# ABSTRACT

Title of Dissertation: APPLICATIONS IN INDUSTRIAL ORGANIZATION AND ECONOMIC GEOGRAPHY

Sarah Maria Anastasia Webb, Doctor of Philosophy, 2026

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The first two main chapters examine the effects of a 2018 US anti-dumping (AD) duty against China on consumer prices, seller costs, and trade flows of aluminum foil sold in grocery stores. Reduced-form results show a 7% price increase attributed to the imposition of AD duties for both foreign and domestic brands. I estimate a random coefficient logit model of demand and decompose prices into costs and markups. Both marginal costs and markups rise following the policy, implying more than 100% pass-through of cost increases to prices. These price increases translate to a more than 8 million dollar loss in consumer surplus each year. Compared to the no circumvention counterfactual, the model suggests that as much as 78% of potential price increases from the policy are mitigated by circumvention, which provides the first benchmark of its kind in the literature.

The final chapter 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.

# APPLICATIONS IN INDUSTRIAL ORGANIZATION AND ECONOMIC GEOGRAPHY

by

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# Chapter 1

# Introduction

This dissertation is composed of three main chapters of research I conducted while at the University of Maryland. The main aim of the research is to apply empirical analysis to real-world scenarios, both in terms of international trade policy and the effects of war and shifting borders on economic growth. In broad terms, the analysis of trade policy focuses on more detailed short-run outcomes, while the investigation of short-term changes in governments evaluates coarser effects in the long-run.

The detailed nature of the analysis in international trade lends itself to two separate but complementary analyses and techniques. I investigate the market for retail aluminum foil in detail to uncover the effects of a 2018 anti-dumping duty against aluminum foil originating in China. A key feature of this setting is that the duties were subsequently found to be circumvented. While there are reported cases of similar circumvention, my research is the first academic economic analysis of a widely circumvented trade policy. First, using detailed panel data on sales of goods heterogeneously affected by the anti-dumping duties, I utilize reduced-form linear regressions, in particular a two-way fixed effects model, to estimate the

aggregate effect of the anti-dumping duties on consumer prices. The results are precise, robust, and clear; despite circumvention, aggregate prices increased as a result of the duties. This result demonstrates the effect that trade policies can have on consumer prices even when not fully enforced.

The next chapter builds on this conclusion by utilizing demand estimation techniques from the field of Industrial Organization. In particular, I model demand as a Random Coefficient Logit model augmented with micro-moments derived from real consumer purchase behavior. To complete the analysis, I model firms as competing in a Nash-Bertrand fashion. Together, the model implies that price increases from the duties stem from both increased costs and markups, though more from rising costs. This strategy allows for the analysis of several counterfactual scenarios. A no anti-dumping counterfactual highlights the validity of the model by producing aggregate price effects in line with those from the reduced-form estimation. A no-circumvention counterfactual estimates the price equilibrium in a scenario where the anti-dumping duties are fully enforced. The baseline estimation suggests that as much as 78% of potential consumer price increased are mitigated by the trade policy circumvention or deflection.

The final chapter addresses the lasting economic consequences of shifting borders and governments on the Korean Peninsula between the Second World War and the Korean War. The Korean War (1950-1953) resulted in territory gained and lost by both sides, implying regions with regime changes five years after the initial partition of Korea horizontally at the 38th parallel (1945). The historical nature of the topic and limited official data sources from North Korea require a broader approach. I leverage night-time lights data processed to reflect economic activity. Using GIS software, I divide the regions of interest into 5 km

square grid cells. After extracting the night-time lights and other geographic information for each grid cell, I apply two econometric techniques. First, a regression discontinuity approach using distance to the 38th parallel as a running variable suggests no discontinuity in terms of economic activity for either side. However, aggregate regressions of regions in each country on either side of the border suggest significantly more economic activity in the region of present-day North Korea which was governed by Southern forces from 1945-1950, compared to similar regions of the country. Overall, the results suggest some lasting consequences of a government lasting only five years.

Broadly speaking, the research has two main contributions. First, while the two contexts studied in the dissertation demand various methods and belong to different fields, they both demonstrate empirical economic effects in settings where theory alone is insufficient. The consumer price effects of even fully enforced import-taxes has recently received much political attention. Yet at first glance, it is not obvious whether a circumvented trade-policy would reach consumer prices or not. The work in the first and second chapters answers this question clearly and emphatically: circumvented import taxes can increase consumer prices while failing to protect domestic producers or collect tax revenue. Similarly, one might wonder whether the transitory governments will affect long-run economic outcomes. In the case of Korea, I show that they can. Given the current wars in both Eastern Europe and the Middle East, my results indicate that even a five-year occupation can have lasting consequences more than half a century later.

Second, the work contributes to a growing literature applying econometric and industrial organization methodology to new sets of topics. In particular, the chapters here show how tools that analyze firm behavior and market competition can be extended to a variety of

settings shaped by policy distortions or institutional frictions. By bringing a structural IO framework to an international trade question, the analysis highlights the flexibility of modern IO techniques and their applicability to a wide range of economic questions traditionally viewed as outside the field. Likewise, by exploiting night-time lights, the final chapter sheds light on a country and economy with little to no credible official data sources. More broadly, it demonstrates the usefulness of alternative data sources in extending empirical analysis to settings where traditional statistics are unreliable or unavailable.

Overall, I hope that the analyses presented here are thought provoking and lay groundwork for further research. Across chapters, the work highlights the importance of consumer and firm behavior when evaluating the effects of economic policy, as well as the value of extending empirical tools to settings where standard data are limited or absent. More broadly, I hope it encourages the application of modern empirical methods to a wider set of economic questions and environments that have traditionally been difficult to study.

# Chapter 2

# Anti-Dumping Reaches the Grocery Store: Part I

**Disclaimer:** *Researcher(s)' own analyses calculated (or derived) based in part on data from Nielsen Consumer LLC and marketing databases provided through the NielsenIQ Datasets at the Kilts Center for Marketing Data Center at The University of Chicago Booth School of Business. The conclusions drawn from the NielsenIQ data are those of the researcher(s) and do not reflect the views of NielsenIQ. NielsenIQ is not responsible for, had no role in, and was not involved in analyzing and preparing the results reported herein.*

## 2.1 Introduction

One of the major concerns of the current US administration regarding trade policy is the circumvention of import taxes by what the White House calls "transshipment." This is the evasion of import duties by exporting goods from high-tariff countries through low-tariff

countries and then to the US (White House, 2025). For example, Chinese steel exporters can avoid high duties by shipping their products to the US through South Korea, which faces a much lower tariff level. Putting blanket tariffs on almost every country is one strategy to prevent this behavior. However, if policymakers wish to block import-tax circumvention, they should have a benchmark that quantifies the extent to which it can mitigate price increases to consumers. While there is an extensive international trade literature investigating the aggregate effects of trade policy on import prices, empirical evidence of the direct impacts of import taxes on consumer prices is rarer in the literature (Irwin, 2019; Flaaen et al., 2020). Moreover, the effects of the taxes may be underestimated if they are assumed to have been fully enforced. To my knowledge, no economics study has evaluated the consumer price effects of an import tax with documented circumvention of the nature described nor provided a benchmark for the extent to which circumvention mitigates price increases. This paper aims to fill these gaps.

To analyze the effects of a circumvented import tax, and to estimate the "dampening" effect of the policy circumvention, I exploit an anti-dumping (AD) duty levied on aluminum foil imports coming from China. Anti-dumping laws, which impose taxes on imports deemed to be “dumped” (sold below fair value), have become a common trade policy tool since the 1980s. Initially employed by only a few developed countries, AD policies have since been adopted worldwide and today account for the overwhelming majority of all contingent protection measures used globally (Blonigen and Prusa, 2003). In the United States, the frequency and scope of AD enforcement have expanded steadily over the past four decades. Gallaway et al. (1999) estimate the aggregate welfare cost of US AD laws at between 2–4 billion dollars, making them the costliest US trade policy. Since then, the number of AD investigations in

the US, as well as the share which result in final affirmative decisions, has only increased. As of October 2025, the US has 783 active AD and Countervailing duty (CVD) orders. AD laws were originally motivated as a means to protect domestic producers from predatory pricing of low-cost importers, but their current importance extends far beyond this narrow case of producer protection. In practice, AD duties serve as a key instrument of "administered protection"—a flexible substitute for tariffs which the WTO permits as exceptions to ratified tariff commitments. In other words, they provide policymakers with a legal channel to utilize trade protectionism in politically sensitive sectors. As a result, industries facing import competition frequently use the AD petition process to gain an advantage over their foreign competitors. Their use now deviates far beyond cases of simple predatory pricing. For example, imports to the US can be concluded to be "unfair" even when importing firms charge a *higher* price to the US market than to their own domestic market (Blonigen and Prusa, 2003).

The stakes in AD are substantial. Regardless of motivation, curtailing low-priced foreign imports will soften price competition and lead to higher prices in the domestic market. If the affected good is an intermediate input, higher prices will have ripple effects throughout the economy. Moreover, import taxes can also cause the protected domestic producers' marginal costs to rise as they move along their own cost curve (Loecker et al., 2016). This dual channel, higher output prices and elevated marginal costs, makes AD an especially distortionary policy instrument. Understanding how these duties affect both consumer prices and firm-level costs is therefore essential for evaluating their broader welfare implications.

The aluminum foil duties are broadly relevant and offer an ideal case to study the effects of AD policy in general. Given the standardized administrative process of granting AD

protections, AD duties unsurprisingly target similar types of industries. Typical AD goods are non-branded, homogeneous, intermediate inputs. Common examples include chemical products, finished and unfinished steel parts, and other crude metals. These are exactly the kinds of goods which lend themselves to the circumvention described, since price is the primary dimension of competition and verifying the true country of origin is difficult once a product arrives at the port. Although recent AD duties on goods like washing machines and solar panels have allowed researchers to examine the consumer price effects of AD duties (Flaaen et al., 2020; Houde and Wang, 2025), these goods are fundamentally different from the ones typically affected by AD policy. Aluminum foil is a rare and notable product for the study of the impacts of AD duties. It is a mostly homogeneous good which is used significantly as an intermediate input in industries such as food packaging and HVAC construction and repair. However, it is also sold directly to consumers in the form of retail aluminum foil available in grocery stores. The likeness of aluminum foil to goods which can more easily circumvent AD laws bolsters the external validity of the results of the study.

The broad effects of the AD policy on trade flows of aluminum foil from China to the US can be seen immediately. In February 2018, the Department of Commerce announced its affirmative final determinations of the AD investigation, and duties of 106% were levied on aluminum foil from China. Foil imports from China to the US plummeted. However, US imports from other countries rose substantially, so that total imports actually increased from 2017 to 2020 (Figures 2.1 and 2.2). Subsequent investigations reported high levels of circumvention, where Chinese foil was exported to the US via 3rd party countries such as Korea and Thailand (U.S. Department of Commerce, 2022; U.S. Court of International Trade, 2024). Suggestive evidence for this can also be seen in publicly available trade data.

Total exports of aluminum foil from China to the rest of the world increased significantly in 2018, and remained constant for the rest of the study period. Figures 2.3 plots imports of aluminum foil from China and exports of aluminum foil to the US for the top nine US supplying countries. While most graphs support the findings of circumvention (Chinese imports and exports to the US rising together), particularly Brazil, Turkey is a notable exception.

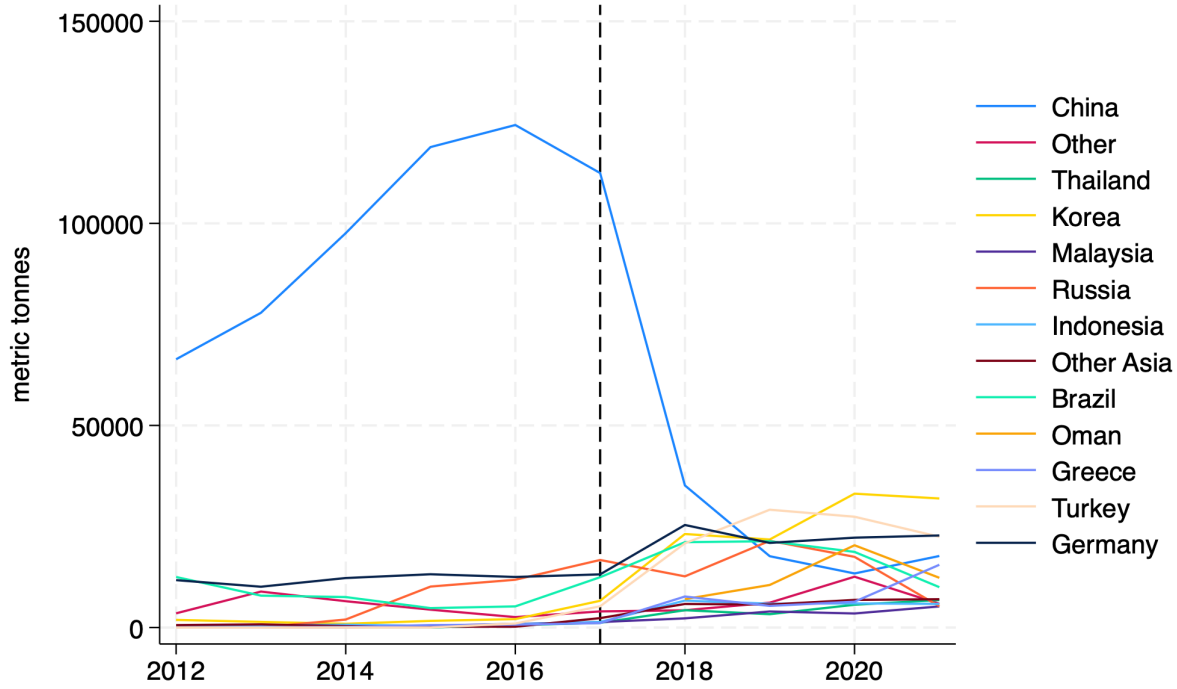


Figure 2.1: Top 10 exporters of Aluminum Foil to the US (BACI database).

