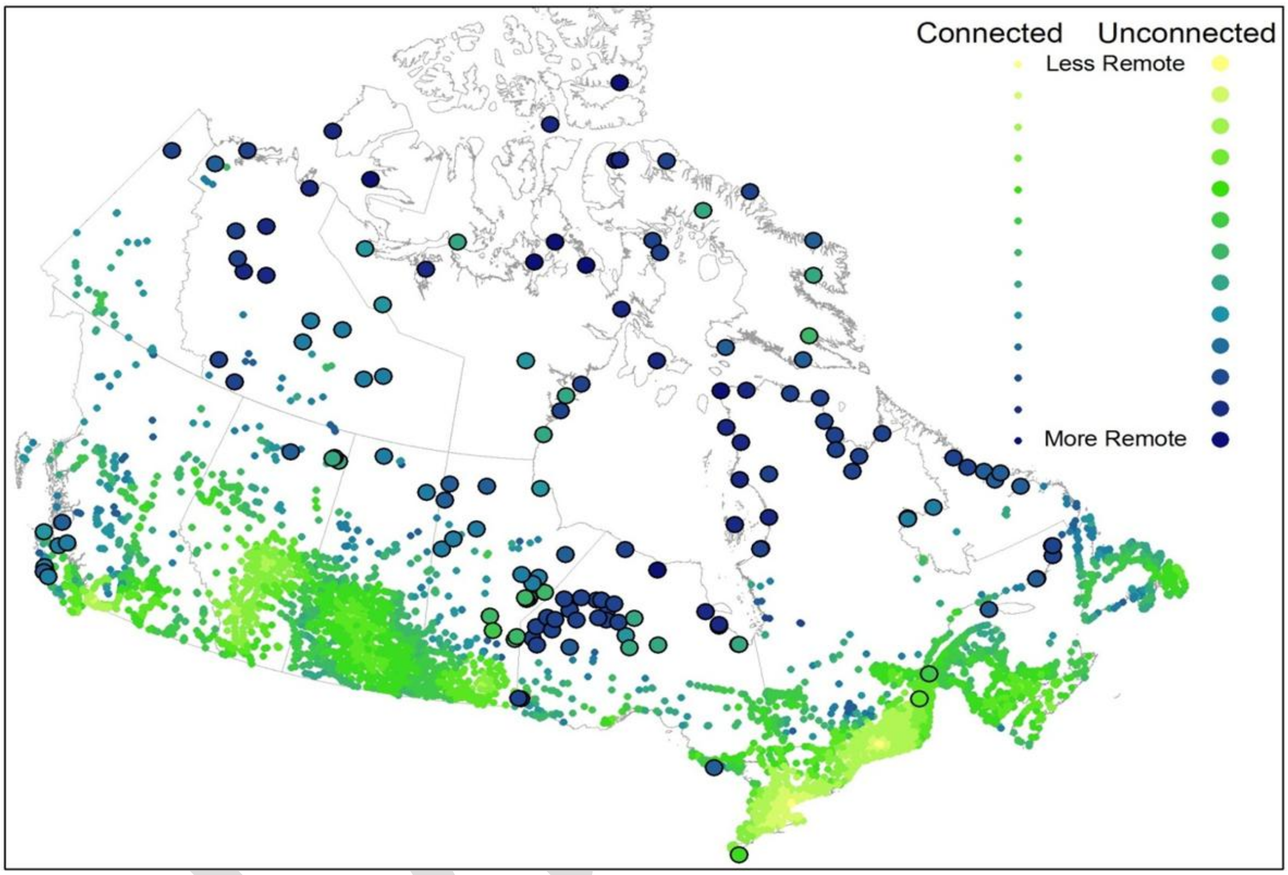
[4] Compared to the Remoteness index which varies between 0 and 1 with 1 being the most remote, Statistics Canada also provides the equivalent Remoteness Level that varies between 1 and 15 with 1 being the most remote. In the current analysis the implications of using the Remoteness Level rather than the Remoteness Index is explored. The resulting Cost Adjustment Factors remain the same regardless of whether one uses the Remoteness Level or the Remoteness Index. The Remoteness Index of 0 to 1 is chosen for this analysis as it was the preferred option of an internal working group.

[5] Cut-off to distinguish least remote versus most remote.

off point does not affect the Fly-in/Not-fly-in classification for any of the Isolated Posts. It only affects one First Nation's location in the current analysis: Band #582 Skawahlook First Nation population count is zero and a Remoteness Index of 0.1761 – so it is set to be a Not-fly-in community.

Due to the size of the national data table it is not included in its entirety in this Annex. In Annex B, the remoteness data are included for all Isolated Posts (Data Table B.4) and for all First Nations (Data Table B.6 and B.7).

Figure A.1: Statistics Canada's Remoteness Index



Note: - The chart shows the remoteness of all communities (including First Nations) in Canada based on the cost of travel.
- The small dots represent communities that are connected by year-round access to the road network.
- The colouring represents the relative costs for each community to reach a population center normalized by population size of the commuting radius.

- Source: Alasia et al, 2017.

The Remoteness Index is used to estimate a functional relationship between remoteness and two cost factors. To be able to multiply the cost factor by the First Nations base funding level, each of the cost factors require data for a numerator and a denominator, and they are weighted to obtain a Cost Adjustment Factor per location.

- First an Employment Allowance Factor is used as a proxy for labour cost differentials inremote areas:
    - Numerator - employment allowances for civil servants in Isolated Posts (IPGHD).

  - Denominator - the national median income for First Nations living on reserve ($20,337 per person per year from the 2016 census escalated to $21,518 in 2018 dollars).[6]
- Second a Shipping Cost Factor is used as a proxy for material cost differentials to remote areas from Point of Comparison (PoC) cities:
  - Numerator - Shipping Costs Differential = Cost of shipping a 10 kg package (10 inch cube) from PoC city to Isolated Post less Cost of shipping within PoC city.
  - Denominator - cost of standard Canada Post shipping of same package within each of the seven PoC cities.
- To determine the weighted average Cost Adjustment Factor for each location, Statistics Canada data on national Gross Domestic Product (GDP) by industry are used as split between services (currently 70% of GDP) and goods (currently 30% of GDP). The services share of GDP is used here as proxy for the labour share of base funding levels, while the goods share of GDP is used as a proxy for the material share.

A number of possible options were considered for the numerators, denominators and weights.

For the first numerator, Isolated Posts allowances are chosen as a proxy for increased labour costs in remote areas. The allowances aim to offset select expenditures, such as the cost of goods and service, fuel and utilities, and shelter in select remote locations. The classification of all Isolated Posts are included in Annex B (see Data Table B.1) and includes the post's name, province, CSD number, postal code, and PoC city with its postal code. The dollar amounts for different allowances are also shown in Annex B (Data Table B.2). The directive operates with seven different PoC cities: Edmonton, AB; Montreal, QB; Saskatoon, SK; St. John's, NL; Toronto, ON; Vancouver, BC; Winnipeg, MB. The allowances and benefits can be claimed by employees if they work and live in an Isolated Post, as determined by the National Joint Council (NJC).

Some Isolated Posts data are excluded from the first numerator. The available data used in this analysis includes 278 Isolated Posts in Canada as listed in Data Table B.1. The table also shows twelve additional locations that are included under one of the other Isolated Posts and have therefore not got their own IPGHD classification. Finally, six Isolated Posts originally included in the list of 296 locations in the IPGHD directive are excluded because either their CSD number is not determined (Pallant Creek, BC, and Pitt, BC), or because they have no Remoteness Index (Kangiqsujuaq, QC, and Lansdowne House, ON), or because they are islands with an Isolated Post location that does not correspond to their CSD number (Sable Island, NS, and Sand Point Island, ON). These islands cannot be included in the dataset because it makes them appear as urban but with very high cost differentials to the Isolated Posts PoC city.

An alternative denominator for the Employment Allowance Factor could be the median salary of civil servants who receive the employment allowances at Isolated Posts. However, these salaries are substantially higher than and - not indicative of - the earnings of First Nations people living on reserves. The IPGHD also provides the same dollar amount to all eligible employees regardless of their base salary. If one used this alternative denominator, the adjustment factor would be too low to reflect the situation on First Nations reserves. Another alternative could the median income for First Nations in each province/territory. These values, however, already include some impact of remoteness

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[6] 2016 Census amount received from INAC. The escalation factors used are 1.23% from 2015 to 2016, 1.7% from 2016 to 2017, and 2% per year onwards based on Department of National Defence GL Account 01101. V1 INDETERMINATE CIVILIANS (PSEA).

and could lead to an underestimation of the cost differences between less remote and more remote locations across provinces/ territories.

