Korean Peninsula 1945-1950: Are there long-run effects of short-term Governments in Korea?

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Abstract

This paper inspects the regions defined between the 38th parallel north and the DMZ on the Korean peninsula. These areas were governed by "different Koreas" from 1945-1950 and after 1953. Using nighttime lights data and geolocated population estimates, RD and OLS analysis find that there is *(i.)* no economic discontinuities at the 38th parallel, *(ii.)* that the region in the present-day DPRK which was presided over by the ROK from 1945-1950 is associated with significantly higher economic activity per capita than similar regions of the country, and *(iii.)* that economic activity and per capita economic activity in the DPRK is concentrated around the 38th parallel.

Keywords: Korea, economic history, development economics, political economy, persistence, government.

JEL Codes: N4, N9, O1, O5, P5, P2

1 Introduction

This paper explores the lasting economic consequences of shifting borders on the Korean peninsula in the middle of the 20th century. When I began this project in 2020, I mostly considered it as a historical curiosity. Now in 2025, with two wars of territorial expansion, constantly shifting borders, and major international intervention, it sadly could not be more relevant.

Following World War II, the Korean Peninsula was partitioned at the 38th Parallel North from 1945-1950. The North was under control of the USSR and later, the Soviet-style dictator Kim Il Sung, while the South was under control of a US provisional government, and later the

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authoritarian and vehemently anti-communist president Syngman Rhee (Lee 2006). After the Korean War (1950-1953), the new and present-day border passed through the 38th parallel, meaning that modern-day North Korea (DPRK) and South Korea (ROK) preside over territories that were officially part of the other from 1945 to 1950. This paper aims to discover if the five-year "treatment" period of North and South Korean rule had lasting effects in the reclaimed territories in present-day South and North Korea respectively. The treatment is defined as belonging to a different Korea the five years before the war. Persistent detectable differences in treatment and control regions support the hypothesis that even short-term regimes can have long-term economic consequences.

While data from the DPRK are extremely limited, I will use nighttime lights imagery and geolocated population estimates from both countries to examine the spatial distribution economic activity on the Peninsula. Additionally, I will use official regional GDP (GRDP) data at the subprovince level to further the study in the South Korean context. As reliable data from before and during the Korean War are also scarce, this paper will focus on the recent outcomes in each country. The main goal of the paper is to evaluate the persistence of the effects of a short-term government with different ideologies from the succeeding government on the general welfare of the people living in those areas 60 years later. It should be noted that both DPRK and ROK governments during the treatment period were exceedingly authoritarian(Lee 2006).

A literature review will provide historical background for the geographic idiosyncrasy in Korea and will discuss the historical "other government treatment" in the context of other persistence studies in the economics literature. A regression discontinuity (RD) and OLS regression analysis will follow for both countries, although the Korean War (1950-1953) and a lack of historical data pose issues for identification. It will close with a discussion of the main findings and limitations of the study, concluding remarks on the subject, and suggestions for future areas of research.

2 Literature Review

2.1 Background and Historical Context

The Korean peninsula has a more than thousand-year history as an independent, sovereign state. Although it was often subject to Chinese influence and endured Mongul and Japanese invasions, the landmass was united by the Goryeo[1] dynasty from the years 918-1392 (Hong 2019), and by

[1] From which the English word *Korea* is derived.

the Joseon dynasty from 1392 until the annexation of Korea by Japan in 1910 (Lee 2006). The 35-year colonial rule officially ended when Japan surrendered to the Allied Powers ending World War II.

Despite Korea's long past, the winning powers of the war opted for a "trusteeship" of the peninsula for up to 5 years, instead of granting immediate independence. The United States and the Soviet Union became the predominant players in this arrangement. They agreed on a temporary partition of the Korean Peninsula at the 38th Parallel North. From 1945-1948, the North and South were ruled by Soviet and American provisional military governments respectively, with plans for reunification and independence in 1950. In 1948, the US and the UN formally oversaw the election of American-educated president Rhee Syngman in South Korea, while Soviet-educated Kim Il Sung was granted the position of premier and ruled without the Soviet military in the North. These acts officially established the Republic of Korea (ROK) and the Democratic People's Republic of Korea (DPRK) (Lee 2006).

Chosen out of convenience and to some extent ignorance, the 38th Parallel North had little meaning to Koreans, and as such, can be seen as exogenous to any economic or social realities on the ground. Former US Secretary of State, then Colonel in the US Army, Dean Rusk recalls how the 38th parallel was selected (Rusk 1991):

> *"During a meeting on August 14, 1945, the same day as the Japanese surrender, Colonel Charles Bonesteel and I retired to an adjacent room late at night and studied intently a map of the Korean peninsula. Working in haste and under great pressure, we had a formidable task: to pick a zone for the American occupation. Neither Tic nor I was a Korea expert, but it seemed to us that Seoul, the capital, should be in the American sector. We also knew that the U.S. Army opposed an extensive area of occupation. Using a National Geographic map, we looked just north of Seoul for a convenient dividing line but could not find a natural geographical line. We saw instead the thirty-eighth parallel and decided to recommend that. SWINK [State-War-Navy Coordinating Committee] accepted it without too much haggling, and surprisingly, so did the Soviets."*

Rusk later notes that unbeknownst to the Americans, Japan and Russia had considered the 38th parallel as a line of division between each other earlier in the century. He states that had they known this, they almost certainly would have chosen a different partition, as to not give the USSR the impression of having more legitimacy in the region than the US intended.

The Korean War began in 1950, with the invasion of the South by the North, and following three years of brutal warfare, ended without a peace treaty. In 1953, the Demilitarized Zone (DMZ) was created, and the new border was established, this time passing through the 1945 partition as shown in figure 1.

Figure 1.

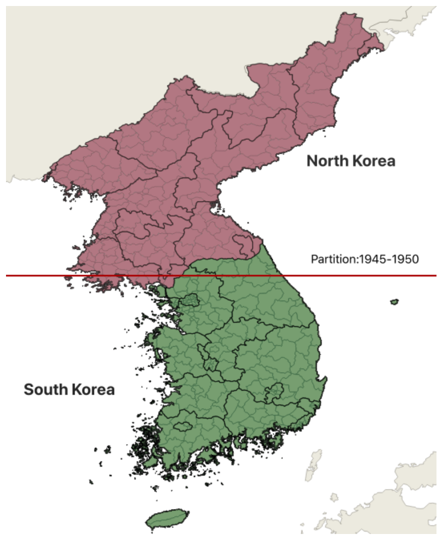

Figure 1: Map of the Korean Peninsula showing the 1953-present border and the temporary partition at the 38th parallel in red (1945-1950).

The exogeneity of the present-day border is subtler. During the initial invasion of the South, the communist armies made it all the way to Busan (at the bottom of the peninsula). It was at this point that the US and UN forces entered the war on behalf of the ROK. They swiftly pushed the DPRK's forces back north of the 38th parallel, and almost took the entire peninsula. At this point China entered the war on behalf of the DPRK and effectively drove the war front to around the 38th parallel where it shifted slightly thereafter. From mid-1951 to 1953 there was stalemate along the current border. It is hard to say why the fighting ended there; there is no natural geographic boundary or historical significance to the placement of the DMZ. It cuts through the former Goryeo Capital of Kaesong and through the Joseon-era provinces of Gyeonggi and Gangwon (resulting in two modern-day Gangwon provinces, one in the ROK and one in the DPRK) (Jung 2017). Although the terrain is similar and mountainous on either side of the current border, it should noted that the stalemate occurred along natural fault lines and waterways. Once the DMZ was established in 1953 at the end of the war, however, it was almost impenetrable, so that migration between the South and North was practically impossible for most people.

