Road development, income, unemployment and crime: evidence from Arctic Canada*

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Abstract

14% of the world's population lives more than 2 km from an all-season road. From 1974 to 2017, a winter ice road was the only ground transportation from Tuktoyaktuk, Northwest Territories, to Inuvik, the regional centre and subsequently the rest of Canada. On November 15, 2017, the Inuvik-Tuktoyaktuk Highway (ITH) opened, allowing people to travel to the community year-round (Government of the Northwest Territories, 2010). I use a synthetic control analysis to study the impact of the causal effect of the opening of the ITH on crime, income, employment and population. I find non-positive results for income and employment outcomes and mixed results for crime outcomes. This contributes a new context and a new methodology to the literature on the economic impacts of new road development. It gives insight into locally important socioeconomic measures to provide an understanding of a broad set of outcomes that contribute to well-being.

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JEL Codes: J15, J21, K14, O18, P25, R23
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1 Introduction

14% of the world's population lives more than 2 km from an all-season road (Wenz, Weddige, Jakob, & Steckel, 2020). Globally, road development is often cited as a means for isolated and remote communities to facilitate economic development (Foster, Gorgulu, Straub, & Vagliasindi, 2023). In Canada, winter roads are the primary overland infrastructure for 52 remote Indigenous communities (Salles, Mullan, Spagnolo, & Catney, 2025), and there is a total of 8,000 km of official winter roads (Government of Canada & National Research Council Canada, 2025). Winter roads facilitate shipping of bulk and heavy items such as building materials and fuel, provide links for remote communities to access southern amenities, and aid in resource extraction activities (Barrette, Hori, & Kim, 2022). These roads exist on a combination of frozen ground and ice that forms on rivers and lakes. This natural construction is distinctly vulnerable to climate change, which has been happening at a faster pace in polar regions (Barrette et al., 2022; Zhang, Chenier, & Roghani, 2024). The Indigenous population in Canada sees lower socio-economic outcomes than non-Indigenous Canadians (Government of Canada & Indigenous Services Canada - Geomatics Services, 2023). Given the combination of potential economic opportunities and the knowledge that current infrastructure is highly vulnerable to a changing climate, there is ongoing policy discussion about expanding year-round overland infrastructure in Canada (Senate of Canada, 2017, 2016).

The Inuvik-Tuktoyaktuk Highway (ITH) was born out of the desire for local economic opportunity (Bennett, 2018). It connects Tuktoyaktuk, a predominantly Inuit hamlet of 900 people on the Arctic Ocean, to Inuvik, the regional centre. Stretching 138 kms, the opening of the ITH in November 2017 was the first time Tuktoyaktuk had year-round overland access to a hospital, pool, and other amenities in the regional centre of Inuvik (GNWT Finance, n.d.). As the only public road to the Arctic Ocean in North America, the ITH created the first connection in Canada to its northernmost ocean, and gave those in the south a chance to dip their toes into the Arctic waters. A tourist rush ensued with reports of 30 to 50 tourists coming through Tuktoyaktuk a day in the first summer the road was open (Scott, 2018). Impact assessments and development reports promised economic development opportunities

through tourism and resource extraction. Fears of increased crime tempered the hope of these economic opportunities, and changes to access of traditional hunting, fishing, and wild plant harvesting activities (Bennett, 2018).

This paper seeks to understand the effects of the Inuvik-Tuktoyaktuk highway on those living in Tuktoyaktuk. I focus on population, income, labour force and crime outcomes using a synthetic control research design. I study these outcomes because of their relevance to those living in Tuktoyaktuk and their feasibility given the synthetic control design. The synthetic control method is an ideal method for understanding this question because it considers a single treated unit at an aggregate level, making explicit counterfactual weights, allowing for causal understanding of an important and immediate policy question – how effective is all season road development for community socio-economic improvement in Arctic Canada – in a context where there are limited numbers of possible controls, a single treatment and relatively infrequent data available at a local and control unit level.

There is a general assumption that new transportation infrastructure creates positive economic outcomes. There is evidence of a positive relationship between transportation infrastructure and national and regional GDP (Banerjee, Duflo, & Qian, 2020; Jaworski & Kitchens, 2019), employment (Fiorini & Sanfilippo, 2022; Lei, Desai, & Vanneman, 2019; Frye, 2024), improved consumer choice (Aggarwal, 2018; Wiegand, Koomen, Pradhan, & Edmunds, 2023) improved gender outcomes (Lei et al., 2019; Anti & Zhang, 2023).

One cannot infer from the existing literature, however, that transportation is ubiquitously positive, particularly when looking at newly created rural roads. A 2023 meta-analysis of papers on the effects of road development found that though outcomes were firmly positive in sub-Saharan Africa, that was not the case when looking at studies in Asia and Latin America (Foster et al., 2023). Asher and Novosad (2020) find that impacts on local incomes, wages, and wealth are ambiguous four years after a major rural road development initiative in India. There is evidence of heterogeneous effects across income, skill and sector dimensions. Banerjee et al. (2020) find increased income inequality after new railroad development in China, results that are echoed in Chatterjee et al. (2025) who find skill premiums increasing in labour markets in India with increased road development, no association between road development and increases in employment for high or low skilled labour and in Perra et

al. (2024) who find heterogeneous outcomes between formal and informal labour markets in Ethiopia. There is also evidence of geographic heterogeneity. Faber (2014) found that urban connector communities realize economic benefits, but this may come at the cost of economic development in communities peripheral to the new transportation infrastructure. Jaworski and Kitchens (2019) find substantial leakages from the Appalachian region after major highway development through the region starting in 1965. Gachassin et al. (2015) find heterogeneous effects on poverty reduction from new road development in Cameroon depending on local characteristics and levels of isolation. They suggest that it is not the road itself that reduces poverty but the facilities and services that often follow road development. In Brazil, Bird and Straub (2020) find different effects of road development on GDP and local labour markets depending on where a connected community was on the road network and its relative market size.

Road development impacts aspects of life that are not directly economic outcomes, and studies that incorporate the effects on the environment and measures of subjective wellbeing indicate a new road may not be net-positive for a community, even if economic outcomes such as income and employment tend to be improving. A pan-African study by Djemaï et al. (?) finds differences in material and subjective wellbeing after new transportation infrastructure. They found higher material wellbeing, but no changes in subjective wellbeing, pointing to the nuance of the many aspects of life that transportation impacts. Reyes-García et al. (?) find mixed opinions from Indigenous people in Bolivia about the effects of new road development, depending both on community location and the income level of the individual's family. In the tropical rainforest context of the Democratic Republic of Congo, new road development leads to deforestation in many areas (Damania & Wheeler, 2015; Damania, Russ, Wheeler, & Barra, 2018).

Arctic road development in Canada has its own small body of literature. Like the global literature, there are patterns of benefit in some areas, and ambiguous change in others. Stringer and Joanis (2022) find positive correlations between road connection, employment rates, and education in Nunatsiavut and Nunavik, though they do not find robust effects on income. Relating directly to the ITH Fellows et al. (2022) consider the decrease in remoteness, as measured by the Canadian Remoteness Index, as a predictor of economic

outcomes. They predict that the ITH would increase incomes and high school graduation rates without statistically significant changes to violent and property crime. Kenney et al. study the effects of ITH on food prices and find prices in Tuktoyaktuk rose compared to an adjacent ice road community after the opening of the ITH due to a loss of food subsidies to the community (Kenny et al., 2025).

Much of the previous literature has relied on large national or regional infrastructure programs. This paper contributes to the literature by applying synthetic control to a unique circumstance of new road development that would otherwise not be feasible to get causal evidence from. The synthetic control method provides the ability to study a context where there are limited numbers of possible controls, a single treatment and relatively infrequent data. The specific context of the ITH is worth considering because of its unique context as a remote region of a high-income country. This context includes substitutes for overland transportation, such as barges and planes. The community and region are primarily Indigenous, with a large proportion of the population participating in traditional land-based economic activities. Given the heterogeneous results found elsewhere in the world, this new context provides insight into when and where new road development might benefit a community and when the results might be neutral or negative. This paper also contributes to the broader literature by studying multiple outcomes that are of interest to the community. Particular to these outcomes are the impact of roads on crime, an area of anticipated increase, which, if economic outcomes appear positive. However, crime also rises, may mean the creation of a road is not net positive for a community in an overall sense.

The rest of the paper proceeds as follows. Section 2 provides the context of the ITH, Tuktoyaktuk and Inuvik, and the Inuvialuit Settlement Region. Section 3 motivates the outcomes of interest based on community hopes and concerns about the effects of the ITH. Section 4 outlines the methods used. Section 5 describes the data and its sources and Section 6 discusses the results and concludes.

2 Context

Canada is one of the largest countries by land area. However, most of its population is concentrated in the south, with two-thirds living within 100 km of the southern US-Canada border (Government of Canada, 2017). This leaves millions of kilometres for the other third of the population, where overland infrastructure is increasingly sparse as networks move North. The Canadian Territories have only four highways connecting them to southern Canada. Many communities don't connect year-round to these highways and either have ice roads, summer barge access or are fly-in only.

The Inuvik-Tuktoyaktuk Highway connects Tuktoyaktuk, a hamlet of approximately 900 people on the coast of the Arctic Ocean, to Inuvik, a regional centre with a population of approximately 3000 (Government of Canada, 2022), and the rest of Canada. Inuvik connects to the southern highway network via Dempster Highway, a 740 km gravel highway. The closest Census Metropolitan Area (Statistics Canada's designation of larger population centres) is Prince George, BC, 2 844 km away by road (Google, 2024). Figure 2 shows the roads between Tuktoyaktuk, the Yukon, British Columbia and Alaska.

Tuktoyaktuk and Inuvik are both located in the homeland of the Inuvialuit, the westernmost Inuit group in Canada. Land use is governed by, among other things, the Inuvialuit Final Agreement, which was the second comprehensive land claim agreement (or modern treaty) signed in Canada in 1984. The agreement covers 435 000 square kilometres, an area slightly smaller than Sweden, with 20% of the land owned by the Inuvialuit, including 12 980 square kilometres where this ownership extends to subsurface mineral rights (Government of Northwest Territories, n.d.).

