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Good Red Dog: The Long Term Economic Impact of Mining Activity in Rural Alaska*

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Abstract: While resource booms in rural areas have the potential to transform communities, they also raise questions about the distribution and sustainability of the benefits/costs in both the short and long run. We estimate the long term effects of the Red Dog mine, an Alaska mine in the Northwest Arctic borough, on a variety of economic outcomes. We find suggestive evidence of immediate and long lasting effects of the mine on wages as well as evidence of increases in employment and reductions in government dependence. These findings suggest that even in the absence of pre-conditions to maximize the multiplier effects, the borough's attempts to internalize the wealth generated by the mine have been successful because of agreements that prioritized local employment and revenues. This model could be potentially be implemented by other rural communities with newfound resource riches.

Keywords: resource Boom; Alaska; regional development; long term effects
JEL Codes: Q3, Q4

1. INTRODUCTION

In 1971, Congress passed the Alaska Native Claims Settlement Act (ANCSA) which was a new approach by Congress in handling federal Indian policy. It divided the state of Alaska into twelve distinct regions and mandated the creation of twelve private, for-profit Alaska Native regional corporations and over 200 private, for-profit Alaska Native village corporations. ANCSA manadated the transfer of roughly 10% of the lands in the state to Indigenous-owned corporations. The regional corporation for the NANA region, located in northwest Alaska, largely above the Arctic Circle, and encompasses 38,000-square miles, is called NANA corp. NANA is owned by the more than 15,000 Inupiaq shareholders, or descendants, who live in or have roots in northwest Alaska. It was capitalized with 44 million dollars and was given the right to select over 2 million acres of land in the region. In 1978, NANA selected the area of what became the Red Dog mine because of its mineral values.

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The first step in developing the mine came in 1982 when NANA signed the Development and Operating Agreement for Red Dog that gave Cominco (now Teck) the right to build and develop the mine. In return, NANA received 1.5 million dollars, plus an additional 1 million every year until the mine went into production (which turned out to be 1989).

The Red Dog mine now produces nearly 10% of the world's new zinc supply each year. The revenues from shipping out more than 1 billion pounds of zinc annually, along with healthy portions of lead, silver, and minor amounts of germanium, have served as a catalyst to grow the Inupiat-owned company into a global enterprise that generated US$1.66 billion in gross revenues during 2019. NANA's net proceeds royalty from Red Dog increases by 5% every five years, up to a maximum of 50%.[1]

While many view the Red Dog mine as a success story,[2] others have concerns about the share of the gains going to residents, the environmental consequences of the mine and the long terms effects on the boroughs' residents. [3]

In this paper, we evaluate the evolution of a range of economic outcomes in the Northwest Arctic Borough since production began in 1989 using the synthetic control method (SCM). The method develops a counterfactual for the Northwest Arctic borough based on gender composition, median age, share of employment in government, share of proprietors, and lagged outcomes of interest.[4]

We use the Economic Profile Data from the Bureau of Economic Analysis (1969-2013) containing employment, earnings, and federal transfer receipts at the borough level and our strategy develops a counterfactual for the Northwest Arctic borough using data from the rest of the Alaska boroughs where no significant economic shocks had occurred.

Relative to the counterfactual, we find suggestive evidence that the Northwest Arctic borough experienced an increase in wages, earnings per capita, and an increase in employment. We also find decreases in government dependence as measured by income maintenance, and government transfers.

This paper builds on works such as Rickman and Wang (2020) who examine the long term employment effects of energy booms and busts at the state level. Closely related to our paper is Berman et al. (2020) who evaluate the long term effects, not since production began, for people who worked at Red Dog any time between 2002-2005 - either for NANATeck or a contractor (drilling, construction, hauling) - excluding catering and housekeeping (NMS) workers. They compare the outcomes of interest to a matched sample of Northwest Arctic Borough (NWAB) residents with no work history in Red Dog. In essence, their paper examines the wage trajectories of Red Dog workers and those who lived in the NW Arctic borough but were not employed at the mine; thereby assessing the direct effects of being employed in the mine for a 14 year period that starts 13 years after production began.

Our paper differs from Berman et al. (2020) along three important dimensions. First, we analyze the effect of the beginning of production on a range of outcomes and we compare the

[1]By 2022, the proceeds reached 40%.

[2]https://www.ktoo.org/2021/12/09/red-dog-mine-ancsa/

[3]https://theworld.org/stories/2018-06-09/most-toxic-town-america

[4]We assess six different outcomes: average wages, earnings per capita, employment, population, unemployment insurance, and income maintenance. In Table 4, we provide the quality of the match between the treated and counterfactual units.

evolution of the NWAB to other boroughs in the state of Alaska whereas Berman et al. (2020) follow mine workers' earnings starting in 2002 and are therefore not evaluating the initial effect of the mine. Second, we examine borough-wide outcomes rather just focus on mine workers which means our results capture not only direct effects of mine employment but also indirect and induced effects. Lastly, our results also capture the payments to NANA that would induce economic activity through other channels such as local government employment or other spending.

2. BACKGROUND

The Northwest Arctic Borough is one of the most remote and sparsely populated areas of Alaska. In Figure 1, we provide a map showing the location of the Northwest Arctic borough and its size relative to the rest of the state. Prior to the Red Dog mine's opening, the average wage in the borough came in well below the statewide average; a year after the mine opened, the borough's average wage exceeded the state average. In 1997 -eight years after the beginning of production-, the borough's average monthly wage was $3,210, compared to $2,732 statewide, and most of this premium can be attributed to the mine. Even with these developments, almost all of the boroughs' residents engage in subsistence Fried and Windisch-Cole (1999)

From an economic standpoint, approximately 70 percent of the borough's personal income came from public sources via federal, state, local and tribal government payrolls and transfer payments. The absence of a substantial private sector is a factor in the public sector's dominance in the local economy. NANA and Teck's predecessor originally set a goal for its workforce to be nearly 100% shareholders by 2001, though it has long lingered at closer to 60%.

We use 1989 as the treatment year in our analysis and assess if the economic outcomes of interest evolved differently than their counterfactual in the 24 years after the mine went into production. Once production began, NANA received 4.5 percent of net smelter returns (essentially a gross royalty before costs are deducted). After Teck recovered its capital investment in 2007, NANA shared in the net proceeds of the mine beginning at 25 percent and increasing every 5 years until NANA and Teck share equally in the profit. As of 2015, NANA receives 30 percent of net smelter returns. According to the McDowell Group (2014), 55 percent of the year-round jobs at Red Dog are filled by NANA shareholders, including jobs with Teck Alaska, NANA Lynden and NMS. Red Dog directly employs an average of 447 year-round workers with another 100 workers as contractors. Wages in 2015 for all these workers totaled approximately $65 million in total annual wages. Loeffler (2015) estimates in the past few decades, employment at the mine provided more than 10% of jobs in most of the borough's villages. NANA and Teck's predecessor originally set a goal for its workforce to be nearly 100% shareholders by 2001. It has, however, long been stuck at closer to 60%.