Balance tests for the initial partition at the 38th parallel and for the present-day border are performed using the Caloric Suitability Index of Galor and Özak (2016) and are presented in section 3. Given the agrarian nature of the Korean economy during the treatment period, this is a good proxy for economic potential.

Following the Korean War, the North appeared to have an industrial advantage. It continues as a dictatorship which pursues soviet-style military-industrial policies until the present (Lane 2019, Lee 2006). According to Lane (2019), in 1960, the ROK was politically corrupt and unstable. Economically, the ROK was one of the poorest countries in the world, poorer than Cameroon, Haiti, and Tanzania (Feenstra et al. 2015). Until 1969, with the arrival of the "Nixon Doctrine", a promise to end direct U.S. military support in East Asia, the South relied heavily on US financial support and lagged industrially. However, during the 1970s, South Korea underwent one of the most dramatic economic transformations yet seen, and by the 1980s the ROK was one of the richest countries in Asia (Lane 2019).

2.2 Persistence and Mechanisms

To what should we attribute any differences in economic activity between those regions of the countries which temporarily belonged to the other and the rest? This paper will argue that the main mechanism for persistence would have been the temporal transmission of culture or ideology of the short-term governments.

In one of the most powerful papers on persistence in the economics lituratue, Voigtländer and Voth (2012) study local continuity in anti-Semitism in Germany from 1350-1930s. They find that plague-era pogroms in German towns reliably predict violence against Jewish people in the 1920s, and votes for the Nazi Party in 1933. On one hand, this indicates that culture can persist even through long and traumatic wars. To list only a few examples, during this period the territory belonging to present-day Germany underwent the German Peasants' War (1524-1525), the Thirty-Years War (1618-1648), the Franco-German War (1870-1871), and the First World War. This indicates that the 3-year Korean War may have not decimated all of the effects of the "other Korea" treatment. On the other hand, Voigtländer and Voth (2012) find that this cultural persistence is lower in cities with high levels of trade and immigration.

According to Jung (2017), the ROK county of Cheorwon, a thin county running along the DMZ and entirely contained in Northern sector from 1945-1950 (see figure 2), lost around 85 percent of its original population during the Korean War, with most heading further into present-day DPRK and about 10 percent going south. Although Cheorwon is likely the most extreme case of emigration, as it shares the longest border with the DMZ of any South Korean county or city, all of the areas around the DMZ would have certainly experienced emigration during the war and immigration afterwards. Further, it could be reasoned that those who identified the most strongly with the Communist cause would have been most motivated to flee North, leaving behind only those who identified more with the ideology of the ROK.

Figure 2.

Figure 2: Map of Cheorwon County - entirely contained within the treatment area.

Overall, Voigtländer and Voth (2012) reveal that once a certain culture is established, it can persist for centuries. Was there time for North and South Korea to make a cultural foothold in the affected regions from 1945-1950? Both the ROK and the DPRK were war-torn fledgling countries recovering from decades of Japanese imperialism. Moreover, because of the short treatment period, any economic or social policy that could have been implemented would have necessarily been short lived. However, there are signs that the North Korean agenda was active and alive in the region currently contained in the ROK. It was here that they built their initial Workers' Party Headquarters, whose ruins now form a tourist attraction in South Korea (Jung 2017). Additionally, the proximity of the treatment region in present-day DPRK to the ROK's capital Seoul indicates that it may have been more affected by South Korean policies and media than more remote areas of the country .

However, in comparison to other studies which measure the cultural persistence of a certain treatment, the five-year treatment period is relatively short. Caicedo (2019), which examines the effects of Jesuit missions in South America on current levels of educational attainment and development, had a 158-year treatment period from 1609-1767. Dell (2010) studies the long-term effects of the 239-year forced mining labor system (mita) in Peru from 1573-1812. The Jesuit mission treatment in South America is more than 31 times the length of the treatment in Korea. Caicedo (2019) finds significant effects of the Jesuit missions on education and income 250 years after treatment occurred, only around four times longer than the treatment-measurement gap in Korea (60 years). Dell (2010) uses an RD design to show that districts that were subjected to mita mining have significantly lower levels of household consumption and higher prevalence of stunted growth in children. These papers are important because they provide well-identified evidence that treatment effects can persist even hundreds of years after the treatment has ended, and they can provide an indication of the length of treatment period necessary to induce persistent effects.

2.3 The Effects of War

As those areas that surround the DMZ experienced the most intense fighting of the Korean War, the treatment areas, particularly in the ROK, were undoubtedly more affected by war than their northern and southern neighbors (Jung 2017). As such, it is important to understand what effects more traumatic warfare may have had on the treated areas. How might the more intense warfare have impacted attitudes in general in the treatment areas in the ROK? Dell and Querubin (2018) find that the United States' "overwhelming firepower" approach in Vietnam may have worsened attitudes towards the US and South Vietnamese governments. Using a discontinuity in US bombing patterns, they reveal the causal effect that bombing increased communist activities and reduced non-communist civic engagement in the affected areas. While there are certainly differences between the Korean War and the Vietnam War, after the entry of China in the Korean War, the US Air Force changed its policy from only bombing precision military targets to also bombing North Korean cities and villages as main targets themselves (Kim 2012). This means that the villages and cities in the treatment region in the present-day ROK would have also been affected by this policy, and it is plausible that US bombing also increased communist activities in the treatment areas during the war.

Within the literature, there is no unifying conclusion on the effects of conflict on economic development, and several results are difficult to reconcile with each other. The correlation between civil war and lower per-capita incomes is a well-established relationship (Blattman and Miguel 2010). However, technological and institutional developments in Western Europe are often attributed to the pressures of war. Moreover, there is contemporary evidence of strong states emerging out of civil war in East Africa and Southeast Asia (Blattman and Miguel 2010).

Besley et al. (2014) analyze recorded conflicts in precolonial Africa from 1400-1700. They find that precolonial conflict is correlated with postcolonial conflict, and that historical conflict is correlated with lower levels of development. However, this result is not universal. Miguel et al. (2011) find that the long-term impacts of bombing in Vietnam are "negligible" in terms of education, infrastructure, literacy, population, and poverty. The main difference between these two studies is the type of warfare examined. Precolonial warfare in Africa was likely endogenous to various regions and cultures. However, bombing in Vietnam, while related to how communist-leaning the US viewed a given village to be, could be seen as relatively exogenous by comparison (Dell and Querubin 2017). Considering these studies in the Korean context, we might be more convinced by Miguel et al.'s (2011) result, as the type of warfare experienced during the Korean War likely mirrored that of the Vietnam War significantly more than that of precolonial Africa. In any event, there is no reason to believe that treatment and control areas in this context would have been affected differently.

