Taking the Scenic Route

Estimating the Effect of the Russian Airspace Closure on Bilateral Trade

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ABSTRACT

This paper examines the impact of the 2022 Russian airspace closure on bilateral trade flows between four Nordic countries (Sweden, Norway, Finland, and Denmark) and two East Asian economies (Japan and South Korea). By employing a novel approach combining Coarsened Exact Matching with the Synthetic Control Method, a synthetic control unit is constructed for each of the sixteen country-pairs, allowing for estimation of the treatment effect. The analysis finds substantial negative effects for multiple country-pairs and reveals directional asymmetries. In-space placebo tests are conducted to verify robustness, finding strong support for several results. This paper contributes to a broader literature examining the effect of air transport on bilateral trade and extends the application of the Synthetic Control Method in trade contexts.

Keywords: Synthetic Control Method · Coarsened Exact Matching · Air travel · Bilateral Trade · Russian Airspace Closure.

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I. INTRODUCTION

Shortly after the invasion of Ukraine in February 2022, Russia closed its airspace to airlines operating from any country it was currently sanctioned by. This severed flight paths between Europe and East Asia, significantly increasing the effective flight distance between these regions. Routes that had relied on Russian airspace for efficient travel, especially those connecting Northern Europe with East Asia, were forced to take longer and costly detours. As a result, flight times increased, raising operational costs and disrupting both cargo and passenger travel. This sharp and exogenous shock presents a rare opportunity to study how air connectivity affect bilateral trade.

In this paper, I aim to answer the question: *what is the impact of the Russian airspace closure on bilateral trade?* Specifically, I seek to estimate the causal effect of the Russian airspace closure on bilateral trade flows for sixteen individual country pairs. To accomplish this, I employ a novel approach combining Coarsened Exact Matching (CEM) with the Synthetic Control Method (SCM). CEM ensures that each treated country-pair is compared to highly similar control pairs in terms of gravity-model covariates, while the SCM constructs unit-specific counterfactuals to isolate the causal effect of the airspace closure on trade.

I find large and asymmetric effects. Swedish, Danish and Finnish exports to Japan fell sharply compared to their synthetic counterfactual following the airspace closure, seeing an average reduction of 23% in the post-treatment period. Conversely, Japanese exports to Sweden, Denmark and Finland were far less affected. In contrast, the effects on trade flows to and from South Korea were found to be far less pronounced. This directional asymmetry highlights that Swedish, Danish, and Finnish exporters were much more vulnerable to the loss of Russian airspace access. Placebo tests and robustness checks confirm the statistical credibility of the results for several pairs, particularly Finnish exports to Japan.

This paper aims to contribute to the existing literature in two main ways. First, it provides new empirical evidence on the role of aviation and effective distance in influencing bilateral trade, contributing to the growing body of literature examining the impact of air transportation on trade (e.g., Hummels, 2007; Söderlund, 2023; Wang et al., 2025). Second, it provides evidence for the applicability of the SCM as an alternative to more traditional approaches in trade contexts, demonstrating its usefulness as part of the growing empirical toolkit for causal inference.

II. Background

Within days of the Russian invasion of Ukraine in February 2022, most Western democracies, as well as Japan, South Korea, imposed economic, financial, and political sanctions on Russia (Reuters, 2022). In response, Russia imposed reciprocal sanctions on these countries, which included prohibiting both commercial and private aircraft from any sanctioning country from flying over, into, or out of Russian airspace (Bychkov & Efremov, 2022). This restriction has remained in effect since February of 2022. The Russian airspace closure had an especially strong impact on flight routes between Europe and East Asia, which under normal circumstances rely on crossing Russian airspace for the majority of the journey to minimise flight distance and fuel consumption. With Russian airspace closed, airlines were forced to reroute flights travelling between Europe and East Asia. Flights were rerouted primarily through one of three alternative corridors: southward via the Middle East, northward via the North Pole, and westward via North America. Each of these alternatives led to significantly increased flight distances, operational costs, and fuel consumption, and in some cases even led to a reduction in departure frequency or closure of the route entirely (Wang et al., 2023).

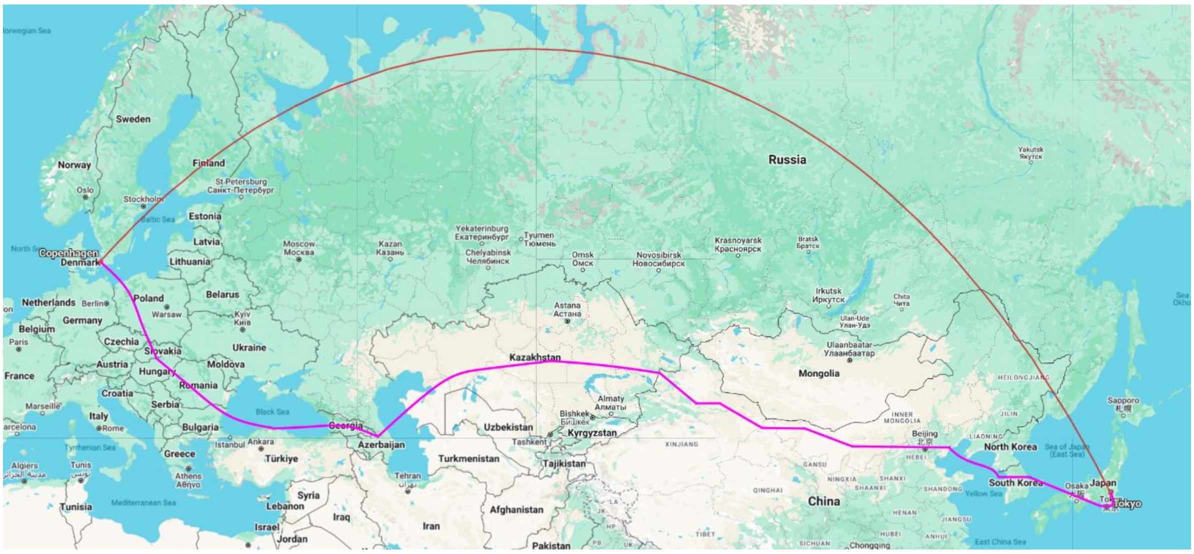

Figure 1. Copenhagen to Tokyo before and after Russian airspace closure. Source: Flightradar 24.

Among the impacted routes, flights between the Nordic countries and Japan or South Korea were most heavily affected by the closure of Russian airspace, as their geographic location made them uniquely dependent on the trans-Siberian corridor to minimise flight distance and fuel consumption. Prior to 2022, the most efficient routes passed almost entirely over Russia, and this allowed airlines to offer fast and direct connections between the Nordics and East Asia. Note that for the purposes of this paper "Nordic countries" will refer to Sweden, Norway, Denmark and Finland. Iceland is excluded here as prior to 2022, Iceland's most efficient route already passed primarily over the North Pole and was not as dependent on Russian airspace. When Russia closed its airspace, routes from Nordic countries faced few viable alternatives compared to Central and Southern Europe where flights could be more readily rerouted via the Middle East. This led to the effect on flight time, and thereby fuel consumption and operational costs, being much more pronounced for flights between Nordic countries and Japan or South Korea (Thessen, 2025).

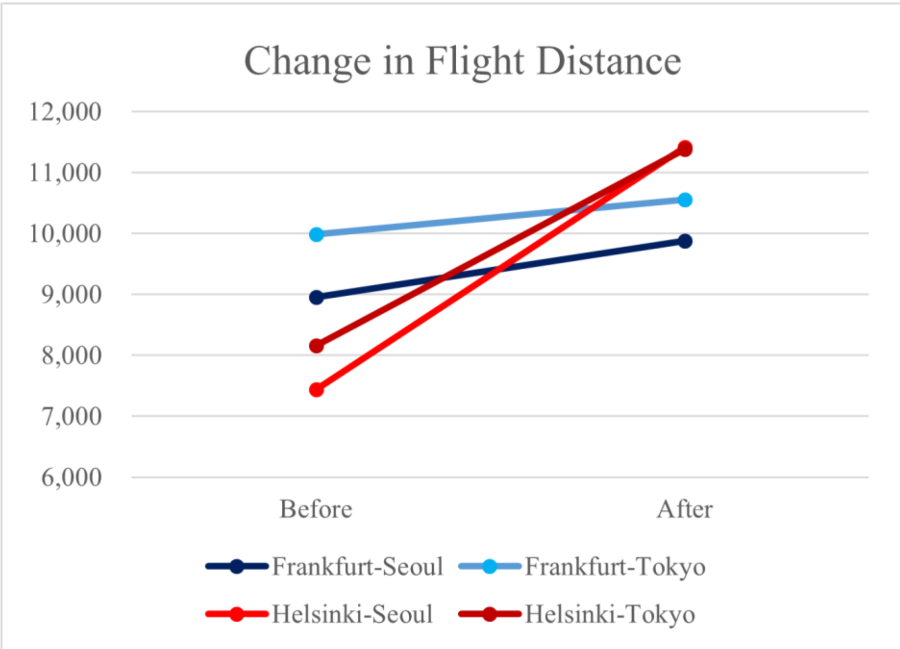

Figure 2. Flight distance (km) before and after Russian Airspace Closure. Source: EUROCONTROL Data Snapshot #29.