Tuktoyaktuk is a primarily Inuvialuit community whose name means 'resembling a caribou' in Inuvialuktun. It was used as a fishing and caribou harvesting place for Inuvialuit before it was made a permanent settlement in 1905 due to the shore's natural harbour near the mouth of the Mackenzie River. This made it a useful location for fur trading boats and an easy place to receive community supplies. The town boasts of a blend of traditional and modern lifestyle. Land-based activities are important to a large proportion of the community, with most community members actively engaged in land-based economic activity. 55.4%

of people said they fished in 2019 and 55.3% of people said they gathered wild plants in 2019, and 38% of households obtained 75% or more of their meat and fish through wild harvest (Northwest Territories Bureau of Statistics, 2019). A sense of community is high in Tuktoyaktuk, with 84% of people saying they were “satisfied with their sense of belonging" and 74% of community members saying they were “overall satisfied with the community they call home". This satisfaction does not extend to employment opportunities and cost of living, with only 17% and 24% of people being satisfied with these, respectively, in 2019. Food security and financial security are seen by residents to be concerning, with 31% of households being worried about making ends meet, and 44% of households being worried about having enough money for groceries (Northwest Territories Bureau of Statistics, 2019). In 2013, at the start of road construction, Tuktoyaktuk had a health centre with four nurses, six community police officers, two grocery stores and no banking institution or ATM. The majority of housing was public housing rented by community members (167 out of 284 dwellings). (Northwest Territories Bureau of Statistics, 2013)

3 Motivation of outcomes studies

Understanding all the socio-economic effects of a new all-season road is inherently broad to the point of being unwieldy. In an ideal world the richest possible set of variables would be used to understand all the areas of life that have seen benefits due to the opening of the ITH, and what areas have been negatively affected by its opening. To hone in on a feasible set of outcomes to study in this context two main factors are considered. First, how relevant are outcomes to those living in Tuktoyaktuk, to those making policy about all season road building and the overall economic literature; Second, is it feasible to study these outcomes given the data available. To this end, labour force, income, and crime variables are used in this analysis. All data is aggregated at the community level.

Community members hopes and fears about what a new all season road might bring to Tuktoyaktuk and the Beaufort Delta region has been recorded in economic and environmental assessments, and academic literature. Bennett (?) interviewed community members about the creation of the road, how it was funded and what they thought about the possible

benefits and harms it might cause the community. Her study found mixed feelings on the ground about what the road might bring. Some interviewees were hopeful that prices would fall, access to medical, mental health and recreation services would increase, and incomes would rise. Bennet also recorded anxieties that a road would open up bootleggers for drugs and alcohol – Tuktoyaktuk is an alcohol-restricted community with only approximately two litres of spirits allowed to be brought into the community at a time unless there are special circumstances (GNWT Finance, n.d.). This is echoed in the review of the ITH development proposal done by the the Inuvialuit and Government of Northwest Territories co-managed Environmental Impact Review Board citing concerns about access to harvesting and increased access to drugs and alcohol (Environmental Impact Review Board, 2013).

Economic and environmental assessments anticipated the ITH increasing economic activity. This would happen first during construction, with a boom in employment estimated around 1000 full time equivalent jobs, and then a lower level of increased economic activity after the completion of the road. The anticipated drivers of economic activity were increased activity in tourism, the potential for Tuktoyaktuk to become an Arctic port, and oil and gas sectors. In the first 45 years of the highway opening there was an estimated increase in GDP of $27 million in the NWT (Environmental Impact Review Board, 2013; GNWT Department of Transportation, 2010).

The Environmental impact review board indicated strong community support for the project because of the jobs and training that would come with it. Particularly, the need for employment and income to increase participation in traditional harvesting activities, and thereby increasing cultural activity was particularly important. (Environmental Impact Review Board, 2013). Community concerns were that with this increase in tourism there would be increase disturbance of traditional areas by tourists, which might impact harvesting and traditional land use. Noted in the report is the likely long run effects on culture a road might bring, some of which would be hard to mitigate once detected.

In 2010, the Government of the Northwest Territories commissioned a report on the anticipated economic impacts of the Inuvik-Tuktoyaktuk Highway (GNWT Department of Transportation, 2010). Their focus was on the effects on jobs and GDP both in the Northwest Territories and in Canada. They anticipated a net rise in both Canadian and Northwest

Territories GDP, with an increase in one-time jobs for construction in the territory. The report noted an anticipated decline in jobs and income previously needed for winter road maintenance and freight flights. These declines were anticipated to be offset by decreased cost of living and jobs created by increased oil and gas development and increased tourism. The report anticipated a price reduction of 10%. Tourism was anticipated in this 2010 study to increase by 500 tourists a year, spending $2935 in the region each visit. This study, looking at on-the-ground effects, considers the job creation and local incomes. Looking at changes in Inuvik also allows us to take a broader regional look at income and job creation, though notably, this analysis falls short of being able to identify changes in Canada and NWT overall jobs and GDP.

Fellows et al. (2022) study the anticipated effect on community outcomes in Tuktoyaktuk using the change in remoteness index - a Statistics Canada measurement of community connectedness - to predict what would happen in Tuktoyaktuk once the Inuvik-Tuktoyaktuk Highway opened and Tuktoyaktuk's remoteness level declined. They predicted positive results for incomes, with a weaker positive effect on labour force outcomes. They predict better housing results and higher high school education attainment but lower Indigenous people speaking Indigenous languages. They cannot draw conclusions on the effects of the road on birth and death rates. They consider crime in the same five categories I will highlight, and only find a positive and significant predicted effect for 'Other Criminal Code Violations'.

The above reports and studies consider many aspects of socio-economic well-being in both Tuktoyaktuk and Inuvik. Most of these aspects are measured in some way by the Northwest Territories Statistics Bureau or the Canadian Census. However, to run this analysis, data used in synthetic control must be available and aggregated at the community level across treated and control communities, have had a long enough time horizon post-treatment for outcome changes to be realized, and have enough pre-treatment periods for a reasonable estimation of community weights from pre-treatment data This limits the analysis, as certain important outcomes - such as education or retaining an Indigenous language - may not meet the post-treatment requirements. Other variables may not have the frequency of occurrence to produce meaningful results.

4 Methods

The building of the Inuvik-Tuktoyaktuk Highway provides a case study of happens when a community goes from having seasonal overland access to year-round overland access. In this circumstance there is only one treated unit, and the data available for study is available either annually, or every 2-3 years. This poses a few issues for empirical analysis. One such issue is how to choose an appropriate control group that would be considered a valid proxy for Tuktoyaktuk and Inuvik if the road had never opened. Another is what to do about a small sample size given limited post treatment years. These circumstances make synthetic control a useful tool for determining the causal effect of the creation of the Inuvik-Tuktoyaktuk Highway.

The synthetic control methodology is a form of comparative case study, not unlike difference in difference estimation. In a standard difference in difference, either an adjacent community or an equal weighting of several other communities would serve as the control. The synthetic control methodology uses a pool of eligible control communities and weighs them according to how similar pre-treatment outcomes are to the treated unit. This methodology is particularly useful for studying the effects of the Inuvik-Tuktoyaktuk Highway. The Inuvik-Tuktoyaktuk Highway is a single intervention, and the other possible counterfactual communities are heterogeneous in their similarities to the treated communities. Only using one community means we lose potential information that other communities could provide. Using all of the communities with equal weight may mean that we are adding irrelevant information and losing a tight pre-trend fit. In this circumstance, a weighted combination of communities will likely serve as a better control than any single community, or an equal weighting of all possible communities.

4.1 Syntehtic Control

As in Abadie, Diamond and Hainmueller (2010, 2015), I consider $J+1$ communities, where $j=1$ is the treated community - this is either Tuktoyaktuk or Inuvik. Other communities used to create the weighted counterfactual are indexed $j=2$ to $j=J+1$. The full time period spans $t=1,...,T$, with T_0 pre-periods and T_1 post periods, with treatment occurring

at time $T_0 + 1$, and $T_0 + T_1 = T$.

I estimate how outcomes in the treated community, Y_{1t}, differ from the predicted outcomes of the synthetic control counterfactual, Y_{jt} for $j \neq 1$, constructed as a weighted combination of all the other communities, with weighting $W = (w_2, ..., w_{J+1})$:

$$\tau_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j Y_{jt} \tag{1}$$

Pre-intervention characteristics are represented by a $k \times 1$ vector X_j. This includes lagged outcome variables. The optimal weights W^* come from the solution to minimizing the sum of squared differences between treated pre-intervention characteristics and non-treated pre-intervention characteristics. These characteristics are similarly weighted by vector v_m. This means we are seeking to find W^* that solves:

$$min \sum_{m=1}^{k} v_m (X_{1m} - X_{0m} W)^2 \tag{2}$$

V is chosen to maximize the predictive power of our pre-intervention characteristics. I use the V^* that minimizes the mean squared prediction error (Cuninnigham, 2021):

$$min \sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{J+1} w_j^*(V) Y_{jt} \right)^2 \tag{3}$$

(?) outlines a set of requirements for the appropriate use of synthetic control methods. (1) For the synthetic control estimator to detect changes in outcomes, the effect must be large compared to the normal volatility of the outcome. If an outcome only has a small effect or, under normal circumstances, would vary substantially, the synthetic control estimator won't be able to estimate the change. (2) There needs to be small differences in characteristics between the treated and control communities, such as convex hull conditions. That is, the communities that make up the donor pool need to be able to approximate the treated community's pre-treatment characteristics. (3) There needs to be an adequate comparison group to compare the treated community to. (4) There cannot be interference from the treatment and (5) no anticipation. (6) There needs to be a combination of units not effected

by treatment that can adequately predict pre-treatment characteristics of the treated unit - the *convex hull condition*. (7) An adequate time horizon needs to be available for outcomes to be realized and there needs to be adequate data collection on these outcomes. (8) There needs to be adequate data on predictors and outcomes aggregated at the community level. Finally there needs to be sufficient (9) pre-treatment and (10) post treatment.

Choosing a pool of counterfactual communities needs to meet requirements 2-4. I exclude Fort McPherson and Tsiigehtchic for all of my analyses. These are both on the Dempster Highway, which connects the Inuvik Tuktoyaktuk Highway to the rest of Canada, and I would anticipate spillover effects in these communities. For the same reason, when considering Tuktoyaktuk as the treated unit I exclude Inuvik and vice versa. The main specification draws from a pool of 17 of the communities in the Northwest Territories. This includes every community that consistently has a population of over 100[1]. For crime outcomes, only communities with a police detachment are included. Communities that are along the Dempster Highway - the connecting road network to the ITH - are excluded because of anticipated spillovers. Łutselk'e is excluded from employment analysis because of missing data. Whati is excluded because it obtains an all-season road shortly after Tuktoyaktuk during the study period. Generally, I find the results to be similar between the two donor pool analyses. The complete set of ice road community donor pool results are presented in an appendix as robustness, unless they lead to different conclusions than the main results, in which case they are presented in the main text.

The Inuvik-Tuktoyaktuk Highway opened in November 2017, but construction began in 2014, which is likely to violate requirement 5, no anticipation. Anticipated effects are more likely to impact certain outcomes compared to others, for instance road construction was anticipated to create 1,086 one-time jobs (GNWT Department of Transportation, 2010), so the income and employment effects are likely to be seen before the opening of the road. Using the earlier treatment date however may also be inappropriate, as issues arise with calculating the mean squared prediction error ratios if treatment is set either too early or too late. If treatment is set too early, the prediction may do quite well from 2014-2018 because no change has occurred, making the MSPE ratio too low because we have overestimated the fit in the

[1]Data is suppressed for communities with a population of less than 100, and therefore cannot be used.

post-treatment period. Two issues arise if treatment occurs in 2014, but it is specified that it will start in 2017. The first is that the MSPE in the pre-period may be too large if outcomes are already changing. The MSPE ratio will once again be underestimated. The second issue is that the weights on control communities may reflect a closer post-treatment fit than a pre-treatment fit. To mitigate this, separate analyses are run using both 2014 as T_0+1 when road construction began and 2018 as $T_0 + 1$, the first year the road came into year-round effect. The main results for income and employment use 2014 as a treatment year. This is because of the anticipated job creation related to road construction. The main results for crime outcomes use 2018 as the treatment year, as this is the point where entry and exit from the community changes. Results using alternative treatment times are presented in the appendix unless conclusions differ substantially, in which case they are presented in the main text.