One of the main concerns we might have about measuring the effects of a treatment so close to the Korean War, both spatially and temporally, is the large amounts of emigration and trauma the areas surrounding the DMZ experienced during the war. Are the towns in the treatment areas as prominent as they once were? While this paper does not have access to detailed historical data on the population distribution in Korea, Davis and Weinstein's 2002 study on the distribution of regional population in Japan can give us some insight into this issue. Over 10,000 years of history, they reveal that the relative sizes of Japanese cities were remarkably constant. Moreover, in the long run, the relative populations of these cities were unaffected by even the most devastating bombing of WWII. If the Korean case follows the same pattern as the Japanese, the long-run relative populations of the treatment areas may have been unaffected by the Korean War.

3 Data Description

3.1 Nighttime Lights and Geolocated Data

All data used are publicly available. A great challenge was posed by one of the treatment areas falling into the present-day DPRK. GDP estimates for North Korea are extremely difficult to come by. Even the comprehensive Penn World Tables omit the DPRK from its estimates due to the scarcity of reliable data (Feenstra et al. 2015). Nighttime lights have been used extensively in the literature to estimate the GDPs of countries for which little to no reliable data exists (Lee 2018; Henderson et al. 2012; Ghosh et al. 2010). They have the advantage of being completely objective, and they reflect consumption and production of both the formal and informal economies. Moreover, the detailed spatial component of nighttime lights data makes it an ideal option for this project, where they will be utilized for the analysis of both the DPRK and the ROK.

The Defense Meteorological Satellite Program (DMSP) collects images of the earth twice per day. These nighttime lights images have been made publicly available since 1992 on the National Oceanic and Atmospheric Administration (NOAA) website. Processing of nightlights images includes adjusting for cloud cover, gas flares, and fires (Lee 2018). Particularly, this paper uses a nighttime lights image of the year 2006 from Ghosh et al. (2010). This raster image was specifically processed in order to estimate economic activity, and it is also available on the NOAA website. In particular, it geocodes estimates of GDP in 2010 USD.

Gridded population count estimates were taken from NASA's Socioeconomic Data and Applications Center (CIESIN 2018) in 1 kilometer squared resolution raster format. This data is available for the years 2000, 2005, 2010, 2015, and 2020. In order to most closely match the date of the nighttime lights image (2006), this paper uses the estimates for 2005. The geographic controls for the RD plots are elevation, mean annual temperature, and mean annual precipitation. Elevation raster data was derived from the ASTER Global Digital Elevation Model, and temperature and precipitation raster data were taken from the Bioclim website. Average potential calories per hectare post-1500 (Columbian Exchange) were taken from the Caloric Suitability Index database. Administrative shapefiles for all maps and data processing were taken from the Database of Global Administrative Areas (GDAM) website. The shapefile used for the coastline combines NASA and World Bank data, and was sourced from Natural Earth, a public domain vector and raster database.

Using GIS software, I divided the administrative areas of the DPRK and ROK into grid cells of dimension 0.05 degrees latitude by 0.05[2] degrees longitude. Then, overlaying the nighttime lights image, I extracted the sum of values for all lit areas (GDP estimates) per grid cell. Using the same method, I also extracted the population estimates and geographic variables for each grid cell. Due to the nature of the data and the extraction method, the population estimates are likely slightly overestimated.

From the map, it is evident that the treatment area in the present-day DPRK is dominated

[2] 1 degree $\approx$ 111km, so grid cells are approximately 5x5 km.

by coastline. Despite numerous sanctions against the DPRK, international, and sometimes illicit, maritime trade form an integral part of the North Korean economy (Huish 2017). Since increased access to maritime trade disproportionately affects the treatment area, it is desirable to control for distance to the coastline. Additionally, the distance from the Demilitarized Zone (DMZ), the most heavily fortified border in the world, is also controlled for in the regression analysis. It should be stressed that these distance variables are approximations. I calculate the shortest linear distance in kilometers from the centroid of each grid cell to the respective features. Linear distance does not take into account the shortest route for someone to actually take, as it may go through a mountain range, the ocean, or in some cases, the DMZ.

Because grid lines do not align perfectly with province borders, some consideration has to be made when assigning a grid cell to a certain province. Since I want to be able to exclude certain provinces from my analysis, I assigned all grid cells to provinces in order of exclusion. In other words, the first province that should be excluded is assigned all of the grid cells along its border, the same follows for the second province of exclusion, unless those grid cells were previously assigned to the first. As a result, the grid cells assigned to the main provinces of interest, North and South Hwanghae Provinces in the DPRK and Gangwon Province in the ROK, are contained entirely in those provinces.

3.2 Additional Data for South Korea

For the modern-day ROK, official population data and Gross Regional Domestic Product (GRDP) are available from the Korean Statistical Information Service (KOSIS) Korean-language website (국가통계포털) [3]. The 1945-1950 partition runs through two ROK provinces, Gangwon and Gyeonggi. For these, GRDP data was available for the years 2000-2011 and 2010-2016 respectively. As a result, this study uses GRDP data from 2010 and 2011.

The majority of the treatment area falls in Gangwon province (see figure 3). It has 18 sub-provinces which are classified as either county (gun) or city (si), 7 of which fall in the treatment area. In 2010, the population of Gangwon province was 1,529,818, and the current price GDP per capita was 18,840,000 Korean won (KRW) or approximately 16,768 USD. In Gyeonggi province, only 2 of 31 sub-provinces fall into the treatment area. In 2010 the population of Gyeonggi-do was 11,786,622, and the current price GDP per capita was 22,620,000 KRW or approximately

[3] Sub-province level data is *not* available on the english-language KOSIS website.

20,132 USD.[4]

Figure 3.

Figure 3: Gangwon Province forms the majority of the treatment area in the ROK.

3.3 Balance Tests

Results for balance tests for both the initial partition and the present-day border are presented in Table 1. Both OLS regressions and RD specifications confirm the exogeneity of each border and suggest similar economic potential on either side of them. Economic potential is measured in average producible millions of calories per hectare. Observations are 5 km squared grid cells, as explained in Section 3.1. In all specifications, we fail to reject the null hypothesis, that there are statistically significant average differences or discontinuities in economic potential on either side of the borders. Figures 4 and 5 plot the associated RDs. The plots confirm the descriptive evidence that the present-day border was settled on natural fault lines due to fighting in the war, while the initial partition was more random.

Table 1: Balance Regressions

	(1) OLS	(2) OLS	(3) RD	(4) RD
Km North of Present-Day Border	28.60			51.12
	(16.45)			(44.47)
Km North of 38th Parallel		-7.987	18.56	
		(12.22)	(22.63)	
N	1104	1035	7359	8461

Notes: Standard errors in parentheses. Kilometers south of both borders are negative values. OLS regressions are restricted to 50 km north and south of the borders to avoid comparisons across locations that are too longitudinally distant. Tests for differences on either side of the 38th parallel exclude grid cells on the coastline. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

[4]Using the exchange rate of 0.00089 USD = 1 KRW (12 March 2010).

Figure 4.