While all of these statistics seem to indicate that Red Dog has been beneficial to the community's welfare, there have also been concerns about the extent to which the original residents are benefiting from these developments along with fears about the environmental consequences of mining. Recently, the Environmental Protection Agency Recently named

Kotzebue, Alaska, [5] the worst industrially polluted town in the United States and Alaska as the 17th most polluted state out 56 states and territories based on total releases per square mile (Rank 1 = highest releases). [6] [7]

3. RELATED LITERATURE

An extensive literature has examined different aspects of the short run social and economic consequences of sub-national energy booms such as Weber (2012); Brown (2014); and Munasib and Rickman (2015). Consistent with economic theory (e.g., Corden and Neary (1982)), such studies tend to find that wages and employment rise during energy booms. In their literature review survey, Marchand and Weber (2018), provide a comprehensive assessment of the labor market effects of resource development. They conclude that resource extraction raises aggregate earnings and income, although the magnitudes of these effects vary. Importantly, they find that across studies a booming resource sector can create jobs in other sectors, indicating that there is not a one-to-one crowding out of other industries.

Even with the established evidence of the short term effects of resource development, there is continued debate around the long term economic consequences as work such as Aragón et al. (2018) shows that resource booms can stimulate complementary investments in local non-extraction sectors and augment growth, while other work like Sachs and Warner (1995) and Van Der Ploeg (2011) shows that resource rich communities can suffer from lower growth. Recently, Rickman and Wang (2020) addressed this question by examining the long term employment effects of energy booms and busts at the state level for the four most dominated oil and gas states. They find all four states experienced statistically significant increases in per capita income during both boom periods and the entire period, suggesting longer-run income benefits of the energy cycle. There was, however, variation in the size of the employment multiplier across periods and states.

Our findings contribute to this growing literature on the long term effects of natural resource based economic development, which has focused on whether resource booms are beneficial or not to economic growth. Our focus is on a resource rich rural community in Northwest Alaska. Local economic effects from natural resource development such as oil and mineral extraction are typically described by their direct impact to the shocked sector, and spillover effects into other sectors via indirect and induced effects. In our analysis, we do not decompose the effects in this manner but focus on borough-wide outcomes which capture not only the direct effects of the mine but also the indirect and induced ones.

In general, the size of direct and spillover effects relies on a number of pre-conditions Tiebout (1956) and Kilkenny and Partridge (2009). First, the size of the resource sector must be large relative to the economy as a whole in order to generate enough employment and wage growth that would create spillover effects into other sectors through indirect and induced effects. In our case, the boroughs' small size coupled with the significant employment associated with the mine potentially indicates the likelihood of the existence of indirect

[5]https://theworld.org/stories/2018-06-09/most-toxic-town-america

[6]https://enviro.epa.gov/triexplorer/tri$_{f}actsheet.factsheet_{f}orstate?pstate = akpyear = 2020pParent = TRIpDataSet = TRIQ1$

[7]Environmental Protection Agency:https://www.epa.gov/toxics-release-inventory-tri-program

and induced effects. But even in circumstances where the direct effect is large, the direct benefits for local residents may be small if in-migration or commuting is relatively easy and/or local residents lack the skills and expertise demanded by the shocked sector. In our case, commuting is not a concern given the remoteness of the area but due to the small population of the Northwest Arctic borough, fly-in/fly-out workers are typically relied upon. However, the nature of the agreement between the borough and the mine which provides preferential treatment to residents may alleviate some of these concerns. Second, the size of the indirect effect depends on the presence and strength of linkages between the resource sector and upstream and downstream firms in the area. In the Northwest Arctic borough, the indirect effect is likely to be small given that most of the inputs are imported from outside the region. Third, the size of the induced effect depends on whether the beneficiaries of direct and indirect effects purchase locally produced goods and services.

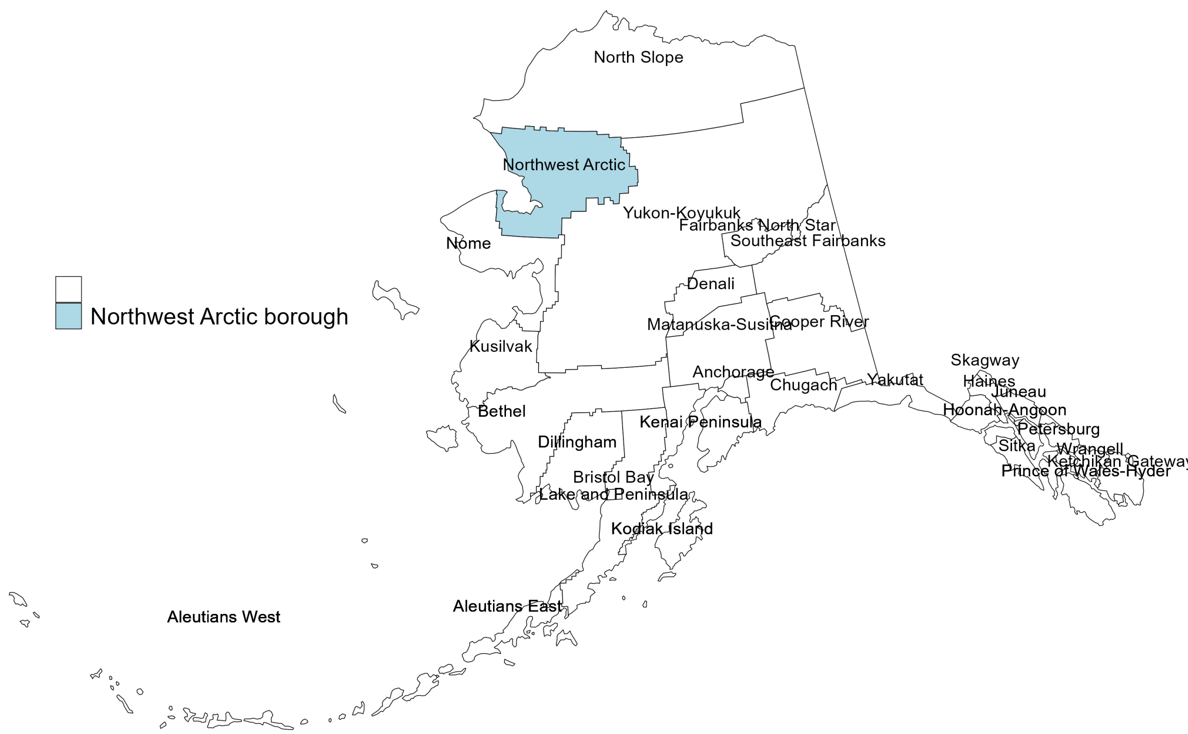
Overall, communities that experience higher relative shocks, have significant inter-industrial linkages, and have several opportunities to spend earnings locally are the most likely to experience significant gains from natural resource development. These circumstances are, however, less likely to exist in rural areas -even less so in Northwest Alaska- where the labor markets are thin and the suppliers are few.