4.2 Inference

Because I only consider a single treated unit, standard confidence intervals constructed under the assumption that large sample statistics are likely to be inappropriate. Abadie, Diamond and Hainmueller (2010, 2015 & 2021) propose inference based on permutation techniques. They set up a set of placebos by comparing all the other counterfactual units ($j = 2$ to $j = J + 1$) to the synthetic control. The synthetic control analysis is then done for each community in the donor pool, including the treated community - either Tuktoyaktuk or Inuvik - in the pool. This creates a distribution of placebo outcomes. If the treated unit falls to the extreme of these other placebo units, there is evidence that treatment has affected the outcome compared to the control.

To formally test this I once again follow Abadie, Diamond and Hainmueller (2010, 2015 & 2021) who compare the pre-treatment fit of the predicted synthetic control to the realized outcomes to the post-treatment fit. Like them I use the mean squared prediction error (MSPE) to judge the goodness of fit between the synthetic control and realized data. This is the squared difference between the predicted outcomes ($\hat{y}_t$) and actual values of those outcomes (y_t) in time t: MSPE $= 1/n \sum_{t=1}^{n}(y_t - \hat{y}_t)^2$. The ratio of the post-treatment and the pre-treatment MSPE measures how much the outcome has differed from the predicted

outcomes in the later period compared to the earlier one. A higher MSPE ratio means the post treatment fit is much worse than the pre-treatment fit. If the treated unit has a much greater MSPE ratio than the placebos this is evidence that the change in outcome is due to treatment. To calculate p-values for the estimated result the MSPE ratio is ranked compared to the placebo MSPE ratios. The p-value becomes the number of communities with a higher MSPE ratio than the treated community, divided by the full donor pool plus the treated unit, $J + 1$.

5 Data

The study utilizes data aggregated at the community level by the Northwest Territories Statistics Bureau, originally sourced from the Canadian Census, the Northwest Territories Community Survey, the T1 Family File, vital statistics, the Uniform Crime Reporting Survey, and community-level population estimates. The study period begins in 2004, ten years prior to the construction of the ITH. The latest year varies depending on data availability for each outcome and ranges from 2021 to 2024.

I study four outcome categories: population, income, labour force outcomes and crime. These categories are linked to the community's identified hopes and fears regarding the opening of the ITH, as well as other economic studies on the socioeconomic effects of infrastructure development, as noted in Section 3. They also meet the feasibility requirements needed for identification in a synthetic control setting, as noted in Section 4.

I include all outcomes as covariates to predict the synthetic control weights and include additional data that does not meet the requirements for the synthetic control estimator but provide useful information on community characteristics that can predict outcomes. A list of covariates, their source, and the years available can be found in Table 3.

5.1 Population

Important to understanding changes in income and employment outcomes is understanding how the opening of the ITH effects population and age demographics. Figure 1a shows Tuktoyaktuk's population as a whole. From 2004-2010 the population declines, and then

increases steadily after 2011. This can be broken down by age, where an interesting demographic shift emerges. Table 1 Show significant increases in Tuktoyaktuk's population after the ITH opens, with absolute values and significance being greater than in the other two pools. The NWT Statistics Bureau provides population estimates broken down into seven categories, from 0-4, 5-10, 10-15, 15-25, 25-45, 45-60 and 60 plus. This doesn't directly map on to other definitions of working age populations, for instance the low income variable in this analysis looks at low income status between 18-64, and the labour force is calculated by the total population over 15. Given the limitations from these categories I consider a rough working age population of 15-60, which is the grouping that most closely matches working age population in the other two categories. The population between 15-60 also increases from 2011 until 2016, but then falls and levels out to around 610 people as shown in Figure **??**. The 60 plus population continues to rise as shown in Figure 1c. This is striking when comparing the percent of the population age 15-60 in the two donor pools used in the synthetic control. Figure **??** shows how the proportion of those who are 15-60 in Tuktoyaktuk follows the means other two pools until Tuktoyaktuk's proportion drops starting the year before the ITH opens, 2018, and continuing after. This is driven by the rise in those who are 60 plus with a relative stagnation of those 15-60.

Regardless of whether or not the ITH is causally responsible for these population changes, which will be discussed more in the results section, all the results need to be read in this context. An increase in the proportion of those over 60 in the community might cause shifts in family income on its own, as those who are retired are more likely to have a fixed income, and it may also labour force outcomes as more people choose to retire and are no longer in the labour force.

5.2 Income outcomes

I study four income outcomes: average family income, employment income, % of individuals who are considered low income in the whole population and the % of working-aged individuals, age 18-64, who are considered low income. Studying average family income allows me to examine the overall sense of income-related well-being for different distributions of intra-household income earnings. The shortcomings of using only average family income,

however, are that it includes both employment and transfer income and does not account for changes in family composition. The anticipated changes in income because of the ITH were through the mechanisms of employment. Isolating the effects of the ITH on employment income is important to get a sense of the ITH's effects on this mechanism, particularly. I also consider the % of the community that is low-income. Statistics Canada provides a comparative measure of low incomes. The low-income cutoff is 50% of the median Canadian income. I consider low-income status among the full population. I also look specifically at low-income status for those between 18 and 64 in order to mitigate some of the effects of the change in the population of elders.

Annual community-level family income statistics come from the T1 family file, produced by Statistics Canada and published by the Northwest Territories Statistics Bureau (Northwest Territories Bureau of Statistics, n.d.). The data includes every person who files taxes. Tax filing rates are very high in the Northwest Territories, with 89% of people aged 15 and over filing taxes in Tuktoyaktuk, 99% in Inuvik and 95% in the Northwest Territories overall. (Statistics Canada, 2022a, 2022b, 2022c). These high rates are likely because of benefits received when filing taxes, including the Northern Living Deduction, a tax deduction of at least $11 a day per person (Canada Revenue Agency, 2022), and the Northwest Territories cost of living offset (Canada Revenue Agency, 2017). Despite the high level of income filing rates, there is still a possibility that these income statistics underestimate material well-being because of a large country food and traditional economic activity sector.

Figure 5 shows time series plots of income variables for Tuktoyaktuk, the average annual value for both the full NWT communities pool and the ice road donor pool. Incomes, as measured by both average family income and average employment income, are lower in Tuktoyaktuk, and low-income rates are higher. Incomes rose in 2020 as the number of individuals with low-income status decreased, but this trend did not continue in 2021 and 2022. The fall in low-income status is seen across pools, as is a rise in average family income – likely a function of COVID-19 emergency transfer payments across the country. Although the rise in employment income increases across pools during this time, the rise in Tuktoyaktuk appears much steeper, though it does not catch up with the means from the

other pools.

When looking at just the pre and post treatment averages for these variables, as shown in Table 1, the % of those with a low income (both the full sample and restricted age group) fall across the pools, but less in Tuktoyaktuk than in the other control pools. Average family income and employment incomes rise, but the magnitude is not as great as the rise in incomes in the other two pools.

5.3 Labour force outcomes

Unemployment and labour force participation rate data come from the Canadian Census and the Northwest Territories Community Survey (NWT Bureau of Statistics, n.d.-b; Statistics Canada, 2001). Both occur at 5-year intervals, which corresponds to a two- to three-year interval between each observation. Because the Labour Force Survey is conducted regionally in the Canadian Territories, this is the only consistent option for community-level labour force outcomes. Each outcome reflects the labour force status of the people living in Tuktoyaktuk, not necessarily people coming from other communities to work in Tuktoyaktuk.

The average labour force participation rate falls 6.7 percentage points after the ITH opens. In both periods it is much lower than the two control pools, as displayed in Table 1, by 7 percentage points for the full NWT community pool and 8.8 percentage points for the ice road community pool in the pre-treatment period with the gap increasing in the post period by 12.4 and 15.2 percentage points respectively in the post period. The unemployment rate on average also falls by 5 percentage points after the ITH opens, compared to a 2.5 percentage point and 1.3 percentage point decline in the full NWT pool and the ice road pool, respectively. Looking at Figure 3, Tuktoyaktuk seems to generally follow similar trends as the other two pools, with a sharper decline in participation rate from 2020 to 2021.

5.4 Crime outcomes

Crime data comes from the Canadian Uniform Crime Reporting Survey (UCR), which publishes data on police reported crimes. It is compiled at the community level by the Northwest Territories Statistics Bureau in rates per 1000 population (NWT Bureau of

Statistics, n.d.-a) . I study crime in five broad categories: (1) traffic crimes, (2) violent crimes, (3) property crimes, (4) other criminal offences, and (5) other federal statutes. The first four categories are all violations of the Canadian criminal code. Other federal statutes include criminal violations in acts such as the Firearms Act, the Controlled Drugs and Substances Act, and the Youth Criminal Justice Act (Department of Justice Government of Canada, 2021).

Table 2 shows the means of crime rates by category before and after the opening of the ITH for Tuktoyaktuk, the larger pool of eligible communities in the Northwest Territories, and the smaller ice road pool. Other federal statute violations fall in every geography after the ITH opens, likely driven by the legalization of cannabis in Canada in 2018. All other crime categories rise across each pool. In Tuktoyaktuk, the rise is much more pronounced than the averages of the other pools, with more than twice the increase in crime in the violent crime, property crime, traffic crime and other criminal code violations categories.

Violent crime

The top individual offence within the category of violent criminal code violations is level one assaults, making up 54.8% of the total crimes in the category. Level one assaults are 'common assaults' and are the lowest level of assault in the Canadian code. Uttering threats and level 2 assaults make up the next most prevalent violent crimes with 15.4% and 11% of total violent crimes, respectively as displayed in Table 2. Following this are indecent/harassing communications and level 1 sexual assaults. Intimate partner violence and family violence are not differentiated from other violent crime categories in the Canadian criminal code, so this study cannot look at the effects of new road development on these situations of violence. Tuktoyaktuk starts with a much higher violent crime rate than the averages of the other two groups from 2004-2010, but comes closer to their averages from 2010 until the road opens, as shown in Figure 5a. The violent crime rate then jumps higher than the other groups during road construction, reaching a maximum in 2021 of 385 violent crimes per 1000 population, which is relatively high, and 200 incidents higher per 1000 than the average across the communities in the full NWT pool. This spike corresponds with the COVID-19 pandemic, after which violent crimes start to fall, at a still higher rate than the years immediately

preceding construction.