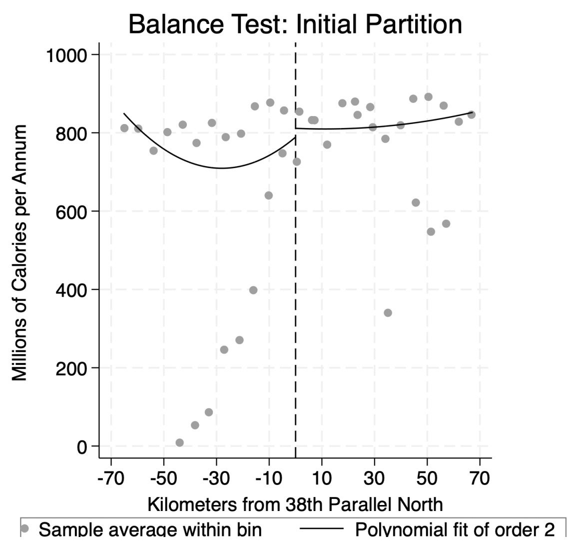

Figure 4: RD Plot showing no discontinuity at the 38th Parallel.

Figure 5.

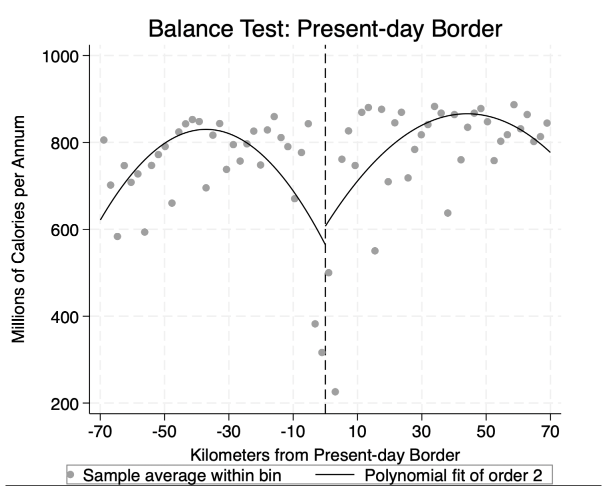

Figure 5: RD Plot showing no discontinuity at the present-day border.

4 Empirical Strategies

4.1 North Korea

4.1.1 Regression Discontinuity

The RD plots are presented using two different dependent variables. The first is the GDP estimate, which captures the overall economic activity for each grid cell in 2010 USD. The second uses the GDP estimates divided by the population estimates for each grid cell. This is what I will call the "population adjusted GDP." This variable describes the estimated per capita economic activity for each grid cell. Three geographic controls (elevation, average yearly temperature, and average yearly precipitation) will be used to check for other possible discontinuities at the 38th parallel.

The first RD plots use equal bandwidth on both sides, and take the maximum distance from the south as the limit for the bandwidth in the north (see fig. 6). The maximum distance south of the 38th parallel contained in the DPRK is around 56 km, so the limit in the north is taken as 56 km. Second, using an MSE-optimal bandwidth selector, I created the same RD plots with a shorter, equal bandwidth on both sides (Imbens and Kalyanaraman 2012). All exact RD specifications are reported in appendix A.3.

Figure 6.

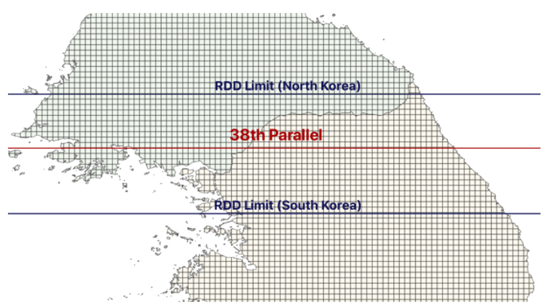

Figure 6: Gridded maps and maximal RD limits showing unit of observation and control areas.

Even using the largest bandwidth, all observations in the DPRK fall into North Hwanghae, South Hwanghae, Gangwon, or Kaesong provinces. It should be noted that the Kaesong Industrial Complex, a Special Economic Zone where South Korean firms operated using North Korean labor between 2004-2016, falls within the treatment area (Hong 2019). Its location is due to its proximity to the ROK and is unrelated to the ROK: 1945-1950 treatment. Additionally, none of the treatment area falls into Gangwon province, North Korea. For these reasons, I perform the RD analysis using observations from North and South Hwanghae provinces only. As these two provinces were historically one province for more than 700 years during the Joseon era, and little is known about their differences today, I will not analyze them separately.

4.1.2 OLS Regression

In order to augment the RD plots, the paper will use OLS regression with additional covariates to estimate the following models:

$$GDP = \alpha + \beta ROK + \phi DistCoast + \psi DistDMZ + \varepsilon \tag{1}$$

$$\frac{GDP}{Population} = \alpha + \beta ROK + \phi DistCoast + \psi DistDMZ + \varepsilon \tag{2}$$

Where *GDP* is the estimated GDP in millions of 2010 USD for each 5 by 5 km grid cell, *ROK* is a dummy treatment variable indicating whether a grid cell was a part of the ROK from 1945-1950, *DistCost* is the approximate linear distance in kilometers to the coastline, and *DistDMZ* is the approximate linear distance in kilometers to the DMZ. $\frac{GDP}{Population}$ estimated GDP divided by the population estimate. Since maritime trade is an important part of the DPRK economy, the distance to the coastline is meant to control for differences in economic activity due to variation in ability to engage in maritime-related trade. Additionally, the most intense fighting of the Korean War occurred along the DMZ, so the distance to the DMZ is a proxy variable for the effects of war. As with the RD analysis, the OLS models will be estimated with data from North and South Hwanghae provinces only.

4.2 South Korea

4.2.1 Regression Discontinuity

Following the same framework as the North Korean analysis, I use geographic GDP estimates derived from nighttime lights data from Gangwon province in the ROK to create RD plots. The maximum distance north of the 38th parallel contained in the ROK is around 70 km, so the bandwidth of the first RD plot uses those grid cells 70 km north and south of the 38th parallel (see fig. 5). Since almost all of the treatment area in present-day South Korea falls into Gangwon province, I create the RD plots using observations from Gangwon province only. RD specifications are again reported in appendix A.4.

4.2.2 OLS Regressions with Fixed Effects

The OLS regression models also follow from the North Korean case with the addition of province fixed effects:

$$GDP = \alpha + \beta DPRK + \phi DistCoast + \psi DistDMZ + \delta Prov + \varepsilon \quad (3)$$

$$\frac{GDP}{Population} = \alpha + \beta DPRK + \phi DistCoast + \psi DistDMZ + \delta Prov + \varepsilon \quad (4)$$

Here, *DPRK* is a dummy treatment variable indicating whether a grid cell was a part of the DPRK from 1945-1950, and *Prov* is a dummy variable indicating whether a grid cell belongs to Gyeonggi Province. In contrast to the RD analysis, the OLS models will be estimated with data from both Gangwon and Gyeonggi provinces.