Furthermore, destinations like China and Mongolia remained accessible via carriers that were not subject to the airspace ban, as both China and Mongolia were not targeted by Russia's sanctions and therefore could continue operating over Russian airspace. This meant that while overall connectivity to China and Mongolia was reduced, direct flights were still available on Chinese or Mongolian carriers. For the Nordic-Japan/Korea corridor however, both origin and destination carriers were targeted by the sanctions, meaning flights between these countries were impacted both particularly heavily, and regardless of carrier origin, making it a particularly compelling case study.

The Russian airspace closure can plausibly affect bilateral trade flows through multiple channels. Most directly, longer flight routes increase costs for airlines, which are typically passed on to passengers and cargo shippers through increased prices, making air transportation more expensive. For goods primarily transported via air, such as high-value, time-sensitive or perishable goods, these increased costs can reduce trade competitiveness and volumes.

Multiple studies have also found a positive relationship between business travel and face-to-face interaction on bilateral trade (Söderlund, 2023, Startz, 2016, Cristea, 2011, Alderighi & Gaggero, 2017, Yilmazkuday & Yilmazkuday, 2017, Kulendran & Wilson, 2000). Aside from direct shipping costs, the airspace closure can be plausibly expected to negatively impact trade through its effect on business travel and face-to-face interaction. Longer flight times, higher ticket prices and reduced connectivity can discourage such travel, potentially weakening existing trade relationships or preventing new ones from being formed.

III. LITERATURE REVIEW

A. *The Gravity Model of Trade and the Role of Distance*

The gravity model of trade has long been used as a workhorse for analysing the determinants of bilateral trade (Head & Mayer, 2014). It hypothesises that bilateral trade flows are a function of economic size, distance, and shared institutional or cultural characteristics, and suggests that trade between two countries is positively associated with their economic size and negatively associated with the distance between them (Andersson & van Wincoop, 2003). In an increasingly globalised world, one could imagine that the barrier to trade posed by geographic distance would diminish over time. However, empirical studies continue to find that distance has a substantial negative effect on trade (Disdier & Head, 2008; Head & Mayer, 2014).

Two key mechanisms are often proposed to explain part of why distance remains a substantial barrier to trade. A standard explanation is the increase in transportation costs associated with increased geographic distance. Hummels (2007) finds that air transport costs, although declining over time, remain substantial and sensitive to fuel prices and route length. Furthermore, Limao and Venables (1999) find a strong negative effect of transportation costs on trade volume, demonstrating that a halving in transportation costs increases the volume of trade by a factor of five. Although transportation costs contribute to the effect of distance on trade, Disdier & Head (2008) note that these costs alone are not enough to explain the persistent negative effect of distance.

Another hypothesis is that business travel and face-to-face interaction play a critical role in bilateral trade and maintaining business relationships. Although digital connectivity has allowed for remote coordination, personal relationships and in-person meetings still have a strong impact on bilateral trade (Cristea, 2011). Air travel facilitates this type of interaction, and several studies have found a strong empirical relationship between air travel and trade using a variety of approaches. Söderlund (2023) uses a Difference-in-Differences approach and the liberalisation of soviet airspace as a natural experiment to study the effect of business travel cost on trade, finding a strong positive relationship between shorter travel times and trade. Similarly, Wang et al. (2025) use an instrumental variable approach to study how air connectivity affects bilateral trade by facilitating face-to-face interaction, finding that enhanced air connectivity significantly boosts trade.

Distance continues to be a barrier to trade not just trough transportation costs, but also by hindering opportunities for face-to-face interaction and relationship building. The Russian airspace closure plausibly affects both of these channels, by increasing effective distance, raising air cargo costs, and deterring business travel, making it a compelling case for studying how reduced connectivity and increased costs impact bilateral trade.

B. The Synthetic Control Method

Estimating the causal effect of an intervention or event is a common task in economics and other social science research. Previously, approaches such as regression discontinuity or difference-in-differences have been used in the literature to accomplish this, however, they often rely on assumptions that may not hold in comparative case study settings. In the case of difference-in-differences, which is commonly employed when using a natural experiment, it relies heavily on the identifying parallel trends assumption, which posits that the average of untreated units is a good proxy for the counterfactual of the treated unit. However, this assumption can be hard to defend in empirical settings (Li & Van den Bulte, 2023). The Synthetic Control Method (SCM), introduced by Abadie & Gardeazabal (2003) and Abadie et al. (2010), was developed as an extension to the difference-in-differences approach and offers a more transparent and data-driven method of constructing unit-specific counterfactuals (Abadie et al., 2010). Since its introduction, the synthetic control method has become widely applied in economics and other disciplines (See: Abadie et al., 2010; Bohn et al., 2014; Kleven et al., 2013; Cunningham & Shah, 2018; Pinotti, 2015) and has been called "arguably the most important innovation in policy evaluation literature in the last 15 years" (Athey & Imbens 2017).

The core idea behind the SCM is to construct a synthetic (artificial) control unit that approximates the trajectory the unit exposed to treatment would have taken in the absence of treatment (Abadie et al., 2010). This synthetic control unit is constructed as a weighted average of certain control units not exposed to the treatment, referred to as the "donor pool". The weights for the donor units are chosen to minimise the difference between the treated unit and the weighted average of the control units on a set of pre-treatment characteristics or outcomes (Abadie et al., 2010). The goal is for the synthetic control to approximate the treated unit's outcomes as closely as possible before the intervention, and thus, instead of the parallel trends assumption, the identifying assumption in the SCM becomes that the treated units outcome trajectory would have continued to follow a weighted combination of certain control units in the absence of treatment (Abadie et al., 2010). Once the synthetic control is constructed, the estimated effect of the intervention for a given post-intervention period is simply the difference between the actual outcome of the treated unit, and the outcome of its synthetic control. SCM does not generate traditional p-values or confidence intervals, and therefore, various other methods have been proposed for conducting inference. The most common and straightforward of which being placebo tests (Abadie et al., 2015). "In-space" placebo tests randomly assign treatment to selected control units and compare the estimated treatment effect for each placebo to the actual treatment effect. If placebo effects are as big or larger than the actual treatment effect, the results are not assumed to capture a real effect (Abadie et al., 2015).

SCM has seen extensive application across various fields and policy areas since its inception, ranging from immigration (Bohn et al., 2014) and taxation (Kleven et al., 2013) to legalized prostitution (Cunningham & Shah, 2018) and organized crime (Pinotti, 2015). Early applications include Abadie, Diamond and Hainmueller's (2010) seminal paper evaluating California's large-scale tobacco control program, where the authors used SCM to construct a synthetic California from other U.S. states to estimate the per-capita cigarette sales that would have occurred without the control program. The authors found a substantial reduction in tobacco consumption in California relative to its synthetic control, roughly 26 packs per capita annually, and used placebo tests to demonstrate statistical significance.

Another prominent application, also by Abadie, Diamond and Hainmueller (2015) used the synthetic control method to estimate the economic impact of the 1990 German reunification. By constructing a synthetic West Germany as a weighted average of other OECD countries, the authors estimated the counterfactual GDP per capita trend had Germany not reunified. This comparison found a pronounced negative effect of the reunification on West German income, with GDP per capita estimated to be about 1600 USD lower per year on average between 1990-2003 compared to the synthetic counterfactual.

While SCM has grown significantly in popularity in micro- and macro-economic studies, there exist relatively few studies using this approach in international trade contexts. Hosny (2012) employs the SCM method to study the effect of the GAFTA agreement on Algerian trade. By constructing a synthetic Algeria that joined GAFTA in 1998 instead of 2005, Hosny (2012) finds evidence to support that Algeria's pre-2005 trade would have improved had they joined the agreement earlier.