Traffic crime

The operation of a vehicle while impaired by alcohol accounts for 82.1% of total criminal traffic violations in the Northwest Territories, and all other violations within this category occur less than 50 times per year on average. Table 2 shows that Tuktoyaktuk sees more than three times as many traffic crimes after the Inuvik-Tuktoyaktuk Highway opens, whereas the control communities across the community only see a doubling. Figure **??** shows Tuktoyaktuk following the averages of the other communities in the Northwest Territories and other communities with an ice road fairly closely until 2019, when traffic crimes started to rise above the other two groups.

Property crime

Property crime is the category with the most violations across the Territory, with an average of just under 11,000 incidents annually. Mischief is the leading offence in this category, accounting for 82.1% of incidents. It includes the destruction of property and interruption or interfering with the legal use of property (Legislative Services Branch of Canada, 2024) Total non-vehicle theft under $ 5 000 makes up 8.4% of violations, breaking and entering (4.8% of property violations), theft of a motor vehicle and fraud make up less than 2% of violations in this category each. Both the results from Table **??** and Figure **??** closely align with the trends observed in violent crime, except that violent crime declines in the latest years of the available data, whereas property crime does not.

Other criminal code violations

71.2% other criminal code violations are related to disturbing the peace. Offences relating to the administration of law and justice make up the next most offences in each category, with failing to comply with orders accounting for 14.3% of violations, breach of probation 5.5% and other violations against the administration of law and justice 2.2 %. The last included offence is uttering threats to property or animals, which accounts for 1.3

Other federal statutes

Most other federal statutes fall under the Controlled Substances Act. A significant change to this act occurred during the study period when Canada legalized cannabis nationwide in October 2018 (Government of Canada, 2018). Because cannabis legalization occurred across Canada, it affected all of the donor pool control communities at the same time that it affected Tuktoyaktuk. Therefore, the synthetic control should still adequately represent what would have happened to the treated communities in the absence of the Inuvik-Tuktoyaktuk Highway The largest share of federal statute violations was trafficking cocaine, making up an average of 28% of violations, followed by possession and trafficking of cannabis pre-legalization, making up an average of 23.1% and 13.6% of violations, respectively Other federal statutes and the Youth Criminal Justice Act make up 10.1% and 7.6% of violations on average. Both Table 2 and Figure 5e show that, on average, Tuktoyaktuk has a lower rate of other federal statute violations than the control groups and experiences a decline after the Inuvik-Tuktoyaktuk highway opens.

5.5 Covariates

Available data that does not meet the requirements for synthetic control analysis is also used as covariates to help predict pre-treatment outcomes, as are the outcomes themselves. These covariates include variables with low magnitudes (deaths by suicides), variables with insufficient post-treatment data (prices, housing need, and household structure), and variables where the anticipated time horizon of the effect of the road is unlikely to be realized at the time of this analysis (high school graduation rates and the percent of people who speak an Indigenous language). A list of non-outcome covariates, their sources and the years available is given in Table 3

6 Results

Population

The overall population in Tuktoyaktuk rises above the synthetic control prediction, as shown in Figure 11. The population age 15 to 60 does not show a trend above or below the prediction. Both of these results are insignificant with p-values of %72 and %77 respectively.

Labour force outcomes

No significant difference occurs between Tuktoyaktuk and the synthetic control for either unemployment or labour force participation rates, as shown in Figure 6. Unemployment in Tuktoyaktuk falls below the synthetic prediction, but not enough to be discernible in the placebo distribution or among the MSPE ratios. Labour force participation in Tuktoyaktuk oscillates between lower and higher than the synthetic control prediction post-treatment. Once again, this does not appear to be dramatically varied compared to the placebo distribution or the MSPE ratios.

Income

Figure 7 shows average family income and employment income. Average family income is consistently lower than the synthetic control prediction, though this is not significant with a p-value of 22%. The point estimate for these results is economically significant, however, with as much as $10 000 - $20 000 fall in income. Both the results for employment income with a 2014 and 2017 treatment are shown in Figures 7b and 7c respectively. The anticipated effect from an increase in employment income due to construction activity is likely to occur in 2014; however, there are only two years of data available in the pre-period for this treatment date, so 2017 is also shown. Both treatment dates give insignificant results, with the 2017 treatment yielding a p-value of 22% and 2014 a p-value of %39. With the 2017 treatment, Tuktoyaktuk's realized outcomes also fluctuate between being above and below the synthetic prediction, providing evidence that this is more likely due to a null result than a lack of power. Low-income status appears to rise after road construction begins and then decline a year after the road is open, as presented in Figure 8. These results are relatively extreme compared to

the placebo distributions, with only two other communities showing an MSPE ratio at least as extreme as Tuktoyaktuk, giving a p-value of 0.11. The same trend emerges when looking at the results for a subset of individuals aged 18 to 64. Here, the p-value is %5.5, but once again, the synthetic control and realized outcomes appear to converge as time goes on. This initial increase, compared to the prediction, and subsequent decline suggest that a long-term effect might exist, but has not yet had time to take effect.

Crime

Crime overall increases compared to the synthetic control prediction as shown in Figure **??**. Initially all crimes seem to rise around 2020 - corresponding to the COVID-19 pandemic, and then level off starting in 2022. In the main specification the MSPE ratio ranks to the extreme of all but two of the other communities, giving it a p-value of 0.11. The results are not robust to changes in specification though, and Tuktoyaktuk's ranking in the MSPE ratios drop to the 4th - 6th most extreme when using 2017 as the treatment year while changing the covariates for prediction or demeaning the data. No results are significant using 2014 as a treatment year. Looking only at the ice road access communities along the anticipated Mackenzie Valley all season road shows the results for Tuktoyaktuk falling in the middle of the distribution. These results are presented in Appendix **??**. Breaking crime down in to components tells a more compelling story, with some components of overall crime rising, some falling and some matching the overall crime trend, with a rise around the COVID-19 pandemic and a drop towards the predicted outcomes, and in the case of violent crime a fall below them.

Traffic crime shows the most significant increase. There is a rise in traffic crimes as soon as the ITH opens, though initially this rise matches the prediction of the synthetic control as shown in Figure 9a. In 2020 Tuktoyaktuk continues to see a rise beyond the synthetic control which starts to level out. The placebo distribution in Figure 9a and MSPE ratio rankings in figure 9a indicate the significance of these results with Tuktoyaktuk showing a clear upward path diverging from the synthetic control prediction and an MSPE ratio at the second most extreme end of the distribution, giving a p-value of 0.055. This is robust to demeaning the data to the pre period mean, and using only the outcome as a covariate. When using the

Mackenzie Valley communities as a control pool Tuktoyaktuk falls to the extreme end of the distribution in the MSPE ratio rankings regardless of specification, though this only indicates a p-value of 0.16 because of the small sample size. This result is not surprising. Intuitively, more roads lead to more traffic crime. Given the longer distance available, more people are likely to drive under the influence, which is the primary driver of traffic crimes across the Northwest Territories. Though the results only diverge from the prediction in 2020 it is notable that traffic crimes start their rise as soon as the road opens and continue to rise when the prediction falls.

Property crime also rises, as shown in Figure 9b. Tuktoyaktuk is again on the more extreme end of the placebo distribution, with only two communities showing higher pre and post-MSPE ratios, giving a p-value of 0.11. Tuktoyaktuk is at the extreme end or the distribution only using the Mackenzie Valley ice road communities as a control. This result is robust to using only the outcome as a predicted covariate, but not to demeaning the data to the pre-period mean. An increase in property crime is reasonable to anticipate given an increase in community openness.

Violent crime initially rises above the synthetic control level, then falls back to meet the predicted outcome as shown in Figure 9c. There are only two communities with a higher MSPE ratio than Tuktoyaktuk, but these results are not robust to using only outcomes as a covariate predictor or demeaning the data. Tuktoyaktuk has the extreme ranking when using the smaller pool of the Mackenzie Valley communities. These results do not give conclusive evidence of the effect of the ITH on violent crime in Tuktoyaktuk, both because their lack of robustness and the lack of persistence in the rise of violent crime. It is still possible that the opening of the ITH had effect on violent crime, and it is also possible that the effect is transitory, that there was indeed a rise in violent crime due to the road opening, but as the initial shock of the road opening fades so does the impact of increased violent crime. This however cannot be firmly determined in this analysis.

Figure 10a shows the results for other crimes - which is primarily driven by disturbances of the peace across the Northwest Territories. This analysis does not find evidence that the opening of the ITH has affected these other crimes. The realized outcomes oscillate between being higher and lower than the predicted outcomes, though like many of the crime

variables there is a spike in crime from 2020-2021, during the COVID-19 pandemic. The MSPE ratio rankings put Tuktoyaktuk as one of the less extreme communities in the preferred specification as shown in Figure 10a. The MSPE ratio with Tuktoyaktuk's results continues to be true across other specifications, listed in the Appendix. As the specification changes the resulting synthetic control oscillates between being higher and lower than the realized outcomes - further indicating no effect.

There is evidence that other Federal Statute violations fall. The most common violations in the 'other federal statutes' category in the territory are violations of the Controlled Substances Act, primarily cocaine-related offences. Results are shown in Figure 10b. Tuktoyaktuk is at the extreme end of the MSPE ratios in the placebo analysis, giving a p-value of 0.056. This generally holds true across specifications, though when using only the other ice road communities as a donor pool, Tuktoyaktuk is the second most extreme, giving a p-value of 0.33. Other federal statute numbers in Tuktoyaktuk is generally low, with the average in the pre-period falling from 13.2 to 4.3 in the post period.

7 Discussion

The new Inuvik-Tuktoyaktuk highway has sparked hopes that it will lead to more local economic opportunities. Much of the past economic literature suggests that communities benefit from increased road access, which is why there is advocacy to increase road infrastructure worldwide. The Inuvik-Tuktoyaktuk Highway has not realized these benefits. I find non-positive impacts on income and employment outcomes, as well as mixed results on crime, with particular increases in traffic and property crimes. Connecting a community with overland infrastructure may not be enough to boost economic conditions. Demographic shifts, changes in the local economy's structure, the COVID-19 pandemic, and other economic forces may complicate achieving positive results. Efficiency gains in transportation may be because of the need for fewer jobs in the community.

The average family income declines with the start of construction of the ITH, and those considered to have low income status in the community increase, both overall and for a subset of the community between ages 18 and 64. The changes observed are not statistically

different from zero, with most point estimates indicating an overall negative realization of incomes compared to the prediction. When considering employment income alone, no effect is found with the construction and opening of the ITH.

Labour force outcomes echo these non-positive results. The labour force participation rate does not trend higher or lower than the predicted outcomes. Unemployment, however, appears higher than predicted, though not significantly.

After the road opened, there was a rise in the share of people over 60 in Tuktoyaktuk, while the population between 15 and 60 remained relatively stable, as shown in Figure 1. The higher population of those over 60 leaves open the possibility that people can reside in Tuktoyaktuk later in life than they previously could, possibly even into retirement. If elders have more choices of where to live, the fall in labour market outcomes may point to a positive outcome related to more choices of where to live. Those who are younger and of working age may decide to relocate elsewhere, rather than in Tuktoyaktuk. It is also possible that a change in family structure may mean that some families also require less income. The income results hold when considering the difference between single-headed families and couple-led families as well, but this does not account for the number of dependents in a household.