To compliment the OLS models above, I also estimate the following fixed effects model using official current price GRDP data and population data at the sub-province level from 2010 and 2011 from Gangwon and Gyeonggi provinces. I calculated GRDP per capita (GRDPPC) for each county and city to estimate the following model:

$$GRDPPC = \alpha + \beta DPRK + \psi YearDummy + \phi DMZ + \delta Prov + \varepsilon \quad (5)$$

The treatment dummy variable is DPRK. It is applied to counties and cities for which more than 50 percent of the landmass falls in the treatment area (the area between the DMZ and the 38th parallel). Year effects for 2010 are used in every regression. The two other controls are a dummy for Gyeonggi province, and DMZ, a dummy variable which indicates whether a county or city is bordering the DMZ.

5 Results

5.1 Results for North Korea (North and South Hwanghae Provinces)

As an overview of the spatial distribution of economic activity in Hwanghae provinces, the paper will first examine the plots of estimated GDP and population adjusted GDP. Figure 7 shows the sum of lights for each grid cell in North and South Hwanghae province. The treatment area is on the *left* side of the red line, since it is the area south of the 38th parallel that was governed by the ROK from 1945-1950.

Here we can see that there is heightened activity in the treatment area and around 90 kilometers north of the 38th parallel. There is a “hump” of economic activity around the 38th parallel,

Figure 7.

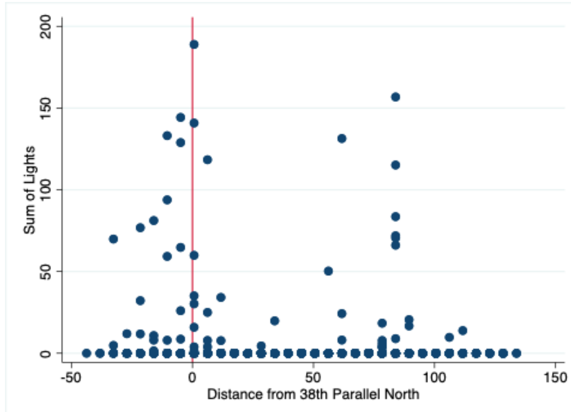

Figure 7: Hwanghae Provinces: Scatter plot of Estimated GDP by grid cell.

as the highest observation occurs at the 38th parallel, with other relatively high observations clustered in the treatment area. Figure 8 uses the same parameters as figure 7, but depicts the GDP estimates adjusted by population.

Figure 8.

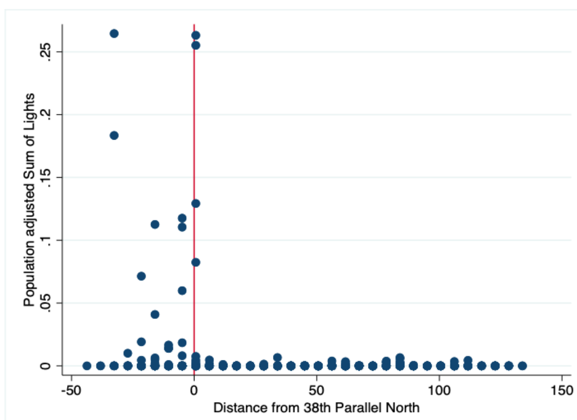

Figure 8: Hwanghae Provinces: Scatter plot of population adjusted GDP estimates.

This shows that the increased activity around 90 kilometers north of the 38th parallel can be accounted for by a larger population, while the higher activity in the treatment area cannot. After adjusting for population, some of the highest observations occur effectively at the 38th parallel. Although there are about 15 visible observations with increased economic activity, the rest of the 846 observations are bunched near zero.

Next we will see how this data translates into RD plots. Figure 9 shows the RD using the maximal bandwidth on either side of the 38th parallel, while Figure 10 uses the MSE-optimal estimate for bandwidth. Both show confidence intervals of 95 percent for each average distance. These RD plots both reflect what the simple plot showed. The estimated GDP is not statistically discontinuous at the 38th parallel, but it does form a "hump" around it.

Figure 9.

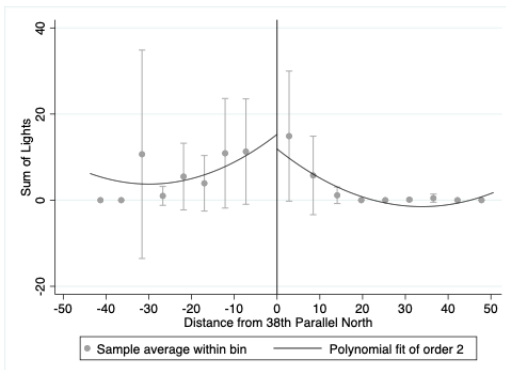

Figure 9: Hwanghae Provinces: RD plot for estimated GDP using maximal bandwidth.

Figure 10.

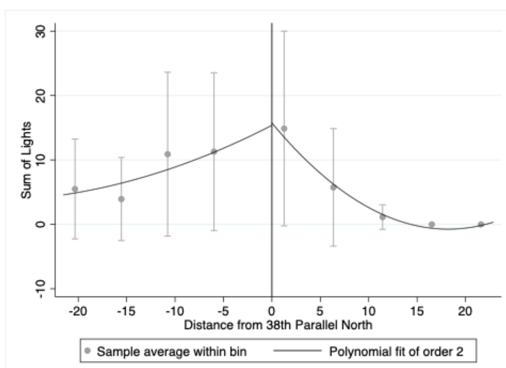

Figure 10: Hwanghae Provinces: RD plot for estimated GDP using MSE-optimal bandwidth.

Figures 11 and 12 use the same parameters as 9 and 10, but depict the average sum of lights adjusted by population estimates. Using the maximal bandwidth, we see that population-adjusted activity is generally higher in the treatment area, but that there is no significant discontinuity. This is likely because the 15 or so observations that are visibly above zero, are not enough to outweigh the hundreds of near-zero observations.

Using the MSE-optimal bandwidth, we can see more precisely that higher activity adjusted

Figure 11.

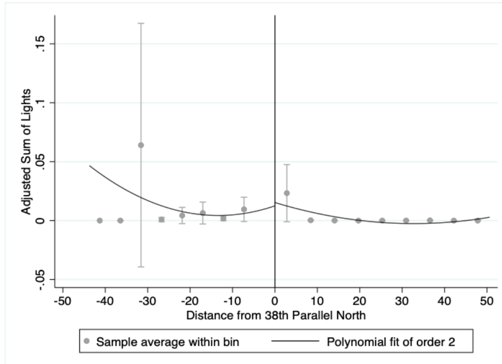

Figure 11: Hwanghae Provinces: RD plot for population adjusted GDP using maximal bandwidth.

Figure 12.

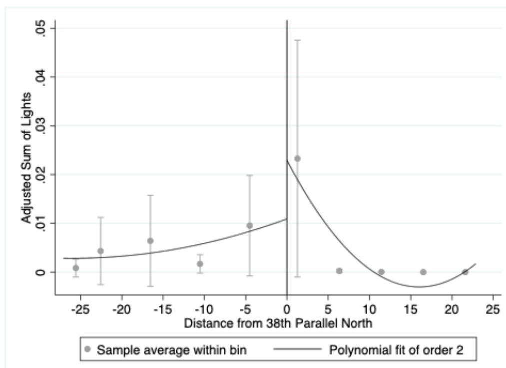

Figure 12: Hwanghae Provinces: RD plot for population adjusted GDP using MSE-optimal bandwidth.

by population occurs consistently in the treatment area and just north of the 38th parallel. Further north, all of the averages are effectively zero. A discontinuity does occur almost at the 38th parallel but just north of it.