Similarly, Hannan (2017) uses the SCM to evaluate the impact of trade agreements in Latin America. By using variables from the gravity model of trade as covariates to construct synthetic counterfactuals for 64 Latin American country-pairs, the author finds that trade agreements have substantially improved exports, averaging an increase of 76.4 percent over ten years.

C. Gap Identification and Contribution

This study aims to contribute to the existing literature in two main ways. First, while previous research has extensively examined the impact of geographic distance, transportation costs, and face-to-face interaction on bilateral trade, relatively few studies have leveraged sudden exogenous shocks to air travel to evaluate these effects. The closure of Russian airspace provides a rare natural experiment in which flight distances between specific country-pairs increased abruptly due to geopolitical decisions, rather than gradual policy or market driven changes. This context allows for quantifying the effect of this shock on trade flows, contributing to the large body of literature that highlights the persistence of distance in determining international trade flows.

Second, this study builds on the application of the Synthetic Control Method in the field of international trade. Although SCM has become a widely adopted tool for causal inference in multiple fields, it's applications in examining trade shocks remains limited. By applying SCM to a sudden transportation shock, this paper shows how the method can be effectively employed to estimate counterfactual evolutions of trade flows at the country-pair level.

IV. DATA

A. *Sources and Coverage*

This study utilises two primary data sources:

- **UN Comtrade:** Monthly bilateral trade data is sourced from the UN Comtrade database, covering the period May 2019 - December 2024. The data provides trade values in current US dollars at the country-pair level, including both imports and exports across all goods categories.

- **CEPII Gravity (2023):** This dataset provides country-level characteristics up to the year 2022, covering the entire pre-treatment period. The data includes standard gravity covariates such as GDP, distance, common language, colonial ties, etc.

After initial cleaning, the datasets are merged into a final dataset consisting of monthly observations between May 2019 and December 2024. To ensure a strongly balanced panel, the final dataset includes all country-pairs with complete data across the full period. In the original downloaded dataset, there exist 36,869 unique country-pairs, including those with missing or incomplete data. After the initial cleaning and merging with the CEPII Gravity dataset, we are left with 10,034 unique country-pairs with complete data across the full period. Note that country-pairs are expressed as “origin-destination”, i.e. they indicate a direction of trade, so SWE-JPN would refer to Swedish exports to Japan and is not equivalent to JPN-SWE which refers to Japanese exports to Sweden.

B. Key Variables

The outcome variable of interest in this study is the log of total monthly bilateral trade, measured at the country-pair level. Log transformation is used to mitigate skewness and improve comparability between country-pairs.

The covariates used in the construction of the synthetic control, and in Coarsened Exact Matching, are drawn from the gravity model of international trade, which hypothesises that trade flows are a function of economic size, distance, and shared institutional or cultural characteristics. In this paper, the following covariates are used:

- Log of Distance between most populated cities
- Log of GDP and GDP per capita
- Contiguity (shared border)
- Common Language
- Colonial dependent relationship (ever)
- Free Trade Agreement
- Remoteness

The remoteness variable is created using the following formula:

$$R_i = \sum_j \left(\frac{d_{ij}}{Y_j / Y_w} \right)$$

Where d_{ij} is bilateral distance between country i and j, Y_j is the GDP of country j, and Y_w is world GDP. Following Head and Mayer (2014), the remoteness measure is included as a matching criterion to account for multilateral trade resistance and capture each country's relative position in the global trade network. This ensures that matched control pairs face similar external trade opportunities.

V. EMPIRICAL APPROACH

A. *Research Design*

To estimate the causal effect of the Russian airspace closure on trade flows, I employ the Synthetic Control Method (SCM). Unlike traditional approaches more prevalent in the literature, such as Difference-in-Differences (DiD), the SCM does not rely as heavily on the parallel trends assumption. The key assumption in DiD is that in the absence of treatment, the treated and control groups would have followed parallel trends over time. Since this is an assumption about the counterfactual trend, it is not testable. In the SCM parallel trends is not assumed, instead, for each treated unit, a synthetic control unit is constructed from a weighted combination of control units, aiming to replicate the treated unit's pre-treatment behaviour as closely as possible.

Given the heterogeneity in bilateral trade patterns, and the relatively small number of treated units, the SCM provides a more flexible and data-driven way to construct country-pair specific counterfactuals. This is especially valuable since the Russian airspace closure plausibly had non-uniform effects across treated country-pairs, depending on reliance on air-transport, trade composition, and geographic constraints.

The key identifying assumption in the SCM, known as the convex hull assumption, is that in the absence of treatment the treated unit would have continued to follow the path of its synthetic control. This assumption requires that:

- The set of untreated units used to construct the synthetic control were unaffected by the Russian airspace closure.
- No other unobserved shocks affected only the treated unit during the post-treatment period.

To address potential violations of these assumptions, I carefully construct the donor pool and conduct robustness checks via placebo tests.

In this study, a country-pair is classified as treated if it includes one country from Europe (including EU member states, Norway, Iceland, or Switzerland) and one country from East Asia (Japan, South Korea, Mongolia, or Taiwan), note that China is excluded here as Chinese airlines are still able to operate over Russian airspace, both to and from Europe. This classification captures bilateral trade routes plausibly affected by the Russian airspace ban. All other country-pairs are considered untreated and eligible for inclusion in the donor pool.

B. SCM Methodology

1) Formal Setting

Consider a setting where we have observed outcomes for $J+1$ units over T time periods, with unit $j=1$ exposed to treatment at time $T_0 < T$. The remaining J units, which are not treated, constitute the "donor pool". For each unit j and time t, let Y_{jt} denote the observed outcome, and Y_{jt}^N denote the potential outcome without treatment.

For the treated unit $j=1$, during the post intervention periods $t > T_0$, the treatment effect is defined as:

$$\tau_{1t} = Y_{1t} - Y_{1t}^N$$

Note that the above equation allows the treatment effect to vary over time, which is highly beneficial, as the intervention might not be instant, and might increase or decrease over time post-intervention. Since Y_{1t} is observed, the primary challenge in estimating the treatment effect is to estimate the counterfactual Y_{1t}^N, i.e. what would have occurred in the absence of treatment. To accomplish this, the synthetic control unit is constructed.

2) Synthetic Control Construction

The synthetic control is formed as a weighted combination of the J untreated units. Let:

$$W = \left(w_2, w_3, \dots, w_{j+1}\right)'$$

where the weights are non-negative and sum to one:

$$w_j \geq 0 \quad and \quad \sum_{j=2}^{J+1} w_j = 1$$

The synthetic control estimator of the counterfactual Y_{1t}^N is then:

$$\widehat{Y_{1t}^N} = \sum_{j=2}^{J+1} w_j \, Y_{jt}$$

With the synthetic control estimate, the treatment effect can be estimated as follows:

$$\widehat{\tau_{1t}} = Y_{1t} - \widehat{Y_{1t}^N}$$

3) *Weight Optimisation*

Expressing the synthetic control as a weighted average of control units prompts the question of how these weights should be chosen in practice. Abadie and Gardeazabal (2003) and Abadie et al. (2010) propose choosing the weights so that the synthetic control best resembles the pre-intervention values for the treated unit's predictors of the outcome variable. Given X_1, a $k \times 1$ vector of covariates (which may include pre-intervention values of Y_{jt}) for the treated unit, and X_0, a $k \times J$ matrix of the same covariates for the donor pool, as well as a set of non-negative constants $v_1, \dots, v_k$, the optimal weights $W^* = \left(w_2^*, \ \dots \ w_{J+1}^*\right)'$ are chosen such that they minimise:

$$\left||X_1 - X_0 W|\right| = \left(\sum_{h=1}^{k} v_h \left(X_{h1} - w_2 X_{h_2} - \ \dots \ - w_{J+1} X_{hJ+1}\right)^2\right)^{1/2}$$

subject to the restrictions that the weights are non-negative and sum to one. The vector $V = (v_1, \ \dots \ v_k)$ assigns relative importance to each predictor in terms of reproducing the values of the treated unit. With this approach, the estimated treatment effect at time $t = T_0 + 1, \dots, T$ can be expressed as:

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

C. Coarsened Exact Matching Procedure

To reduce interpolation bias, and improve the credibility of the SCM estimate, restricting the donor pool to control units that are similar to the treated unit is critical, especially when interpolating across units with very different characteristics (such as country-pairs). Abadie et al. (2010) and Abadie & Vives-i-Bastadia (2022) both emphasise the importance of restricting or "trimming" the donor pool to control units that are similar in terms of pre-treatment covariates, both to avoid interpolation bias and improve the performance of the SCM estimate. While it is in practice very common to pre-process the donor pool based on outcome or covariate differences, there exists little formalised guidance for how to best accomplish this. Therefore, the preprocessing found in the literature is commonly based on qualitative logic, and different authors will have different standards regarding what is similar enough to be included in the donor pool (Greathouse et al. 2023).