In particular, this paper investigates the effects of the 2018 AD duties on the market for retail consumer aluminum foil. I estimate the magnitude of the price and cost effects of the realized AD policy and counterfactual policies, and I provide an upper bound for how much circumvention mitigates price increases from the policy. To isolate the effect of the AD duties on prices, I exploit an exemption within a subsequent aluminum-related AD order to identify

an appropriate comparison product. Despite widespread and documented circumvention of the policy, the two-way fixed effects (TWFE) estimates suggest that the imposition of AD duties raised prices by approximately 7% for foreign brands and 6% for domestic brands, consistent with the effects obtained from the corresponding event study.

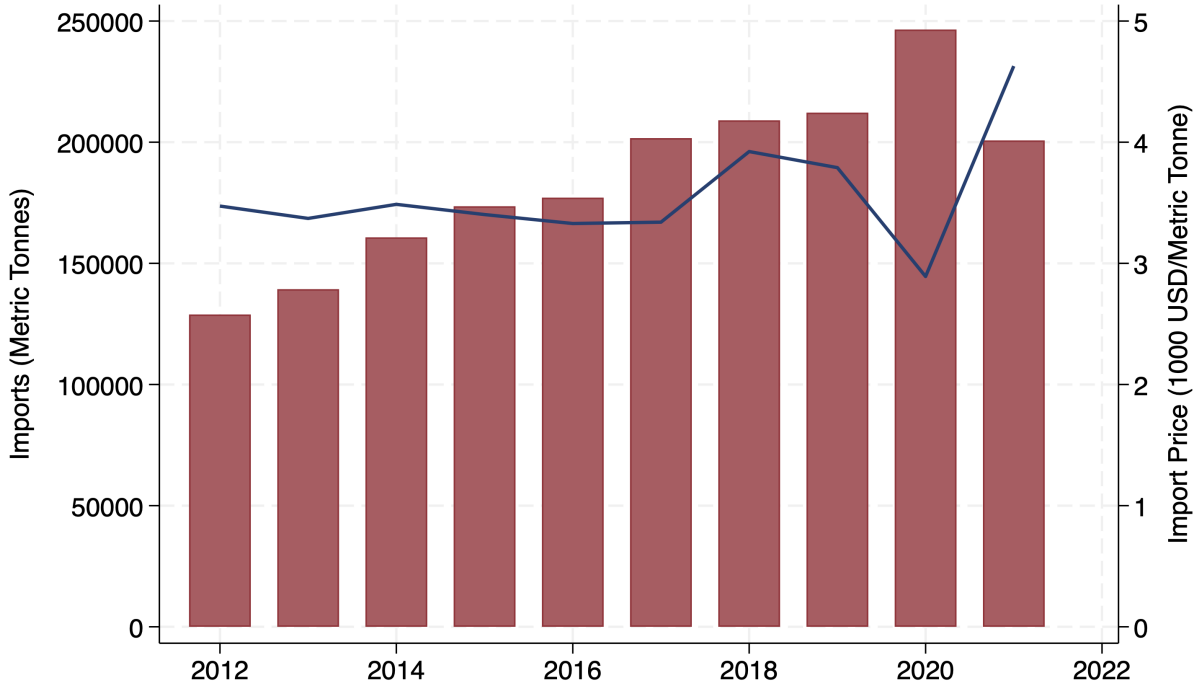


Figure 2.2: Total US imports quantity and price of Rolled Aluminum Foil

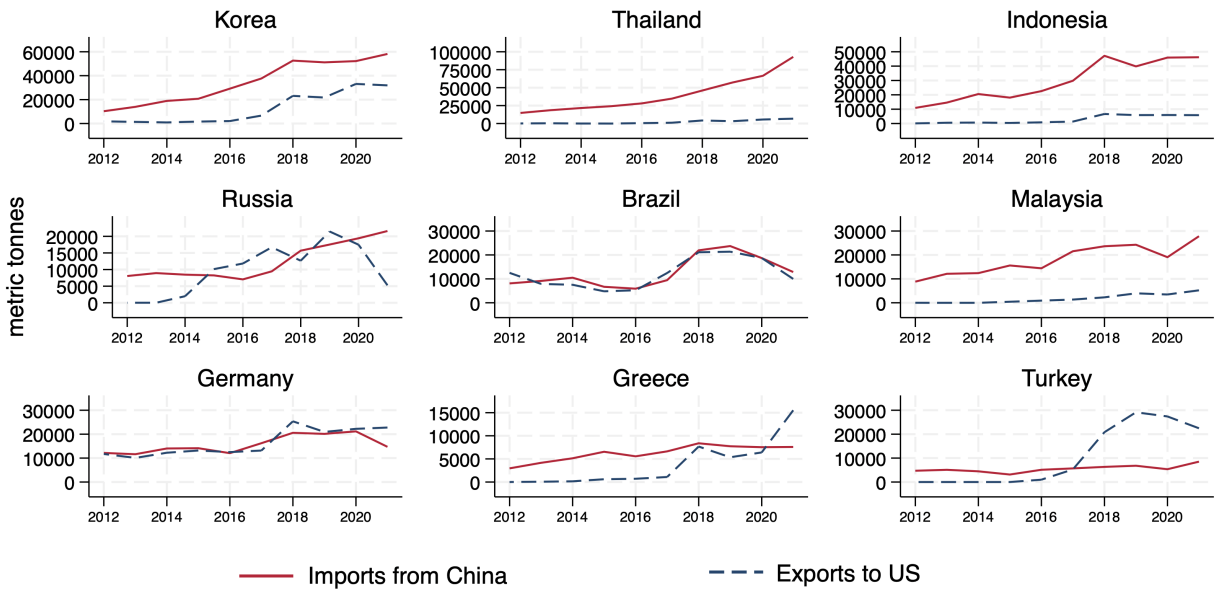


Figure 2.3: Imports of Aluminum Foil from China and Exports to the US

To interpret the mechanisms underlying the observed price increases and to evaluate counterfactual price equilibria, I estimate demand using a random coefficient (RC) logit framework. The model allows consumers to differ in both their baseline preferences for aluminum foil and their price sensitivity by income group, capturing heterogeneity in substitution patterns between brands. On the supply side, I model firms as competing in prices under Nash-Bertrand conduct, where each brand sets prices to maximize its own profits given rivals' prices. This allows for the decomposition of observed prices into marginal costs and markups, for testing alternative conduct assumptions, and for simulating equilibrium outcomes under different states of the world.

The results from the demand model are sensible. The parameters are precisely estimated, and the implied price elasticities are closely in line with the baseline from the literature. I find that both estimated costs and markups rise after the policy, implying a more than 100% pass-through of the cost increases to consumer prices in the post AD period. Results from a

supply regression imply that marginal cost increases from the policy are seen for both foreign and domestic brands, but more for foreign brands.

A "no-AD counterfactual" uses the supply regression to estimate the cost increases attributed to the AD policy. The model implies an average 5% price increase as a result of these cost increases, in line with the reduced-form results. A "no circumvention counterfactual" is also computed by calculating how much marginal costs would have been for each brand had the AD duties been binding. Comparing the prices implied from this counterfactual with those in the data and those in the "No AD counterfactual," I find that as much as 78% of the potential price increases from the policy were mitigated by the circumvention, and this provides the first benchmark of its kind in the literature.

The structure of the paper is as follows: Section 2 reviews the relevant literature. Section 3 presents the data and descriptive statistics. Section 4 describes the reduced-form models and results. Section 5 estimates demand. Section 6 calculates the counterfactuals. Section 7 describes domestic production, and Section 8 concludes.

## 2.2 Literature Review and Contribution

This paper builds on and contributes to a wide range of literature in the fields of both Industrial Organization and International Trade. Broadly speaking, studies of anti-dumping in International Trade analyze the import price effects for a range of industries, while the Industrial Organization research addressing trade policy tends to focus on the effects of a particular product or industry.

Overall, anti-dumping is a pervasive yet historically understudied policy. Before the

ground-breaking paper of Finger et al. (1982), anti-dumping was mostly considered an obscure part of US trade policy and was largely overlooked in economic research (Irwin, 2005). The paper shows which kinds of industries are most likely to receive AD protections. Consistent with more recent research (Oliveira, 2014), they show that economic distress and the ability to organize politically are the biggest indicators of whether an industry will receive AD protections or not. Note that these are both characteristics of the domestic industry, rather than the pricing behavior of importers. Following this, there is a rich study of anti-dumping laws in the trade literature.

Early theoretical work in the 1980s and 1990s established the mechanisms by which AD laws can lead to higher domestic prices (Dixit, 1988). Under imperfect competition, the mere threat or imposition of anti-dumping duties can dampen competitive pressures and facilitate outcomes akin to collusion (Staiger and Wolak, 1992). Veugelers and Vandenbussche (1999) show how European AD policy can sustain both national and international collusion, enabling domestic and foreign firms to coordinate on higher prices.

Empirically, AD duties have been found to have the highest pass-through to final prices of any protective trade policy (Blonigen and Haynes, 2002). For example, Blonigen and Haynes (2002) use price regressions to show greater than 100% pass-through for iron and steel imports from Canada to the US, by exploiting products that were and were not involved in AD duties. Because AD duties are applied based on past pricing and are subject to continued administrative review, foreign firms have an incentive to raise prices. This process can facilitate implicit price coordination, allowing consumer prices to rise significantly above the level implied by standard tariffs (Blonigen and Prusa, 2003). As AD duties are expressly intended to combat low prices,Nizovtsev and Skiba (2020) find that AD duties affect import

prices on average more than twice as much as tariffs. Konings and Vandenbussche (2005) also show that domestic firms increase markups as a response to AD protections, as they exercise increased market power when foreign firms are penalized. The results for the foil market presented in this paper are consistent with this finding. Additionally, AD duties have been shown to decrease exports for affected firms and increase trade "deflection," so that rather than paying duties, exporting firms simply supply to buyers in other countries (Felbermayr and Sandkamp, 2020). This deflection can also be the first step in circumvention if the demand for the product is low in 3rd party countries. While a wealth of papers estimate the pass-through of trade restrictions and tariffs to import prices (Winkelmann and Winkelmann, 1998; Trefler, 2004; Broda and Weinstein, 2006; Broda et al., 2008; Spearot, 2012; Ludema and Yu, 2016; Fitzgerald and Haller, 2018; Feenstra, 1989), few are able to connect import prices to consumer prices (Irwin, 2019). For consumer price effects, we turn to the Industrial Organization literature.

The model in this paper builds on the Berry et al. (1995) random coefficient logit framework. There is a rich tradition of demand estimation techniques being exploited to analyze policies in international trade. In fact, one of the first applications of the RC logit model was in the Berry et al. (1999) paper evaluating the effects of Voluntary Export Restraints (VERs) (self-imposed quotas) of Japanese automakers during the 1980s. In the more recent empirical Industrial Organization literature, there are also several studies which investigate various effects of specific AD duties. First, Flaaen et al. (2020) analyze price and production relocation effects on washers and dryers of trade restrictions (AD and Tariffs) on Washers only. In this market, no price increases were seen after the imposition of AD duties, and prices only rose after tariffs affecting all countries were placed on washers. Houde and Wang

(2025) investigate effects of AD duties on solar panels and incorporate vertical structure between manufacturers and installers. In particular, they find that AD duties disproportionately affected US consumers, in line with the results from the trade literature. In contrast to the Flaaen et al. (2020) paper, they find $> 100\%$ pass-through of the AD duties to consumer prices. The price effects of the AD duties investigated in this paper fall in between these two.

This paper also adds to the growing literature on re-exporting. This is a broad term which refers both to the exporting of imported goods after undergoing value-added processes and also to "transshipment," where imported goods are exported without any transformation. Complex supply chains allow firms to exploit differences in comparative advantages and logistic costs as well as differences in import taxes. Early work on East Asian processing trade highlighted the rise of Hong Kong and other entrepôts as re-export hubs for Chinese production Feenstra (1989), while later studies trace how global value chains and multinational production structures enable rapid re-routing of goods in response to tariff shocks Amiti et al. (2019); Fajgelbaum et al. (2020). Re-exporting and re-importing are not limited to tariff avoidance: they also reflect the fragmentation of production and assembly across multiple economies, making the measurement of trade incidence and price effects more complex. Using firm-level data, Felbermayr and Sandkamp (2020) show that trade diversion through re-exports is a common adjustment margin, as exporters shift shipping routes and processing locations following policy changes. Overall, the prevalence of re-export underscores that modern trade policies operate within deeply integrated global supply chains.

This paper makes several contributions to the literatures in International Trade and Industrial Organization. First, it provides the first quantitative benchmark for how much

import-tax circumvention mitigates consumer price increases, and the analysis shows that even circumvented policies can still raise both consumer prices and firms' marginal costs substantially. Second, by combining detailed retail scanner and consumer panel data, the paper is able to analyze heterogeneous effects of the policy with respect to demographics such as income. While the distributional impacts of trade policy are typically measured from a labor perspective in the trade literature, far fewer consider the distributional impacts of trade policy from a demand perspective (Goldberg and Pavcnik, 2016). Third, the study analyzes retail rather than import prices, allowing for a direct measurement of how AD duties transmit to final good consumers. Moreover, aluminum foil sharing key characteristics of goods typically targeted by AD laws distinguishes it from the markets addressed in the existing IO-Trade literature, which improves the external validity of the results (Flaaen et al., 2020; Fajgelbaum et al., 2020; Amiti et al., 2019). Finally, by integrating reduced-form evidence with a structural demand model, the paper provides a unified framework to evaluate the implications of anti-dumping duties and enforcement.