For the second numerator, the time and resources available did not allow for collection of standardized and comparable data on actual cost of goods transported to all of the Isolated Posts. Instead, shipping cost data are collected from Canada Post online tool. To standardize the data, costs are recorded for shipping of a 10kg package (10 inch cube) within each PoC city as well as to each Isolated Post. The cost differential is divided by the PoC cost to arrive at the estimated Shipping Cost Factor specific to each location. In Annex B, Data Table B.3 shows the collected shipping costs for 278 Isolated Posts. The current analysis assumes that the additional value of time it takes to reach remote locations is reflected in shipping costs.

The weights used to estimate the average Cost Adjustment Factor are based on GDP data by industry. An alternative measure of the split between labour and material costs could involve using Statistics Canada GDP data by expenditure category so as to remove household consumption from total services and goods data referenced above. This results in a split of 92% services and 8% goods which is very different from information available for some programs and was not used[7].

After establishing the preferred data sources for both numerators and denominators, Table A.1 provides an overview of how the different data sources are merged. By using the classification numbers and name of the Isolated Posts, data from Data Table B.1 are merged with the level and dollar allowances in Data Table B.2 for: environment (EA), living cost differential (LCD), fuel & utilities differential (F&UD), and shelter cost differential (SCD).[8] Note that, employment allowances are provided to civil servants in Isolated Posts either as an individual or as an individual with dependant. For the purpose of using the Cost Adjustment Factor for scaling funding allocations, this model uses data for individuals without dependants so that funding for program and services is adjusted to reflect each individual resident and correspond with individual earnings (rather than household earnings) that have been used as the denominator. Canada Post data are merged with Isolated Posts data by using the postal codes. If no postal code is available, the nearest post office is used. Statistics Canada Remoteness Index data are merged with Isolated Posts data by using the CSD number. After merging all the data sources, the complete data set is shown in Annex B Data Table B.4.

Table A.1: Merging Data Sources with Each Other

Source	Name and Province	CSD	Postal Code	PoC City w Postal Code	Environment Allowance	Living Cost Differential	Fuel & Utilities Differential	Shelter Cost Differential	Shipping Costs	Remoteness
Data Tables B.1 + B.2:	Name, Province	Number	Postal Code	Name, Province, Postal Code						

Isolated Post (IPGHD April 2017 Directive)	Name, Province				Level 0-5
					$ per year
					$ per hour
					w/wo dependants
						Level 0-16
						$ per year
						$ per hour
						w/wo dependants
							Level 0-30
							$ per year
							$ per hour
							w/wo dependants
								5 Isolated Posts
								$ per year
								$ per hour
								w/wo dependants		

[7] For example, the comparable known information for the infrastructure operations and maintenance program had a ratio for material that was much higher.

[8] In terms of the shelter cost differential, the allowance rates for private housing options are used rather than those provided for government housing because there are only three data points for the latter.

Data Table B.3: Canada Post	Name		Postal Code	Name, Province, Postal Code	$ PoC to location, $ within PoC	
Data Table B.4: Statistics Canada	Name	Number				A. Level: 15-0 B. Index: 0-1 Transport Infrastructure

Note: - IPGHD data are mapped using the Name and Province notation. Statistics Canada data are mapped using the CSD number.
- When analyzing 2016 Remoteness Index data, six locations must be excluded. Two locations are excluded because no CSD number was found (Pallant Creek, BC and Pitt, BC). Two other locations are excluded because they have no 2016 Remoteness Index data (Kangiqsujuaq, QC 2499888, and Lansdowne House, ON 3560081). Two island locations are excluded because their CSD number is the nearest urban area but their Isolated Posts ranking classifies them as remote (Sable Island, NS 1209034; Sand Point Island, ON 3547003).

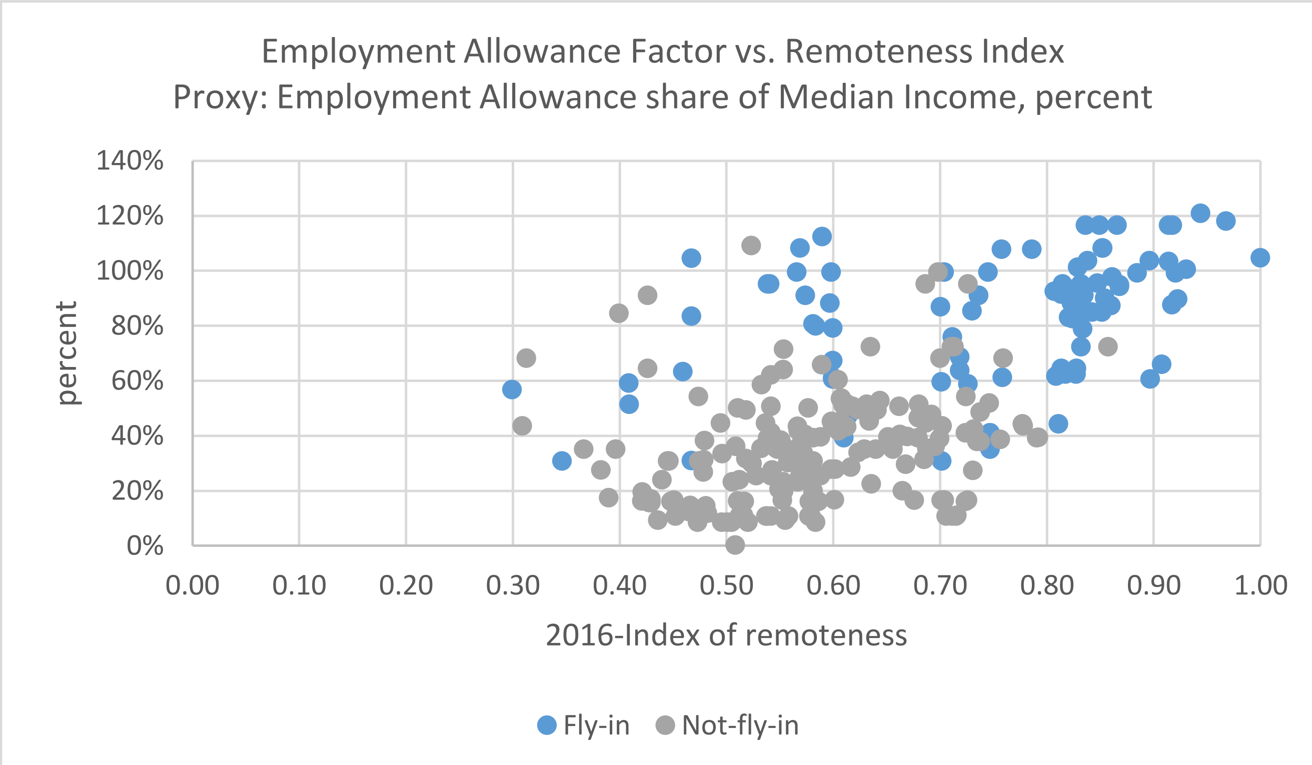
By choosing to use these easily available data sources, some assumptions are made implicitly. Before discussing the methodology, it is important to be reminded of these key underlying assumptions:

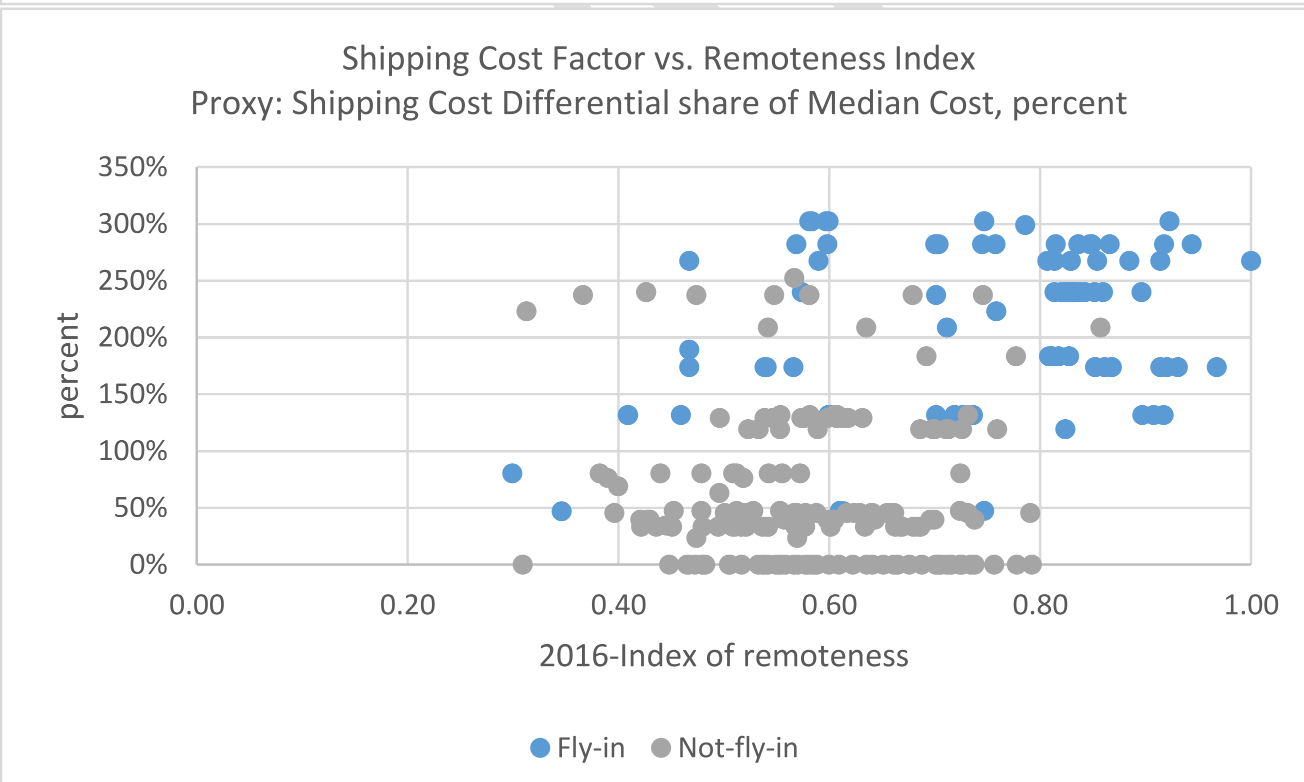
- Relative cost increases between two locations can be captured via the Remoteness Index, and whether the location is accessible by air (a fly-in community) or by main road or ferry access.
- IPGHD allowances are sufficient to attract people to and retain people in remote locations.
- IPGHD allowances for civil servants approximate the increased average costs experienced by First Nations people on reserves. (Ideally, the same survey could be expanded to First Nations locations to capture more relevant data on spending and cost differentials).
- Civil servants in Isolated Posts that qualify for all four allowances are eligible to receive all of them (EA, LCD, F&UD, and SCD). The same rules would apply in First Nations locations if the IPGHD-approach was taken in those locations too.
- Shipping cost differentials are related to remoteness. (Ideally more relevant data could be built if IPGHD survey data was collected for representative First Nations locations).
- To calculate the funding level adjusted for remoteness, the Cost Adjustment Factor will be multiplied by funding level before it has been adjusted for inflation.

A.2. Exploring potential functional relationships

The assembled dataset in Annex B (Data Table B.4) for 278 Isolated Posts is used to estimate a functional relationship between the Remoteness Index and the factors for employment allowance and shipping cost. Figure A.2 shows scatter plots of the data set with grey dots for communities that have main road or ferry access and blue dots for the other locations (i.e. Fly-in locations). Using regression analysis, the functional relationships tested in the model are summarized in Table A.2. The estimated regression coefficients are a, b, and c. Using notations in the table, a function with no intercept (notation: a = 0) implies that the cost differentials are zero in locations with zero Remoteness Index. The slope of the function (notation: b>0) estimates how the cost differentials increase when remoteness increases. By including a binary variable for fly-in locations (notation: c>0), often referred to as a dummy variable, the cost differentials are higher than in locations that have road/ferry access. The statistical significance of these regression coefficients is assessed against a 95% criterion such that if their p-values are less than 5%, they are statistically different from zero and can be included in the final estimated function.

Figure A.2: Scatterplots of Data for 278 Isolated Posts





Note: - Grey dots for communities that have main road or ferry access and blue dots for the other locations (i.e. Fly-in locations).

Table A.2: Functional Relationships Tested in the Analysis

Option	Functional Relationships	Function
1	Linear, Fly-in dummy, Intercept	y=a+b*x1+c*x2
2	Linear, Fly-in dummy, No Intercept	y=b*x1+c*x2
3	Linear, No fly-in dummy, Intercept	y=a+b*x2
4	Linear, No fly-in dummy, No Intercept	y=b*x2
5	Exponential, Fly-in dummy, Intercept	ln(y)=a + b*x1+ c*x2
6	Exponential, No fly-in dummy, Intercept	ln(y)=a + b*x1

Note: - y is employment allowance share of median income or shipping cost differential as share of median cost; x1 is Remoteness Index; x2 is a dummy variable for access via road/ferry (=0) or a fly-in location (=1).

To give a numerical flavour of the methodology, a calculation example for a linear relationship with a dummy-variable for fly-in and no intercept is shown here when the Remoteness Index x1= 0.8 and Fly-in x2=1. The resulting Cost Adjustment Factor is 125% which can be multiplied by the base funding level to calculate the additional dollar amount for remoteness. Note how the weighted average can be calculated directly from the regression coefficients without calculating the two cost factors first:

- Employment Allowance Factor: y1 = b1 * x1 + c1 * x2 = 0.600 * 0.80 + 0.382 * 1 = 86%
- Shipping Cost Factor: y2 = b2 * x1 + c2 * x2 = 1.011 * 0.80 + 1.360 * 1 = 217%
- Cost Adjustment Factor: y = 0.7 * y1 + 0.3 * y2 = 0.7 * 86% + 0.3 * 217% = 125%

or directly y = (0.7 * b1 + 0.3 * b2) * x1 + (0.7 * c1 + 0.3 * c2) * x2

y = 0.723 * x1 + 0.674 * x2 = 0.723 * 0.8 + 0.674 * 1 = 125%

Initial analysis of the data helps identify potential correlations between different variables. The bottom left chart in Figure A.3 shows that when all allowances are included without a dummy variable, the correlation coefficient to Remoteness Index is 0.58 (square root of R^2 0.34). In other words, the Remoteness Index explains 34 percent of the variation in the Isolated Post allowances. The remaining 66 percent must be explained by other factors. The other charts show the allowances that explain most of the variation in the data. Most of the correlation comes from the LCD allowance followed by the Environment and F&UD allowances (R^2= 0.34, 0.33 and 0.12, respectively). Because very few isolated posts are eligible for the SCD allowance, this adds little to the correlation (R^2= 0.02). As a side-note, fragmentation of the data points (in the plots) indicate that the allowances are provided in levels (amounts shown in Data Table B.2) and not on a sliding scale. This fragmentation is not visible when all allowances are added together in the bottom left chart in Figure A.3.

The visual assessment of Figure A.3 provides information about the order in which the allowances should be added when comparing results from the functional relationships in Table A.2. While not reported here, detailed analyses indicate that the regression coefficient for the intercept, a, is not significantly different from zero and is therefore excluded from the remaining analyses. This makes sense in that the Cost Adjustment Factor in a location with zero remoteness with road/ferry access is also zero. These detailed analyses are included in the Excel model file.

Figure A.3: Initial correlation and functional relationship between remoteness level and different allowances

Table A.3 shows that the inclusion of the LCD allowance alone gnerates a correlation coefficient of 79%. When the Environment allowance is added, this coefficient increases to 81%. When the F&UD and SCD allowances are added, the correlation coefficient decreases slightly to 78%. A strict interpretation of these results suggests that one should only include the LCD and Environment allowances. However, it is advisable to include all allowances for completeness and in case more Isolated Posts become eligible for these allowances in the future. The Isolated Posts and Government Housing Directive is being implemented such that if an employee is eligible for all allowances, they can receive all of them. When assessing the correlation and goodness-of-fit measures, the validity and statistical significance of the model does not decrease much when all allowances are included. The large statistical significance of the fly-in dummy variable supports the assumption that cost differentials are highly dependent on the level of road/ferry or air-access.