Several papers have advocated for employing matching procedures to refine the donor pool prior to applying SCM. For instance, Greathouse et al. (2023) and Kellogg et al. (2020) both discuss combining various matching procedures and SCM as a method of reducing interpolation bias in SCM estimates and demonstrate that matching pre-SCM can enhance the credibility of the estimate.

In this paper, I choose to refine the donor pool by using Coarsened Exact Matching (CEM) before implementing the SCM. I choose CEM for its simplicity, transparency and effectiveness in achieving covariate balance. CEM temporarily groups continuous covariates into bins, then discards all control units that do not fall into the same coarsened strata as the treated unit. This balances the covariates before estimation, reducing reliance on the SCM optimisation alone, as well as eliminating highly dissimilar control units from the donor pool to minimise the risk of interpolation bias. Furthermore, CEM is computationally efficient and well-suited for analysing country level data, where exact matches are unlikely due to the heterogeneity among units. By employing CEM, I ensure that the donor pool contains control units that are comparable to the treated unit across key gravity covariates, enhancing the credibility of the SCM estimate.

For each treated country-pair, I match untreated country-pairs on the following covariates, drawn from the gravity model of trade, all measured pre-treatment:

- **Log transformed**: trade value, distance, GDP, GDP per capita, remoteness.
- **Binary indicators:** contiguity, common language, free trade agreement, colonial ties.

The log-transformed variables are coarsened into four bins each, and all untreated country-pairs not falling into the same strata as the treated unit are classified as too dissimilar and discarded before proceeding with SCM. On average, for the 16 country-pairs of interest, the CEM procedure reduces the donor pool to 95 control-units from which the SCM is constructed.

D. SCM Implementation

After donor pool construction and matching, I implement SCM to estimate the synthetic counterfactual for the treated country-pair. Since all covariates have already been utilised in the CEM matching procedure, I specify only the pre-treatment monthly observations of log-transformed trade as predictors in the SCM. This approach follows Abadie, Diamond, and Hainmueller (2010) who suggest that matching on pre-treatment outcome values as predictors helps control for unobserved factors and for the heterogeneity of observed and unobserved factors effects on the outcome variable. The intuition behind this being that only units that are similar in both observed and unobserved determinants of the outcome variable, as well as in the effects of those factors on the outcome variable, should produce similar trajectories of the outcome variable over extended periods of time.

This combined approach of using gravity covariates in the CEM procedure, as well as matching on pre-treatment outcomes in the SCM, allows me to achieve as close a pre-treatment fit as possible, which is central to the credibility of the SCM estimate (Abadie, 2021) while maintaining a donor pool that is well balanced and highly comparable to the treated unit in terms of structural trade determinants.

In practice, the synthetic control is constructed in Stata, using the synth command (Abadie et al. 2011) which takes the outcome variable, pre-treatment covariates, treated unit, and treatment period as inputs, and returns the weight assigned to each control unit, as well as a graphical comparison of the treated and synthetic control unit's trade values over time.

This process is then repeated for each treated country-pair of interest. For each treated country-pair:

- A new dataset is constructed, removing all other treated country-pairs.
- CEM is applied to construct the donor pool.
- SCM is implemented using the matched donor pool.

While CEM and SCM restrict the donor pool to units with similar observable characteristics, I conduct additional post-estimation checks to ensure that the selected control country-pairs are not plausibly affected by the treatment. After each SCM estimation, I manually inspect the composition of the synthetic control unit. If any country-pairs used in the synthetic control are ambiguously or borderline affected by the Russian airspace closure despite not being classified as treated (e.g. Germany-Malaysia), the SCM estimate is flagged as invalid and discarded to preserve the validity of the counterfactual and ensure that only unaffected routes are used for inference.

E. Robustness Checks

To strengthen the credibility of the obtained SCM estimates, I conduct placebo tests which are standard practice in SCM applications. The SCM procedure is repeated for a subset of untreated country pairs in the donor pool, by iteratively assigning them an artificial treatment date, and estimating synthetic controls for each. The goal of this being to evaluate whether the post-treatment gap between the treated and synthetic control unit is unusually large compared to what would be expected without treatment. By comparing the gap between actual and synthetic post-treatment trade values for the treated country-pair to those of placebo pairs, I can assess whether the treatment effect is statistically distinguishable from noise. The case for a causal interpretation is strengthened if these placebo tests show that large treatment effects are not commonly observed among untreated units with similar economic characteristics.

To strengthen the credibility of the obtained SCM estimates, I employ two complementary approaches. First, the gap between the treated unit and its synthetic control is visually compared against the same gap for all placebo units. This visual comparison serves to provide an insight into whether the treated unit's gap stands out as unusually large compared to the placebo distribution.

Second, this comparison is formalised by using the RMSPE ratio test following Abadie (2021). This approach measures the pattern of prediction errors between the treated and placebo units by calculation the following ratio:

$$r_j = \frac{\text{Post-treatment RMSPE}}{\text{Pre-treatment RMSPE}}$$

Where RMSPE is calculated as $\text{RMSPE}_j = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(Y_{jt} - \widehat{Y_{jt}}\right)^2}$ and is a measure of how far predicted values are from observed values, on average, in squared units. Therefore,

r_j measures the quality of the fit for a synthetic control for unit j in the post-treatment period, relative to the quality of the fit in the pre-treatment period.

If the intervention had no effect, the gap between the treated unit and synthetic control would be expected to remain consistent before and after treatment. Conversely, if the intervention did have an effect, this gap should widen significantly after treatment. The RMSPE ratio captures precisely this by measuring how much the fit worsens after treatment relative to the pre-treatment period. This approach offers a significant advantage over simply comparing the post-treatment RMSPE, by accounting for the quality of the pre-treatment fit. Country-pairs with poor synthetic matches are effectively penalised, as their post-treatment gap needs to be proportionally larger to achieve the same ratio, and vice versa.

To implement the test, the SCM is applied to each control unit in the donor pool as if it had received treatment. For each placebo treatment, the RMSPE ratio is calculated and saved. The distribution of placebo ratios forms a reference against which the treated unit's ratio can be judged. A p-value is calculated which represents the probability of observing a ratio as large as the treated unit’s by chance alone, according to the following formula:

$$p = \frac{1}{J+1} \sum_{j=1}^{J+1} I_{+}(r_j - r_1)$$

where I_{+} is an indicator function that takes the value one for non-negative arguments and zero otherwise. A small p-value indicates that the treatment effect we observe is unlikely to have occurred by chance, strengthening the credibility of our results.

VI. RESULTS

This section presents the empirical results of the impact of the Russian airspace closure on bilateral trade between Nordic countries and Japan and South Korea. The results are presented separately for each direction of trade, that is, Nordic exports to Japan & South Korea, and Nordic imports from Japan & South Korea. For each direction of trade, the synthetic control outcomes are visually assessed, followed by a quantification of the treatment effects, and finally, the robustness checks and statistical validity of the results are presented.

The synthetic control methodology is applied to each of the sixteen country-pairs individually using the approach outlined in the previous section, where treatment (Russian airspace closure) takes place in February 2022, with the pre-treatment period being May 2019 - January 2022, and the post-treatment period being March 2022 - December 2024. For the sake of clarity, country-pairs are expressed as “origin – destination” where Swedish exports to Japan would be “SWE-JPN” and not equivalent to “JPN-SWE”.