In order to put these patterns into a geographic context, I include the RD plots of elevation, mean annual temperature, and mean annual precipitation which can be seen below (figs. 13-15). None of these indicators jump at the 38th parallel, although they do exhibit different trends from south to north as expected.

The second part of the analysis is the OLS models as described in section 4. The following tables estimate equations 1 and 2 respectively. Table 2 shows the output of the regression of

Figure 13.

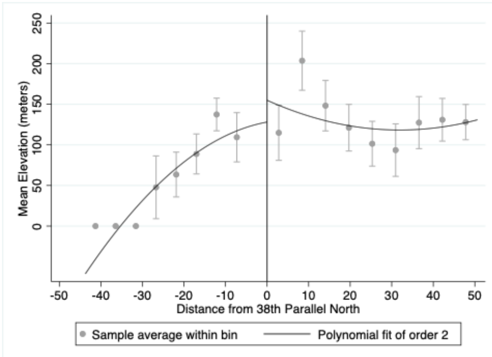

Figure 13: Hwanghae Provinces: RD plot of elevation.

Figure 14.

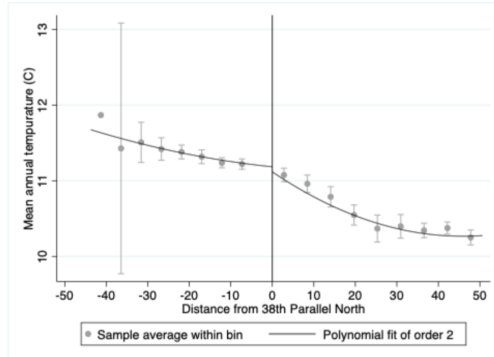

Figure 14: Hwanghae Provinces: RD plot of mean annual temperature.

Figure 15.

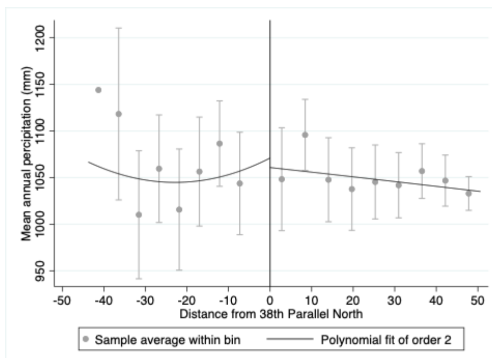

Figure 15: Hwanghae Provinces: RD plot of mean annual percipitation.

the estimated GDP for each grid cell against the dummy treatment variable (ROK:1945-1950) and other controls. Column 1 estimates the effect of treatment on lights using no controls, and column 4 estimates the full model. After incorporating all the controls, we see that only distance to sea is significant with a p-value less than 0.01.

Table 3 estimates the effects of treatment and controls on the population adjusted GDP estimates, and column 4 estimates the full model. The effect of treatment on the adjusted GDP remains large and significant, even when using all controls. This indicates that North Koreans living in the treatment areas of North and South Hwanghae are better off than those living in areas that were always controlled by the DPRK. Moreover, it implies that the ROK treatment can partially explain these differences and does so better than proximity to the DMZ or ability to engage in maritime trade.

Table 2: GDP (Millions of 2010 USD per 5 km^2): North and South Hwanghae

	(1) Treatment Only	(2) Coast	(3) DMZ	(4) All
ROK: 1945-1950	5.303***	2.823	6.206***	3.207
	(1.605)	(1.747)	(1.721)	(1.954)
Kilometers to Sea		-0.0726***		-0.0697**
		(0.0209)		(0.0219)
Kilometers to DMZ			0.0277	0.00876
			(0.0192)	(0.0200)
N	848	848	848	848

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Population Adjusted GDP (2010, Thousands of USD): North and South Hwanghae

	(1) Treatment only	(2) Coast	(3) DMZ	(4) All
ROK: 1945–1950	7.17***	5.63**	9.24***	8.10***
	(1.81)	(1.98)	(1.93)	(2.20)
Kilometers to Sea		-0.0449		-0.0266
		(0.0237)		(0.0247)
Kilometers to DMZ			0.0640**	0.0569*
			(0.0216)	(0.0226)
N	846	846	846	846

Standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.2 Results for South Korea (Gangwon and Gyeonggi)

The spatial RDs for the ROK are all restricted to Gangwon province, as almost all of the treatment region falls in it, and it is economically, geographically, and historically distinct from Gyeonggi province, where the rest of the treatment region lies. Figures 16 and 17 plot the spatial distribution of the estimated GDP and population adjusted GDP in regards to the 38th parallel. In the South Korean case, the treatment region is on the right of the red line. Here, the 38th does not seem to have any significance to either the sum of lights or to the adjusted sum of lights. Additionally, both variables follow similar patterns on either side of the 38th parallel.

The RD plots for the GDP estimates using both bandwidths reflect the same pattern as the simple plots, with no major differences in level and no discontinuities at the 38th parallel (figs. 18-21). In contrast to the North Korean case, economic activity forms a slight “valley” at the 38th parallel. The plots for the population-adjusted GDP also suggest no discontinuities at the 38th parallel.

Figure 14.

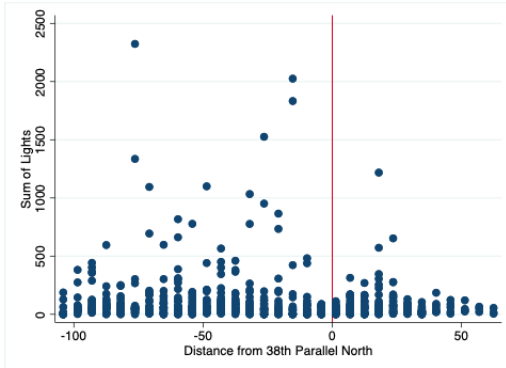

Figure 16: Gangwon Province: Plot of GDP Estimates.

Figure 15.

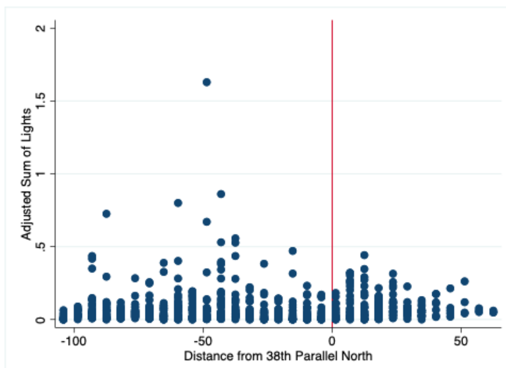

Figure 17: Gangwon Province: Plot of population adjusted GDP estimates.

Figure 18.

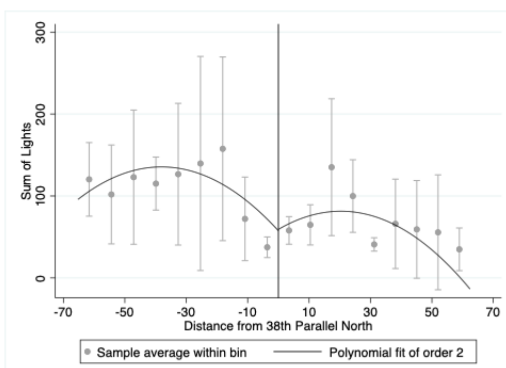

Figure 18: Gangwon Province: RD plot for GDP estimates using maximal bandwidth.