## 2.3 Data and Descriptive Statistics

The data for this paper were collected from several sources. Retail data for aluminum foil and comparison goods comes from the NielsenIQ Scanner Data. A product is defined at the Unique Product Code (UPC) level, and observations report the price and quantity sold of a certain UPC-store-week. Data are further aggregated to the UPC-store-quarter level for the reduced-form model and to the product-county-quarter level for the demand model. This results in 2,240,499 foil observations in the reduced-form data and 192,297 observations in

the demand model. Overall, the data cover over half of US grocery stores, to which I restrict the sample. This should capture a significant share of consumer spending on aluminum foil. The demand estimation augments the sales data using the NielsenIQ consumer panel. Data from the aggregate aluminum sheet, plate, and foil industry[1] are taken from the US Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages. Annual trade flows are taken from the BACI Database. Cost shifters including global aluminum prices, diesel prices, producer price index for rolled aluminum products, and a China import index are taken from FRED. The country of origin of fringe brands was collected by hand by contacting brands and suppliers and inquiring about the reported COO for each product. Weights of store-brand foils were obtained by weighing product samples and computing a sales-weighted mean.

The first key pattern to recognize in the sales data is the dominance of store-brand and national-brand aluminum foils (Figure 2.4). The total quantity of aluminum foil sold is relatively stable over the study period, but falls very slightly after the AD treatment (2018 onward). The aggregate market shares of store brands also fall slightly after the AD treatment. Table 2.1 breaks down the three brands by country of origin (COO). National-brand foil is rolled in the United States and considered to be *Made in the USA*. Domestically produced aluminum foil does, however, rely heavily on imported raw aluminum as an input. Observational evidence suggests that most store-brand foil came from China before 2018, with a shift to many suppliers after the imposition of the AD duties. In the NielsenIQ data, store-brand UPCs are anonymized, so that even the reported COOs cannot be collected. Due

[1] Aluminum foil is flat-rolled aluminum less than 0.2 mm thick; aluminum sheet ranges from 0.2 to 6 mm; aluminum plate exceeds 6 mm in thickness.

also to circumvention, it is impossible to conclude the COOs of store brands. In general, store brands source foil products from private label suppliers, which process large industrial rolls of foil into consumer products. These suppliers source input foil from the lowest-cost suppliers, which were consistently in China before the AD duties. After the AD duties were levied, few imports come directly from China. Due to circumvention, however, imports coming from non-Chinese countries may have originated in China, as intermediaries in third-party countries gain rents by exporting lower-cost Chinese-origin foil.

The final data contains 11 unique fringe brands, which are defined as non-national brand and non-store brand. Only 35% of markets have at least one fringe brand, while the other 65% do not. Figure 2.5 shows the sales of fringe brands broken down by COO. US brands sell the most in the fringe market. Overall, sales of fringe brands are growing over time, yet they never exceed even 1% of total foil sales. Notably, the total share of fringe brand foils coming from China is constant over the study period.

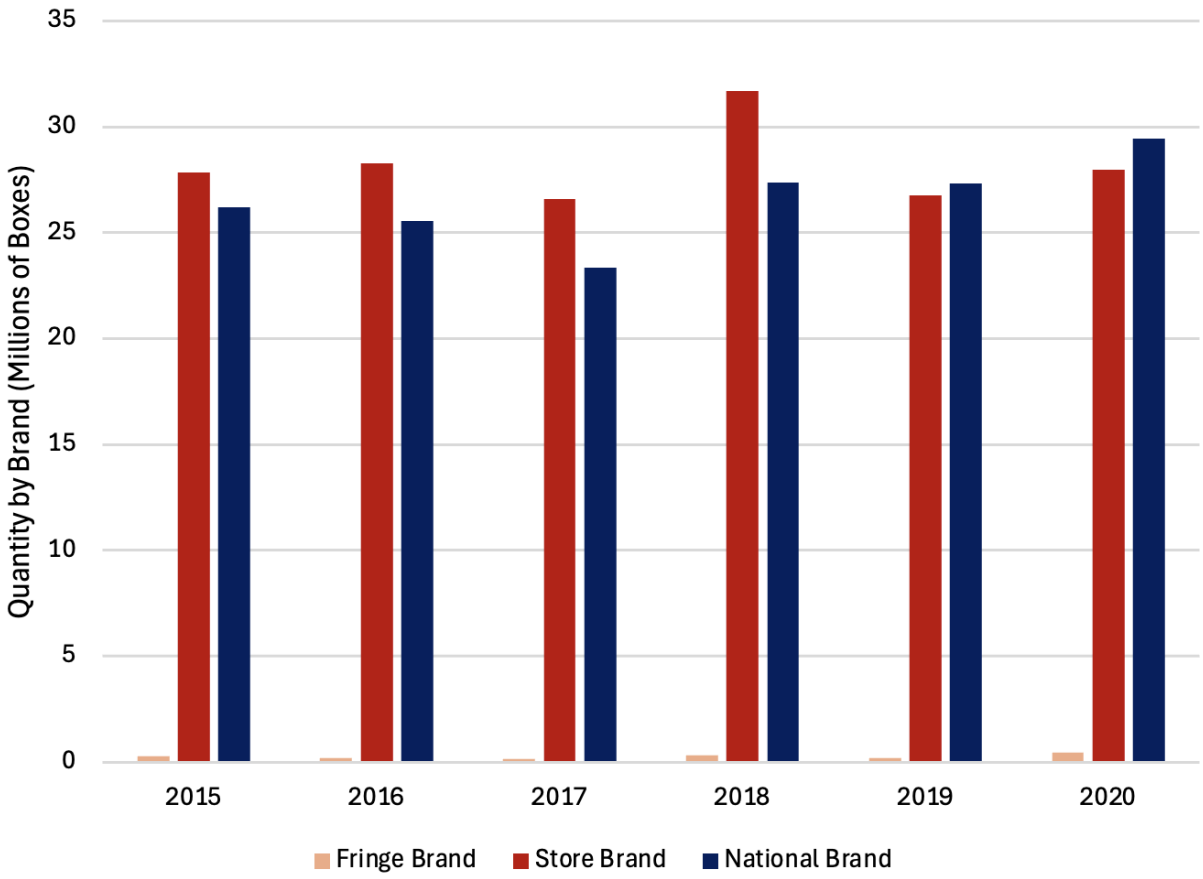


Figure 2.4: Duopoly-like structure of US consumer aluminum foil market.

Table 2.1: Country of Origin by Brand

| Brand | Reported Country of Origin |
|---|---|
| National Brand | Made in the USA |
| Store Brand | Mostly imported |
| | Masked Countries of Origin/Circumvention |
| Fringe | Varies: USA, China, India, Italy. |

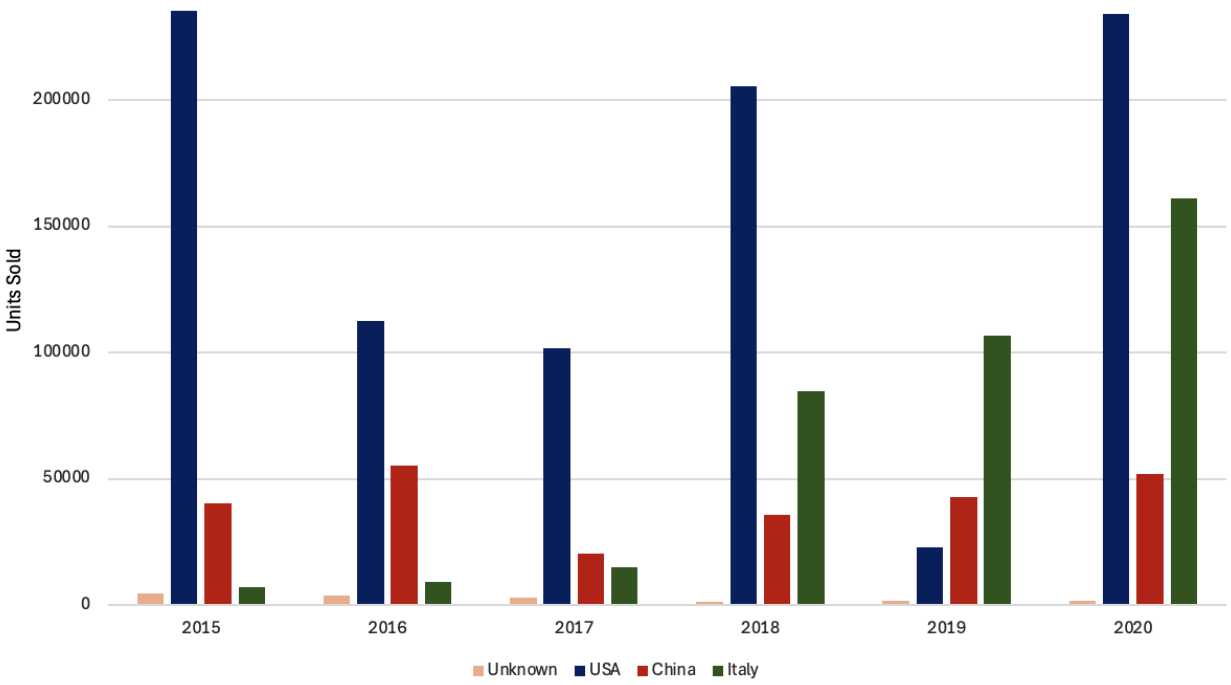


Figure 2.5: US brands dominate the fringe market.

Figure 2.6 shows how prices for consumer aluminum foil evolve over time. The blue line shows the average price of non-store brand aluminum foils, while the red line shows the price of store brand foils. The three vertical lines mark key dates in the anti-dumping investigation: Initiation, Preliminary Determination, and Final Determination. In particular, it can be seen that the average price of aluminum foil rises after the AD treatment, while global aluminum price shown in yellow falls sharply over the same period.

A timeline of the aluminum-related import policies can be seen in Figure 2.7. The AD investigation was initiated in the Spring of 2017, and a preliminary affirmative decision was reached in the Winter of 2017. The final affirmative decision was published at the beginning of 2018. Duties were officially levied on "aluminum foil having a thickness of 0.2 mm or less, in reels exceeding 25 pounds, regardless of width." While rates were set individually for several firms, most Chinese aluminum foil producers faced 106.09% duties when exporting

to the US. This begins the AD treatment period, which is highlighted in blue. Note that a broad 10% aluminum tariff is levied on all aluminum products coming from all countries at the very beginning of the AD treatment period. Additionally, there is a subsequent AD duty finalized on aluminum sheet in the beginning of 2019. Aluminum sheet is produced similarly to foil but is of a greater thickness (>0.2 mm).

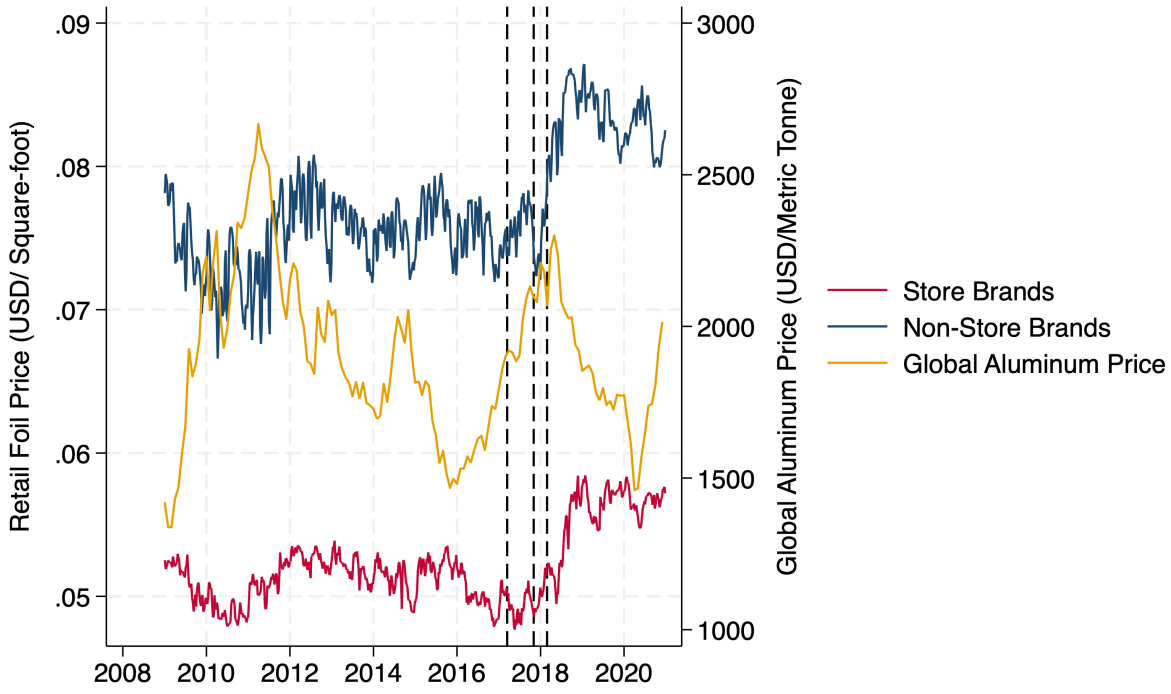


Figure 2.6: Average Price of Aluminum Foil and Global Aluminum Prices (FRED). Vertical lines correspond to initial investigation, preliminary, and final decisions of the AD duties.

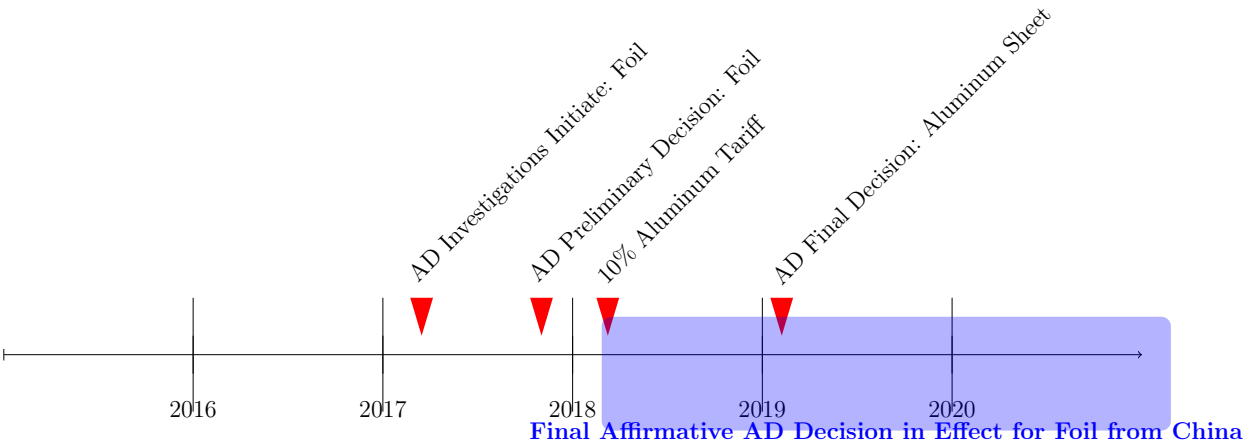


Figure 2.7: Timeline of Aluminum-related US Trade Policies

## 2.4 Reduced-Form Evidence

While descriptive evidence shows clear motivation that the AD duties are associated with higher prices for consumers in the post-AD world, this section verifies that part of the observed price effects on aluminum foil are caused by the AD duties described above. Using products that would have been affected by all other aluminum-related policies, including the 10% tariff levied in the Spring of 2018, I perform fixed effects estimations with log price as the dependent variable.