A. *Nordic Exports to Japan & South Korea*

1) Synthetic Control Results

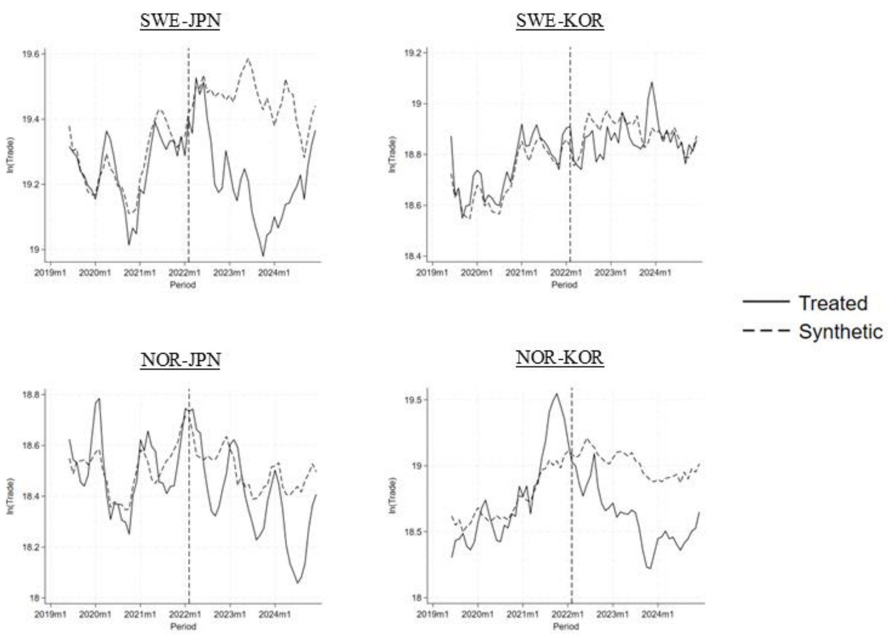

Figure 3. Synthetic controls for Sweden and Norway to Japan and South Korea.

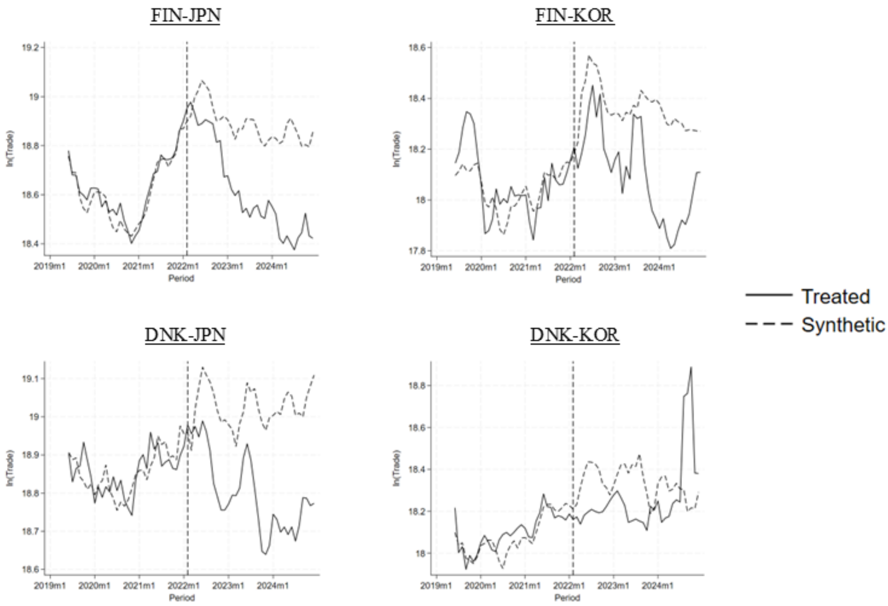

Figure 4. Synthetic Controls for Finland and Denmark to Japan and South Korea.

Figures 3 and 4 show the trajectories of log transformed trade for all country-pairs consisting of a Nordic origin and Japanese or South Korean destination, and their respective synthetic controls. To see which untreated country-pairs were used to construct each synthetic control and the weights assigned to them, see Tables 2A – 17A in the appendix. From the graphs in Figures 3 & 4, it is evident that there is a lot of variation between the pairs, both in terms of pre-treatment fit and post-treatment divergence.

In terms of pre-treatment fit, Swedish exports to both destinations show a strong fit between actual and synthetic values, suggesting a valid synthetic control, while Norway-Japan and Norway-South Korea exhibit weaker pre-treatment alignment which raises validity concerns. Finnish and Danish pairs show mixed results, with Finland-Japan demonstrating an extremely strong pre-treatment fit, Denmark-Japan and Denmark-South Korea having reasonable, although slightly misaligned fits between actual and synthetic values, and Finland-South Korea exhibiting a weaker pre-treatment fit.

Post-treatment patterns illustrate heterogenous treatment effects among the pairs. Swedish exports to Japan show a strong treatment impact, with actual values dropping substantially below synthetic values before partially recovering towards the end of the post-treatment period. It should be noted however that this divergence does not take place until a few periods after February 2022, suggesting a potentially delayed treatment effect. Swedish exports to Korea show a visibly worse fit between actual and synthetic values post-treatment but exhibit minimal sustained divergence. For Norway-Japan, both actual and synthetic values seem to follow the same cyclical trend post-treatment, with peaks lining up very closely, but troughs being substantially lower for actual values. Norwegian exports to Korea decrease below synthetic values post treatment despite actual values diverting far above synthetic values pre-treatment. Like Sweden-Japan, Finland-Japan shows a strong impact immediately following treatment, with the gap continuing to widen during the entire post-treatment period. Finland-South Korea demonstrates high volatility post-treatment with limited sustained gaps. Danish exports to Japan show a divergence of actual and synthetic trends following treatment, while Denmark-South Korea shows more modest effects until a dramatic spike in actual trade values towards the end of the period.

Overall, the variation in both pre-treatment fit and post-treatment effects across country pairs indicates heterogenous treatment impacts. The strong pre-treatment alignment for Finland-Japan and both Swedish pairs strengthens confidence in these synthetic controls, while the poor fit for Norway-South Korea and Finland-South Korea undermines the validity of their counterfactuals, justifying cautious interpretations in subsequent discussion.

2) Estimated Treatment Effects

Table 1. Estimated treatment effects for all Nordic exporting country-pairs.

Country-pair	ATE	ATE (%)	Max	Min
SWE-JPN	-0.252	-22.8	0.133	-0.551
SWE-KOR	-0.025	-2.47	0.338	-0.387
NOR-JPN	-0.112	-10.60	0.324	-0.423
NOR-KOR	-0.417	-34.10	0.130	-0.707
FIN-JPN	-0.299	-25.84	0.051	-0.524
FIN-KOR	-0.270	-23.66	0.154	-0.583
DNK-JPN	-0.230	-20.55	0.095	-0.481
DNK-KOR	-0.069	-6.67	1.403	-0.505

Table 2 presents the estimated average (ATE), maximum, and minimum treatment effects for all Nordic export pairs across the entire post-treatment period. These results support the heterogenous treatment impacts observed in Figures 3 & 4.

The largest negative effects are seen for Norway-South Korea (ATE = -0.417) and Finland-Japan (-0.299), representing a 34.1% and 25.8% average decrease in trade respectively. Sweden-Japan shows a strong negative average treatment effect of -0.252, corresponding to a roughly 22% decrease in trade, while Sweden-South Korea shows minimal average impact (ATE = -0.025), with the range of treatment effects (0.338 to -0.387) suggesting impacts varied considerably over time, consistent with the graph observed in Figure 3.

Denmark-Japan exhibits a strong effect of -0.230, while Denmark-South Korea shows a minimal average treatment effect of -0.069. However, Denmark-South Korea shows considerable volatility with effects ranging from 1.403 to -0.505, indicating unstable treatment effects which aligns with the graph observed in Figure 4.

Overall, the quantified treatment effects generally align with the patterns observed in the synthetic control plots, with pairs showing clear divergences exhibiting substantial negative effects. However, these results require careful interpretation when considering the varied quality of pre-treatment fit observed in Figures 3 & 4.