It is unclear a priori whether the leakage due to the rural location may dampen the overall impact of the mine. We, therefore, attempt to determine whether the agreement between the mine operators and the borough potentially counter-acted many of the typical leakages observed in the typical rural areas. This is because the employment agreements coupled with the revenue sharing may serve as boosts to local economic activity.

4. DATA

We rely on the Bureau of Economic Analysis (BEA) county level data which are essentially economic profiles that include information on population, employment, government assistance, and income variables. These measures are available from 1969 to 2021. The Alaska economy is comprised of 29 boroughs/census areas which are fairly diverse. However, they are marked by a significant reliance on government. In fact, 14 of the 29 boroughs have 40 percent or more their employment in state and local government. For the past quarter-century, Alaska's economy has been characterized by relatively slow and steady growth in population and employment driven by growth across many sectors such as the federal government, mining, tourism, air cargo, healthcare, and retail trade, and with significant regional variation. In Table 1, we provide descriptive statistics that show that most of the Alaska population is concentrated in Anchorage, Fairbanks, Matanuska-Susitna, and Juneau. The rural boroughs are smaller and more reliant on government assistance. Only 18 boroughs have complete data and those are the ones we present in Table 1 and rely on for our synthetic control analysis.

Figure 1: Alaska boroughs/Northwest Arctic borough



5. IDENTIFICATION

The Northwest Arctic Borough is unique for a variety of reasons, only one of which is that it is resource rich. It is located in Alaska's northern-most region and is relatively sparsely populated. At the start of our sample period (1969) the population of the Northwest Arctic borough was 3,983 whereas that in Anchorage was 123,265 and in the average Alaskan borough it was 22,164 (though the median population (7,846) was more similar to that in the Northwest Arctic borough). According to BEA data, at the start of the sample period wage and salary income was also lower in the Northwest Arctic borough than in other boroughs. Anchorage, for example, is clearly not a suitable comparison unit for the Northwest Arctic borough. Instead of subjectively choosing a set of comparison units based off of geographic proximity or economic similarity, we construct one using the Synthetic Control Method (SCM).

Abadie et al. (2010) argue that, unlike the traditional regression-based difference-in-difference model that restricts unobserved effects to be time-invariant, SCM allows the effects of such unobserved characteristics to vary with time. In particular, Abadie et al. (2010) show that by matching on pre-event outcomes and characteristics, a synthetic control also effectively matches on time-varying unobserved factors.[8]

[8]Abadie et al. (2010) put it, "...only units that are alike in both observed and unobserved determinants of the outcome variable as well as well as in the effect of those determinants on the outcome variable should

Table 1: Basic descriptive statistics

County	Avg(W&S)	Per-capita earnings	Employment	Population	Unemp. insurance	Income maintenance	Government transfers
Anchorage	31,565	20,211	124905	227391.	143.	346.1	2985.9
Bethel	26,984	13,248	5616	14892.	220.6	1177.2	5173.8
Bristol Bay	27,699	22,132	1,194	1,218	179.6	372.02	3316.93
Dillingham	28,696	18,216	2,302	4905	170	778.4	4,149.8
Fairbanks North Star	29,732	16,132	36,810	74,330	176.6	295.2	2,879.2
Haines	27,809	24,838	904	2,235	277.85	433	4892.8
Juneau	29,838	20,832	14,367	25,832	144.9	270.7	2,794.2
Kenai Peninsula	32,814	18,127	16,000	45,055	293.02	383.02	4159.6
Ketchikan	28,114	19,360	6,910	12,972	201.4	405.08	3616.1
Kodiak Island	25,850	16,505	6,448	12,202	170.5	283.9	2686.4
Matanuska-Susitna	24,809	16,180	10,121	44,738	232.93	248.6	2747.8
Nome	25,731	12,036	2,980	8,126	200.4	892.2	4,489.6
North Slope	6,6457	24,310	9,476	6,920	163.05	403.57	3183
Northwest Arctic	31,236	11,725	2,202	6,121	253.8	878.11	4741.8
Sitka	30,705	18,881	4,283	8665	182.8	290.68	3737.8
Skagway	–	–	–	–	–		
Southeast Fairbanks	34,363	16,446	2,246	6,430	262.0	585.42	4284.8
Valdez-Cordova	37,962	21,504	4,705	9,772	326.0	325.2	3,724.7
Wade Hampton Census Area	17,861	6,146	1,560	5,941	216.31	1173.7	4,695.7
Yukon-Koyukuk Census Area	30,637	11,432	2,542	7,068	353.5	1,377.6	6,754.6

Note: Earnings, unemployment insurance, Income maintenance, and Government transfers are all on a per-capita basis.

Finally, because the construction of a synthetic control does not require access to post intervention outcomes, SCM allows us to decide on a study design without knowing its bearing on its findings (Abadie et al. (2010)). The ability to make decisions on research design while remaining blind to how each particular decision affects the conclusions of the study is a safeguard against actions motivated by a "desired" finding (Rubin, 2001).

To obtain the synthetic control we follow Abadie and Gardeazabal (2003) and Abadie et al. (2010). For boroughs $i = 1, ..., J+1$ and periods $t = 1, ..., T$ suppose state $i = 1$ is exposed to the intervention (oil price shock) at time $t^* \in (1, T)$. The observed outcome for any borough i at time t is

$$Y_{i,t} = Y_{it}^N + \alpha_{it} S_{it}, \tag{1}$$

where Y_{it}^N is the outcome for borough i at time t in the absence of the intervention, the binary indicator variable, S_{it}, denotes the intervention taking the value of 1 if $i = 1$ and $t > t^*$, and α_{it}, the coefficient to be estimated, is the effect of the intervention for borough i at time t.

produce similar trajectories of the outcome variable over extended periods time."