Due to the wide scope of the AD order on aluminum foil (0 - 0.2mm) and the subsequent AD order on aluminum sheet (0.2 - 6.3 mm), finding a comparison group is not straightforward. I exploit the fact that exactly one exception was made for the AD order on aluminum sheet. The final order states:

> *"Excluded from the scope of this order is aluminum can stock, which is suitable for use in the manufacture of aluminum beverage cans, lids of such cans, or tabs*

*used to open such cans. Aluminum can stock is produced to gauges that range from 0.200 mm to 0.292 mm."*

Thus, 12-packs of canned diet beverages are chosen as a comparison group. One concern about using canned beverages as a comparison group may be that the aluminum can forms a trivial amount of the total cost of the whole product. This is not the case. The US imported 242 million dollars of aluminum can stock, and The Beer Institute reported that the beverage industry lost $2.175 billion from 2018 to 2023 as a result of the 10% tariffs on aluminum (The Beer Institute, 2023). Additionally, the threat of the AD duties on aluminum sheet was costly enough to induce lobbying for this exception. In order to further alleviate this concern, I restrict the sample of cans to 12-packs of carbonated, low-calorie products. Quantity discounts may drive the price of these products closer to the price of production, and low-calorie beverages may be less affected by ingredients with volatile prices such as fruit juices. Additionally, they will be unaffected by taxes on sugary beverages. Overall, canned beverages are a good comparison group for several reasons: First, aluminum cans are affected by aluminum tariffs, but never any Anti-Dumping laws. Second, the aluminum in canned beverages forms a non-trivial portion of costs. Third, beverage cans are close to the maximum thickness of aluminum foil. Finally, beverage cans are uniform and easy to standardize and identify in the scanner data; each canned beverage is consistent and contains almost an identical portion of aluminum.

Figure 2.8 shows the raw price trends for foil and canned beverages. The dashed lines indicate the three critical dates of the aluminum foil AD case. Here, we see that the relation in price is strong before the AD duties are levied and that there is divergence in price during

the post-AD period. Note that this graphs raw price trends and does not control for any time or region trends.

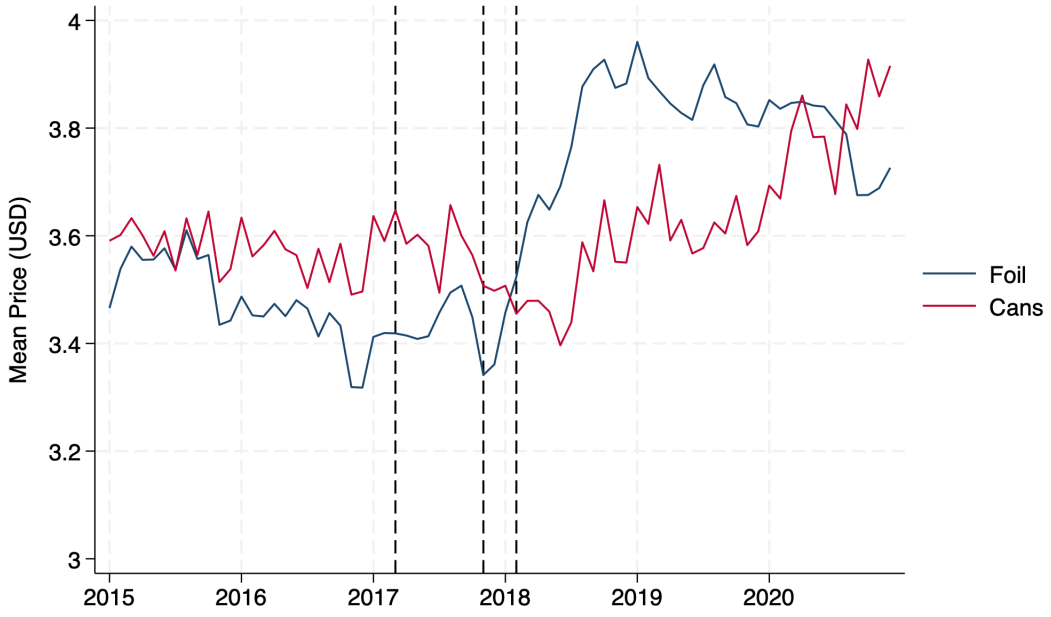


Figure 2.8: Graph of normalized prices aluminum foil and 12-packs of canned diet beverages. Vertical lines correspond to initial investigation, preliminary, and final decisions of the AD duties.

Moving to the TWFE model, I estimate the following equations, where $treat_{jt}$ is defined as $foil_j \times post_t$, and X includes quarter-year, region, and UPC fixed effects

$$ln(price_{jt}) = \alpha + \beta_{treat} treat_{jt} + \gamma X + \varepsilon_{jt} \tag{2.1}$$

$$\ln(price_{jct}) = \alpha + treat_{jt}\Big[\beta_1\, store_j + \beta_2\, national_j + \beta_3\, fringe_j\Big] + \gamma X + \varepsilon_{jct}. \tag{2.2}$$

Where the first equation estimates the treatment effect in the aggregate and the second estimates the treatment effect for each of the three brands. Figure 2.9 reports the results of the event study using equation 1 as a baseline. The effects of the treatment are very clear and stable in the post-AD period.

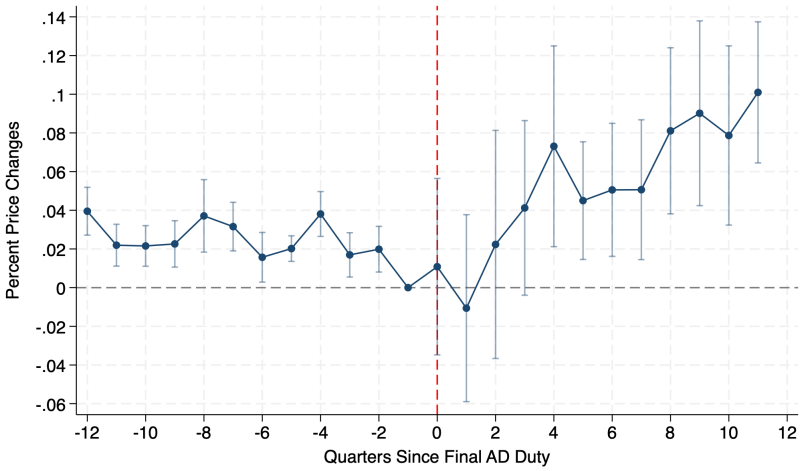


Figure 2.9: Event Study - Using 12-Packs of Canned Beverages as a comparison. Vertical line corresponds to the final affirmative decision for the AD duties.

The estimations can be seen below. Table 2.2 shows the estimated coefficients of Equations 1 and 2 using sales-weighted regressions for different timings of the post-policy period. All specifications include UPC, time, and region fixed effects. All regressions show positive and statistically significant price effects in the aggregate. Treatment effects are the smallest using the initial investigation as a starting point, and largest using the preliminary determination as a starting point. The preferred timing is the final decision, as before that date there was still uncertainty about the ultimate decision. The rest of the paper will refer to post-AD as the period *after* the final determination. Columns 1 through 4 of Table 2.3 present estimations for equation 1 using different subsets of the data. Regressions are estimated separately

for all products, store brand, national brand, and fringe brand, and comparison groups aim to mirror the brand under consideration. For example, in column 2, only store brands of 12-packs of canned diet beverages are included as a comparison group, while in columns 3 and 4 only branded items are included as comparison groups. The final column estimates the preferred specification of equation 2. In the preferred specification, the treatment effect for the aggregate is around 7%. Regardless of specification, similar price effects are seen for *both* store-brand and national-brand foils; however, fringe brand prices seem to be unaffected by the AD policy. Results are robust to using more granular data at the weekly level, but are shown here at the quarterly level to best mirror the demand estimation. The results are also robust to various clustering, to using price rather than log price as a dependent variable, and to the inclusion of store and chain fixed effects.

The 7% effect is in line with the subsequent modeling and estimation in Chapter 3. In particular, the marginal cost increases attributed to the AD duties imply cost increases of a little more than 5%. We can also consider these cost increases in the context of the circumvention itself. From the port of Shanghai to LA, a detour in Busan, Korea increases the journey by approximately 5% (6000 vs 6300 nautical miles). Other countries indicated in the circumvention, however, represent a much larger detour. A detour in Thailand increases travel distance by nearly 67% (10,000 nautical miles), and one to Brazil 167% increase (16,000 nautical miles). Given that shipping cost accounts for at most around 5% of the total import value of aluminum foil, the estimates here are consistent with rerouting costs as one of the main mechanisms for cost increases of store-brand foils, and thus price increases of both store- and national-brand foils.

Two main robustness checks were made to account for the downward trend seen in the

event study before the AD policy. First, in the case that the trend represents a temporary dip, I remove quarters -1, -2, and -3 from the estimations. The estimates result in less than a 0.1 reduction of the coefficients compared to the preferred specification presented in Table 2.3. To find an upper bound on the treatment effect and to investigate the case that that downward trend would have been continued in the absence of the AD duties, I control for a unit-time (upc × quarter) fixed effect. This yields a higher average treatment effect of 0.11 or 11%. Overall, the estimates reported in Table 2.3 can be seen as falling on the conservative side of this range.

Table 2.2: Anti-Dumping Price Effect by Treatment Timing

| | Final | | Preliminary | | Initial | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Treat | 0.066*** | | 0.068*** | | 0.049*** | |
| | (0.016) | | (0.016) | | (0.014) | |
| Treat × Nat. | | 0.073*** | | 0.076*** | | 0.066*** |
| | | (0.014) | | (0.013) | | (0.012) |
| Treat × Store | | 0.059** | | 0.059** | | 0.027 |
| | | (0.021) | | (0.021) | | (0.019) |
| Treat × Fringe | | -0.045 | | -0.046 | | -0.043 |
| | | (0.041) | | (0.041) | | (0.035) |
| $N$ | 12,105,418 | | 12,105,418 | | 12,105,418 | |
| **Fixed Effects** | Quarter-Year, UPC, and Region | | | | | |

Standard errors clustered by store chain in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2.3: Estimates by Brands

| | (1) log(price) | (2) log(price) | (3) log(price) | (4) log(price) | (5) log(price) |
|---|---|---|---|---|---|
| Treat = Foil × Post | 0.066*** | 0.116*** | 0.050*** | -0.072 | |
| | (0.016) | (0.024) | (0.012) | (0.041) | |
| Treat × Store Brand | | | | | 0.059** |
| | | | | | (0.021) |
| Treat × National Brand | | | | | 0.073*** |
| | | | | | (0.014) |
| Treat × Fringe Brand | | | | | -0.045 |
| | | | | | (0.041) |
| Treatment Group | All | Store | National | Fringe | All |
| Comparison Group | All | Store | Branded | Branded | All |
| $N$ | 12,105,418 | 3,362,290 | 8,717,107 | 7,496,336 | 12,105,418 |
| **Fixed Effects** | Quarter-Year, UPC, and Region | | | | |

Standard errors clustered by store chain in parentheses.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

# Chapter 3

# Anti-Dumping Reaches the Grocery Store: Part II

## 3.1 Demand Estimation

### 3.1.1 Data

Data are further aggregated to the county-quarter-UPC level for the demand estimation. I define a market as a county-quarter, and products are defined at the UPC level. The market size is defined as the mean foil sales times 3 which yields outside shares that match those observed in consumer panel data. Summary statistics are presented in Table 3.1. Unique UPCs for store brands are generated, so that in a market, store brands compete with national brand, fringe brand, and other store brand products. This follows the strategy of Dubé et al. (2018). Prices are aggregated as sale-weighted means and are standardized to a 50 square

foot package size. Additionally, stores only observed in all 24 quarters are kept in the sample, and UPCs with fewer than 10 county-quarter observations are dropped. Q1, 2018 is also dropped, since the AD order is finalized in the middle of the quarter. I include two sets of instruments in the estimation. First, I compute 60 price instruments, which are constructed as the product of a dummy for a UPC and a dummy for the post-AD period. To avoid collinearity, instruments are kept only for UPCs which are available before and after the final AD order. The second set of instruments follows the "BLP-style" construction, using the characteristics of own and competing products as excluded variables. These include the mean package length, the mean share of heavy-duty foil, and the number of UPCs within the same market for own- and competing-brand products. These are valid instruments as product characteristics do not develop or change over time. The first stage of the price instruments is strong, and weak instruments are rejected by every F-test.

The micro data are organized in a similar manner. Household trips are aggregated to the quarter level, and only those households that fall into the markets defined in the retail data are kept. A dummy variable "inside" indicates whether a household consumed an inside good in each quarter. If the household did consume foil, the mean price per square foot is also calculated. Households are also grouped into three income levels: High ($>$ 90k), Middle ($\leq$90k & $\geq$ 45k), and Low ($<$ 45k).