Figure 19.

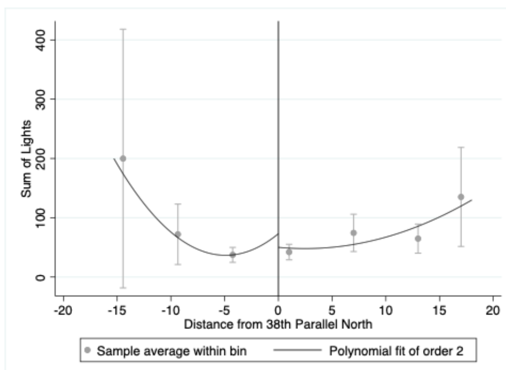

Figure 19: Gangwon Province: RD plot for GDP estimates using MSE-optimal bandwidth estimate.

Figure 20.

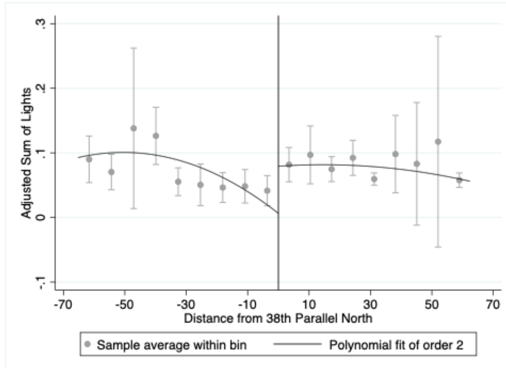

Figure 20: Gangwon Province: RD plot for population adjusted GDP using maximal bandwidth.

Figure 21.

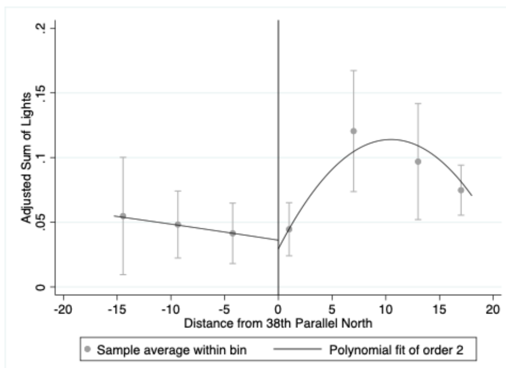

Figure 21: Gangwon Province: RD plot for population adjusted GDP using MSE-optimal bandwidth estimate.

Finally, the RD plots for geographic variables show no discontinuities at the 38th parallel (figs.22-24).

The OLS models outlined in equations 3 and 4 are estimated in Tables 4 and 5 respectively. Table 4 contains the output of the regression of the GDP estimates against treatment and co-variates. Column 1 is the regression against the treatment only, all other regressions contain province fixed effects, and column 5 estimates the whole model. The treatment, having been under control of the DPRK from 1945-1950, has a negative and significant effect on the sum of lights in every regression. This was not visible from the RD plots and suggests that there is less light creating activity south of the maximum RD bandwidth limit. As expected, Gyeonggi province is significantly associated with more lights in every regression. Unsurprisingly, further distance from the sea, and further distance from the DMZ are significantly associated with less

Figure 22.

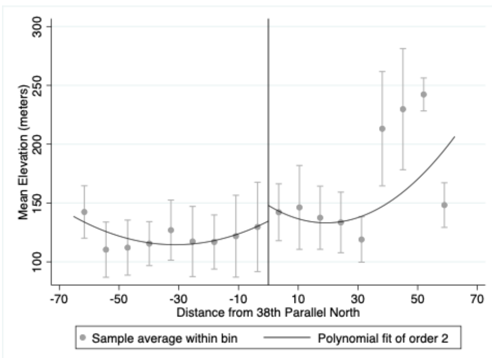

Figure 22: Gangwon Province: RD plot of Elevation.

Figure 23.

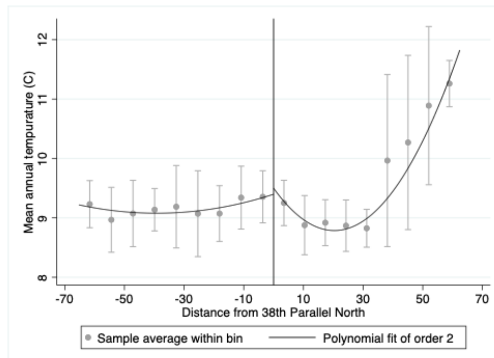

Figure 23: Gangwon Province: RD plot of mean annual temperature.

Figure 24.

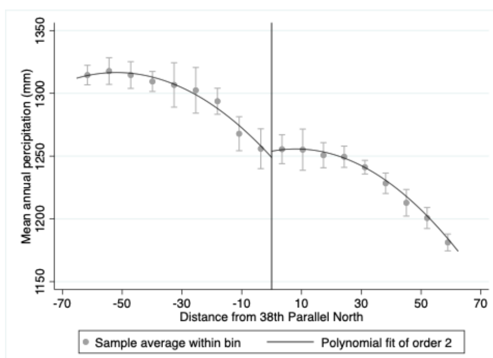

Figure 24: Gangwon Province: RD plot of mean annual precipitation.

economic activity. This supports the hypothesis that the extremely devastating effects of war do not persist over time, at least not economically.

Table 4: GDP Estimates (Millions of 2010 USD): Gangwon and Gyeonggi Provinces

	(1) Treatment only	(2) Province FE	(3) Province FE	(4) Province FE	(5) All
DPRK: 1945-1950	-266.6***	-118.4**	-122.8**	-289.2***	-311.6***
	(42.46)	(41.08)	(40.57)	(57.17)	(56.47)
Gyeonggi Province		469.3***	429.2***	406.7***	357.6***
		(35.15)	(35.45)	(37.86)	(38.21)
Kilometer to Sea			-2.822***		-3.001***
			(0.507)		(0.504)
Kilometers to DMZ				-2.341***	-2.582***
				(0.549)	(0.543)
N	1167	1167	1167	1167	1167

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5 reports the outputs of the regression of the population adjusted sum of lights against the treatment and controls. After including province fixed effects, the treatment effect is not significant in any of the regressions, although it is associated with more economic activity per capita. Although Gyeonggi province is generally richer than Gangwon province, the negative and significant coefficient for Gyeonggi province is difficult to explain.