3) Robustness Checks

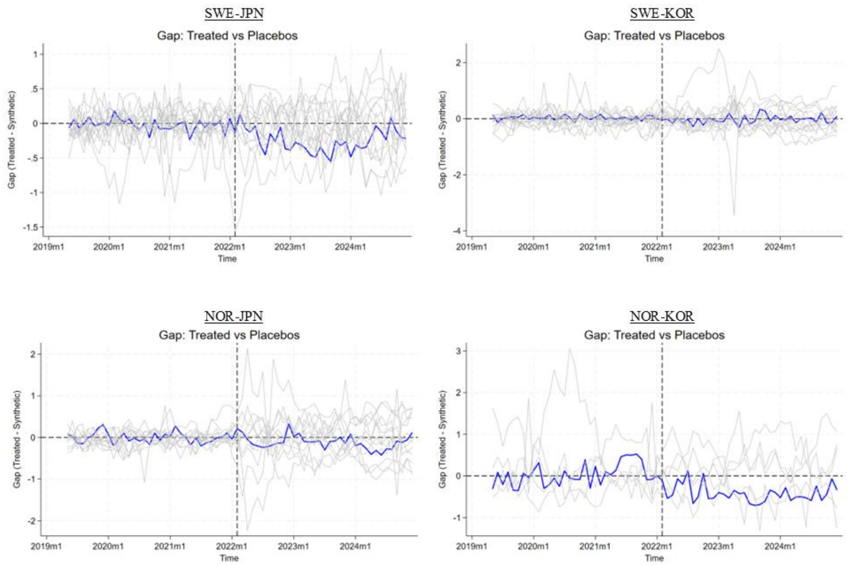

Figure 5. Treated (blue) vs Placebo (grey) gaps for Swedish and Norwegian exporting pairs.

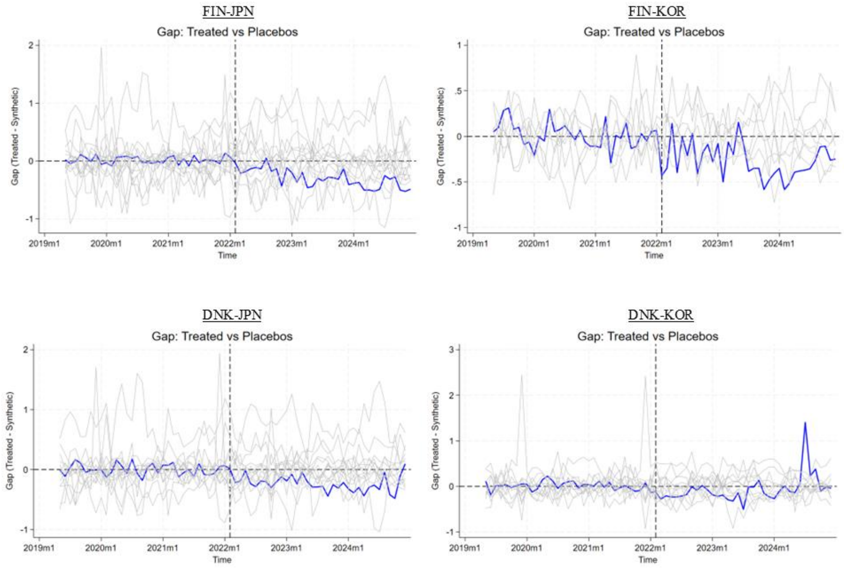

Figure 6. Treated (blue) vs Placebo (grey) gaps for Finnish and Danish exporting pairs.

Figures 5 and 6 present placebo distributions comparing actual treatment effects against placebo effects from untreated country pairs. The blue lines show the gap between actual and synthetic values for the treated pair, while grey lines show placebo gaps, providing a visual assessment of how large the actual treatment effect is compared to the placebo distribution.

For most pairs, we can see that the pre-treatment gap remains relatively centred around 0, suggesting a strong pre-treatment fit. However, for Finland-South Korea and Norway-South Korea, we can observe large volatility in the gap during the pre-treatment period, which is in line with the relatively poor pre-treatment fits we saw in Figures 3 & 4.

Sweden-Japan, Norway-South Korea, Finland-Japan and Denmark-Japan show actual effects consistently falling towards the lower end of the distribution during the post-treatment period, while Sweden-South Korea, Norway-Japan, and Denmark-South Korea show actual effects that fall largely in the middle of the placebo distributions, suggesting these results might not be statistically distinguishable from random variation.

Table 2. RMSPE ratios and p-values for all Nordic exporting country-pairs.

Country-pair	RMSPE Ratio	P-value
SWE-JPN	3.449	0.125
SWE-KOR	1.706	0.333
NOR-JPN	1.527	0.846
NOR-KOR	1.812	0.167
FIN-JPN	5.370	0.067
FIN-KOR	2.123	0.125
DNK-JPN	2.976	0.071
DNK-KOR	3.385	0.083

Table 3 provides formal statistical inference using RMSPE ratios and corresponding p-values. As a brief reminder, the RMSPE ratio measures the quality of the post-treatment fit relative to the pre-treatment fit, where a larger ratio indicates both substantial post-treatment divergence, and good pre-treatment fit. The p-value measures the probability of observing a ratio as large as the treated unit's by chance alone.

The results in Table 3 confirm the visual patterns observed in Figures 3 & 4. The largest RMSPE ratios are held by Finland-Japan and Sweden-Japan indicating their post-treatment divergence is substantial compared to their high pre-treatment fit, with p-values approaching conventional significance levels for Finland-Japan (p=0.067), while Sweden-Japan fails to achieve the same level of statistical significance (p=0.125). Danish exports to Japan and South Korea show marginally significant ratios (p=0.071 and p=0.083 respectively), and modest RMSPE-ratios, though it should be noted that Denmark-South Korea's relatively high ratio is likely influenced by the sudden dramatic increase in actual trade values towards the end of the post-treatment period.

For Sweden-South Korea, Norway-Japan, and Finland-South Korea, we observe both low RMSPE-ratios, weakening the credibility of the SCM estimate, and high p-values, indicating that the estimated treatment effect is not particularly unusual compared to placebo effects.

These results support the observations made in Figures 3 & 4, and Table 2. Showing that several pairs exhibit meaningful treatment effects, but with limited statistical precision. Overall, the findings demonstrate moderate robustness with pairs showing both visual separation and reasonable p-values (SWE-JPN, FIN-JPN), some pairs having both poor pre-treatment fit and high p-values, and some pairs demonstrating a mix of moderate effect but limited statistical evidence.

B. *Japanese & South Korean exports to Nordics*

1) Synthetic Control Results

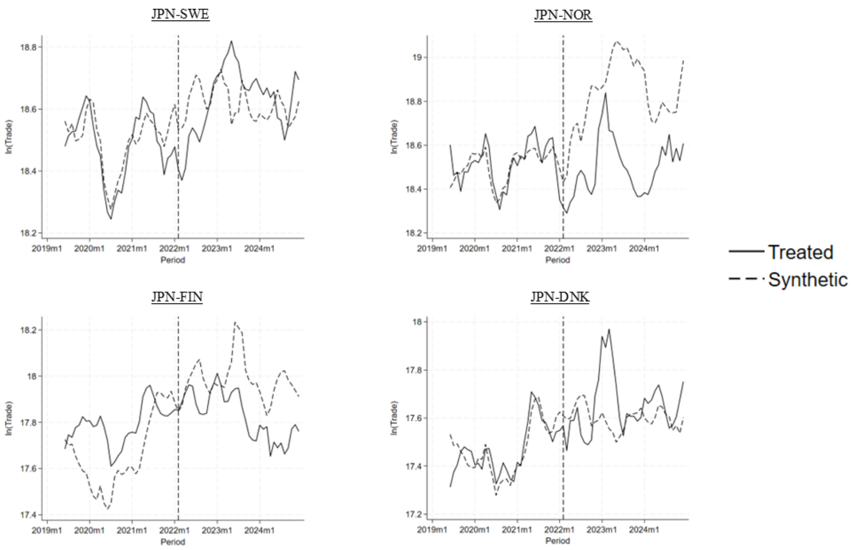

Figure 7. Synthetic controls for Japanese exporting pairs.

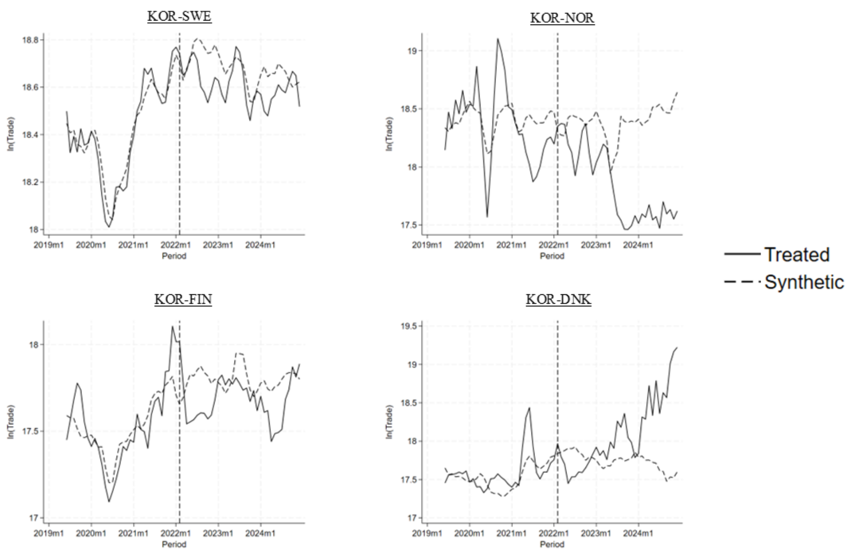

Figure 8. Synthetic controls for Korean exporting pairs.