Under standard conditions, there exists $W* = (w_2^*, ..., w_{J+t}^*)'$ such that pre-intervention matching is achieved with respect to the outcome variable as well as characteristics (or predictors), and we can use

$$\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}, \quad t \in T_0 + 1, ..., T, \tag{2}$$

as an estimator for α_{1t}. The term $\sum_{j=2}^{J+1} w_j^* Y_{jt}$ on the right-hand-side of (2) is simply the weighted average of the observed outcome of the control boroughs for $t \in T_o + 1, ..., T$ with weights W^*. The optimal weights placed on each unit are found by minimizing

$$(X_1 - X_0 W)' V (X_1 - X_0 W), \tag{3}$$

where X_1 is a $k \times 1$) vector of pre-event predictors for the treatment borough (Northwest Arctic), X_0 is a $(K \times J)$ matrix of pre-event predictors for the control group of boroughs, and W is a $(J \times 1)$ vector of weights that are assigned to controls in the donor pool that sum to one. Finally, V is a $(K \times K)$ diagonal matrix, where the diagonal elements describe the importance of each predictor. For each of the outcome variables, we create the counterfactual for each outcome based on gender composition, median age, share of employment in government, share of proprietors, and lagged outcomes of interest. We use 1989 as the event year as it is the year before production began in the Northwest Arctic borough.

5.1. Inference

Once an optimal weighting vector W is chosen, the "synthetic" is obtained by calculating the weighted average of the donor pool. The post-intervention values of the synthetic control serve as our counterfactual outcome for the Northwest Arctic borough. The post-intervention gap between the actual outcome and the synthetic outcome, therefore, captures the impact of the intervention. We follow Bohn et al. (2014) and Munasib and Rickman (2015) to calculate a difference-in difference estimate for the Northwest Arctic borough,

$$\Delta_{TR} = |Y\overline{Post}_{TR,actual} - Y\overline{Post}_{TR,synthetic}| - |Y\overline{Pre}_{TR,actual} - Y\overline{Pre}_{TR,synthetic}| \tag{4}$$

where $Y_{TR,actual}^{Post}$ is the average of the post-intervention actual outcome of the -Northwest Arctic borough- treatment county, $Y_{TR,synthetic}^{Post}$ is the average of the post-intervention outcome of the counterfactual. Similarly, $Y_{TR,synthetic}^{Pre}$ is the average of the pre-intervention actual outcome of the -Northwest Arctic borough- treatment county, and $Y_{TR,synthetic}^{Pre}$ is the average of the pre-intervention outcome of the counterfactual. If the outcome changed in response to the intervention in time T_0 we would expect $\Delta_{TR} > 0$ for average wages and salaries, per capita earnings, total employment and total population as these would be benefits of the mine. On the other hand, for variables such as Unemployment insurance, income maintenance, and government transfers, we would expect $\Delta_{TR} < 0$. Similar to Munasib and Rickman (2015), we test the significance of this estimate by applying the permutations or randomization test – as suggested by Bertrand et al. (2004), Abadie et al. (2010) and Bohn et al. (2014). Specifically, for each county in the donor pool, we estimate the difference-in-difference as specified in Eq. (4) as if these boroughs were exposed to the begining of production at the Red Dog mine in time T_0 (i.e., apply a fictitious intervention). The distribution of these "placebo" difference in-difference estimates then provides the equivalent of a sampling. We also calculate a rank based on the ranking of the absolute value of the magnitude of the difference-in-difference of the Northwest Arctic borough against all the placebo difference-in-difference magnitudes. For example, if DID rank is 1 then the estimated impact of the intervention in the Northwest Arctic borough is greater than any of the estimated placebo impacts.

6. RESULTS

We report results for a number of economic variables to evaluate different dimensions of the mine's effects. We show the results for wages/earnings in section 6.1, those for employment/population 6.2, and those for government dependence as measured by income maintenance, unemployment insurance, and government transfers in section 6.3. For each variable, we show the actual and synthetic outcome and the placebos of all the boroughs. Table 1 contains the basic descriptive statistics, Table 2 shows the weights that the donor boroughs contribute in the construction of the synthetic control for each of the variables of interest, Table 3 presents the statistical results for the full sample of the permutations or randomization tests, and Table 4 shows the average difference between the actual and synthetic in the post period for each variable as well as the average difference. We present the predictor balance for each of the outcome variables in Table 5. In section 7, we present the sensitivity analysis we conduct by dropping the biggest donor for each of the outcomes and re-estimating the synthetic control. We do this to rule out the concern that our control units may be benefiting from the Red Dog mine and therefore biasing our results downward.

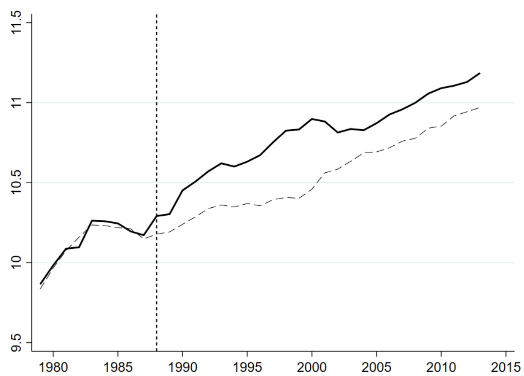
6.1. Average wages and earnings per capita

In panel (a) of Figure 2, we present the actual (solid line) and synthetic line (dashed line) for average wages and salaries. We observe a good pre-intervention fit indicating the synthetic is able to recreate a combination of units that is similar to the Northwest Arctic Borough. Immediately after 1989, there is a divergence between the two lines with the Northwest Arctic borough growing at a much faster pace than its synthetic. Panel (b) shows the difference between the actual and synthetic as well as the same difference from all of the placebos. It is clear that the divergence for the Northwest Arctic borough (dark black line) is more pronounced than in other units. From Table 4, we can see that the average yearly difference between the Northwest Arctic borough and its synthetic is \$11,241 dollars which is very large as the pre-treatment wage average was only \$16,374 dollars. As we show in Table 3 3, the difference between the actual and the synthetic in the Northwest Arctic borough is the second largest -rank 2- which translates to a 0.11 p-value as we only have 18 units with complete data in our analysis. The small number of boroughs in our analysis means that even a rank of 1 would not pass the conventional statistical significance threshold.

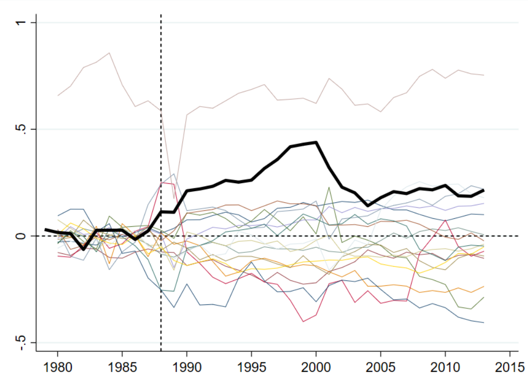
Panel (c) of Figure 2 gives the results for earnings per capita and similar to the average wage and salary variable, the treatment effect is positive as we see a divergence between the actual and synthetic but only has a rank 4 as we show in Table 3 which means there are three other boroughs that experienced faster increases in earnings in the post intervention period. The results from average wage and salary and earnings per capita, however, both indicate that the mine had spillover effects as we find that overall wages and earnings per capita increased substantially after the mine production began.