### 3.1.2 Model

This section estimates a RC logit model, where consumers can purchase at most one of the goods in the market per quarter or consume the outside good. Consumer i's utility from

Table 3.1: Summary Statistics

| | Mean | St. Dev. | Median | Pctl(25) | Pctl(75) |
|---|---|---|---|---|---|
| Price ($) | 3.19 | 1.40 | 2.82 | 2.12 | 3.98 |
| Sales (50 sqft. Units) | 1029 | 2603 | 350 | 125 | 956 |
| Shares | 0.017 | 0.019 | 0.010 | 0.004 | 0.025 |
| Outside Share | 0.667 | 0.044 | 0.669 | 0.642 | 0.693 |
| Length (sqft.) | 101.8 | 143.5 | 50.0 | 37.5 | 75.0 |
| Share Heavy Duty | 0.5 | 0.039 | 0.5 | 0.476 | 0.524 |
| Share Store Brand | 0.551 | 0.111 | 0.556 | 0.462 | 0.64 |
| Share National Brand | 0.421 | 0.110 | 0.412 | 0.333 | 0.5 |

purchasing good j in market t consists of three parts:

$$u_{ijt} = \delta_{jt} + \mu_{ijt} + \varepsilon_{ijt} \tag{3.1}$$

$$\delta_{jt} = \xi_j - \alpha p_{jt} + \gamma X_{jt} \tag{3.2}$$

$$\mu_{ijt} = \sigma_1 \nu_{i1} + p_{jt}(\pi_{p,mid} \times mid_i + \pi_{p,high} \times high_i) + \pi_{mid} \times mid_i + \pi_{high} \times high_i \tag{3.3}$$

Where $\delta_{jt}$ is the mean utility shared by all consumers, $\mu_{ijt}$ is the household-specific utility, and $\varepsilon_{ijct}$ is an idiosyncratic logit shock assumed to follow a TIEV distribution. The utility of the outside good (j=0) is therefore: $u_{i0t} = \varepsilon_{i0t}$.

$\nu_{1i}$ is a random taste shock which follows a standard normal distribution. The model estimates the standard deviation of the random coefficient on the constant, which tells how

much consumers vary in the baseline preference for foil. The constant is also interacted with household income bins for middle and high income. I introduce price heterogeneity through the interaction of price with the income bins. In total, 5 non-linear parameters are estimated.

The model includes two sets of moments in GMM objective function:

Standard BLP Macro Moments:

$$E[Z'\xi(\theta)] = 0$$

and three types of Micro Moments:

$$\text{E(price} \mid \text{y = Y)},$$

$$\text{E(inside} \mid \text{y = Y)},$$

$$\text{E(inside} \mid \text{inside at t-1)},$$

Where income y is separated into two income bins - middle and high, so that a total of five micro moments are included.

### 3.1.3 Identification

My approach leverages both market-level and household-level variation to estimate a coherent model of consumer demand. Identification of the parameters in Equations 4 and 5 follows the standard logic of the random coefficient logit model introduced by Berry et al. (1995). Mean taste parameters $\alpha$ and $\gamma$ are identified from variation in observed market shares conditional on product and market fixed effects, while the random coefficients are identified from differences in substitution patterns across markets, products, and demographic groups.

The inclusion of micro moments derived from the NielsenIQ Consumer Panel provides critical identifying power (Berry and Haile, 2024). These moments ensure that the estimation matches observed household purchase behavior in the data. In particular, E(inside | inside at t-1) aids in the identification of $\sigma_1$, while E(inside | y = Y) and E(price | y = Y) identify $\pi$s and $\pi_p$ respectively for each income group.

Finally, the instruments are strong and intuitive. The first set exploits the price variation arising from the AD duties which constitute a shock to firms' marginal costs, and thus prices, and is unrelated to consumer preferences. The second set aids in the identification of parameters ruling price sensitivity because they generate exogenous variation in prices across markets that allows substitution patterns differ across consumers with varying income levels.

### 3.1.4 Estimation

The estimation minimizes the weighted sum of macro and micro moments using one-stage GMM. The weighting matrix for the macro moments is the standard $inv(Z'Z)$, and for the micro moments it is the inverse covariance matrix of the data moments, following Conlon and Gortmaker (2025). The weight between the micro and macro moments is set to give the micro moments one fifth of the weight of the macro moments after the first iteration. This prevents the macro moments from dominating the estimation.

### 3.1.5 Results

The results from the estimation can be seen in Table 3.2. Here, we see a high variation in consumers' baseline preference for foil. Additionally, we can see that lower-income households

Table 3.2: RC logit parameter estimation

| | Parameter Estimates |
|---|---|
| Price Per 50 sqft Package ($\alpha$) | -0.896 |
| | (0.086) |
| $\sigma_1$ | 7.590 |
| | (2.528) |
| Middle Income ($\pi_{\text{mid}}$) | -6.864 |
| | (2.055) |
| High Income ($\pi_{\text{high}}$) | -10.521 |
| | (3.052) |
| Price $\times$ Middle Income ($\pi_{p,\text{mid}}$) | 0.134 |
| | (0.002) |
| Price $\times$ High Income ($\pi_{p,\text{high}}$) | 0.319 |
| | (0.002) |
| N | 192,297 |
| **First Stage**: Cragg-Donald Wald F stat | 570.18 |
| **Fixed Effects**: Quarter & Year & UPC | |

Standard errors in parentheses.

have a stronger preference for foil than middle- and high-income households. As expected, the estimates suggest that high-income households are the least price sensitive while low-income ones are the most price sensitive.

Table 3.3: Fit of Micro Moments

| | Data Moment | Model Moment |
|---|---|---|
| E(price \| y = middle) | 2.668 | 2.655 |
| E(price \| y = high) | 2.715 | 2.862 |
| E(inside \| y = middle) | 0.166 | 0.250 |
| E(inside \| y = high) | 0.167 | 0.146 |
| E(inside \| inside at t-1) | 0.028 | 0.023 |

Table 3.4 reports mean own- and cross-price elasticities between national-, store-, and fringe-brand foil. The implied elasticities are closely in line with the benchmark from the literature. Shapiro et al. (2021) report a mean own-price elasticity of national-brand foil at -2.55. The fits of each micro moment are reported in Table 3.3. The fits are generally precise with the exception of the 3rd micro moment, the expectation of consuming an inside good in any given quarter for a middle-income household is 17% in the data, but estimated to be 25% from the model.

Table 3.4: Price Elasticities and Cross-elasticities for National, Store, and Fringe Brands

| | National Brand (P ↑) | Store Brand (P ↑) | Fringe (P ↑) |
|---|---|---|---|
| National Brand (Demand Δ) | -2.972 | 0.063 | 0.005 |
| Store Brand (Demand Δ) | 0.121 | -1.993 | 0.004 |
| Fringe (Demand Δ) | 0.117 | 0.039 | -3.832 |

### 3.1.6 Implied Marginal Costs and Markups

Marginal costs are calculated using the standard FOCs. The objective function for firm f with products j is

$$\Pi_f = \sum_{j \in \mathcal{F}} (p_j - c_j)\, s_j(p|\theta).$$

$s(p|\theta)$: $J \times 1$ vector of RC Logit shares. Stacking these for each product in the market gives the FOC

$$s(p|\theta) + \underbrace{\left(\Omega \odot \frac{\partial s(p)}{\partial p}\right)}_{-\Delta(p,\theta)} (p - c) = 0.$$

Where $\Omega$ is the ownership matrix ($\Omega_{jk} = 1$ if $j, k$ owned by same firm, 0 otherwise) and $\frac{\partial s(p)}{\partial p}$: $J \times J$ Jacobian of shares with respect to prices. The $\odot$ signifies element-wise multiplication. So as long as $\Delta(p, \theta)$ can be inverted, a solution can be reached which decomposes observed prices into estimated marginal costs and markups.

$$p = c + \underbrace{\Delta(p, \theta)^{-1} s(p|\theta)}_{\text{markups}}.$$

I calculate marginal cost using two distinct conducts. First, Nash-Bertrand, where store chains are the owners of their own store brands, and national and fringe brands price their own products. In the other conduct, I calculate marginal costs under joint pricing, so that the ownership matrix is a matrix of ones in every market. I then regress these imputed marginal costs against cost shifters and fixed effects in Equation 6.

$$mc_{it} = \alpha + \beta_1 Diesel_{it} + \beta_2 Import_{it} + \beta_3 PPI_{it} + \gamma_i X + \varepsilon_{it} \tag{3.4}$$

Where cost shifters are quarterly diesel prices, a China import index, and a producer price index for aluminum sheet, plate, and foil. Mirroring the demand model, fixed effects are year, quarter, and UPC. The marginal costs implied by Nash-Bertrand conduct have a better fit according to both the AIC and BIC measures (Table 3.5), and are used as the baseline marginal costs for the rest of the paper.

I also formally test this result using the Rivers-Vuong (RV) test as proposed by Duarte

et al. (2024). The test compares the differences in fits for the analogous GMM models. Duarte et al. (2024) show that the RV test can behave unreliably with too many or too few instruments, particularly when instruments are weak. This can cause the test's distribution to become skewed. They find that distortions are no greater than 2.5% for models with 2–9 instruments. In line with this finding, the main price instrument used differs from the ones in the demand model. Instead, these GMM models use the mean price of a UPC excluding the observations from the own state, along with the "BLP-style" instruments used in the demand model, so that in total there are 7 instruments. The test statistic follows a standard normal distribution, and the null hypothesis of the test is equal fit of the two models, which is easily rejected in both the pre- and post-AD periods. Additionally, there is no change in fit during the post-AD period.

Table 3.5: Fits of Conducts

| | | AIC | BIC |
|---|---|---|---|
| **Pre-AD** | | | |
| Nash-Bertrand | | 254,176 | 254,214 |
| Joint Pricing | | 590,378 | 590,416 |
| RV Test Statistic: | 142.1 | | |
| **Post-AD** | | | |
| Nash-Bertrand | | 264,008 | 264,046 |
| Joint Pricing | | 545,180 | 545,218 |
| RV Test Statistic: | 144.7 | | |

The graphs of implied marginal costs and markups for the preferred Nash-Bertrand conduct are presented below. Both markups and marginal costs increase after the AD duties are imposed for both national- and store-brand foil; however, marginal costs increase significantly more than markups. Figure 3.1 plots the mean marginal costs for a standardized 50 square foot roll by brand. The yellow line plots the "at-port price" for the same unit.

This is derived from the BACI trade data, which reports price per metric tonne. Weights of store-brand standard and heavy-duty aluminum foil were recorded and aggregated to reflect the market shares of each type. The results are sensible, reflecting that the cost of the raw foil contributes to most of the total marginal costs of store brands, while the residual would be sourcing, packaging, and distribution costs. Consistent with AD duties disrupting supply chains, these costs increase as a share of total costs in the post-AD period. Figure 3.2 reveals that markups are increasing visibly for national-brand foil after the policy, but that markups are more or less unchanged for store brands. This implies 100% pass-through of increased marginal costs to prices for store brands and a $>$ 100% pass-through for national-brand foil in the post-AD period.

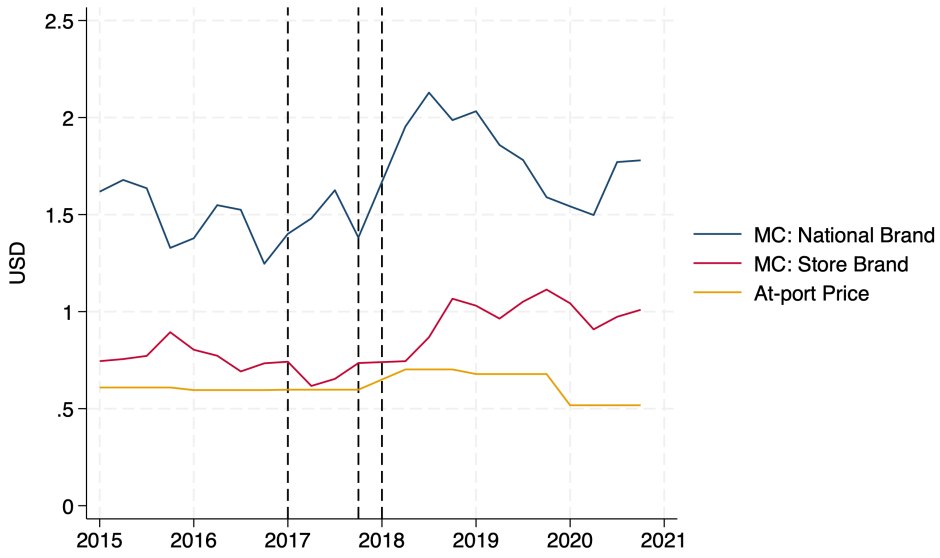


Figure 3.1: Marginal Costs (Nash-Bertrand). Vertical lines correspond to initial investigation, preliminary, and final decisions of the AD duties.

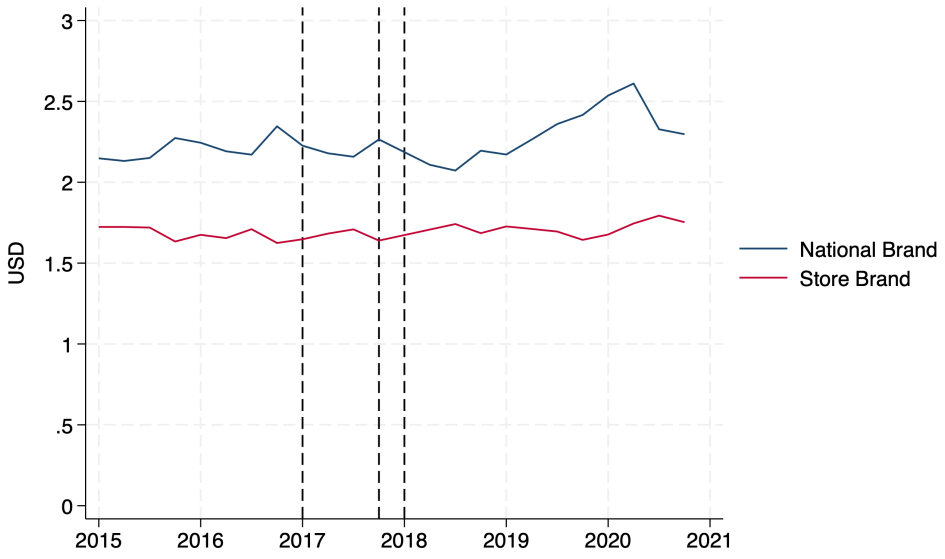


Figure 3.2: Markups (Nash-Bertrand). Vertical lines correspond to initial investigation, preliminary, and final decisions of the AD duties.