Regardless of demographic shifts, the rise in low-income status among individuals in the 18- to 65-year-old age group, along with the lack of change in employment income, follows a non-positive narrative in labour force and income results. Jobs created in Tuktoyaktuk might not mean people in Tuktoyaktuk are the ones who work at the new jobs. People might come in from outside the community to work temporarily, muting local employment effects. It is possible that only a few people benefited from the road opening, and individual benefits were not enough to shift community averages. Unemployment is high in Tuktoyaktuk, and the labour force participation rate is lower than the Canadian average. A low attachment to the labour market may mean that economic changes have had little effect on the ground, and small changes in the economic environment might not be reflected in the averages across the community. It is also possible that, although the ITH might lead to overall efficiency for the economy, this efficiency may come at the cost of jobs. Ice road creation and air transportation are two industries that no longer exist in Tuktoyaktuk, and the other economic opportunities may not have been enough to fill the gaps left by the jobs lost in these areas.

Government predictions of job growth were in oil and gas exploration and tourism. There was a tourist rush when the road first opened, but two summers after its opening, the COVID-19 pandemic struck, which, as stated above, led to a shutdown of tourism in the Northwest Territories. As the COVID-19 shock fades, the community may better capture economic benefits from the new tourist traffic. The ban on offshore oil and gas drilling from 2016 to 2023 meant that the potential economic benefits from this industry were likely not realized. This might not be a problem in this analysis, though, as the COVID-19 shock and ban on offshore drilling also affected the donor pool. COVID-19 affected the entire territory, and the ban on offshore drilling would have impacted other Beaufort Delta communities, which comprise a significant portion of the prediction for many outcomes in the synthetic control.

Tourism and oil and gas exploration are likely to impact land-based traditional economic activity opportunities negatively. If there is less employment in these sectors than predicted, it may be a positive for the community if there are more opportunities for traditional economic activity.

7.1 Crime

The Inuvik-Tuktoyaktuk Highway made it easier for people to move in and out of the community, including people who already lived there and people who had never been to the community before. It is unsurprising then that this openness would lead to changes in criminal violations.

The least surprising crime results found in this analysis is that traffic crimes have significantly increased since the road's opening. A new road means more linear kilometres to drive, making traffic crimes more likely. DUIs are also more likely to occur when moving from one community to the next and are less likely without all-season road access because of the short distances between places in Tuktoyaktuk.

A rise in property crime, driven by mischief offences across the territory, is also unsurprising. Given the large influx of tourists reported coming into the territory, more people can damage property, and more are coming through the community without connection to it.

Given comments about the fear that a new road would increase drug trade to

Tuktoyaktuk, the decline in 'other federal statutes' - which are driven by violations of the Controlled Substances Act - is surprising. There are a few possible drivers of this. All of the crime data used in this analysis is police-reported crime. New overland access to the community might make it easier for controlled substances to flow into the community without detection. The fall in these crimes could represent difficulty in enforcement, not lower amounts of drugs in the community. Another possible mechanism comes from the demand for controlled substances. Demand for illegal access to controlled substances might decline with a new road. Improved community mental health, more choices in activities and more access to legal substances might lead to a decline in demand for illegal substances. The Inuvik-Tuktoyaktuk Highway could open up opportunities for bringing more alcohol into town, which serves as a substitute for other controlled substances. There are local limits on how much alcohol someone can bring into Tuktoyaktuk at one time, and the road may make it easier to facilitate a flow of alcohol into the community.

Another surprising feature is that though there is a rise in property crime, violent crime does not increase. Paired with the decline in 'other federal statutes,' this suggests a change in the structure of crimes committed compared to an overall increase.

8 Conclusion

Often, infrastructure is seen as a panacea for social and economic development in remote communities. This research indicates that the effects of the Inuvik-Tuktoyaktuk Highway are not ubiquitously positive. In the case of the Inuvik-Tuktoyaktuk Highway, there is no evidence of positive effects on income and labour force outcomes. No statistically significant changes in violent crime, a fall in drug-related crime and offences like the disturbance of the peace would be considered a positive thing for a community. However, rising property crime, driven by mischief offences, is likely to be considered negative, and increases in traffic crime, though seemingly inevitable, create more risk for community members.

The mixed results around crime and the non-positive and not statistically significant results around income and employment paint a picture of community change that is neither wholly positive nor wholly negative. There have been changes in community safety, with a

fall in other federal statutes - likely driven by Controlled Substance Act violations, and a rise in property and traffic crimes. Non-positive labour market and income outcomes, with high tourist numbers in the summer, suggest a change in the local economy but a change that might not provide positive economic benefits to the majority of the community. The Inuvik-Tuktoyaktuk Highway, therefore, might not give sweeping positive socio-economic benefits to Tuktoyaktuk but instead relates to a complicated set of changes, some anticipated and some not.

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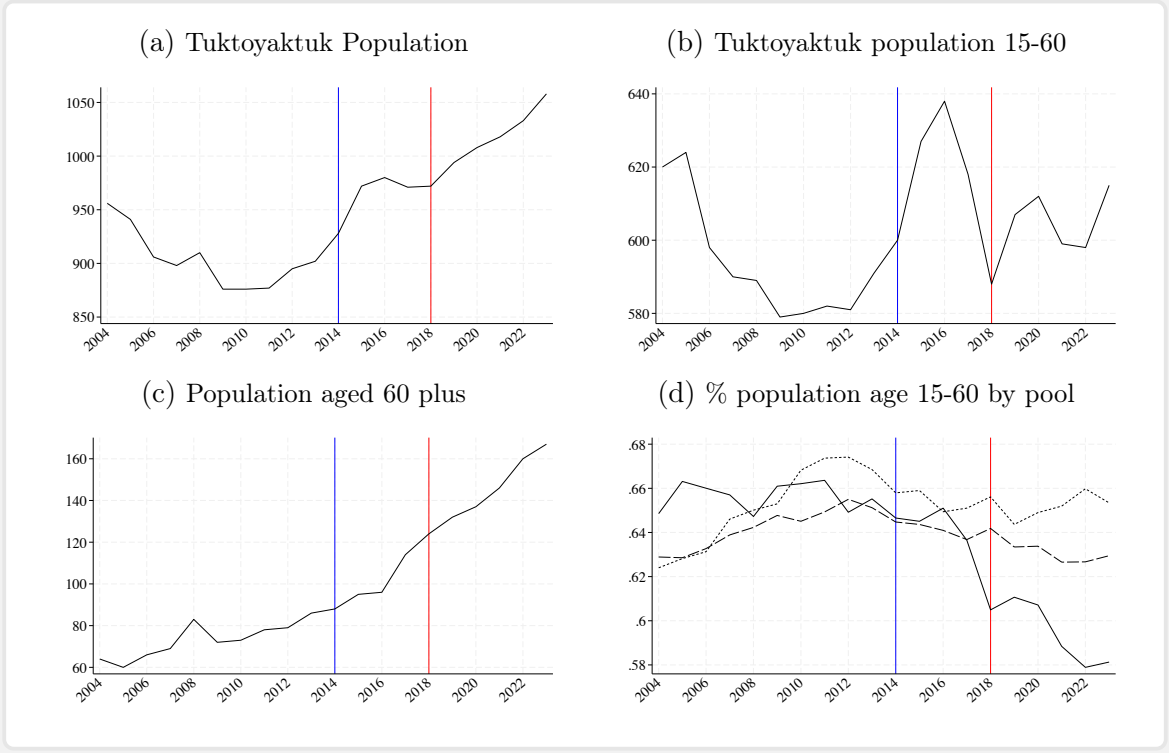
9 Figures

Figure 1: Summary time series plots population



Notes: Annual time series plot of population. All income is in nominal Canadian dollars. The % low income status is the percent of the community who receives less than 50% of the median Canadian income. The blue line at 2014 indicates the start of construction. The red line at 2018 indicates the first year the ITH was open.

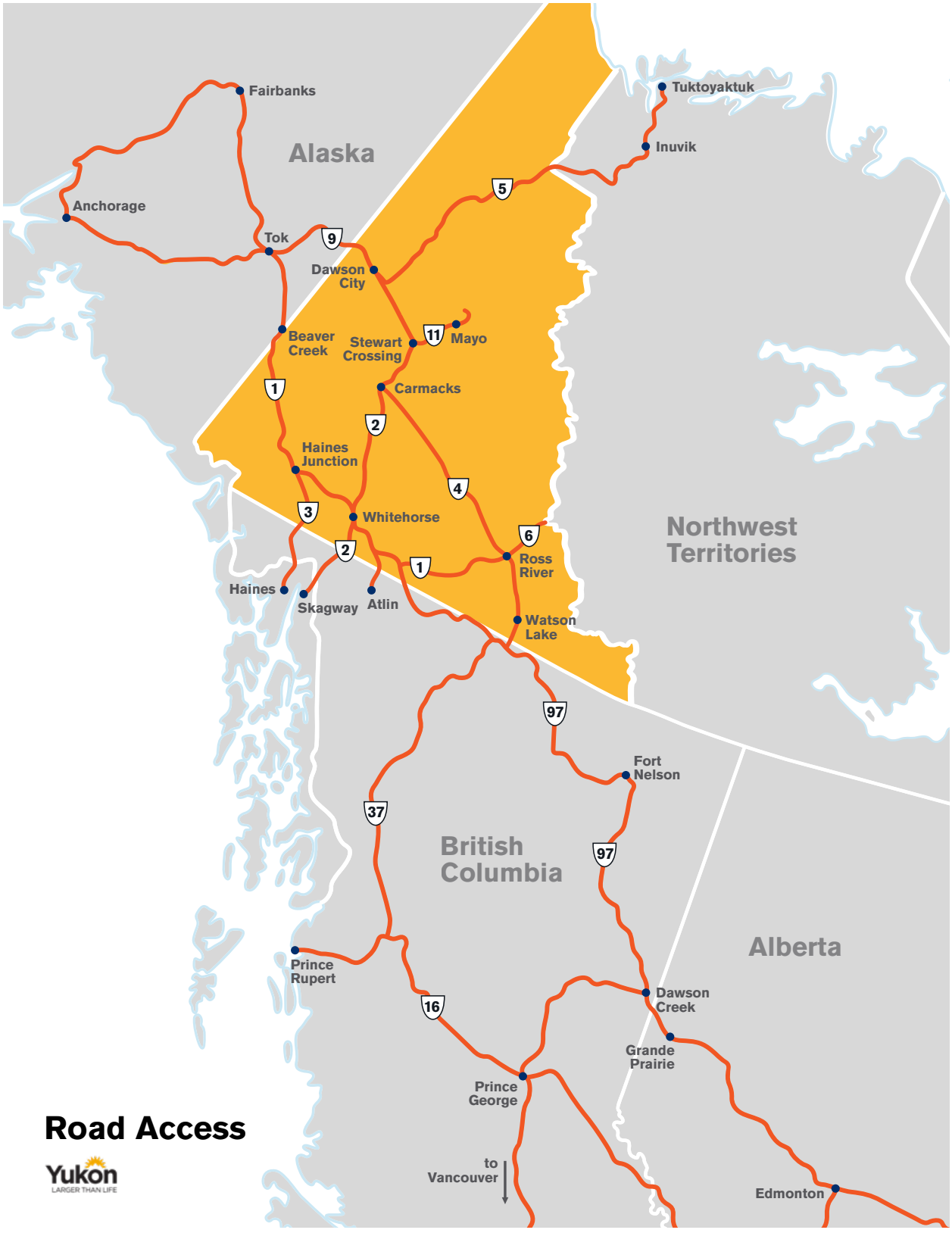
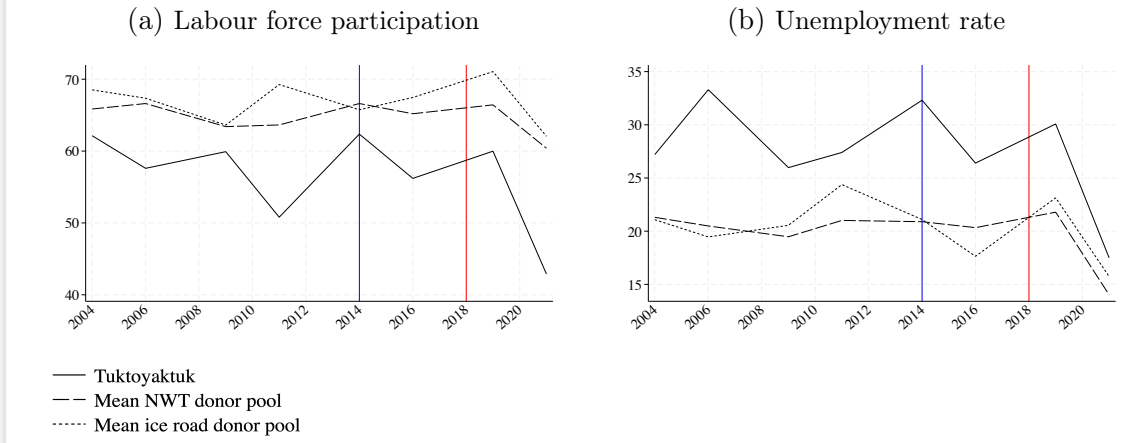