The BEA data is sufficiently rich to explore population, employment, and three different types of government assistance. There is suggestive evidence that the mine increased private sector employment in panels (a) and (b) of Figure 3 and decreased government assistance in the form of lower unemployment insurance in panels (a) and (b) of Figure 4, income maintenance in panels (c) and (d) of Figure 4, and government transfers in panels (a) and (b) of Figure 5.

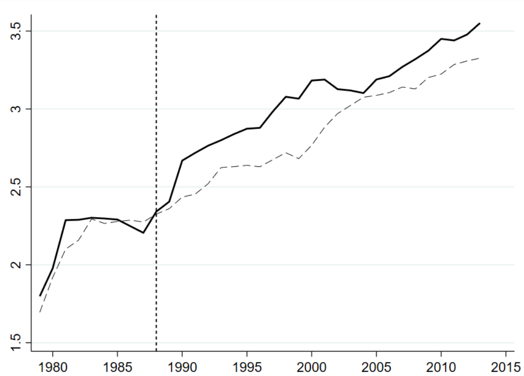
Figure 2: Average wages and earnings per capita



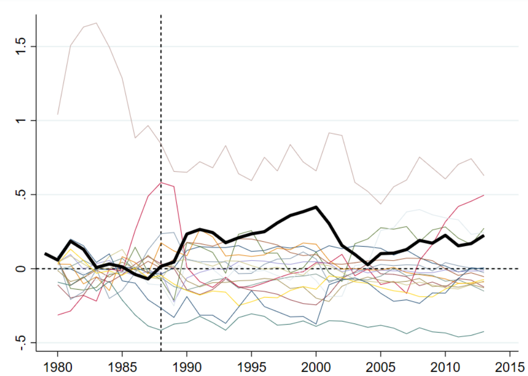
(a) Average wages and its Synthetic



(b) Average wages and Placebos



(c) Earnings per capita and its Synthetic



(d) Earnings per capita and Placebos

Notes: **Earnings per capita:** Consists of earnings by place of work less contributions for government social insurance plus the adjustment for residence.
Average Wage and Salaries: are wages and salaries divided by total wage and salary employment.

6.2. Total employment and population

The direct effects from the mine's activities have been well documented and are the focus of Berman et al. (2020) who focus on whether indigenous employees at the Red Dog mine fared better than otherwise similar workers not employed there by focusing on their long term earnings and mobility. They essentially focus on the direct effects of the mine on the individual Indigenous workers of the region. They find that the workers from the region who were hired by the mine had much larger earnings, and the increased earnings persisted, especially for male workers, even after most no longer worked at Red Dog.

Understanding the borough-wide effects of the mine asks not just whether the mine created jobs but if the number of jobs in the Northwest Arctic borough as a result of the mine is higher or lower than what would have been observed in the absence of the mine. It is not a priori clear if the mine jobs would result in spillovers as there are many fly in out fly out workers and therefore leakage plagues the area.

Our analysis presented in panel (a) of Figure 3 shows that the Northwest Arctic borough (solid line) added more jobs than its synthetic (dashed line). Panel (b) shows that the Northwest Arctic borough (solid line) has one of the most pronounced increases. Table 4 shows that the average difference between the actual and the counterfactual between 1989 and 2013 is 309 jobs per year. In other words, there would have been 309 fewer jobs a year in the absence of the mine. The rank for the employment variable in Table 3 is 3rd but the employment gains are once again economically meaningful as they represent 11 percent of all employment from 1989 to 2013.

On the population front, panel (c) of Figure 3 shows that the population growth in the Northwest Arctic borough (solid line) continued but its divergence from its synthetic is due to a sharp drop in population in the synthetic. [9]

6.3. Government reliance: Unemployment insurance, Income maintenance

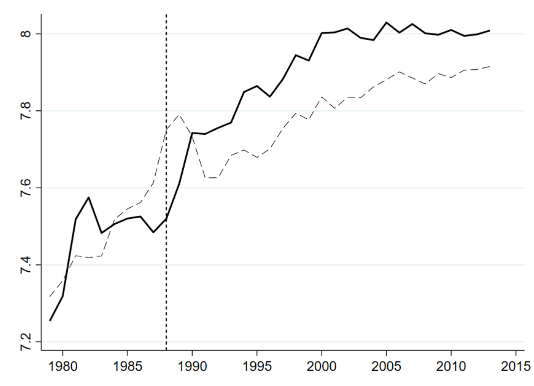
The Northwest Arctic Borough has historically been highly dependent on government receipts as evidenced by the Alaska Department of Labor in a 2009 article. [10] In it, they state "One big difference between the Northwest Arctic Borough and the state is the relative importance of transfer payments as a portion of personal income."

To evaluate if the mine has affected this dependence, we use three different measures which are government transfers, unemployment insurance, and income maintenance. We find that both government transfers -panels (a) and (b) of Figure 5- and income maintenance -panels (c) and (d) of Figure 4 - declined after 1989. Government transfers would have been 1,348 dollars and income maintenance $897 dollars higher per person in the absence of the mine. However, as we show in Table 3, there are many other communities that had more pronounced drops in government dependence post 1989. Unemployment insurance -panels (a) and (b) of Figure 4- is a noisy series and we don't find evidence that the mine has affected its path.

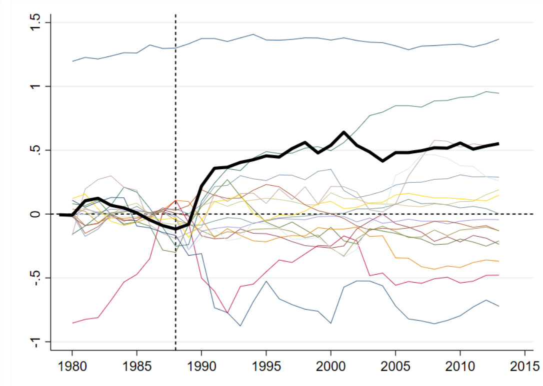
[9] The drop in the synthetic control group is due to a decrease in Dillingham's population which represents a large share of the synthetic group.