## 3.2 Counterfactuals

Using the preferred Nash-Bertrand marginal costs as a baseline specification, equilibrium counterfactual marginal costs and price equilibria are calculated for 2 separate scenarios. The first counterfactual is a no anti-dumping policy counterfactual. Here, the aim is to find what marginal costs would have been without the AD policy and then calculate a counterfactual price equilibrium from those counterfactual costs. To do this, a TWFE regression of marginal costs against cost shifters, fixed effects, and brand dummies interacted with Post-AD dummies is performed using Italian fringe brands as a control group. The logic here is that the Italian brand's costs should not have been affected either directly or indirectly from the policy. Indirect effects for this brand are ruled out since production costs in Italy should not have been affected by events in the US market. The event study for marginal cost effects for store-brand and national-brand foil can be seen in Figure 3.3. The results of the

regressions can be seen in Table 3.6. The first two columns present the estimates using observations from all markets, while the second two show that the results are robust to using only observations in markets where the Italian fringe brand is available. Results are also robust to the inclusion of cost shifters interacted with a post-AD dummy. The preferred specification is presented in the first column. Here it can be seen that the marginal cost effects of the AD policy are about 19 cents for store-brand products and 16 cents for national-brand products. Thus, in the no AD counterfactual, marginal costs are reduced by 19 cents for each store brand product and by 16 percent for each national-brand product. Marginal costs for fringe brands are left unchanged. The counterfactual price equilibrium implied by the marginal cost changes is calculated using the fixed point algorithm of Morrow and Skerlos (2011). The mean prices for the post-AD period from the factual and the counterfactual scenarios are presented in Table 3.7. The bottom row reports the price changes implied from the TWFE model from the reduced form portion of the paper. Overall, aggregate price effects align well with those from the reduced form model, although the counterfactual predicts slightly smaller price effects for national-brand foil compared to the estimation in the TWFE model. When used to calculate consumer surplus, these price changes translate to a 2.5% higher consumer surplus in the no AD counterfactual compared to the CS calculated from the realized factual prices, or about 8 million dollars per year. The associated gains in producer surplus are notably lower. Comparing the same counterfactuals implies producer surplus increased by around 1.8% or less than 2 million dollars, owing to the lower initial magnitude of producer surplus in the market.

The AD duties can affect firms' marginal costs through several channels. The most immediate and transparent channel operates through the duties themselves. Foil imported

directly from China faces a direct increase in marginal costs, as the duties are levied on those imports. A second direct channel operates through the circumvention. Chinese-origin foil imported through third-party countries faces costly rerouting or other circumvention-related expenses. Beyond these direct channels, the policy also raises marginal costs for firms producing domestically. Several mechanisms can generate these indirect effects. First, increased demand for US-made foil may raise input prices, while protection from foreign competition can weaken cost discipline if firms divert resources toward lobbying for continued protection rather than improving production efficiency. In addition, if demand expands sufficiently, domestic producers may encounter capacity constraints.

Several explanations can, however, be ruled out. Figure 2.6 in Section 3 demonstrates that there was no corresponding increase in aluminum prices in the post-AD period. Furthermore, the test of discrete conducts in Section 5 precludes cost mismeasurement attributed to collusive behavior in both the pre- and post- AD periods. This suggests that the implied increases in marginal costs for domestically produced national-brand foil are genuine rather than consequences of altered firm conduct. Overall, the evidence suggests that domestic producers experienced indirect cost increases driven by non-aluminum input costs, efficiency losses, and as they move along their own cost curve. Overall, the results demonstrate that AD protections can raise costs for nearly all suppliers, including domestic ones.

Table 3.6: Regression Results

| | All Markets | | Italian Fringe Only | |
|---|---|---|---|---|
| | MC | MC | MC | MC |
| Store Brand × Post | 0.188*** | 0.188*** | 0.205*** | 0.205*** |
| | (0.041) | (0.041) | (0.041) | (0.041) |
| National Brand× Post | 0.157*** | 0.157*** | 0.146*** | 0.145*** |
| | (0.010) | (0.010) | (0.003) | (0.003) |
| Producer Price Index | -0.009** | -0.010** | -0.009** | -0.011** |
| | (0.003) | (0.003) | (0.003) | (0.004) |
| Diesel Price | 0.259** | 0.202 | 0.274*** | 0.210 |
| | (0.083) | (0.122) | (0.076) | (0.116) |
| China Import Index | 0.085 | 0.124** | 0.161** | 0.193** |
| | (0.052) | (0.043) | (0.054) | (0.055) |
| Producer Price Index × Post | | -0.009* | | -0.008 |
| | | (0.003) | | (0.004) |
| Diesel Price × Post | | 0.600*** | | 0.558*** |
| | | (0.140) | | (0.138) |
| China Import Index × Post | | 0.108* | | 0.106 |
| | | (0.048) | | (0.064) |
| $N$ | 190,894 | 190,894 | 71,119 | 71,119 |
| **Fixed Effects** | Quarter, Year, Region, and UPC | | | |

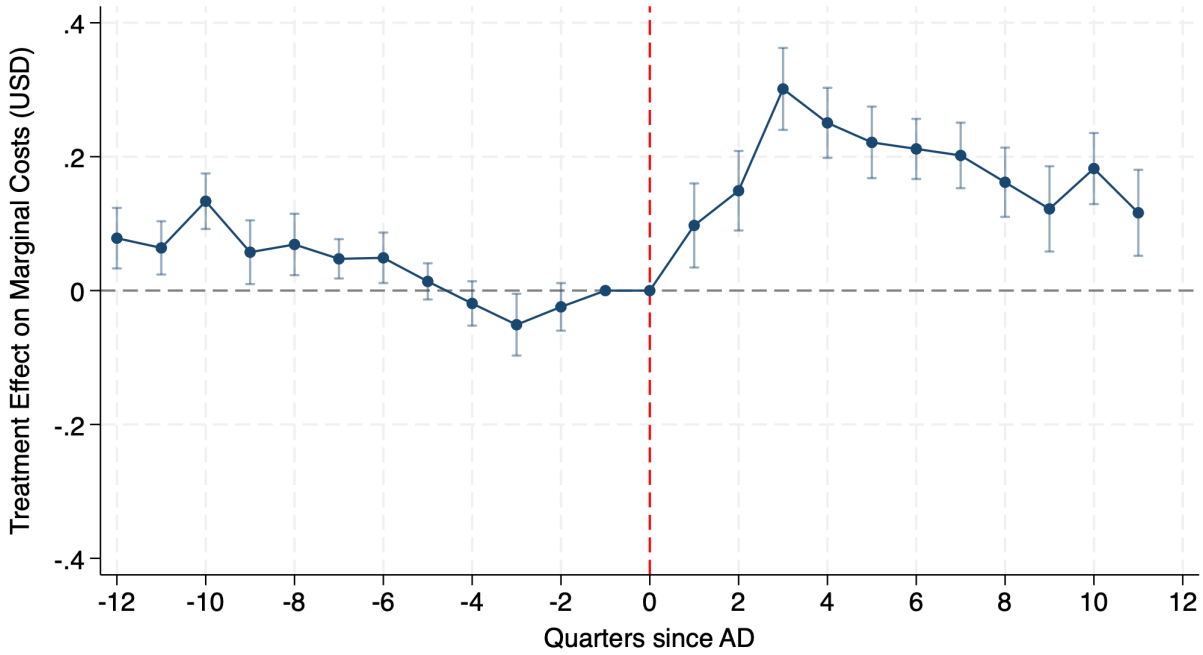


Figure 3.3: Event Study using Italian fringe brand as a comparison group.

Table 3.7: Mean Prices by Brand: Post-AD Period

| | All | Store Brand | National Brand |
|---|---|---|---|
| Realized Data | 3.37 | 2.69 | 4.11 |
| No AD Counterfactual | 3.20 | 2.51 | 3.95 |
| % $\Delta$ (Data $\rightarrow$ No AD) | -5.1% | -6.7% | -3.9% |
| Reduced Form % $\Delta$ | -6.6% | -5.9% | -7.3% |

The second exercise considers a "no circumvention" counterfactual scenario. This attempts to estimate the price equilibrium if there were no circumvention of the AD possible. This means that all imports originating in China would be taxed. To do this, several assumptions must be made which likely result in an upper bound for how costly it would be if

circumvention were not possible.

**Counterfactual Assumption I:** *All store-brand products use imports originating in China and the 106% duties pass completely through to marginal costs (elastic upstream supply).*

This is a strong assumption and does not allow for supplier switching as a response to the AD duties. Elastic upstream supply is a reasonable assumption given the US accounts for a small share of global aluminum foil demand. Before the AD duties, less than 10% of Chinese aluminum foil exports were sold to the US, suggesting that AD-induced cost increases are likely to be passed through to US buyers.

Using this assumption, I decompose marginal cost into a linear function of cost shifters, quantity, and the AD shock, $\omega$

$$mc_{it} = c(w, q) + \omega$$

Let $c(w, q)$ be the baseline marginal costs as calculated above. Then $\omega$ (the amount of duties paid) is just the "At Port Price" (see Table 3.1) of foil times the import tax (106%). So counterfactual store-brand marginal costs increase by the amount of the duties:

$$MC_{cf}^{Store} = MC^{Store} + \omega_{cf}^{Store} = MC^{Store} + AtPortPrice \times 1.06$$

**Counterfactual Assumption II:** *The ratio of marginal cost effects of the AD duties for store-brand and national-brand products is constant across enforcement levels.*

For both national-brand and store-brand foils, $c(w, q)$ should be invariant to the AD policy

so $\frac{\partial c(w,q)}{\partial AD} = 0$. The ratio of marginal cost effects is given by $\eta$ and is calculated using the cost effects estimated in the no AD counterfactual.

$$\eta = \frac{\frac{\partial \omega^{NationalBrand}}{\partial AD}}{\frac{\partial \omega^{Store}}{\partial AD}} = \frac{\frac{\partial MC^{NationalBrand}}{\partial AD}}{\frac{\partial MC^{Store}}{\partial AD}} = \frac{0.16}{0.19} = 0.84$$

Putting everything together, national-brand marginal costs increase by an $\eta$ share of the duties.

$$MC_{cf}^{NationalBrand} = MC^{NationalBrand} + \omega_{cf}^{NationalBrand} = MC^{NationalBrand} + \eta \times \omega_{cf}^{Store} =$$

$$MC^{NationalBrand} + 0.84 \times AtPortPrice \times 1.06$$

Summaries of the two counterfactual calculations can be seen in Table 3.8. The resulting price equilibrium for the no circumvention counterfactual can be seen in the third row of Table 3.9

Table 3.8: Counterfactual Calculations

| | |
|---|---|
| No Anti-Dumping | ↓ National-Brand MC by 0.16 and Store-Brand MC by 0.19. |
| No Circumvention | ↑ MC for Store Brand by "At-Port Price" × 1.06<br>↑ MC for National Brands by $\eta$×"At-Port Price" × 1.06 |

Table 3.9: Mean Prices by Brand: Post-AD Period

| | All | Store Brand | National Brand |
|---|---|---|---|
| No AD (Counterfactual) | 3.20 | 2.51 | 3.95 |
| Realized Data | 3.37 | 2.69 | 4.11 |
| No Circumvention (Counterfactual) | 3.98 | 3.37 | 4.71 |
| $\Delta$ (Data) | 0.17 | 0.18 | 0.16 |
| $\Delta$ (No AD) | 0.78 | 0.86 | 0.76 |

Overall, prices in the no-circumvention counterfactual are 17 cents higher than they are in the factual state of the world, and 78 cents higher than in the no AD counterfactual. Using the aggregate as a baseline, of a potential 78 cent price increase, only 17 cents are realized in the observed state of the world (AD with circumvention). Thus, the results imply that circumvention mitigates as much as

$$\frac{0.78 - 0.17}{0.78} \times 100 \approx 78\%$$

of the potential price increases from the AD duties.

In order to test the sensitivity of this benchmark to the second assumption, I vary $\eta$ from zero to one and recalculate the price equilibrium. The results are presented in Table 3.10 and imply a general insensitivity, which enhances the robustness of the results.

Table 3.10: Sensitivity Test to Assumption 2

| | All | Store Brand | National Brand |
|---|---|---|---|
| Lower Bound ($\eta = 0$) | 3.80 | 3.31 | 4.34 |
| One Quarter ($\eta = 0.25$) | 3.86 | 3.33 | 4.45 |
| One Half ($\eta = 0.5$) | 3.91 | 3.35 | 4.56 |
| Benchmark ($\eta = 0.84$) | 3.98 | 3.37 | 4.71 |
| Upper Bound ($\eta = 1$) | 4.03 | 3.39 | 4.80 |

## 3.3 Domestic Industry

To complement the consumer-side analysis, this section examines whether the 2018 anti-dumping duties generated any measurable benefits for domestic producers in the US aluminum industry. Although data disaggregated specifically for aluminum foil manufacturers are not available, broader industry statistics for the Aluminum Sheet, Plate, and Foil Manufacturing industry provide evidence on how US producers fared during the study period. Table 3.11 reports annual industry-level indicators from the US Census Bureau's Annual Survey of Manufactures (ASM), including total sales, payroll, employment, hours worked, and materials costs. Figure 3.4 graphs quarterly industry trends along with the vertical line indicating the final timing of the AD policy.