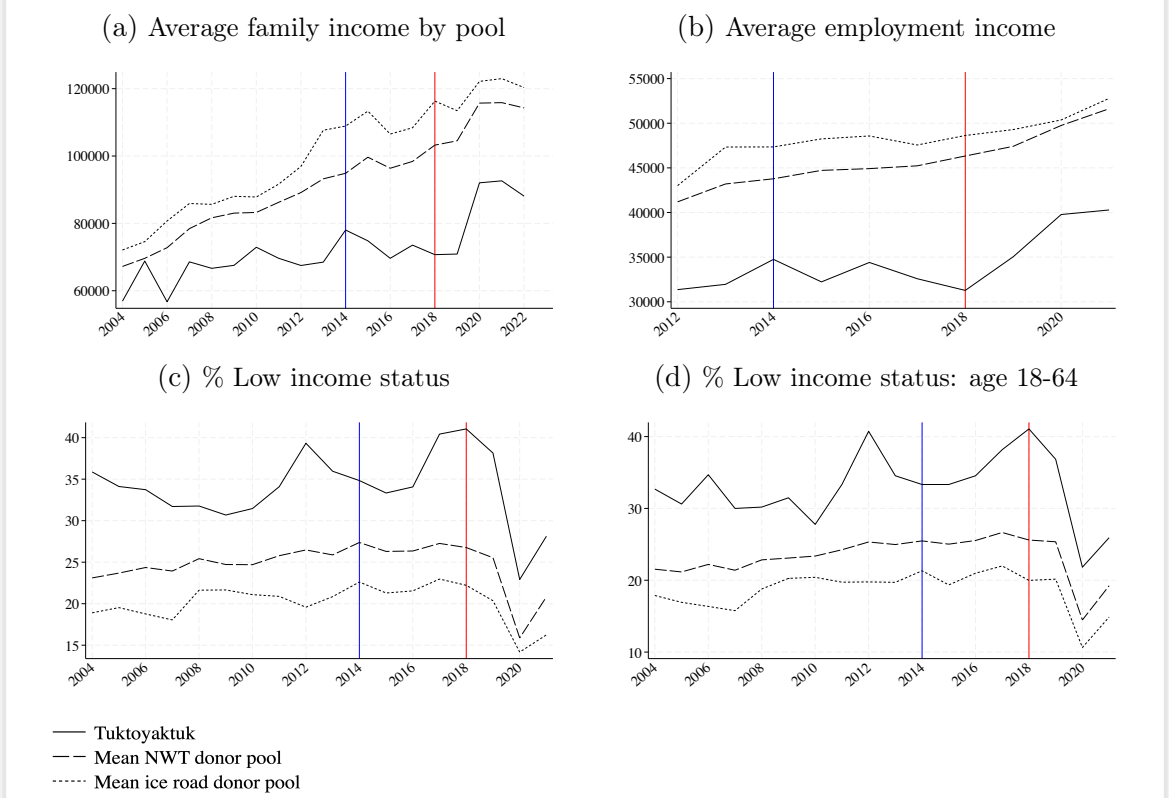
Figure 2: Road Connections to Inuvik and Tuktoyaktuk (Tourism Yukon, 2017)

Figure 3: Summary time series labour force outcomes



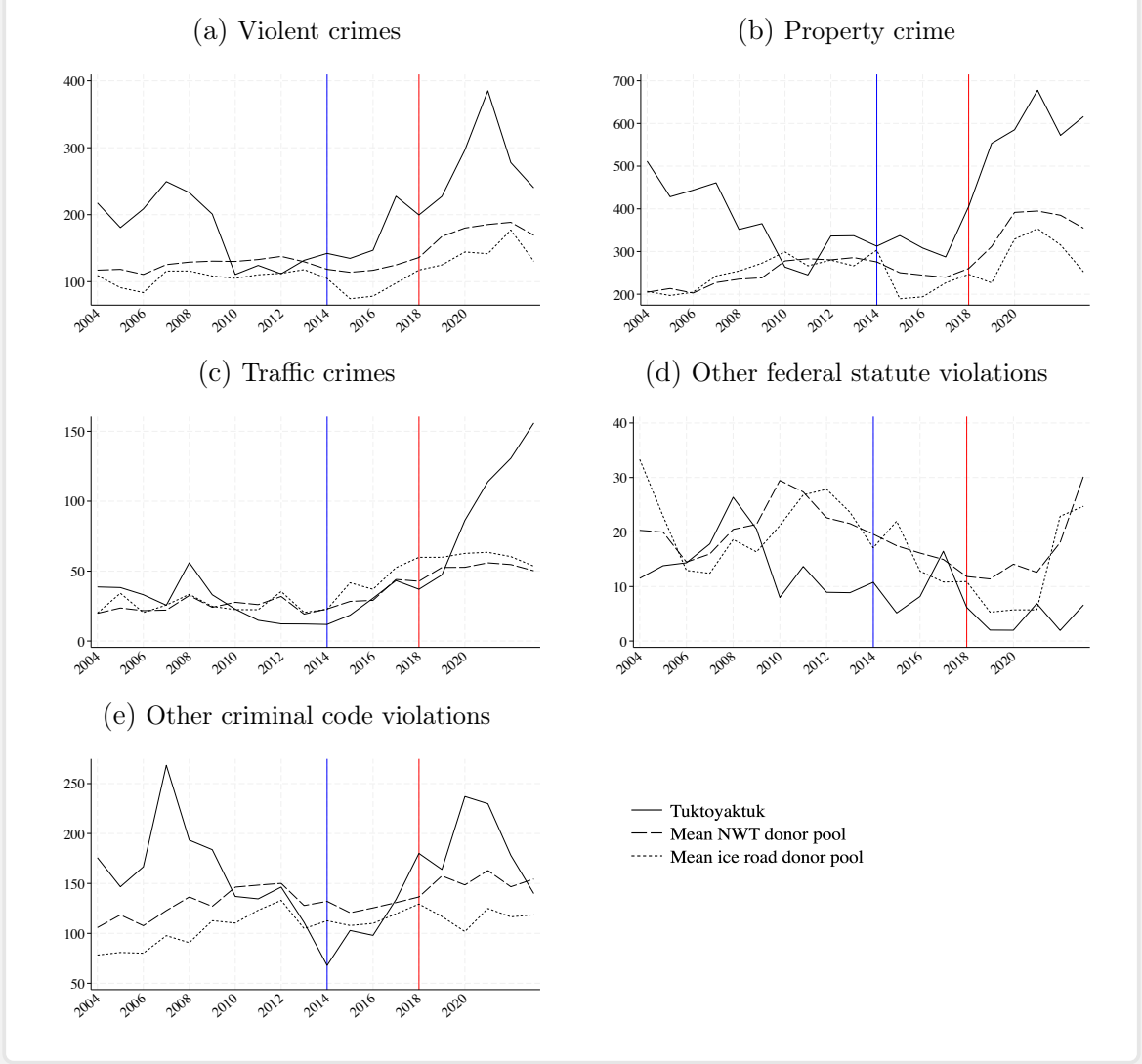
Notes: Annual time series plot of labour force participation rate and unemployment rate. The labour force is those who are 15 years and older who are either employed or unemployed. The unemployment rate is those who are unemployed within those who are part of the labour force.

Figure 4: Time series plots of income outcomes by pool



Notes: Annual time series plot of income variables. All income is in nominal Canadian dollars. The % low income status is the percent of the community that receives less than 50% of the median Canadian income. The blue line at 2014 indicates the start of construction. The red line at 2018 indicates the first year the ITH was open.

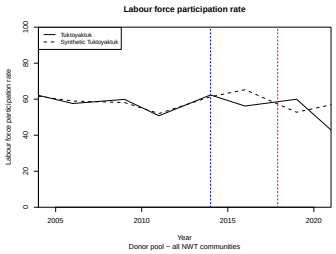
Figure 5: Time series plots of crime by pool



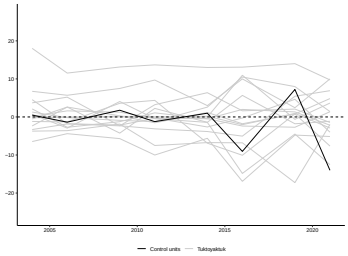
Notes: Annual time series plot of crime. Outcomes are in rates per 1000 population.