[10] https://labor.alaska.gov/trends/trendspdf/jan99.pdfA profile of the Northwest Arctic Borough

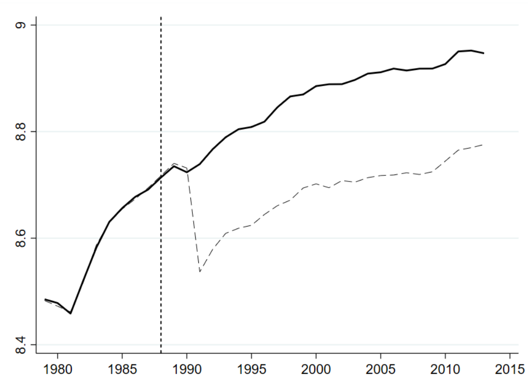
Figure 3: Employment and population



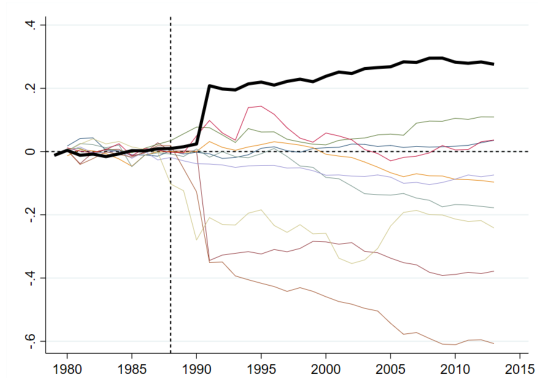
(a) Employment and its Synthetic



(b) Employment and Placebos



(c) Population and its Synthetic



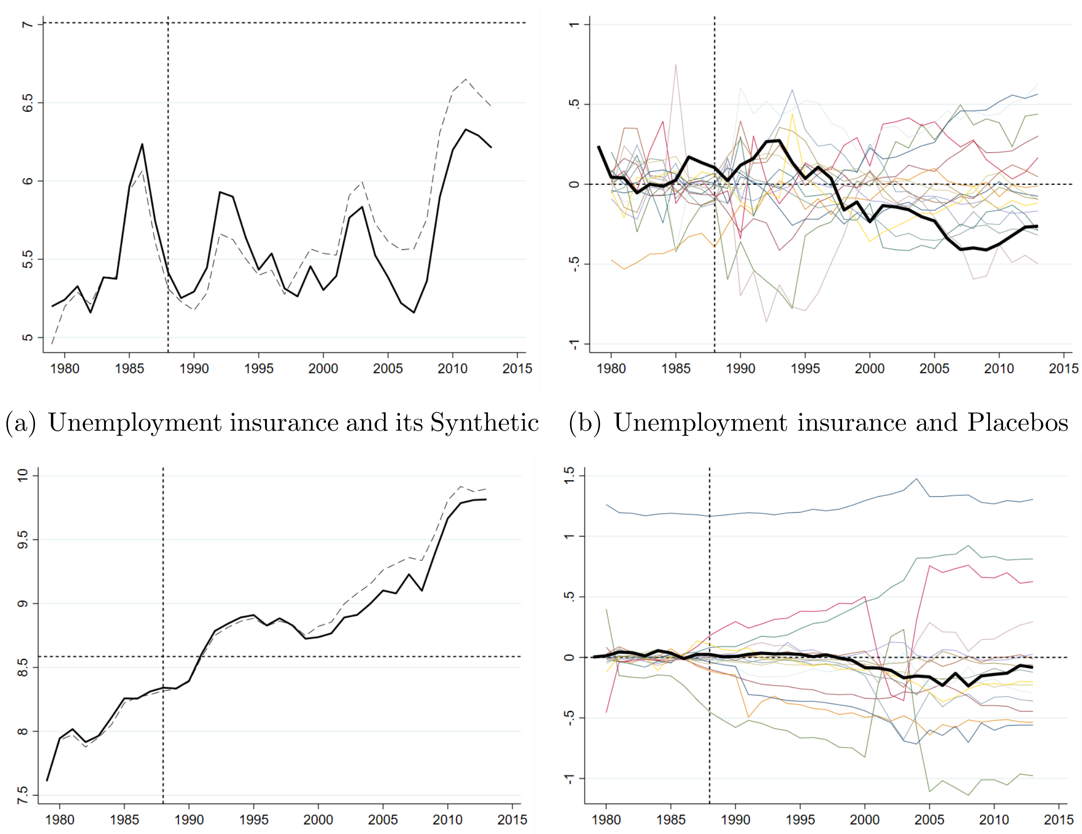
(d) Population and Placebos

Notes: **Total Employment:** A count of jobs, both full-time and part-time. It includes wage and salary jobs, sole proprietorships, and individual general partners, but not unpaid family workers nor volunteers. **Population**: Number of residents in the area.

7. SENSITIVITY ANALYSIS

Given the small labor pool in the Northwest Arctic borough and its isolation, some of the gains of this economic development may be spilling over into other boroughs. These spillovers may, then, result in a downward bias of our results if some of the residents in our control units are benefiting from the Red Dog mine. To address this concern, we re-estimate all our outcome variables by removing the biggest donor from each outcome of interest and present the new weights by variable in Table 6 and the results -synthetic and actual- in Figure 6. It is striking how similar our results are even when eliminating the biggest donor for each of the outcome variables indicating that the isolation of the Northwest Arctic borough and the difficulties associated with commuting in remote Alaska limit within state spillovers.

Figure 4: Unemployment insurance and income maintenance



(a) Unemployment insurance and its Synthetic (b) Unemployment insurance and Placebos

(c) Income maintenance and its Synthetic (d) Income maintenance and Placebos

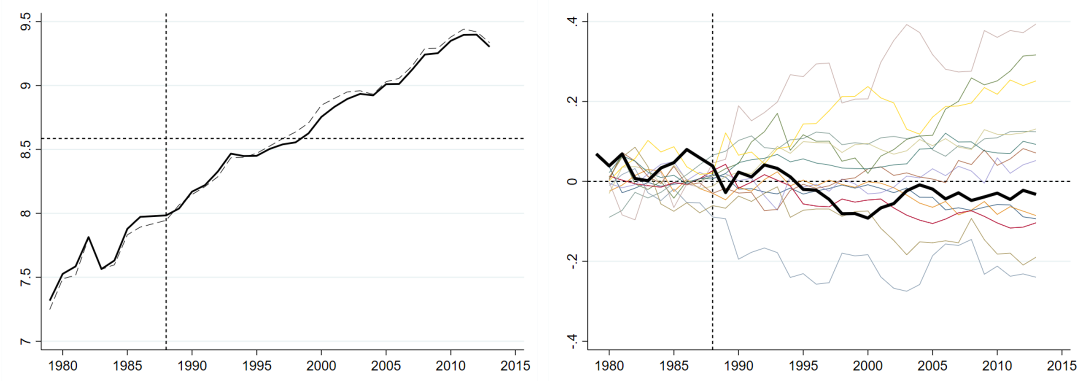
Notes: **Unemployment insurance**: The special benefits authorized by federal legislation for periods of high unemployment. The provisions that govern the eligibility, timing, and amount of benefit payments vary among the states, but the provisions that govern the coverage and financing are uniform nationally. **Income maintenance:** benefits consists largely of Supplemental Security Income (SSI) benefits, Earned Income Tax Credit (EITC), Additional Child Tax Credit, Supplemental.