Table A.3: Comparing model correlation and goodness-of-fit when including some or all of the Isolated Post allowances.

x-axis	**x1: 2016-Remoteness Index | x2: Fly-in = 0 ; Not-fly-in = 1**			
min and max values	Fly-in: 0.30 – 1.00 | Not-fly-in: 0.31 – 0.86			
y-axis (as share of median income)	**LCD**	**LCD+EA**	**LCD+ EA+F&UD**	**Total LCD+EA+ F&UD+SCD**
Degrees of Freedom	276	276	276	276
Correlation (R) - see note	0.79	0.81	0.78	0.77
Goodness-of-fit (R^2) - see note	0.62	0.66	0.61	0.59
F statistic	868.83	1,448.60	1,242.52	1,161.80
T-test	7.86E-146	4.36E-147	9.49E-139	3.87E-135
Slope (b)	0.27	0.49	0.60	0.60
t stat	17.89	27.20	25.55	24.74
p-value	4.76E-48	4.34E-80	1.07E-74	5.33E-72
Slope (c)	0.27	0.33	0.38	0.38
t stat	15.90	16.17	14.58	14.06
p-value	7.14E-41	7.86E-42	4.26E-36	3.03E-34
Significant at 5% level	b and c	b and c	b and c	b and c
Function	y1 = 0.27 * x1 + 0.27 * x2	y1 = 0.49 * x1 + 0.33 * x2	y1 = 0.60 * x1 + 0.38 * x2	y1 = 0.60 * x1 + 0.38 * x2

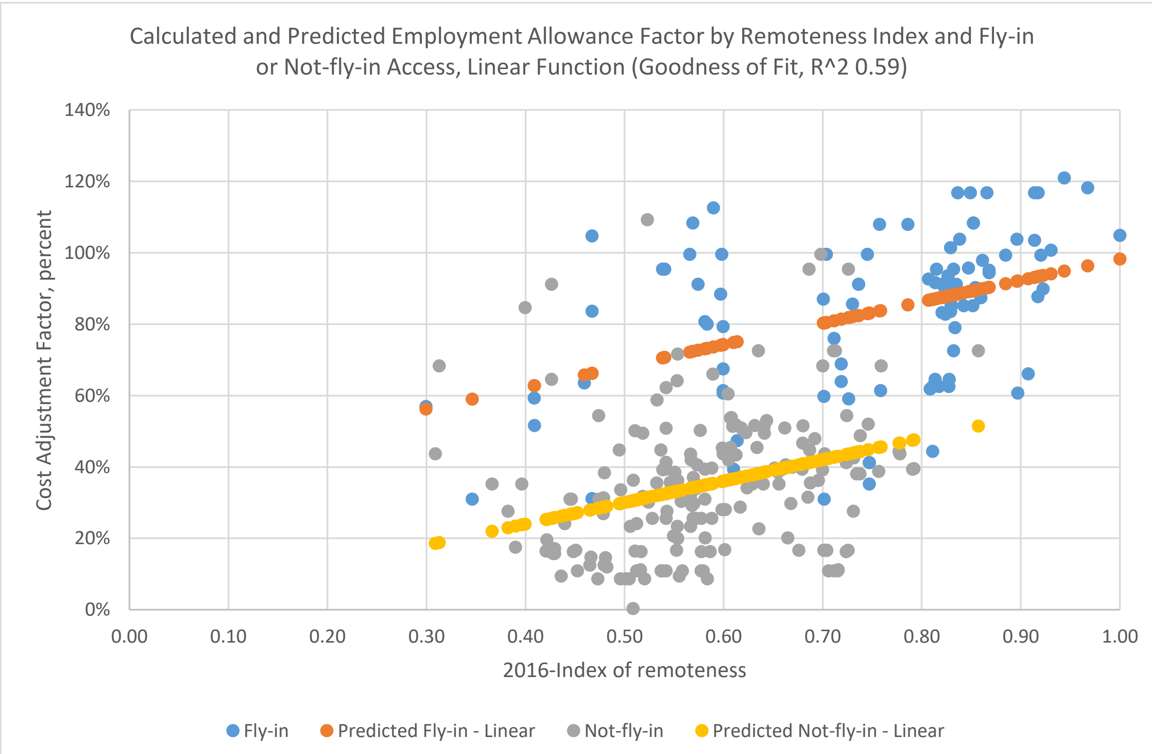
Note: - Linear regression function: y= a + b*x1 + c*x2. P-values <0.05 indicates that the estimated value is significantly different from zero.
- Note that the correlation coefficient (R) and goodness-of-fit (r^2) indicators are not valid in models where the intercept is set to zero. The R and R^2 indicators reported here are those calculated on the model before forcing the intercept to zero.

Figure A.4 compares the impact of using linear and exponential functional relationships for predicting the Employment Allowance Factor based on the Remoteness Index. Compared to the linear function, the correlation and goodness-of-fit decrease if we choose the exponential function. Closer analysis of the exponential regression results shows that estimates are significantly different from zero and therefore are a valid choice. Exponential functions are often chosen to accurately model values close to 1 (one) such as in the most remote areas. However, the linear function is preferred because it also captures the increased costs in the most remote areas through the dummy variable, and it provides a better goodness-of-fit.

As an alternative to using a dummy-variable for fly-in locations, we explored the option of dividing the Isolated Posts dataset into those that are fly-in (94 locations) and those that are not (180 locations). A separate regression function can then be estimated for each dataset. While not reported explicitly in this report, the findings were that the combination of a loss of degrees of freedom (fewer observations) and the variability in the data provided poor goodness-of-fit of 9-16% when splitting the dataset compared to the better fit of 55-59% with a dummy variable in a complete dataset.

In conclusion, the preferred functional relationship in this analysis is linear with a dummy variable for fly-in locations and zero intercept. The findings are the same when estimating employment allowances and shipping cost differentials relative to the Remoteness Index. This is plotted in the bottom right panel of Figure A.3 and in Figure A.5.

Figure A.4: Calculated and Predicted Employment Allowance Factor by Remoteness Index and Fly-in or Road access, Linear versus Exponential Functions.



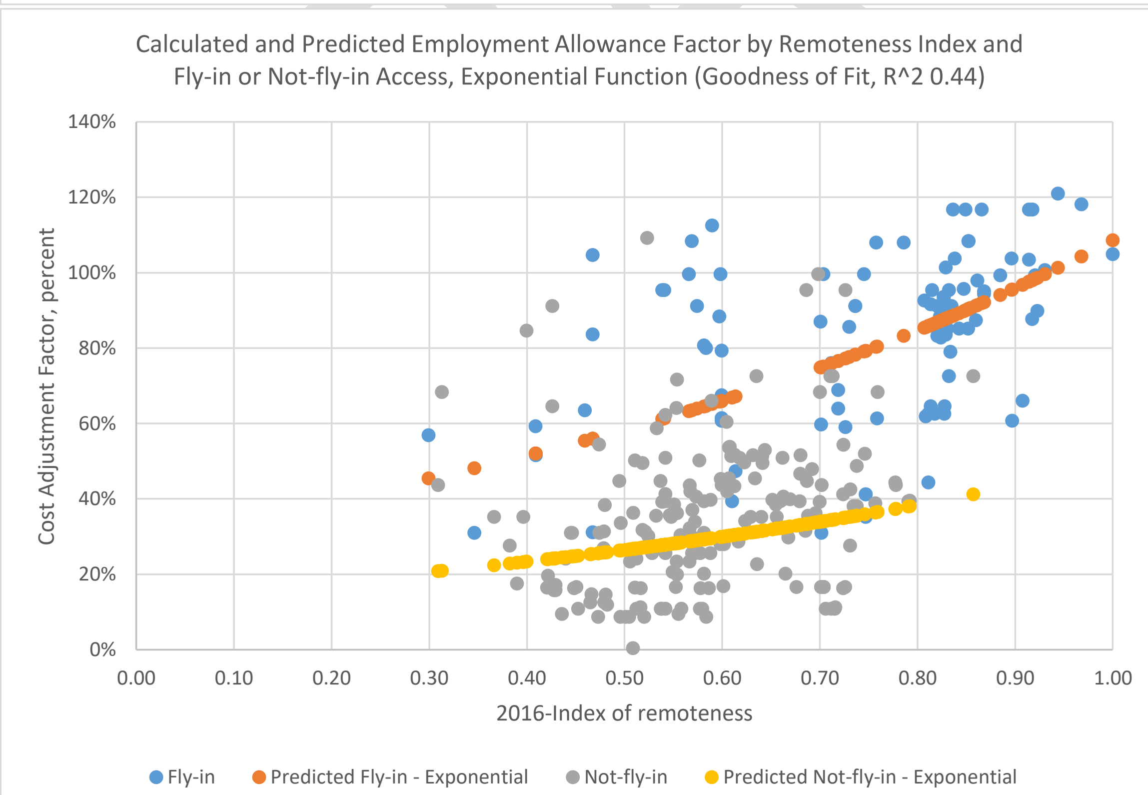
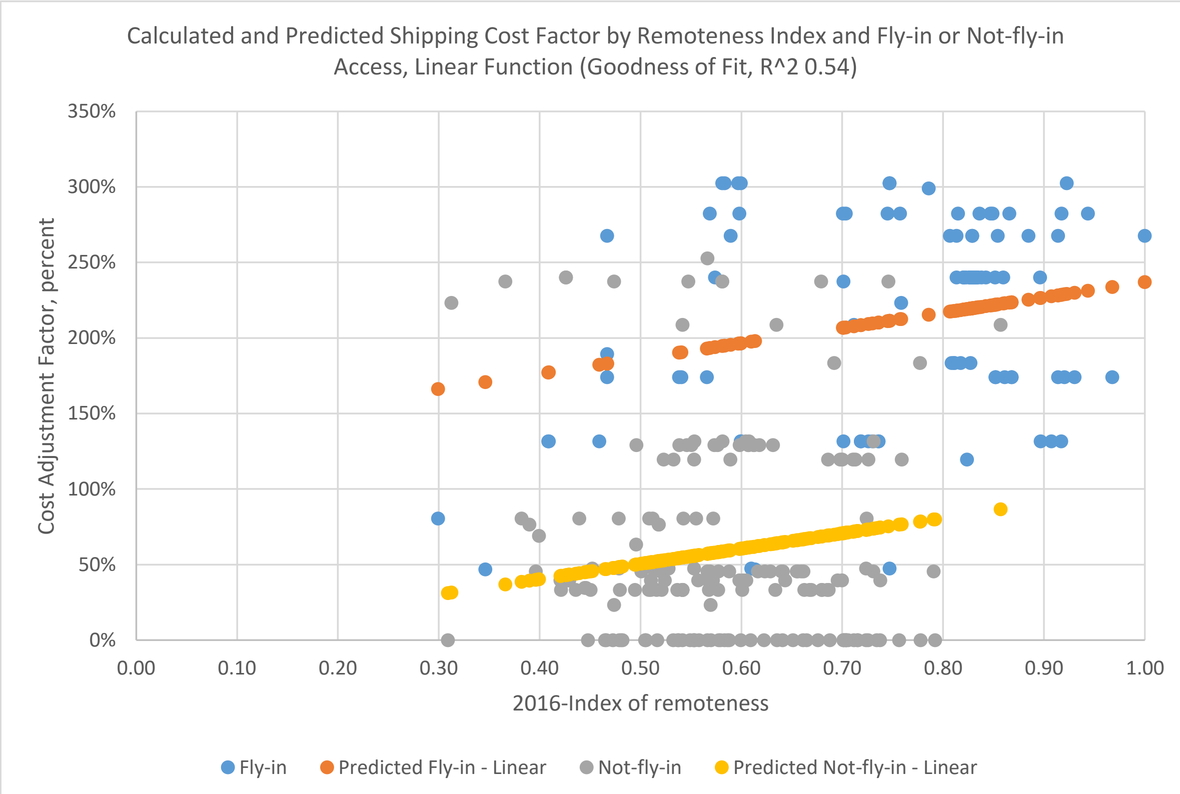