Table 3.11: Industry-level statistics from Aluminum Sheet, Plate, and Foil Manufacturing

| Year | Sales | Payroll | Employees | Hours | Wages | Costs |
|---|---|---|---|---|---|---|
| 2015 | 15,799,355 | 1,293,300 | 18,744 | 29,643 | 920,916 | 11,299,139 |
| 2016 | 14,954,632 | 1,357,064 | 19,056 | 29,673 | 964,904 | 10,492,985 |
| 2018 | 19,014,383 | 1,489,730 | 18,845 | 30,204 | 1,045,976 | 12,057,383 |
| 2019 | 17,504,347 | 1,595,346 | 19,051 | 30,932 | 1,127,247 | 10,559,880 |
| 2020 | 14,649,777 | 1,462,138 | 19,421 | 30,247 | 1,005,029 | 8,687,954 |
| 2021 | 18,273,722 | 1,525,874 | 18,702 | 28,886 | 1,042,548 | 11,466,168 |

BLS, Annual Survey of Manufactures (ASM). Sales, Payroll, Wages, and Costs in 1000s of US dollars. ASM was not conducted in 2017.

The aggregate data reveal little evidence of domestic production benefits following the aluminum foil AD order. From a labor perspective, payroll, wages, and hours remain stagnant throughout the study period. The data suggest that US producers maintained a steady trajectory before and after the policy, implying that the AD duties and related tariffs on aluminum inputs left the industry trends unchanged.

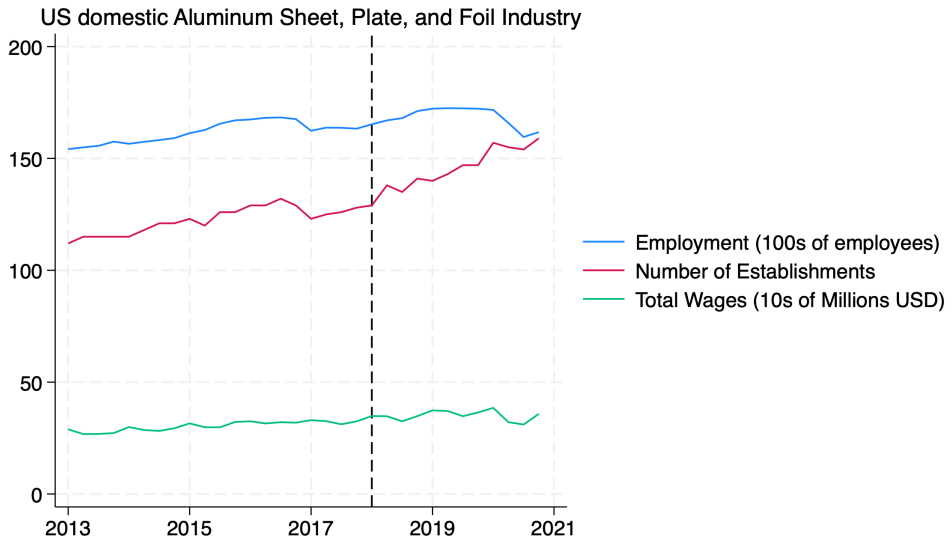


Figure 3.4: Industry trends unchanged by AD policy.

These findings are consistent with the hypothesis that anti-dumping protection in this sector produced limited benefits for domestic firms. The AD duties may have indirectly raised their own input costs, offsetting any gains from reduced foreign competition. Moreover, widespread circumvention implies that import competition from Chinese-origin foil persisted through third-party countries, further diluting potential protective benefits of the policy.

Overall, while the consumer side of the market experienced clear price increases, the producer side appears largely unaffected, with no evidence of expanded employment, increased wages, or rising profits in the post-policy period. Together, these findings highlight the risk

of AD duties. Even when designed to aid domestic producers, anti-dumping duties may not have their intended effects, yet still impose substantial costs on consumers.

## 3.4 Conclusion

This paper provides new evidence on how anti-dumping duties affect consumer prices and firm costs in retail markets, and it offers the first quantitative benchmark for the role of import-tax circumvention in mitigating these effects. As these types of origin-specific import taxes become ever more common, it has never been more important to have high-quality analyses of their effects on consumers and sellers. Using detailed scanner and consumer panel data, I find significant price increases for imported and domestically produced brands implied by both the reduced-form regressions and the structural model. Additionally, the model suggests that costs increased for both foreign and domestic firms in the post-AD period, and that the pass-through of increased costs to consumer prices is >100%. Finally, I estimate that as much as 78% of the price increases from the AD policy were mitigated by circumvention of the AD duties.

These findings have several implications for the design and evaluation of trade policy. First, they demonstrate that even when duties are circumvented, consumers can face substantial welfare losses through higher prices, while domestic producers often experience limited protective benefits. Second, a framework is provided to consider conduct and market structure when evaluating trade policy. This is critical in concentrated downstream markets, where markup adjustments can amplify the price effects of import restrictions. My analysis suggests that tightening enforcement of import taxes would be very costly to consumers.

Given stricter enforcement across many goods, it could also exacerbate inflation, while the enforcement itself may also be expensive. However, since circumvented import taxes often fail to provide the intended protection to domestic producers or to collect tax revenue, policy makers may still find it advantageous to tighten enforcement. Generally speaking, circumvented import taxes should receive increased enforcement only if the protective benefits outweigh the further increases to consumer prices and should be eliminated otherwise.

Several limitations of the study invite further research of this and other AD duties. First, this paper is only able to investigate the effects of the AD policy on retail consumers. Non-retail buyers of aluminum foil would have also been affected by the policy, which likely had downstream effects on the rest of the economy, particularly in the food service and HVAC industries. Moreover, this limitation prevents estimates of government revenue to round out the effect of the policy on total surplus. While very low direct imports from China suggest a negligible revenue effect for the retail foil industry, concrete assertions about total surplus effects cannot be made without more detailed data. Additionally, due to circumvention and masked store-brand UPCs, I am unable to link all products to their true countries of origin. Finally, when looking at the effects of the policy on the domestic industry, I do not observe disaggregated data on the aluminum foil industry only. Although total imports increasing slightly in the post-AD period suggest little protective benefit of the AD duties to the domestic industry, without data on producers' profits and employment, further conclusions about the total welfare effects of the policy are limited. Despite these limitations, the paper contributes by demonstrating that even circumvented import taxes can significantly raise consumer prices and firm costs, and it is the first analysis to my knowledge which provides a benchmark for how trade-policy circumvention mitigates consumer price increases.

# Chapter 4

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

## 4.1 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 2026, with wars of territorial expansion in Ukraine and the Middle East, 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

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.

## 4.2 Literature Review

### 4.2.1 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 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

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

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.**

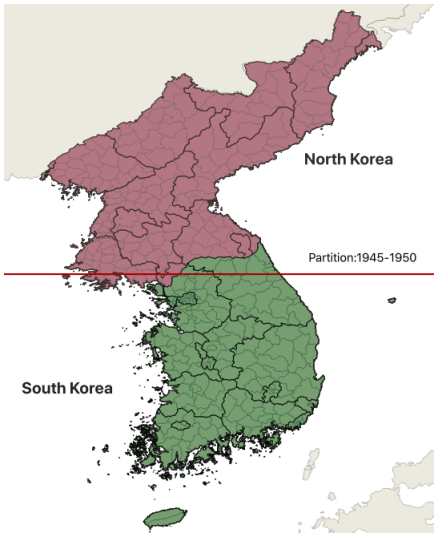


Figure 4.1: Map of the Korean Peninsula showing the 1953-present border and the temporary partition at the 38th parallel in red (1945-1950).

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).

### 4.2.2 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 liturature, 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 4.2: 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.

### 4.2.3 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.

## 4.3 Data Description

### 4.3.1 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 night lights 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 degrees longitude [2]. 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 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

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

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.

### 4.3.2 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 () [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 20,132 USD.[4]

[3]Sub-province level data is *not* available on the english-language KOSIS website.
[4]Using the exchange rate of 0.00089 USD = 1 KRW (12 March 2010).

**Figure 3.**


Figure 4.3: Gangwon Province forms the majority of the treatment area in the ROK.

### 4.3.3 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 4.1: 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. $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$.

**Figure 4.**

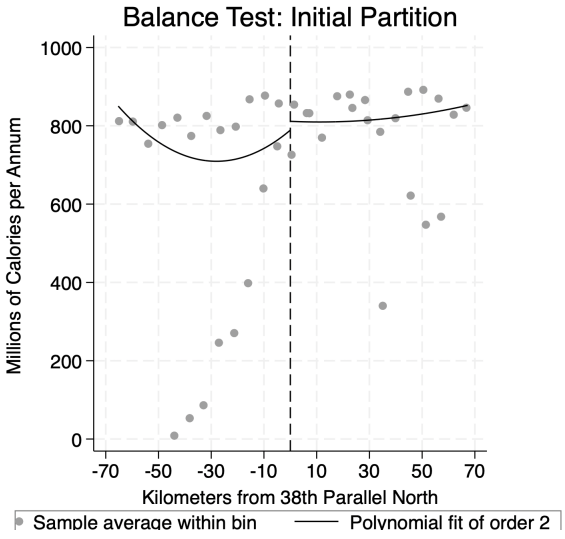


Figure 4.4: RD Plot showing no discontinuity at the 38th Parallel.

**Figure 5.**

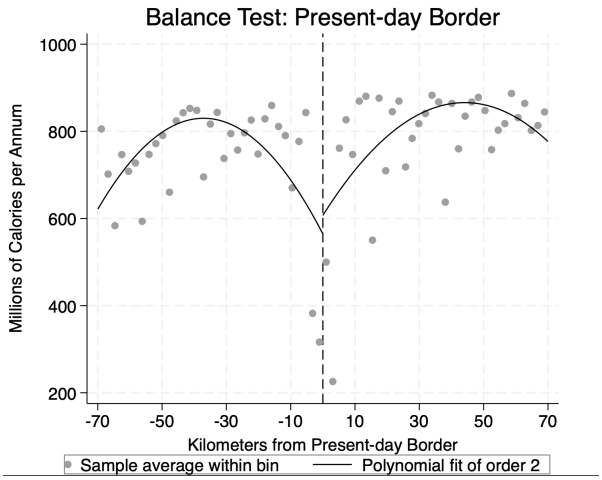


Figure 4.5: RD Plot showing no discontinuity at the present-day border.

## 4.4 Empirical Strategies

### 4.4.1 North Korea

#### 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.

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 treat-

**Figure 6.**

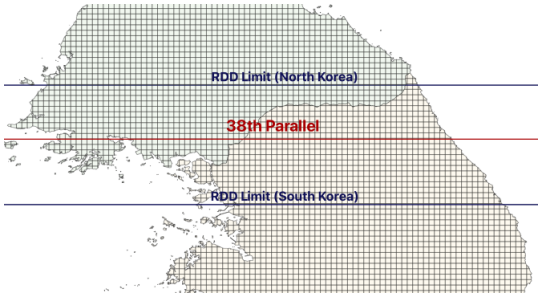


Figure 4.6: Gridded maps and maximal RD limits showing unit of observation and control areas.

ment. 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.

### OLS Regression

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

$$GDP = \alpha + \beta ROK + \phi DistCoast + \psi DistDMZ + \varepsilon \tag{4.1}$$

$$\frac{GDP}{Population} = \alpha + \beta ROK + \phi DistCoast + \psi DistDMZ + \varepsilon \tag{4.2}$$

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.

### 4.4.2 South Korea

#### 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.

#### OLS Regressions with Fixed Effects

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

$$GDP = \alpha + \beta DPRK + \phi DistCoast + \psi DistDMZ + \delta Prov + \varepsilon \tag{4.3}$$

$$\frac{GDP}{Population} = \alpha + \beta DPRK + \phi DistCoast + \psi DistDMZ + \delta Prov + \varepsilon \tag{4.4}$$

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:

$$GRDPPC = \alpha + \beta DPRK + \psi YearDummy + \phi DMZ + \delta Prov + \varepsilon \tag{4.5}$$

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.

## 4.5 Results

### 4.5.1 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.

**Figure 7.**

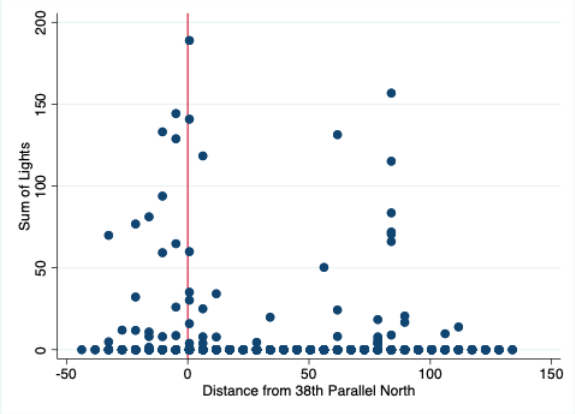


Figure 4.7: Hwanghae Provinces: Scatter plot of Estimated GDP by grid cell.

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, 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.

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

**Figure 8.**

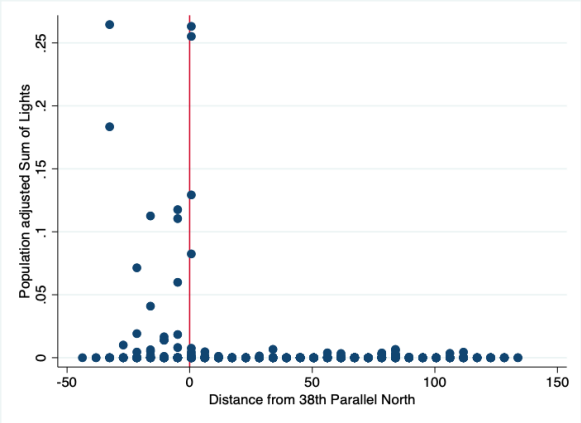


Figure 4.8: Hwanghae Provinces: Scatter plot of population adjusted GDP estimates.

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.

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 ad-

**Figure 9.**

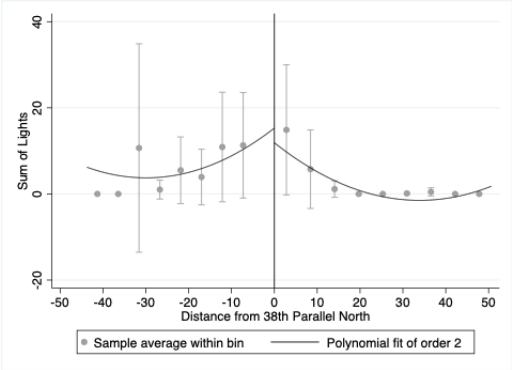


Figure 4.9: Hwanghae Provinces: RD plot for estimated GDP using maximal bandwidth.