8. TAKEAWAYS

We find compelling evidence that the mine changed the trajectory of many economic variables in the Northwest Arctic borough. Specifically, we find that average wages and salaries are considerably higher than they would have been in the absence of the mine. We also find that employment is higher and government transfers are generally lower. The broad gains we find are potentially at least partially a result of the structure of the agreement between the mine's operators and the borough. The agreement established a 12 person committee equally split between NANA and Teck to oversee all mining activities. The agreement also established a goal of 100 percent shareholder employment at the mine by 2001.[11] The mine also agreed to provide "various training and apprenticeship programs, scholarships for

[11]This goal of 100% employment was not achieved.

Figure 5: Government transfers



(a) Transfers and its Synthetic (b) Transfers and Placebos

Note: **Government transfers:** Receipts of persons from government and business for which no current services are performed. Current transfer receipts from government include Social Security benefits, medical benefits, veterans' benefits, and unemployment insurance benefits. Current transfer receipts from business include liability payments for personal injury and corporate gifts to nonprofit institutions.

youth, tuition assistance programs for mine employees, and has established joint venture opportunities for NANA business partners" for contracted activities (such as trucking). The provision for contracting preference to NANA companies has allowed NANA to use the mine to develop companies and expertise that then spin off to compete elsewhere in Alaska. This expands business expertise and shareholder employment opportunities beyond the mine. This relationship potentially explains the borough wide effects we find even in the absence of the traditional necessary factors for a large multiplier.

9. CONCLUSION

There is a large literature documenting the various economic short term effects of natural-resource shocks, and a more recent strand that has investigated the long term consequences effects of resource booms (Berman et al., 2020; Mosquera, 2022; Jacobsen and Parker, 2016). We build upon this emerging literature that estimates the long term effects by analyzing a broad set of outcomes from the effects of the Red Dog mine. We examine the path of wages, employment, population, and government dependence. Even in the absence of the the traditional connectdness needed to have significant multiplier effects, we find long lasting positive impacts from the mine in the form of higher wages and higher employment. The unique relationship between the borough and the mine may explain these positive effects.

Our results offer implications for practitioners and policy makers alike. The emphasis on local hire and localization of the gains may be informative for other rural communities who are facing questions regarding resource development. In this context, policies such as local hire may help localize some of the gains. However, the feasibility and effectiveness of such programs remain speculative until additional research can be carried out.

Table 2: SCM weights by variable

County	Avg(W&S)	Per-capita earnings	Employment	Population	Unemp. insurance	Income maintenance	Government transfers
Anchorage							
Bethel	0.851	.953		.255	0.226	.622	.515
Bristol Bay			0.169	0.067		.013	
Dillingham			0.491	0.547			
Fairbanks North Star							
Haines			0.254			0.129	
Juneau							
Kenai Peninsula							
Ketchikan							
Kodiak Island	0.104						
Matanuska-Susitna							
Nome				0.386			
North Slope	0.159	0.044				0.236	
Northwest Arctic	–	–	–	–	–	–	–
Sitka							
Skagway							
Southeast Fairbanks							
Valdez-Cordova							
Wade Hampton Census Area							
Yukon-Koyukuk Census Area		0.003			.774		.485

Table 3: Statistical Significance Tests

Variable name	(P-value)	(Rank)
BEA Data		
Avg W&S	.111	2
Per capita earnings	0.23	4
Total employment	0.17	3
Population	0.17	3
Unemployment insurance	0.61	11
Income maintenance	.77	14
Government transfers	0.44	8

Notes: : Earnings, unemployment insurance, income maintenance, and government transfers are per-capita variables. "Rank" corresponds to the rank of the Northwest Arctic borough in terms of the absolute change in an outcome variable before and after the intervention period. "P-value" is rank over the number of units. For EPC, while NWAB ranks 4th, the three units who have a larger change are all ones that experienced decreases in employment. For wages and salaries, while the NWAB ranks second, the only unit to have a larger absolute value difference actually experienced a decrease in W&S. For employment, only one other borough experienced faster employment growth. Our SCM approach uses a difference-in-differences method consistent with Bohn et al. (2014) and Munasib and Rickman (2015).

Table 4: What do the results actually mean?

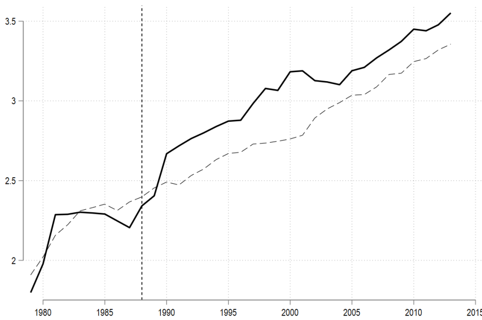
	Avg W&S	Per-capita earnings	Employment	Population	Unemp. insurance	Income maintenance	Government transfers
Average effect (1989-2013)	11,115.80	4.14	308.89	1468.30	-50.23	-838.72	-236.85
Dynamic effect							
1989	3,138.04	0.48	-397.84	93.49	4.26	22.00	-87.48
1990	6,602.127	3.00	21.88	145.23	22.41	30.96	80.60
1991	7,230.729	3.52	247.26	1,172.87	34.63	138.40	41.56
1992	8,093.30	3.43	283.61	1,151.95	88.14	222.94	167.22
1993	9,401.053	2.64	193.15	1,161.74	87.32	195.84	151.70
1994	8,951.65	3.22	358.39	1,282.71	35.76	215.80	53.11
1995	9,530.04	3.70	440.63	1,319.17	8.07	181.36	-94.48
1996	11,702.12	3.93	320.98	1,280.72	25.84	38.12	-109.38
1997	14,071.82	5.25	318.67	1,381.34	7.48	153.38	-234.88
1998	17,175.69	6.54	393.89	1,448.93	-33.76	-30.56	-438.45
1999	17,676.96	6.85	396.63	1,408.80	-27.38	-148.28	-466.90
2000	19,196.84	8.19	456.25	1,530.55	-53.026	-549.91	-609.99
2001	14,592.88	6.38	535.53	1,611.53	-31.34	-589.22	-469.58
2002	10,154.14	3.31	493.98	1,585.48	-48.76	-816.46	-416.37
2003	9,290.54	2.07	425.16	1,686.10	-59.00	-1,365.76	-179.86
2004	6,642.074	0.58	336.16	1,724.60	-56.54	-1,341.07	-65.42
2005	8,651.203	2.348	423.42	1,743.54	-56.40	-1,568.08	-158.950
2006	10,429.39	2.47	289.45	1843.73	-75.10	-2,287.90	-367.56
2007	10,347.06	3.18	400.057	1,826.84	-87.760	-1,430.53	-266.30
2008	11,915.43	4.80	368.15	1,909.17	-104.17	-2,386.91	-504.73
2009	12,316.43	4.61	285.99	1,910.38	-185.59	-1,980.52	-413.51
2010	13,826.57	6.36	350.72	1,852.98	-223.34	-2,378.33	-342.37
2011	11,420.85	4.46	252.51	1,877.89	-212.26	-2,470.27	-555.31
2012	11,566.59	5.05	260.03	1,904	-165.70	-1,244.47	-271.93
2013	13,971.55	7.02	267.56	1,853.19	-149.75	-1578.54	-362.03

Notes: The values represent the difference between the actual and the synthetic control for each of the outcome variables.