Figure A.5: Calculated and Predicted Shipping Cost Factor by Remoteness Index and Fly-in or Road access.



A.3. Validating the selected functional relationship

Based on the initial exploration of potential functional relationships in the previous section, the preferred functional relationship in this analysis is linear with a dummy variable for fly-in locations and zero intercept:

- Factor = b * x1 + c * x2 = b * Remoteness Index + c * Fly-in

The fitted model has been validated by splitting the Isolated Posts dataset into one part (186 locations) for fitting the model (i.e. training the data) and one part (93 locations) for testing the selected model.[9] For the purpose of this validation, the accuracy score is defined as the sum of squares for the residuals divided by their degrees of freedom. The rule of thumb is that if the accuracy score is less than 2 times the training set core, the fitted model is valid. If the accuracy score is very much higher in the test set, the original model is over-fitted to only match the training data such that it should not be applied to other data even if they are sampled from the same population. For the training dataset the accuracy score is 0.039 for Employment Allowance Factor and 0.433 for Shipping Cost Factor. With

[9] The dataset is split by allocating each Isolated Post a random number between 1 and 278 using Excel's RANDBETWEEN(1,278) function. After sorting the data in increasing order by the random number, the first 186 locations are added to the training set, and the remaining 93 locations form the test set. This is a standard statistical testing for testing the robustness of a model.

the test data, one calculates the two predicted cost factors for each location using the function estimated with the training set. By regressing the predicted versus the observed values, the accuracy score is calculated to be 0.04 and 0.49, respectively (See Table A.4). The test set is 1.03 and 1.13 times higher than the training set. This passes the rule-of-thumb test and validates the chosen functional relationship.

Table A.4: Testing validity of chosen functional relationship

	Training Data Set		Testing Data Set	
	Employment Allowance Factor	**Shipping Cost Factor**	**Employment Allowance Factor**	**Shipping Cost Factor**
Observations	186	186	92	92
Accuracy Score (SS-resid / DF-resid)	0.039	0.433	0.040	0.490
Accuracy Score change			1.03	1.13
Rule-of-thumb test of Accuracy Scores <2:			Test OK	Test OK

Note: - Testing model: Linear, Fly-in dummy, No Intercept. y=b*x1+c*x2
- The test uses the model derived from the Training Data Set to predict the values in the Testing Data Set. The Accuracy Score is the SS-resid (sum of squares for the residuals) divided by the DF-resid (degrees of freedom for the residuals). Compare the Accuracy Score of the two regressions of actual versus predicted values. A large difference greater than 2 in Accuracy Score indicates that the selected model may be over-fitted to the training data.

A.4. Results and validation

The rationale for this analysis is to establish a method for estimating a single Cost Adjustment Factor. An assumed weight between the Employment Allowance and Shipping Cost Factors is taken from the services versus goods split in Canada's GDP – currently at 70% versus 30%. Because the functional relationship has been validated in the previous section, the estimated functions are as follows with the regression results shown in Table A.5:

- Employment Allowance Factor = 0.600 * Remoteness Index + 0.382 * Fly-in
- Shipping Cost Factor = 1.011 * Remoteness Index + 1.360 * Fly-in
- Cost Adjustment Factor = 0.7 * Employment Allowance Factor + 0.3 * Shipping Cost Factor

or directly = 0.723 * Remoteness Index + 0.674 * Fly-in

Table A.5: Final Regression Functions for Cost Factors.

	Employment Allowance Factor	Shipping Cost Factor
Degrees of Freedom	276	276
Correlation (R) - see note	0.77	0.74
Goodness-of-fit (R^2) - see note	0.59	0.54
F statistic	1,161.80	555.92
F-test	3.87E-135	1.60E-97
b	0.600	1.011
c	0.382	1.360

standard error, b	0.024	0.082
standard error, c	0.027	0.092
95% confidence interval, b	0.600 -/+ 0.048	1.011 -/+ 0.162
95% confidence interval, c	0.382 -/+ 0.053	1.360 -/+ 0.181
t-stat, b	24.74	12.27
t-stat, c	14.06	14.75
p-value, b	5.33E-72	6.50E-28
p-value, c	3.03E-34	1.07E-36
Significant at 5% level	b and c	b and c
Function	y1 = 0.60 * x1 + 0.38 * x2	y2 = 1.01 * x1 + 1.36 * x2
Weighted Average	y = (0.7 * b1 + 0.3 * b2) * x1 + (0.7 * c1 + 0.3 * c2) * x2 y = 0.723 * x1 + 0.674 * x2	

Note: - Linear regression function: y= b*x1 + c*x2. x1: Remoteness Index, x2: Fly-in = 0 ; Not-fly-in = 1
- p-values <0.05 indicates that the estimated value is significantly different from zero.
- Note that the correlation coefficient (R) and goodness-of-fit (R^2) indicators are not valid in models where the intercept is set to zero. The R and R^2 indicators reported here are those calculated on the model before forcing the intercept to zero.

Table A.6 shows a number of examples that have different remoteness indices and whether a location is accessible by road/ferry or not (fly-in). For a Not-fly-in location the Cost Adjustment Factor ranges from 22% to 72%; for a Fly-in location, the factor ranges from 89% to 140%. These results may be compared to the results of a cost of living survey of 448 households in Nunavik, Quebec (Robitaille et al, 2018). This survey found that the overall cost of living was 28% higher in Nunavit than in Quebec City. Due to housing costs being relatively low compared to Quebec City, other living costs (food, alcohol, transportation, etc.) were 40-60% higher in Nunavik. The Cost Adjustment Factors in the current analysis are similar to the cost of living survey for Not-fly-in communities. Conversely, the estimated factors for Fly-in communities are considerably higher than what was concluded in the cost of living survey by Robitaille et al. The survey noted that some of the cost differences might have been underestimated for several reasons specific to Nunavik including the already low spending pattern of low-income households, community sharing of game, and some health services that are provided free of charge.