**Figure 10.**

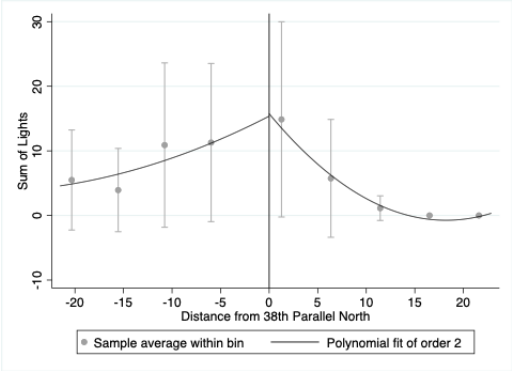


Figure 4.10: Hwanghae Provinces: RD plot for estimated GDP using MSE-optimal bandwidth.

**Figure 11.**

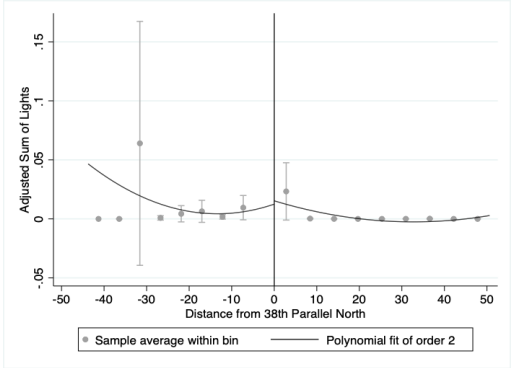


Figure 4.11: Hwanghae Provinces: RD plot for population adjusted GDP using maximal bandwidth.

**Figure 12.**

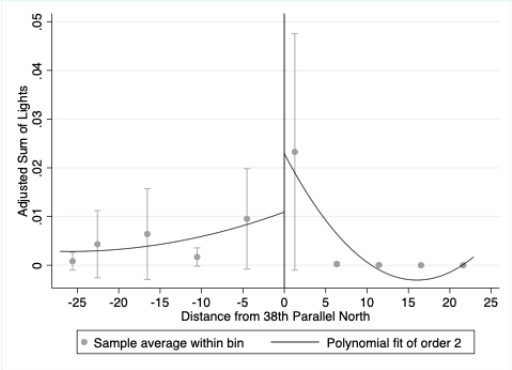


Figure 4.12: Hwanghae Provinces: RD plot for population adjusted GDP using MSE-optimal bandwidth.

justed 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 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

**Figure 13.**

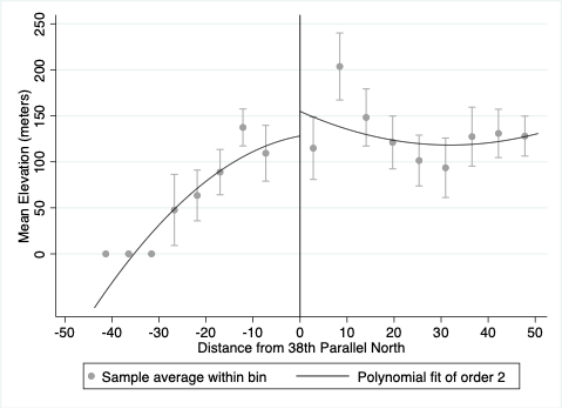


Figure 4.13: Hwanghae Provinces: RD plot of elevation.

**Figure 14.**

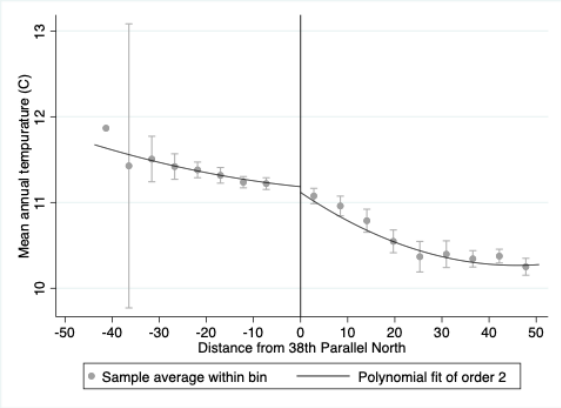


Figure 4.14: Hwanghae Provinces: RD plot of mean annual temperature.

**Figure 15.**

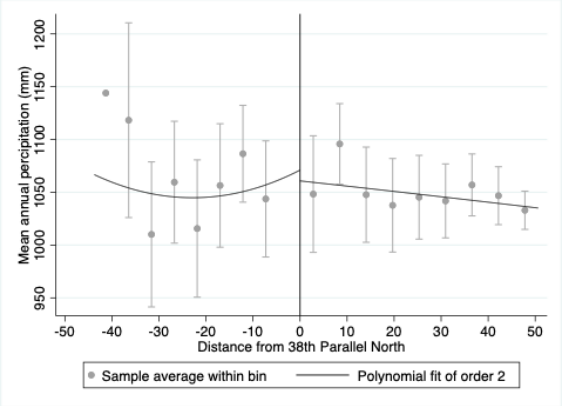


Figure 4.15: Hwanghae Provinces: RD plot of mean annual percipitation.

Table 4.2: 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
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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 4.3: 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.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

### 4.5.2 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.

**Figure 14.**

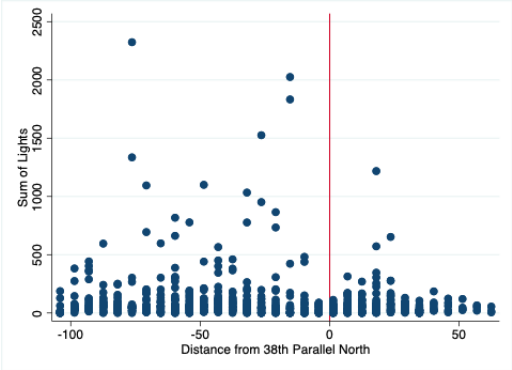


Figure 4.16: Gangwon Province: Plot of GDP Estimates.

**Figure 15.**

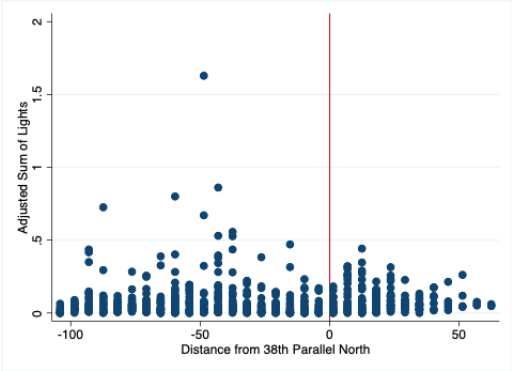


Figure 4.17: Gangwon Province: Plot of population adjusted GDP estimates.

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 18.**

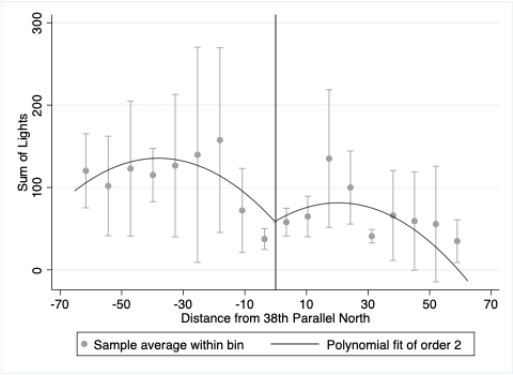


Figure 4.18: Gangwon Province: RD plot for GDP estimates using maximal bandwidth.

**Figure 19.**

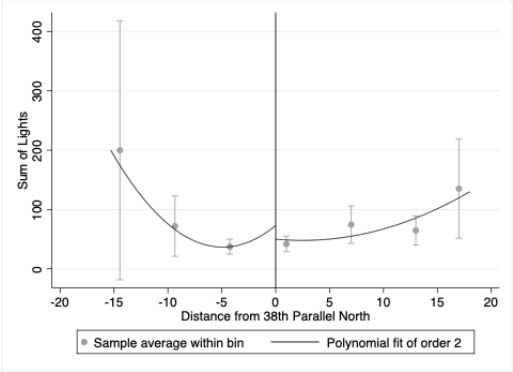


Figure 4.19: Gangwon Province: RD plot for GDP estimates using MSE-optimal bandwidth estimate.

**Figure 20.**

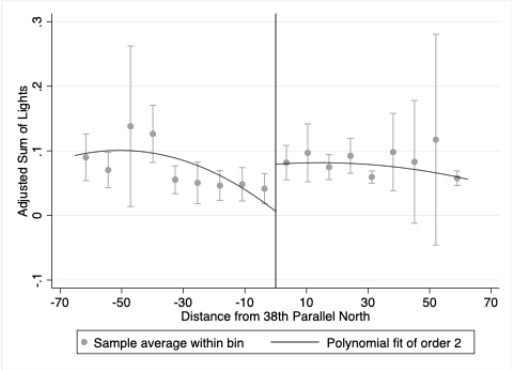


Figure 4.20: Gangwon Province: RD plot for population adjusted GDP using maximal bandwidth.

**Figure 21.**

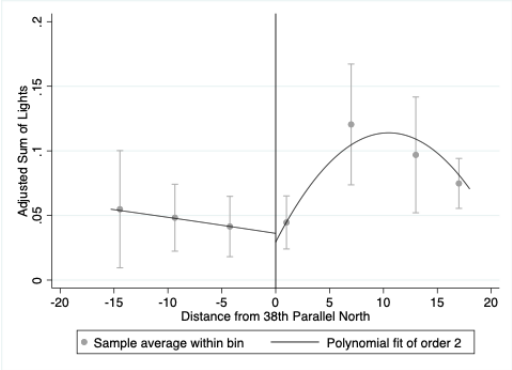


Figure 4.21: Gangwon Province: RD plot for population adjusted GDP using MSE-optimal bandwidth estimate.

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 covariates. 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 ef-

**Figure 22.**

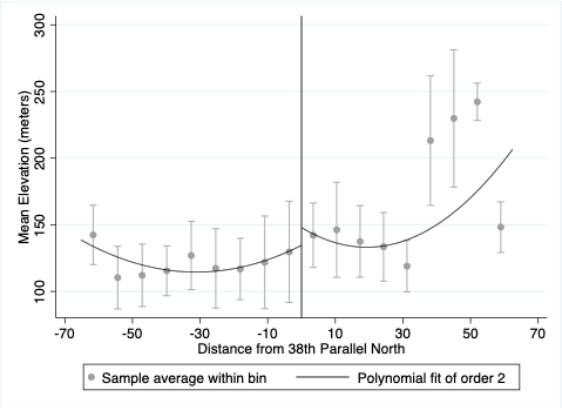


Figure 4.22: Gangwon Province: RD plot of Elevation.

**Figure 23.**

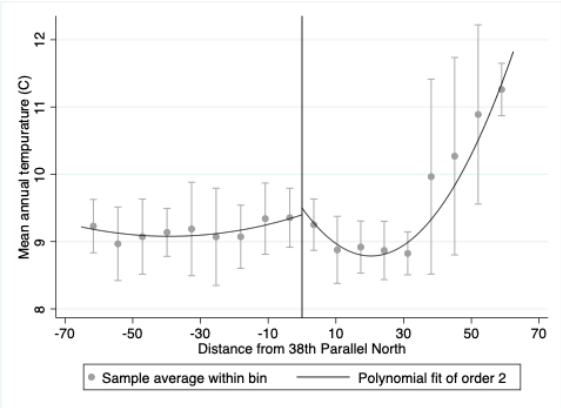


Figure 4.23: Gangwon Province: RD plot of mean annual temperature.

**Figure 24.**

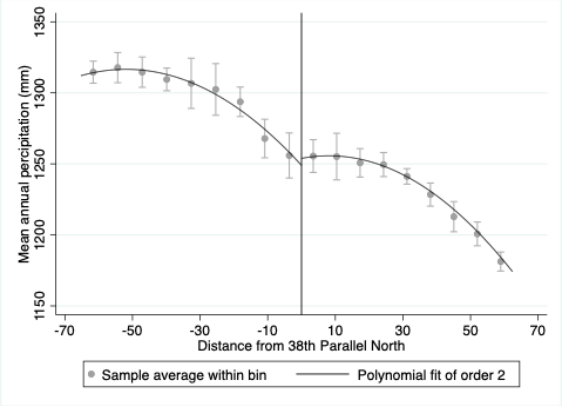


Figure 4.24: Gangwon Province: RD plot of mean annual precipitation.

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

Table 4.4: GDP Estimates (Millions of 2010 USD): Gangwon and Gyeonggi Provinces

| | (1) Treatment only | (2) | (3) | (4) | (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.

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

Table 4.5: Adjusted GDP (2010, Thousands of USD): Gangwon and Gyeonggi Provinces

| | (1) Treatment only | (2) | (3) | (4) | (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.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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 4.6: 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 measured in millions of Korean Won.
1 USD $\approx$ 1200 KRW.
Standard errors in parentheses; * $p < 0.05$

I propose the main mechanisms behind these differences stem from differential investment patterns during the treatment period, and from the transmission and persistence of differing political ideology. Examples could include subsidization of private business vs. state-owned enterprises, or differing levels of investment in education, military, and public goods. From both sides, increased military or political activity around the present-day border is controlled for by the distance from the DMZ, as well as decreased social or economic activity from fears of instability along or near the border. From the South Korean side, investigations using geolocated school data showed no differences on either side of the 38th parallel, suggesting that differing education investment is unlikely to explain the aggregate differences seen in table 4.4. Overall, multiple potential explanations for these differences invite further study of these proposed mechanisms.

## 4.6 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.

## 4.7 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 2026 marks the 116th anniversary of the occupation of Korea, resulting in subsequent war and the ultimate division of the peninsula. The treatment studied in this paper should be remembered in the context of this challenging period of Korean history.

# Appendix 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

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

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