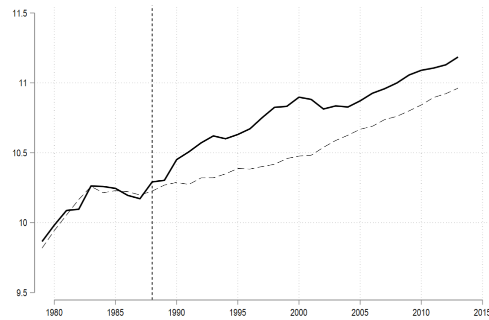
Table 5: Predictor balance by outcome variable

	(1)	(2)	(3)	(4)
	Earnings per capita		*Average wages*	
	Treated	Synthetic	Treated	Synthetic
lagged outcome(1980)	1.97	1.919	9.98	9.96
lagged outcome(1983)	2.30	2.294	10.26	10.23
lagged outcome(1986)	2.24	2.286	10.19	10.21
share over 65	.046	.0417	.0465	.0404
share under 19	.340	.328	.340	.324
share female	.469	.475	.469	.471
Median age	22.46	23.405	22.46	23.64
% state gov.	.0386	.0514	.0386	.0457
% local gov	.395	.300	.395	.2825
% Retail	.112	.102	.1123	.0961
% Proprietors	.065	.103	.0655	.0928
	Employment		*Population*	
	Treated	Synthetic	Treated	Synthetic
lagged outcome(1980)	7.318	7.358	8.47	8.47
lagged outcome(1983)	7.482	7.423	8.58	8.59
lagged outcome(1986)	7.52	7.561	8.67	8.67
share over 65	.046	.0464	.0465	.0420
share under 19	.340	.304	.340	.303
share female	.469	.477	.469	.467
Median age	22.46	25.85	22.46	25.069
% state gov.	.0386	.037	.038	.045
% local gov	.395	.205	.395	.2219
% Retail	.112	.100	.112	.0831
% Proprietors	.065	.250	.065	.207
	Unemployment insurance		*Income maintenance*	
	Treated	Synthetic	Treated	Synthetic
lagged outcome(1980)	5.24	5.197	7.94	7.931
lagged outcome(1983)	5.38	5.38	7.964	7.952
lagged outcome(1986)	6.236	6.065	8.256	8.266
share over 65	.046	.041	.046	.0418
share under 19	.340	.285	.340	.312
share female	.469	.440	.469	.467
Median age	22.462	26.03	22.462	24.75
% state gov.	.038	.0501	.038	.0403
% local gov	.395	.2546	.3954	.243
% Retail	.112	.081	.112	.101
% Proprietors	.065	.116	.065	.113

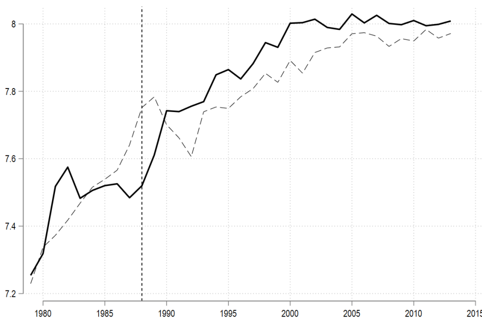
Figure 6: Sensitivity analysis



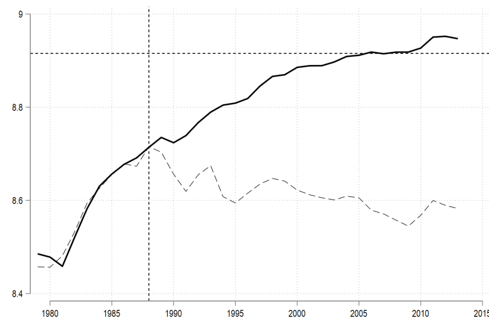
(a) Earnings and synthetic



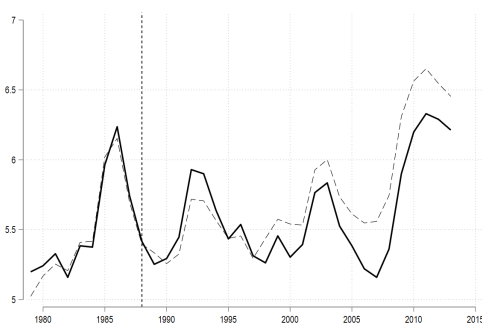
(b) Average wages and synthetic



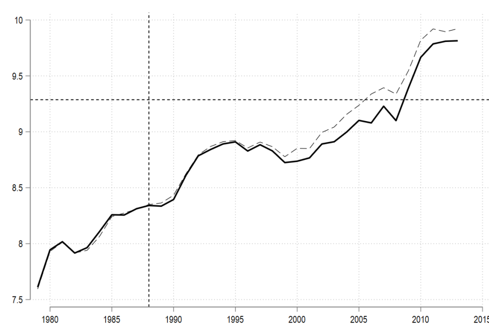
(c) Employment and synthetic



(d) population and synthetic



(e) Unemployment insurance and synthetic



(f) Income maintenance and its Synthetic

Notes: **Unemployment insurance**: The special benefits authorized by federal legislation for periods of high unemployment. The provisions that govern the eligibility, timing, and amount of benefit payments vary among the states, but the provisions that govern the coverage and financing are uniform nationally. **Income maintenance:** benefits consists largely of Supplemental Security Income (SSI) benefits, Earned Income Tax Credit (EITC), Additional Child Tax Credit, Supplemental.

Table 6: SCM weights by variable: Sensitivity analysis

County	Avg(W&S)	Per-capita earnings	Employment	Population	Unemp. insurance	Income maintenance	Government transfers
Anchorage							
Bethel	—	—	.511				
Bristol Bay				.22			.044
Dillingham	.119				.121		
Fairbanks North Star							
Haines			.442				
Juneau							
Kenai Peninsula							
Ketchikan							
Kodiak Island							
Matanuska-Susitna		.036		0.013			
Nome	0.84	.964		.526		.831	.838
North Slope	.04					.147	.119
Northwest Arctic	–	–	–	–	–	–	–
Sitka							
Skagway							
Southeast Fairbanks							
Valdez-Cordova			0.046				
Wade Hampton Census Area							
Yukon-Koyukuk Census Area	.001			.241	.879		

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