Table A.6: Examples: Use Regression function to calculate Cost Adjustment Factors

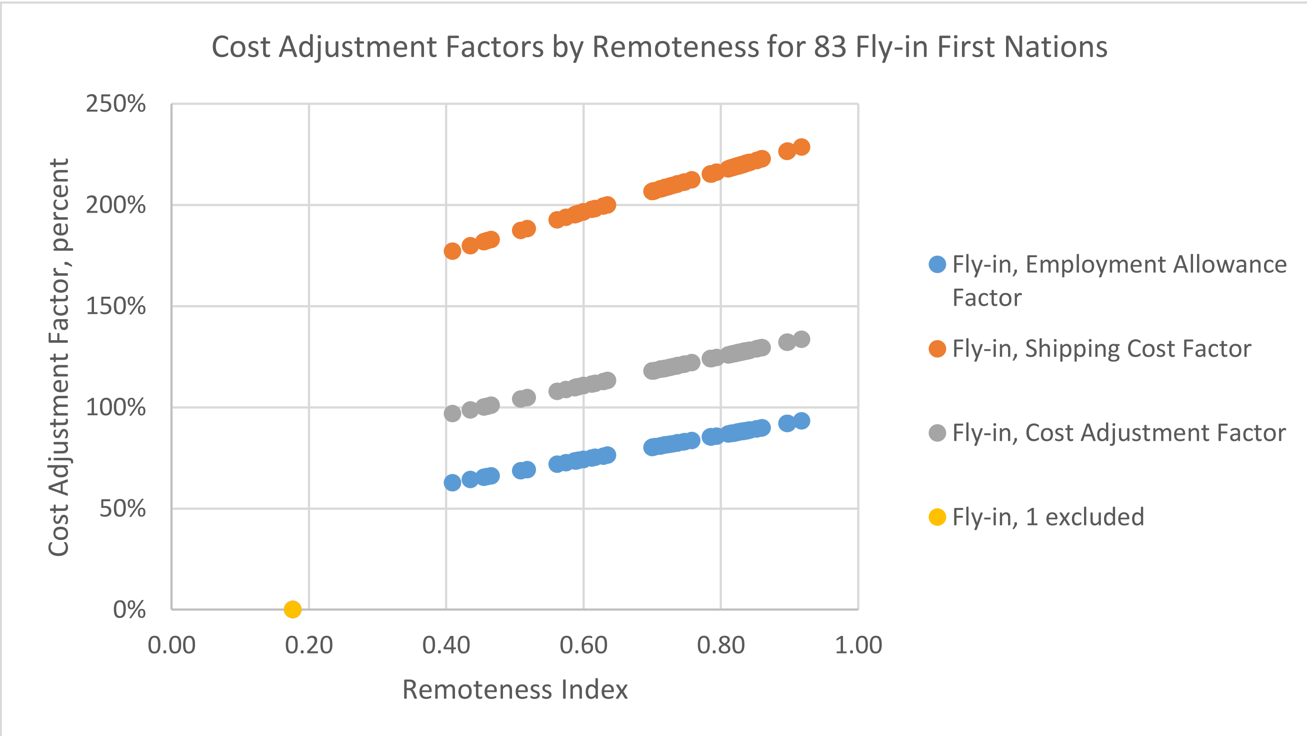
	Not-fly-in Locations Cost Adjustment Factors				Fly-in Locations Cost Adjustment Factors		
Remoteness Index	Employment Allowance	Shipping Costs	Weighted Average	Remoteness Index	Employment Allowance	Shipping Costs	Weighted Average
0.00	na	na	na	0.00	na	na	na
0.31	19%	31%	22%	0.30	56%	166%	89%
0.40	24%	40%	29%	0.40	62%	176%	96%
0.60	36%	61%	43%	0.60	74%	197%	111%
0.80	48%	81%	58%	0.80	86%	217%	125%
1.00	60%	101%	72%	1.00	98%	237%	140%

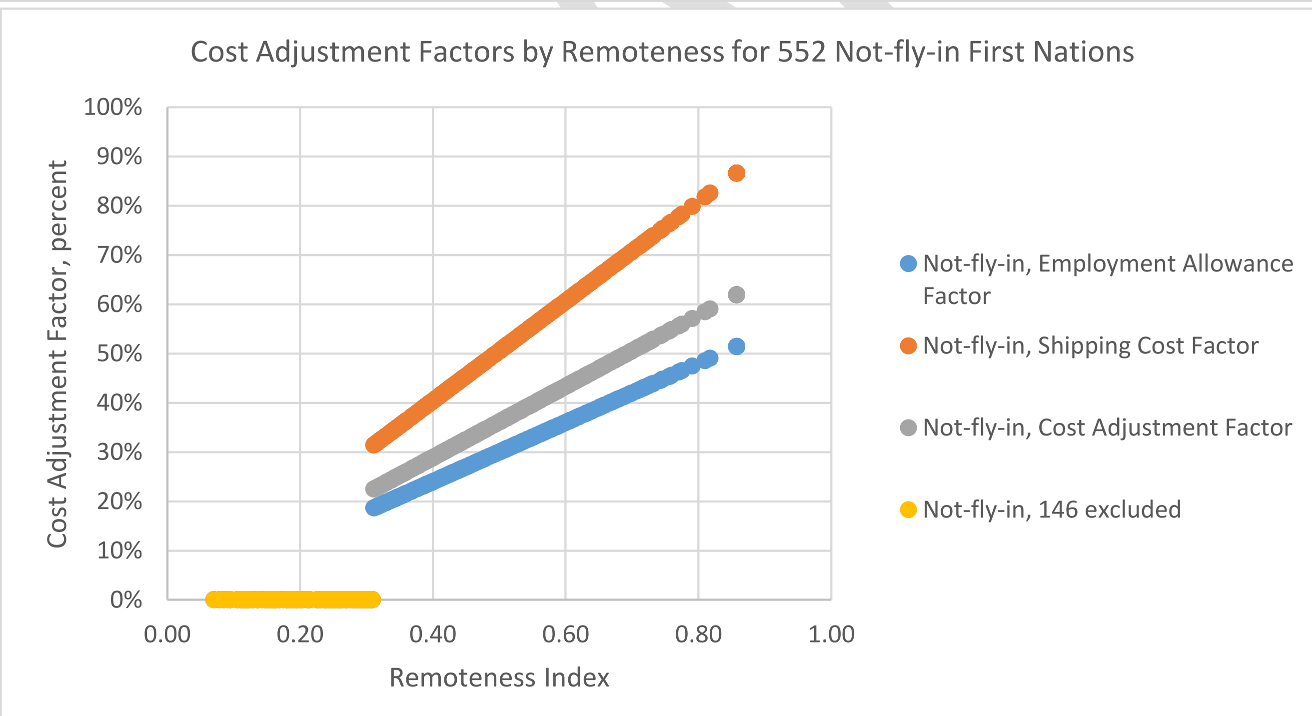
Note: - Best regression function fit – Linear with Fly-in dummy variable:
- Employment Allowance Factor = 0.600 * Remoteness Index + 0.382 * Fly-in
- Shipping Cost Factor = 1.011 * Remoteness Index + 1.360 * Fly-in
- Weighted Average = 0.723 * Remoteness Index + 0.674 * Fly-in
- na – calculation not applicable because source data does not cover locations with Remoteness Index below 0.3.

All Cost Adjustment Factors are plotted for the full list of First Nations in Figure A.6 (see full Data Table B.7 in Annex B). Note that the current Isolated Posts dataset does not cover all possible remoteness indices from 0 to 1. The formula can therefore not be extrapolated to all locations even if it is theoretically possible. The results are not valid for Remoteness Index below 0.30 and for other locations the Remoteness Index must be more than 0.31[10]. This is indicated by “na” notations in Table A.6 and the truncated lines in Figure A.6 that excludes 149 Not-fly-in locations. No Fly-in locations are excluded from the analysis because these have higher Remoteness Indices

[10] This follows the source data (IPGHA) cutoffs (i.e. no isolated post receiving allowances has a remoteness value below 0.3)

Figure A.6: Estimated Cost Adjustment Factors for 635 First Nations, Fly-in and Not-fly-in Locations





Note: - To use the cost adjustment factor, multiply the base funding level by the Cost Adjustment Factor to calculate additional dollar contribution to compensate for remoteness.