Figure 6: Labour force results – full NWT pool

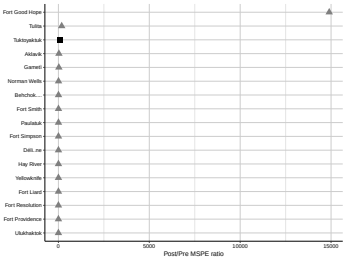
(a) Labour force participation



i. Control vs. realized outcomes

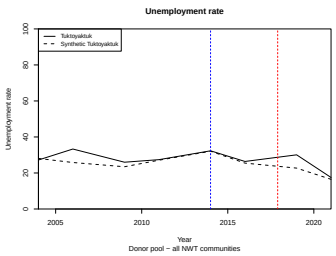


ii. Placebo distribution



iii. Post/pre MSPE ratio rankings

(b) Unemployment rate



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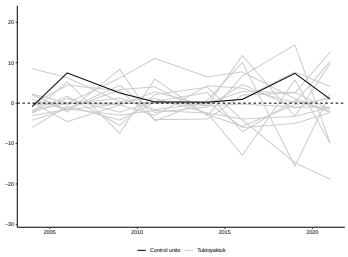

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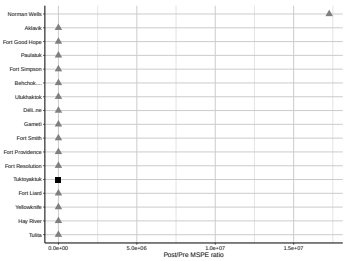
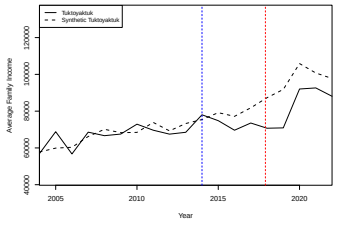


iii. Post/pre MSPE ratio rankings

Note: The treatment year in the preferred specification for labour outcomes is 2014. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. The blue line in the control vs. realized outcomes figures shows the start of construction in 2014, and the red line shows the opening of the road in November 2017.

Figure 7: Average family and average employment income results – full NWT pool

(a) Average family income 2014 treatment



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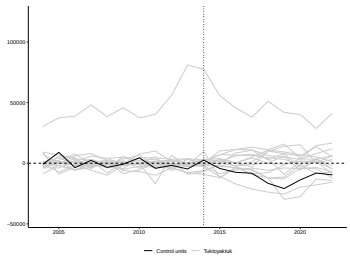

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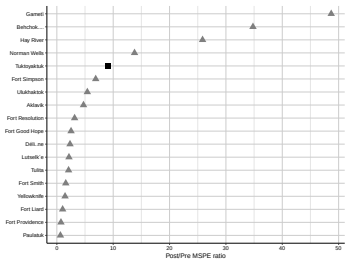
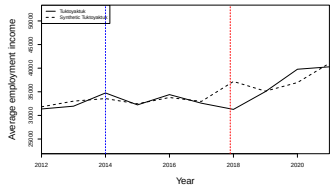
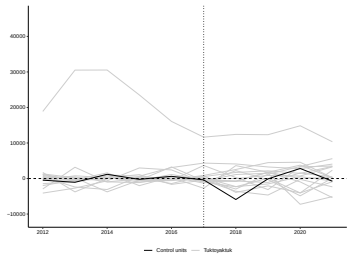


iii. Post/pre MSPE ratio rankings

(b) Average employment income 2017 treatment



i. Control vs. realized outcomes



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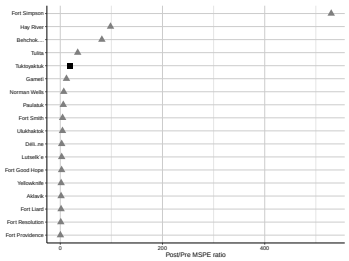
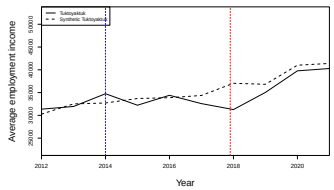
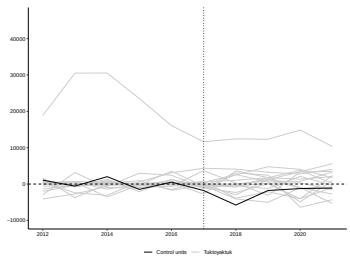


iii. Post/pre MSPE ratio rankings

(c) Average employment income 2014 treatment



i. Control vs. realized outcomes



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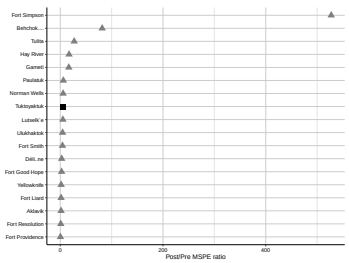
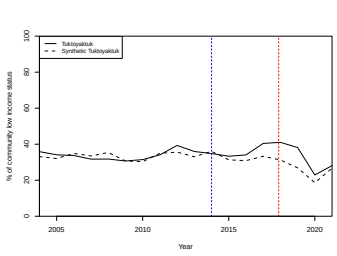


iii. Post/pre MSPE ratio rankings

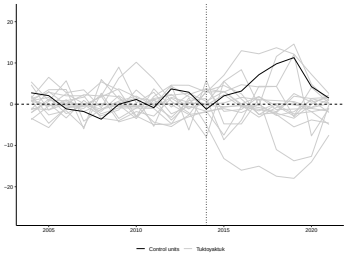
Note: The treatment year in the preferred specification for income outcomes is 2014; however, due to limited data in the pre-period, results for average employment income with both 2014 and 2017 treatment dates are used. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. The blue line in the control vs. realized outcomes figures shows the start of construction in 2014, and the red line shows the opening of the road in November 2017.

Figure 8: Low income status results – full NWT pool

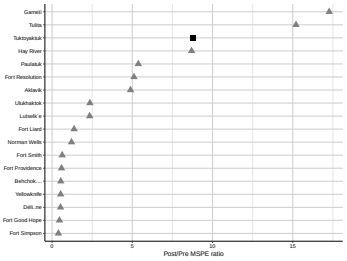
(a) % of the population who have low income status



i. Control vs. realized outcomes

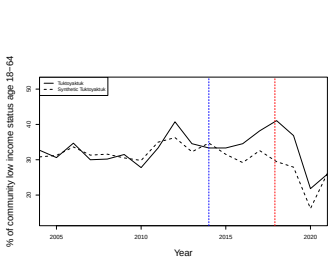


ii. Placebo distribution

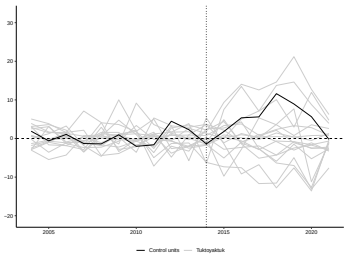


iii. Post/pre MSPE ratio rankings

(b) % of the population who have low income status – age 18-64



i. Control vs. realized outcomes



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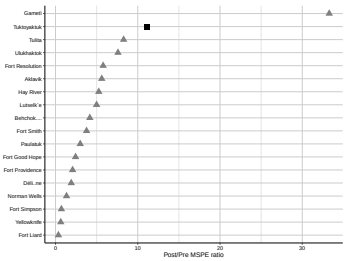
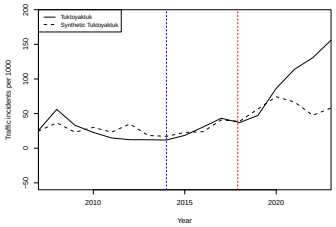


iii. Post/pre MSPE ratio rankings

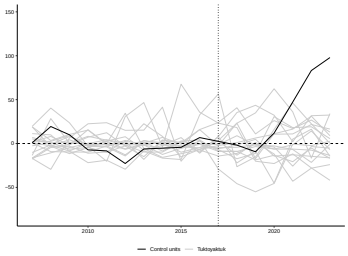
Note: The treatment year in the preferred specification for income outcomes is 2014. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. The blue line in the control vs. realized outcomes figures shows the start of construction in 2014, and the red line shows the opening of the road in November 2017.

Figure 9: Crime results – traffic, violent and property crime – full NWT pool with 2017 treatment

(a) Traffic crime



i. Control vs. realized outcomes



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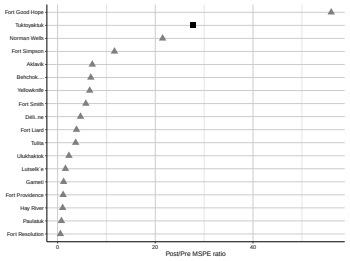
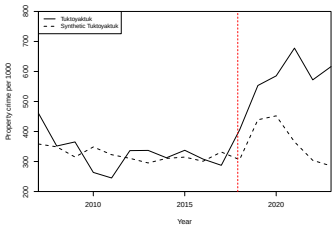
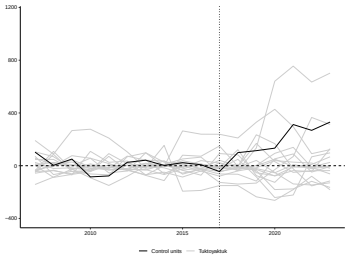


iii. Post/pre MSPE ratio rankings

(b) Property crime



i. Control vs. realized outcomes



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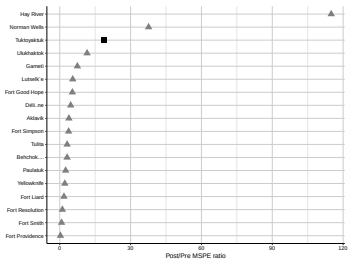
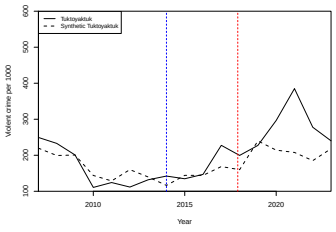
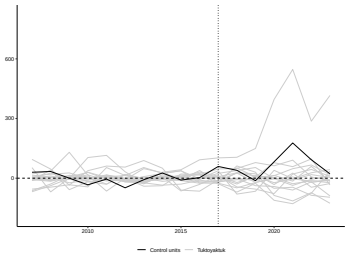


iii. Post/pre MSPE ratio rankings

(c) Violent crime



i. Control vs. realized outcomes



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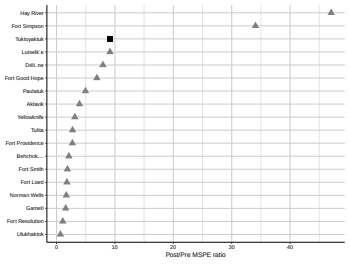
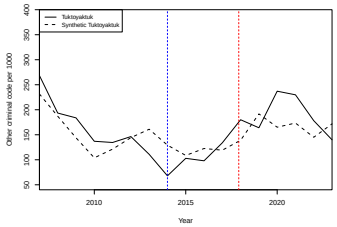


iii. Post/pre MSPE ratio rankings

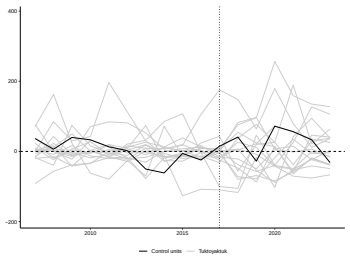
Note: The treatment year in the preferred specification for crime outcomes is 2017. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. The blue line in the control vs. realized outcomes figures shows the start of construction in 2014, and the red line shows the opening of the road in November 2017.