Table 5: Adjusted GDP (2010, Thousands of USD): Gangwon and Gyeonggi Provinces

	(1) Treatment only	(2) Province FE	(3) Province FE	(4) Province FE	(5) All
DPRK:1945-1950	17.0**	10.2	10.5	10.2	11.6
	(6.6)	(6.8)	(6.8)	(9.6)	(9.6)
Gyeonggi Province		-21.8***	-19.2**	-21.8***	-18.8**
		(5.8)	(5.9)	(6.3)	(6.5)
Kilometers to Sea			0.180*		0.181*
			(0.085)		(0.085)
Kilometers to DMZ				0.00093	0.0155
				(0.092)	(0.092)
N	1,167	1,167	1,167	1,167	1,167

Standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The regression results using official GRDP data for counties and cities in Gangwon and Gyeonggi provinces can be seen in table 6. Column 1 controls only for the year; columns 2-3 estimate the effects of one control each; column 4 estimates the full model in equation 5. All of the regressions have R-squared values of less than 0.07. This indicates that the treatment and control variables have very little predictive power. Additionally, none of the coefficients is significant at the 5 percent level. In agreement with the population adjusted nighttime lights analysis, the coefficients for the DPRK treatment and the DMZ control are positive and insignificant. This is a further indication that the increased war intensity may not have had a negative impact on the long-run per-capita GDP in these regions.

Table 6: Effects on GRDP per Capita

	(1) Year effects	(2) Year and Province	(3) Year and DMZ	(4) All
DPRK:1945-1950	1.586	2.390	0.742	1.520
	(2.456)	(2.920)	(2.846)	(3.362)
Year	-0.609	-0.609	-0.609	-0.609
	(1.719)	(1.725)	(1.725)	(1.732)
Gyeonggi Province		1.090		0.942
		(2.119)		(2.146)
DMZ			1.687	1.523
			(2.846)	(2.882)
N	98	98	98	98

Gross regional domestic product (GRDP) measured in Millions of Korean Won; 1 USD ≈ 1200 KRW.
Standard errors in parentheses
* $p < 0.05$

6 Limitations

Possibly the largest complication in this study, particularly for the ROK, is the proximity of the treatment area to the DMZ, the heavily fortified buffer zone reaching 2 kilometers in each direction. This undoubtedly led to higher rates of emigration in the treatment areas from 1950-1953. Moreover, as the Korean War ended only in an armistice, no peace treaty was signed, so the two countries are still technically at war. Consequently, the treatment regions in both North and South Korea have significant military buildup compared to the rest of the countries. From the nighttime lights imagery, it can be easy to mistake this buildup as regular economic activity; however, its placement in the treatment area is due solely to those regions bordering the DMZ. On the southern side, in addition to increased military activity, the DMZ also serves as a sizable tourist attraction in the ROK, boosting the economies of those regions (Jung 2017).

Another limitation of the study is a lack of granular data from before the initial partition in 1945 and from before the lasting split in 1953. Although it seems that the 1945 partition was made with little consideration for and knowledge of the realities on the ground in Korea, we cannot be 100 percent sure that incomes and covariates were balanced on either side of this line before the treatment. The exogeneity of the present-day border is also unclear. Even a review of the battles and military history of the Korean War revealed little in terms of the exact reasons for the current border. While the balance tests aim to alleviate some of these concerns, using crop suitability as a proxy for economic potential may be too crude for some readers.

7 Conclusion

Overall, despite limited data and multiple obstacles to identification, this study makes several notable contributions. First, it is able to rule out any economic discontinuities at the 38th parallel in both countries. Second, it reveals that the region of the DPRK which was under the government of the ROK from 1945-1950 has significantly more economic activity per capita than similar regions not contained in the ROK treatment area. As previously mentioned, five years is a short treatment period when compared to other studies of persistence in the economic literature. This indicates that even a treatment period as short as five years may have lasting economic consequences. The final contribution of this paper is the identification of the "hump" of economic activity around the 38th parallel in North Korea, even when excluding the Kaesong industrial complex from the analysis. As there is no other obvious significance to the 38th parallel, it would be interesting to more closely examine what is driving this result. Despite the scarcity of data, satellite imagery may be able to reveal what kinds of facilities and activities are behind the uptick in lights around the 38th parallel. It could simply be that a majority of military equipment and personnel are coincidentally located at and around the 38th parallel. Although the results from the ROK are less interesting than those from the DPRK, it is encouraging that the nighttime lights analysis mostly aligns with the analysis using official GRDP data, and it adds legitimacy to the nighttime lights analysis of the DPRK.

This paper represents the first attempt to specifically analyze the economies of those regions defined between the DMZ and the 38th parallel. The year 2025 marks the 115th anniversary of the occupation of Korea, resulting in subsequent war and ultimate division of the peninsula. The treatment studied in this paper should be remembered in the context of this challenging period of Korean history.

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A Regression Discontinuity Specifications

A.1 Balance Test: 38th Parallel

$$Calories_i = \alpha + \tau D_i + \beta_{1,-} Dist_i(1-D_i) + \beta_{2,-} Dist_i^2(1-D_i) + \beta_{1,+} Dist_i D_i + \beta_{2,+} Dist_i^2 D_i + \varepsilon_i$$

where
$Dist_i$ = Distance to the 38th parallel in km.

$D_i = \mathbf{1}\{Dist_i \geq 0\}$ = Indicator for being north of the 38th Parallel.

The RD effect of interest is

$$\tau \;=\; \lim_{d \downarrow 0} E[Calories_i \mid Dist_i = d] \;-\; \lim_{d \uparrow 0} E[Calories_i \mid Dist_i = d]$$

A.2 Balance Test: DMZ

$$Calories_i = \alpha + \tau D_i + \beta_{1,-} Dist_i(1-D_i) + \beta_{2,-} Dist_i^2(1-D_i) + \beta_{1,+} Dist_i D_i + \beta_{2,+} Dist_i^2 D_i + \varepsilon_i$$

where
$Dist_i$ = Distance to the DMZ in km.

$D_i = \mathbf{1}\{Dist_i \geq 0\}$ = Indicator for being north of the DMZ.

The RD effect of interest is

$$\tau \;=\; \lim_{d \downarrow 0} E[Calories_i \mid Dist_i = d] \;-\; \lim_{d \uparrow 0} E[Calories_i \mid Dist_i = d]$$

A.3 North Korea

$$Lights_i = \alpha + \tau D_i + \beta_{1,-} Dist_i(1-D_i) + \beta_{2,-} Dist_i^2(1-D_i) + \beta_{1,+} Dist_i D_i + \beta_{2,+} Dist_i^2 D_i + \varepsilon_i$$

where
$Dist_i$ = Distance to the 38th parallel in km.

$D_i = \mathbf{1}\{Dist_i \geq 0\}$ = Indicator for being north of the 38th Parallel.

The RD effect of interest is

$$\tau \;=\; \lim_{d \downarrow 0} E[Lights_i \mid Dist_i = d] \;-\; \lim_{d \uparrow 0} E[Lights_i \mid Dist_i = d]$$

A.4 South Korea

$$Lights_i = \alpha + \tau D_i + \beta_{1,-} Dist_i (1-D_i) + \beta_{2,-} Dist_i^2 (1-D_i) + \beta_{1,+} Dist_i D_i + \beta_{2,+} Dist_i^2 D_i + \varepsilon_i$$

where
$Dist_i$ = Distance to the 38th parallel in km.

$D_i = \mathbf{1}\{Dist_i \geq 0\}$ = Indicator for being south of the 38th Parallel.

The RD effect of interest is

$$\tau \;=\; \lim_{d \downarrow 0} E[Lights_i \mid Dist_i = d] \;-\; \lim_{d \uparrow 0} E[Lights_i \mid Dist_i = d]$$