An example of how the Cost Adjustment Factor should be applied:

- Assume, a First Nations location has base level funding of $2 million. Its Remoteness Index is 0.8 and it is a Fly-in location.
    - Employment Allowance Factor = 0.600 * 0.80 + 0.382 * 1.00 = 86%
    - Shipping Cost Factor = 1.011 * 0.80 + 1.360 * 1.00 = 217%
- Cost Adjustment Factor = 0.723 * 0.80 + 0.674 * 1 = 125%
- Additional budget amount for remoteness = $2 million * 125% = $2.5 million

Another example of how the cost adjustment factor is used:

- Assume a First Nations location has base level funding of $2 million. Its Remoteness Index is 0.6 and it is a Not-fly-in location.
    - Employment Allowance Factor = 0.600 * 0.60 + 0.382 * 0.00 = 36 %
    - Shipping Cost Factor = 1.011 * 0.60 + 1.360 * 0.00 = 61 %
- Cost Adjustment Factor = 0.723 * 0.60 + 0.674 * 0 = 43%
- Additional amount for remoteness = $2 million * 43% = $867,000

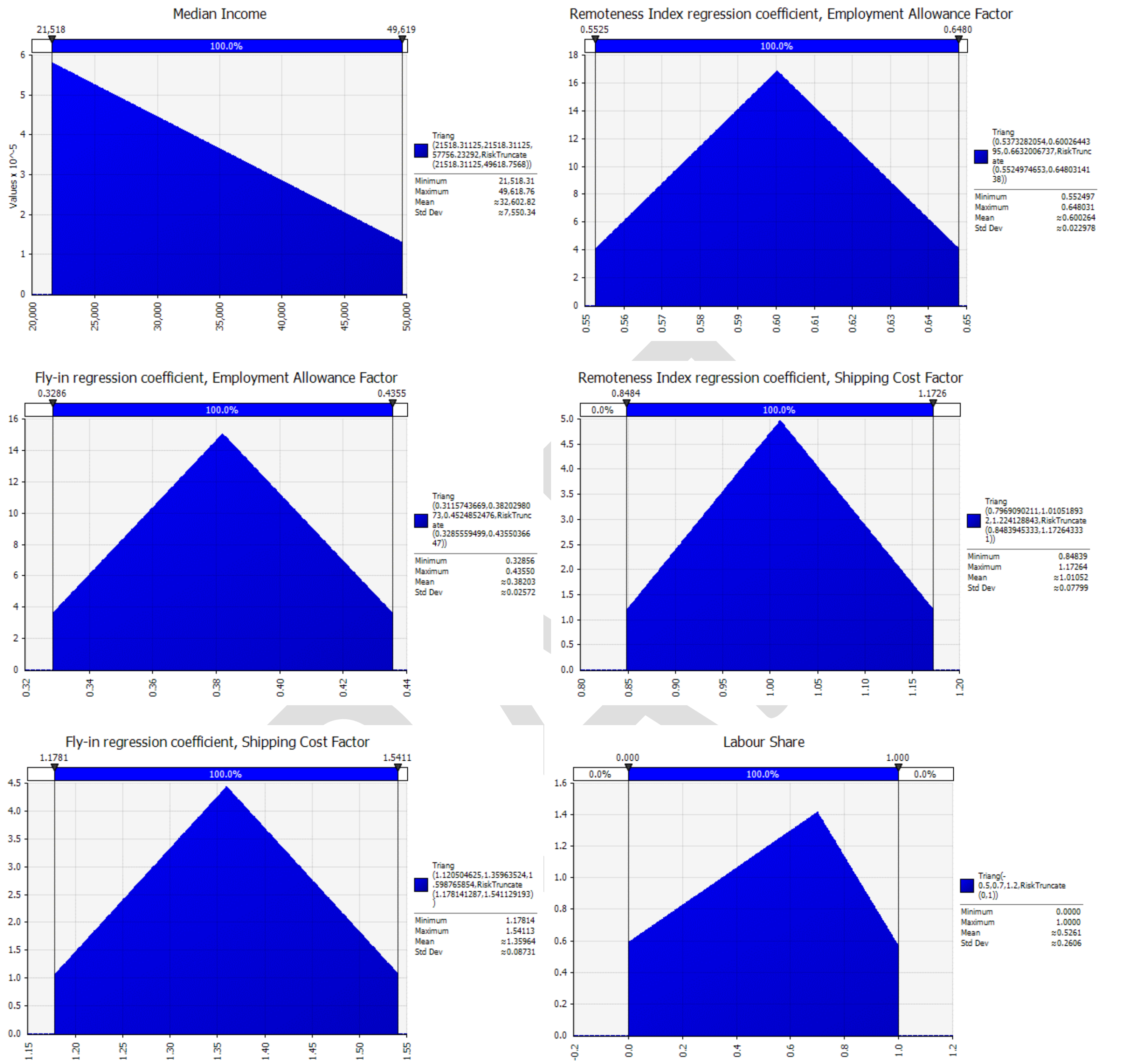
Comparing this new Cost Adjustment Factor to the scaling factors from the *Band Classification Manual* cannot be completed because the current scaling is not consistently applied to the entire base funding amount. Each program determines the proportion of the base funding that is cost-sensitive, thus, requiring an adjustment to capture its remoteness. Currrently, scaling for remoteness varies from program to program and practices are not documented well enough to undertake comparisons for all funding. However, when completed information was available for select programs the comparison has been done and the results show a net increase in cost scaling.

A.5. Risk analysis using simulation

Because of the nature of different programs that fund a wide mix of goods and services, there will always be uncertainty about the actual split between labour and material costs and which weights should be used to reflect these differences. There is also uncertainjty about the median income measure used as a denominator in the Employment Allowance Factor.

To measure the impact of model uncertainties, one could run the model multiple times using different assumptions for these uncertainties. To standardize and automate this type of risk analysis, a commonly used method is to run a Monte Carlo simulation. By defining the possible ranges that the uncertain assumptions can take, rather than just their current most-likely values, the simulation method collects the model results for a selected number of model iterations (for example 50,000 times). Without simulation, the model result is one Cost Adjustment Factor per location. With simulation, the model result is a probability distribution for the Cost Adjustment Factor in each location. This distribution provides us with a range and probability of all possible values for the Cost Adjustment Factor given the model assumptions. Based on an assessment of the overall uncertainty and to allow for the measurable risk, the user can select to apply a Cost Adjustment Factor that differs from the most likely estimate.

Figure A.7. Assumed Probability Density Functions.



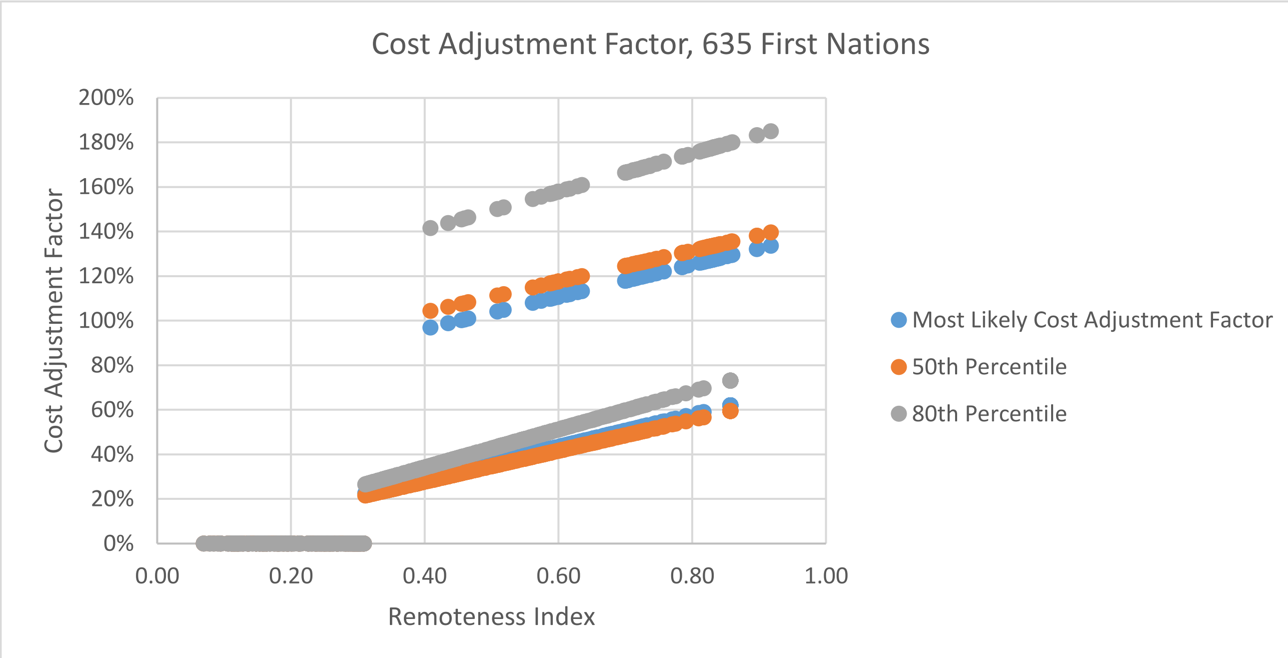
Note: - Median Income Truncated High value is from the Band Support Funding Cost Model, 47,690 $/person/year in 2016.. Maximum value for Median Income approximates 95th percentile of the triangular distribution function.
- Using the regression results in Table 5: Minimum and maximum values for regression coefficients are set equal to their 99% confidence interval. The triangular distributions are truncated at 95% confidence intervals. Confidence intervals = regression coefficient -/+ 1.97 * standard error, where 1.97 is two-tailed inverse of the Student's t-distribution (5%, 276 degrees of freedom). Assumed probability density functions as shown in charts above:

Description	Function	Min	Truncated Low	Most Likely	Truncated High	Max
Median Income, $/person/year, inflation-adjusted to 2018	Triangle	21,518	21,518	21,518	49,619	57,756
Remoteness Index regression coef., Employment Allowance Factor	Triangle	0.537	0.552	0.600	0.648	0.663
Fly-in regression coef., Employment Allowance Factor	Triangle	0.312	0.329	0.382	0.436	0.452
Remoteness Index regression coef., Shipping Cost Factor	Triangle	0.797	0.848	1.011	1.173	1.224
Fly-in regression coef., Shipping Cost Factor	Triangle	1.121	1.178	1.360	1.541	1.599
Labour Share	Triangle	-0.500	0.000	0.702	1.000	1.200

To measure risk, values are assigned to uncertain assumptions in a Monte Carlo simulation analysis. As noted before, the most likely estimate for the Employment Allowance Factor denominator is the “Median income for First Nations single identity, Registered Indians, living on reserve” ($21,518/person/year). Figure A.7 shows the assumption that this estimate may be low and a triangular distribution is used and truncated at $49,519/person/year, inflation-adjusted to 2018 dollars from data for average on-reserve income from the the Band Support Funding (BSF) Cost model (FMC Professionals, 2018). As illustrated in Figure A.7, the four regression coefficients are given triangular distributions with their current estimates as the most likely value and their ranges are informed by the regression results in Table A.5. Minimum/maximum values are calculated from the 99% confidence interval for each regression coefficient and the distributions are truncated at the 95% confidence intervals. The truncation is done to ensure a more complete sampling of the full 95% confidence interval. The labour share is included as a triangular probability distribution truncated at 0 and 1, with most likely value being 0.7. The truncation is done to ensure that sampling covers the entire range of the labour/material-mix.

Figure A.8 shows Cost Adjustment Factors for different locations with the simulation results illustrated by their 50th and 80th percentiles. A closer inspection of the detailed data behind the figure shows, for example, that a Fly-in location with a Remoteness Index of 0.7 has a Cost Adjustment Factor of 118% - this increases to 124% for the 50th percentile. If the location has a base level funding of $1 million, the expected adjustment for remoteness would be $1.18 million or $1.24 million to include the 50th percentile. By comparison, a Not-fly-in location with a Remoteness Index of 0.60 has an expected Cost Adjustment Factor of 43% (close to the 50th percentile). This increases to 53% at the 80th percentile. If this location has a base level funding of $1 million, the expected adjustment for remoteness would be $430,000 at the 50th percentile or $530,000 at the 80th percentile. The increase required to reach the higher percentiles is larger in Fly-in locations because of greater differences between the two underlying cost factors (proxies for employment allowance and shipping).

Figure A.8: Weighted Average Cost Adjustment Factor, expected vs 50th and 80th percentile, 635 First Nations.



Note: - Results from Monte Carlo Simulation with Latin Hypercube sampling and 50,000 iterations and initial seed of 67247 (random number to ensure same result each time simulation is run).
- See Figure A.7 for detailed distribution assumptions.

A.6. Closing comments

The model documented in this report combines easily accessible data from existing sources. The estimated equation for the Cost Adjustment Factor is statistically significant, validated to not be over-fitted, and provides expected values that appear plausible compared to the very limited number of available comparative data. Further comparisons could be done to validate the results when more comparable studies are identified.

Based on the model developed in this paper, some cautionary notes about using a Cost Adjustment Factor are provided.

- To estimate a Cost Adjustment Factor for any given location, one must know the location's CSD number to identify its Remoteness Index and transport infrastructure classification.
  - Further assumptions need to be made to apply Cost Adjustment Factors to First Nations Band locations that span multiple CSDs – with different Remoteness Indices and are both Fly-in and road accessible. See the current approach in Annex B Data Tables B.6 and B.7.
- The Cost Adjustment Factors might not be appropriate to all funding:
  - A comparison of actual to predicted values (in some charts) indicates that not all cost differences in the Isolated Post or shipping cost data are explained by remoteness. Actual costs of remoteness are higher in some locations and lower in other locations. Statistically, this uncertainty is expressed by the goodness-of-fit being less than 100%

(54 and 59% for the two cost factors, respectively. However, the correlation coefficients (77% and 74%) are strong.
    - Cost factors are not comprehensive measures of different costs of labour and materials incurred outside a location (example: healthcare and post-secondary education programs).
    - Use of a weighted average for the employment costs on the shipping cost factors requires information about the split between these in the base funding amount. Better approximation of this split may become available other than the GDP split between goods and services. Note that this uncertainty is incorporated directly in the simulation analysis.
- Results may underestimate the required cost adjustment if background data already include adjustments for remoteness:
    - Using median income by province and territory as a denominator may underestimate the Cost Adjustment Factor if these incomes already reflect elements of remoteness. As such, the chosen denominator is the national median income, but that, too, to some extent, is influenced by higher incomes in some remote areas.
    - Multiplying the Cost Adjustment Factor by the base funding amount assumes that the latter has not been adjusted for remoteness already.
    - The factors exclude inflation and do not need annual adjustment for inflation. The Cost Adjustment Factor should be applied before any inflation adjustment and then escalated for any future price growth.
- The shipping Cost Factor is based on a specific assumption and available data:
    - Factors in addition to remoteness may contribute to the variation in shipping cost across locations. Statistically, the goodness-of-fit is 54% and correlation coefficient is 74%.
    - Using Canada Post cost differential data for standard shipping of 10 kg box (10 inch cube) assumes that the same cost differential ratio will apply for smaller and larger shipments. It provides an upper limit estimate of costs as commercial shipping most likely can obtain better rates as would be the case with government Arctic re-supply programs. Cost estimates from private sector shipping companies could be explored to identify different results.
    - The calculation does not attempt to incorporate an additional value of the time the shipment takes to reach remote locations. This is assumed to be reflected in the cost.
    - Collecting more relevant data from a cross section of First Nations will be costly if one wants to ensure standardized and comparable measurements. If more data were to be collected, however, it could replace both the Isolated Posts and shipping costs data.
- While it is theoretically possible, extrapolation to the least remote locations should be avoided:
    - The Cost Adjustment Factors should not be applied to locations outside the input data range (i.e. with a remoteness level less than 0.3). The NJC-negotiated list of locations for IPGHD currently does not classify any of those locations as Isolated Posts in need of employment allowances for remoteness. Due to the wide coverage in the 278 Isolated Posts data points, this only excludes the least remote locations (Remoteness Index < 0.30 for Fly-in locations and <0.31 for Not-fly-in locations). When applying the new Cost Adjustment Factors to all First Nations, 147 less remote Not-fly-in locations would be excluded and in effect given a zero adjustment factor.

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Statistics Canada. Table 36-10-0434-01 Gross domestic product (GDP) at basic prices, by industry, monthly (x 1,000,000)

Statistics Canada. Table 36-10-0104-01 Gross domestic product, expenditure-based, Canada, quarterly (x 1,000,000)

Background Working Papers by Technical Working Group for “Remoteness of First Nations Communities: How to Measure It and Adjust Funding”:

- ISC – Remoteness Research Scoping Paper
    - NCR-#10553691-v4-CFRDO_-_NFR_-_REMOTENESS_-_SCOPING_DOCUMENT.DOCX, 27 Jun 2018
- Australian Remoteness Index
    - Australian Remoteness Index - Case Study .docx, 27 Jun 2018
- Ontario Ministry of Education Cost Adjustment for Rural and Remote Schools
    - Education Index - Case Study.docx, 27 Jun 2018
- ISC Remoteness Index
    - ISC Remoteness Index - Case Study.docx, 27 Jun 2018
- Isolated Posts Index
    - Isolated Posts - Case Study .docx, 27 Jun 2018
- NRCan Remoteness Index
    - NRCan Remoteness Index - Case Study.docx

Associated Excel Model Files

Model: ISC_Cost_Adjustment_Remoteness_Model_30Aug2018.xlsx

Online Video Demonstration of Excel Model

Web link: http://www.rygnestad.net/business/ISC/index.php
Username: ISC_User Password: Up&Down_2018