Figure 10: Crime results - Other criminal code violations and other federal statutes - full NWT pool with 2017 treatment

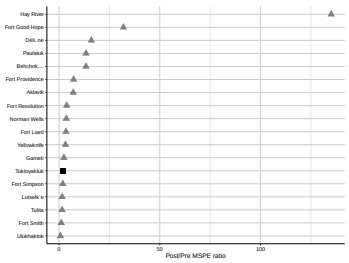
(a) Other crime



i. Control vs. realized outcomes

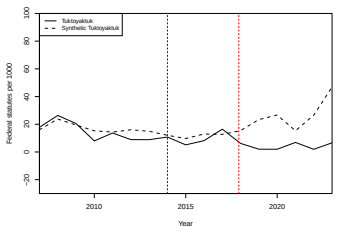


ii. Placebo distribution

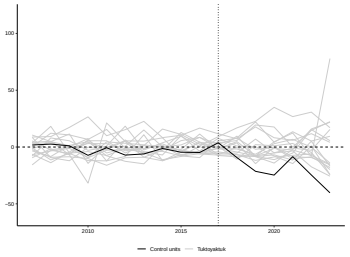


iii. Post/pre MSPE ratio rankings

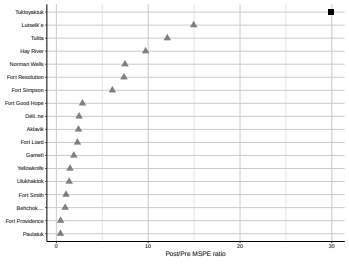
(b) Other federal statute violations



i. Control vs. realized outcomes



ii. Placebo distribution

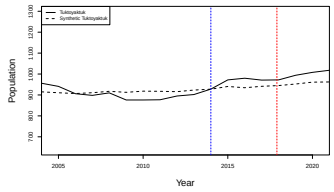


iii. Post/pre MSPE ratio rankings

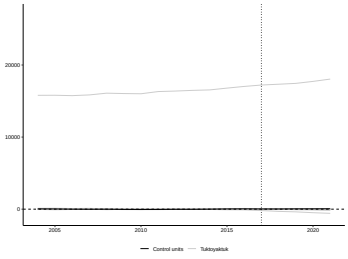
Note: The treatment year in the preferred specification for crime outcomes is 2017. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. The blue line in the control vs. realized outcomes figures shows the start of construction in 2014, and the red line shows the opening of the road in November 2017.

Figure 11: Population results – full NWT pool

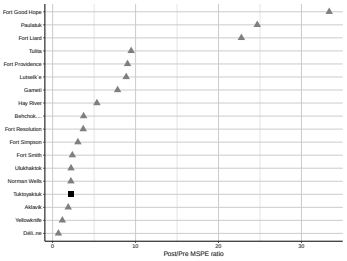
(a) Population



i. Control vs. realized outcomes

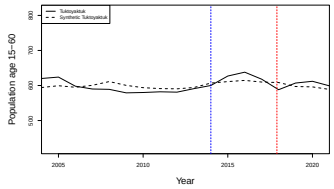


ii. Placebo distribution

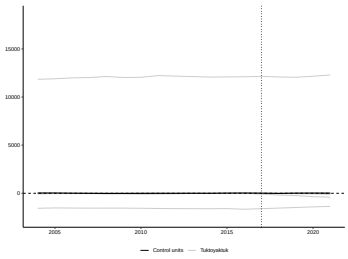


iii. Post/pre MSPE ratio rankings

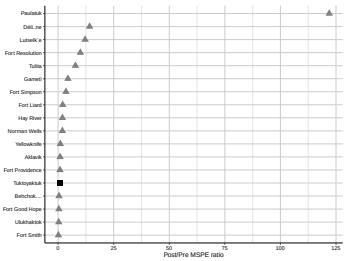
(b) Population age 15 to 60



i. Control vs. realized outcomes



ii. Placebo distribution



iii. Post/pre MSPE ratio rankings

Note: The treatment year in the preferred specification for population outcomes is 2017. The full set of covariates is used in determining the synthetic control. Pre-period optimization is from 2004-2014. The donor pool includes Northwest Territory communities with available data and no anticipated spill overs. Blue line in the control vs. realized outcomes figures show start of construction in 2014 and red line shows the opening of the road in November 2017.

10 Tables

Table 1: Income, labour force outcomes and population summary statistics before and after the opening of the ITH

	Tuktoyaktuk			Full NWT Pool			Ice Road Pool		
	Before ITH	After ITH	Difference	Before ITH	After ITH	Difference	Before ITH	After ITH	Difference
Population									
Population - all ages	920.6	1013.8	93.3***	1784.7	1824.1	39.4	537.3	555.4	18.1
Population - age 25-60	435.7	459.0	23.3**	952.9	956.4	3.5	258.8	279.1	20.3**
Income									
% low income	34.4	32.6	−1.8	25.4	22.2	−3.1***	20.7	18.2	−2.4**
% low income age 18-64	33.2	31.4	−1.8	23.8	21.2	−2.6**	19.2	16.4	−2.8**
Average family income	68560	82875	14319**	85284	110721	25438***	93443	119047	25605***
Avg. indiv. employment income	32880	36594	3714**	43840	48780	4940**	47013	50268	3255
Labour force									
Participation rate	58.2	51.4	−6.7	65.2	63.6	−1.7**	67.0	66.6	−0.4
Unemployment rate	28.8	23.8	−5.0	20.6	18.1	−2.5**	20.7	19.4	−1.3

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Differences reflect pre- to post-intervention changes. Values are rounded to the nearest whole number or dollar. N/A indicates unavailable significance.

Table 2: Crime, traditional activities, housing and high school attainment before and after the opening of the ITH

	Tuktoyaktuk			All NWT Pool			Ice Road Pool		
	Before ITH	After ITH	Difference	Before ITH	After ITH	Difference	Before ITH	After ITH	Difference
Crime rates per 1000									
Violent crime	172.9	271.1	98.2**	124.1	171.1	47.1***	101.8	139.3	37.5**
Property crime	356.4	568.4	212.0***	247.1	349.6	102.5***	243.1	287.3	44.2**
Traffic crime	27.9	95.2	67.3**	26.7	51.5	24.8***	29.5	60.0	30.5***
Other criminal code violations	147.6	188.2	40.6**	128.6	151.1	22.5**	104.4	118.0	13.6**
Other federal statute violations	13.2	4.3	−8.9***	20.1	16.4	−3.8**	19.9	12.5	−7.4**
Traditional activity									
% trapped in the last year	7.1	5.5	$-1.6^{N/A}$	13.6	12.8	−0.7	11.6	8.1	−3.5**
% hunted or fished in the last year	60.2	55.4	$-4.8^{N/A}$	53.6	53.4	−0.2	46.4	47.7	1.3
75% or more of meat comes from country food sources	31.8	37.8	$6.0^{N/A}$	36.6	35.7	−0.9	46.5	40.9	−5.6
Other									
Housing in core need	36.1	34.3	$-1.8^{N/A}$	31.0	27.5	−3.5**	33.4	28.2	−5.1**
Households with 6+ people	13.8	15.4	$1.6^{N/A}$	9.7	7.4	−2.4**	11.6	7.3	−4.2**

Notes: Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. N/A indicates unavailable significance level because there is only one post period observation. All percentages are percent of community members age 15 plus unless otherwise specified.

Table 3: Covariate variables and sources

Source and years available	Variable
Territorial estimates and census	Population
Annually from 1993–2023	
Vital statistics	Number of births
Annually from 1995–2022	Number of deaths
Vital statistics	Teen births
Annually from 2011–2022	Deaths – external causes[1]
	Deaths – suicides
Income assistance data	Income assistance beneficiaries[2]
Annually from 2013–2022	Income assistance cases[2]
	Income assistance payments
T1 family file	Total income
Annually from 2011–2022	Average personal income
	% of taxfilers less than $15,000
	% of taxfilers more than $50,000
Census[3]	% of households with 6 or more people
Every five years from 2006–2021	% of lone parent families
	% of houses owned
	% of households in core housing need
	% of Indigenous that speak an
	Indigenous language

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Source and years available	Variable
Census and NWT community survey 2004, 2006, 2009, 2011, 2014, 2016, 2019, 2021	% with high school diploma or more
NWT community survey Every five years from 1999–2019	% of people who hunt or fish % of households who get most or all of their meat from country food sources
NWT price survey 1997, 2000, 2001, 2004, 2010, 2012, 2015, 2019	Prices relative to Yellowknife

[1] Including suicides.

[2] Monthly averages.

[3] In 2011 the Canadian long form census was replaced by the National Household Survey.

Table 4: 2010-2023 average detailed crimes committed by category in the NWT

Incident type	Average incidents	% of crimes in category
Total violent criminal code violations	4168.4	–
Assault, level 1	2283.9	54.8%
Uttering threats	643.4	15.4%
Assault, level 2, weapon or bodily harm	457.2	11.0%
Indecent/Harassing communications	227.6	5.5%
Sexual assault, level 1	188.6	4.5%
Total criminal code traffic violations	1053.2	–
Operation while impaired (alcohol)	864.5	82.1%
Driving while prohibited	44.6	4.2%
Dangerous operation of motor vehicle, vessel or aircraft	34.6	3.3%
Operation while impaired (drugs)	25.1	2.4%
Dangerous operation of motor vehicle evading police	12.1	1.2%
Total property crime violations	10863.5	–
Total mischief[1]	8957.3	82.5%
Total theft under $5,000 (non-motor vehicle)	911.0	8.4%
Total breaking and entering	522.1	4.8%
Total theft of motor vehicle	200.6	1.8%
Fraud	171.0	1.6%
Total other criminal code violations	6318.0	–
Disturb the peace	4499.9	71.2%
Fail to comply with order	904.9	14.3%
Breach of probation	348.2	5.5%
Other violations against the administration of law and justice	137.2	2.2%
Utter threats to property or animal	81.3	1.3%
Total federal statute violations[2]	629.2	–
Cocaine, trafficking	176.4	28.0%
Possession, cannabis (pre-legalization)	145.1	23.1%
Cannabis, trafficking (pre-legalization)	85.9	13.6%
Other federal statutes	63.5	10.1%
Youth Criminal Justice Act	47.9	7.6%

Notes: Average crimes committed between 2010-2023 by top 5 detailed offence in each major category

[1] Mischief is the wilful damage or destruction of property, including cultural property and hate crime;

[2] Federal statutes are criminal offences that are not included in the Canadian criminal code, but are included in other acts including the Firearms Act, the Controlled Drugs and Substances Act, and the Youth Criminal Justice Act.

Updated appendix can be found here:

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