Figures 7 and 8 present synthetic control results for Japanese and South Korean exports to Nordic destinations. In contrast to Nordic exports, these pairs show minimal systematic treatment effects across most pairs. Aside from Japan-Finland, South Korea-Norway, and South Korea-Denmark, most pairs demonstrate reasonable alignment between actual and synthetic values before treatment, providing a credible synthetic counterfactual.

Post-treatment patterns demonstrate limited sustained divergence between actual and synthetic trade values. Japanese exports show stable relationships post-treatment, with Japan-Sweden, Japan-Finland, and Japan-Denmark all exhibiting synthetic and actual values trending generally in the same direction for most of the post-treatment period. Japan-Norway displays some deviation from its synthetic control, maintaining a modest gap for most of the post-treatment period.

South Korean exports exhibit more variation but lack consistent treatment effects. South Korea-Sweden shows slight deviation for some sections of the post-treatment period, especially compared to pre-treatment, but returns to close alignment with its synthetic control in the middle and end of the period. South Korea-Finland demonstrates a similar relationship, with minimal sustained gaps between actual and synthetic values, though it should be noted that the trends diverged substantially just before treatment. South Korea-Norway and South Korea-Denmark both exhibit divergence between actual and synthetic trends post-treatment, with South Korea-Denmark’s actual values notably diverting above synthetic ones, though it should be kept in mind that both pairs exhibit less reliable pre-treatment fits than South Korea-Sweden and South Korea-Finland.

Overall, these results demonstrate an absence of clear, sustained gaps for Japanese and South Korean exports to Nordic markets, indicating an asymmetric pattern where many Nordic exporting pairs indicate substantial effects, while the impact remains minimal for Japanese and South Korean exports to the Nordics. This suggests the existence of direction-specific mechanisms and warrants examination in the discussion section.

2) *Estimated Treatment Effects*

Table 3. Estimated treatment effects for all Japanese and South Korean exporting country-pairs.

Country-pair	ATE	ATE (%)	Max	Min
JPN-SWE	0.013	1.31	0.449	-0.330
JPN-NOR	-0.348	-29.39	0.259	-0.690
JPN-FIN	-0.152	-14.10	0.241	-0.629
JPN-DNK	0.064	6.61	0.589	-0.269
KOR-SWE	-0.087	-8.33	0.178	-0.295
KOR-NOR	-0.593	-44.73	0.232	-1.275
KOR-FIN	-0.109	-10.33	0.418	-0.429
KOR-DNK	0.420	52.50	1.764	-0.596

Table 4 presents the estimated average (ATE), maximum, and minimum treatment effects for all Japanese and South Korean exporting pairs across the entire post-treatment period. Table 4 confirms the minimal treatment effect observed in Figures 7 and 8, with average treatment effects being substantially smaller overall compared to Nordic exports. Most ATE's are close to 0, and only 3 pairs show effects exceeding 0.3 in absolute terms.

The largest negative effect is found for South Korea-Norway (-0.593), though this should be taken with a grain of salt given the poor pre-treatment fit seen in Figure 8. Most Japanese exports show small effects, with two of four pairs showing positive, although minimal effects. Japan-Norway shows a negative effect comparable to those seen in Nordic exporting pairs (-0.348), and given the good pre-treatment fit stands out as an example of a meaningful effect. South Korea-Sweden and South Korea-Finland display small ATE's, with South Korea-Finland demonstrating high volatility (0.418 to -0.429), supporting the lack of sustained gaps observed in Figure 8. South Korea-Denmark displays notably high volatility (1.764 to -0.596) despite a very high positive average effect (0.420). This suggests an unstable impact, especially when considering the poor pre-treatment fit seen in Figure 8.

Overall, the quantified treatment effects align with the visual evidence of asymmetric treatment effects, with Japanese and South Korean exports (excluding Japan-Norway) exhibiting minimal or unstable effects, while Nordic exporting pairs experienced more substantial disruptions post-treatment.

3) Robustness Checks

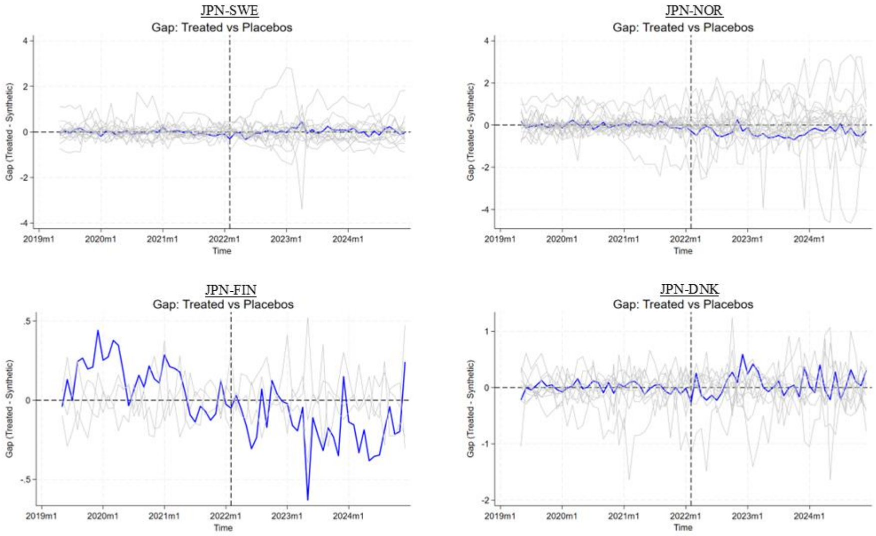

Figure 9. Treated (blue) vs Placebo (grey) gaps for Japanese exporting pairs.

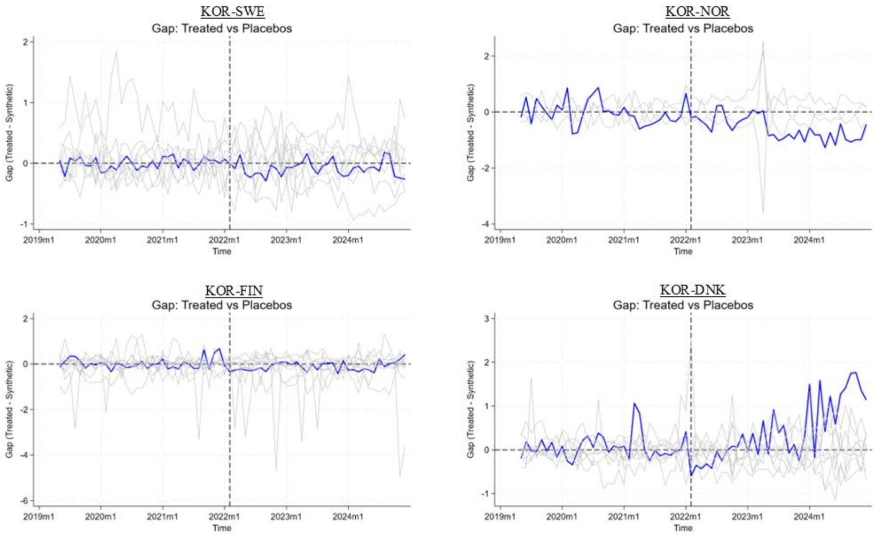

Figure 10. Treated (blue) vs Placebo (grey) gaps for South Korean exporting pairs.

In Figures 9 and 10 we find further support for the lack of sustained treatment effects for most Japanese and South Korean exporting pairs. For Japan-Sweden, Japan-Norway, and Japan-Denmark the gap between actual and synthetic values remains around 0 and in the middle of the placebo distribution post-treatment. Japan-Finland falls visibly below the placebo distribution post-treatment, but the gap is large and volatile pre-treatment, highlighting the lack of a valid synthetic counterfactual.

For Korean exports, South Korea-Sweden and South Korea-Finland gaps remain close to 0 and in the middle of the distribution post-treatment. South Korea-Norway and South Korea-Finland fall outside of the placebo distribution post-treatment, though like Japan-Finland, their pre-treatment gap is large and volatile, calling the validity of their synthetic controls into question.

Table 4. RMSPE ratios and p-values for all Japanese and South Korean exporting country-pairs.

Country-pair	RMSPE Ratio	P-value
JPN-SWE	1.391	0.438
JPN-NOR	3.209	0.105
JPN-FIN	1.216	0.500
JPN-DNK	2.379	0.09
KOR-SWE	1.695	0.222
KOR-NOR	1.725	0.500
KOR-FIN	0.928	1.000
KOR-DNK	2.619	0.222

Table 5 provides formal statistical inference using RMSPE ratios and corresponding p-values for Japanese and South Korean exporting pairs. With only two pairs, Japan-Norway and Japan-Denmark exhibiting a p-value less than 0.2, these results strengthen the notion of asymmetric effects with Japanese and South Korean exports lacking substantial or significant treatment effects. Japanese RMSPE ratios are overall larger than South Korean ones, implying that these pairs have larger post-treatment gaps relative to their pre-treatment fit. However, only Japan-Norway and Japan-Denmark demonstrate moderate significance levels, with Japan-Sweden and Japan-Finland displaying remarkably high p-values, indicating their observed treatment effect cannot be easily distinguished from the placebo distribution.

For Korean exporting pairs, South Korea-Denmark exhibits the highest RMSPE ratio, however from Figure 10, this looks to be mainly driven by the relatively large positive post-treatment gap. All p-values for Korean pairs high and indicate that none of the observed treatment effects are easily distinguishable from placebo effects.

C. *Summary of Results*

The results of the synthetic control analysis reveals heterogenous treatment effects at the country-pair level and indicates directional asymmetry in treatment effects. For Nordic exports, Sweden-Japan, Denmark-Japan, Denmark-South Korea, and Finland-Japan show meaningful treatment effects with moderate statistical significance. In contrast, Japanese and South Korean exports to Nordic countries demonstrate minimal effects, with only Japan-Norway demonstrating a sustained negative effect and moderate significance. Robustness analysis through placebo tests revealed limited statistical significance at conventional levels overall, though several country-pairs showed meaningful effects with reasonable visual separation from placebo distribution. The notable asymmetry, where many Nordic exporting country-pairs faced substantial disruptions while most Japanese and South Korean exporting pairs remained largely unaffected suggests underlying mechanisms that affected one direction specifically and highlights the heterogenous nature of the treatment's impact on bilateral trade.

VII. DISCUSSION

This study aimed to analyse the effect of the Russian airspace closure on bilateral trade between Sweden, Norway, Finland, Denmark, and Japan, South Korea. Using the synthetic control methodology, I sought to isolate the effects of this specific aviation disruption on trade relationships that had previously relied on efficient passage through Russian airspace. The results reveal substantial heterogeneity in treatment effects across different country-pairs, indicating that the impact of the Russian airspace closure was far from uniform, both in terms of the magnitude and robustness of the estimated effects, with some pairs experiencing dramatic trade reductions while others remain largely unaffected.

A. *Nordic Exports to Japan*

In general, the clearest and strongest negative effects were observed among the Nordic exports to Japan, specifically Sweden-Japan (-22.3%), Finland-Japan (-25.8%), and Denmark-Japan (-20.55%). These estimates are supported by both strong pre-treatment fit and consistent post-treatment divergence, lending credibility to their causal interpretation. The substantial reductions suggest they were particularly vulnerable to the airspace closure.

Interestingly, Norwegian exports to Japan did not show a similar effect to the other Nordic countries and maintained a seasonal pattern throughout the post-treatment period. Although a detailed product-level analysis is beyond the scope of this study, trade composition data reveals that Sweden and Denmark's largest exports to Japan are packaged medicaments, while Norway's exports are dominated by fish products (Observatory of Economic Complexity, 2025). This difference could imply that airspace disruptions plausibly had a more severe impact on pharmaceutical trade than seafood exports.

The case of Finland-Japan demonstrated both one of the most robust (p=0.067) and strongest negative effects. Since Helsinki to Tokyo flights saw a 37% increase in flight time (OAG, 2022), this result aligns with expectations. However, Finish exports to Japan are dominated by rare earth minerals and wood products (Observatory of Economic Complexity, 2025), which are typically transported by sea. This suggests that the airspace closure may have impacted Finnish exports indirectly, possibly reducing business travel and face-to-face interaction, rather than affecting goods transportation directly.

B. Nordic Exports to South Korea

In contrast, Nordic exports to South Korea displayed less pronounced effects. Swedish and Danish exports to South Korea saw smaller, and less sustained effects post-treatment compared with exports to Japan. Since the increase in flight distance is comparable for both destinations, differences in export composition could help explain this result as well. Unlike exports to Japan, Swedish and Danish exports to South Korea are dominated by vehicles and machinery rather than pharmaceuticals, suggesting these goods may be less vulnerable to air transport disruption. Norwegian and Finnish exports to South Korea both showed negative effect post-treatment, though their weaker pre-treatment fit suggests difficulty in identifying sufficiently similar control units, hindering attribution of this effect to the closure of Russian airspace alone.

C. Japanese and South Korean Exports to the Nordics

Japanese and South Korean exports to Nordic countries generally showed limited effects. Most country-pairs exhibited minimal post-treatment diversions or insufficient pre-treatment fit, with a notable exception being Japan-Norway, which demonstrated both a strong pre-treatment fit and a meaningful negative effect (-29.4%). This result is particularly interesting given that the reverse trade flow, Norway-Japan, did not show a comparable effect. The lack of a quality synthetic control for Japan-Finland, South Korea-Norway, and South Korea-Denmark suggests challenges in identifying suitable donor units with similar pre-treatment characteristics. Despite prefiltering the donor pool via CEM, and using trade outcomes as predictors in the SCM, this result highlights a limitation in the SCM in situations where treated units have unique trade patterns or characteristics not captured well by the donor pool.

The lack of a substantial treatment effect for Japan-Sweden and Japan-Denmark supports the earlier notion that vehicle and machinery exports may be less vulnerable to air travel disruption, as Japan's exports to Sweden and Denmark are dominated by these categories (Observatory of Economic Complexity, 2025).

Overall, while Nordic exports to Japan are likely more reliant on aviation, both in terms of transportation of goods and facilitating business relationships, Japanese and South Korean exports to the Nordics appear to be less vulnerable to aviation disruptions. This difference indicates a broader asymmetry in trade impacts, which is explored in the following section.

D. Directional Asymmetries

A notable finding is the directional asymmetry between treatment effects. Particularly in the case of Nordic trade with Japan, Nordic exports tend to show stronger and more credible treatment effects than in the reverse direction. For example, while Sweden, Denmark, and Finland all saw significant drops in exports to Japan post-treatment, Japanese exports to the same countries did not exhibit comparable effects, despite both trade flows being subject to the same airspace restrictions.

Several factors could help explain this asymmetric pattern. First, this finding may suggest a difference in business relationships by direction. If trade in goods not transported by air was negatively impacted by the Russian airspace closure via its effect on reduced face-to-face interaction, this would suggest that Nordic firms exporting to Japan may rely more heavily on frequent business travel to maintain and develop their market presence. In contrast, Japanese firms may have more established relationships with Nordic partners that require less travel intensive maintenance.

Second, as discussed earlier, differences in trade composition by direction likely contribute to the asymmetry. Nordic exports to Japan consisting mainly of pharmaceuticals, wood products and rare earth minerals may make these trade flows more vulnerable to the treatment compared with the products flowing from Japan to the Nordics.

Third, the asymmetric nature of the treatment impact on flight time itself may contribute to directional effects. Following the closure of Russian airspace, the effect on flight time was not uniform in both directions. For example, Finnair flight AY61 from Helsinki to Tokyo takes roughly 13 hours currently, while Finnair flight AY62 takes roughly 12 hours on the return journey (Flightradar24, 2025). This suggests that while both directions increased experienced increased travel times, the magnitude of the effect may have been greater for Nordic to Japan travel.

E. External Validity and Limitations

While the findings of this study present compelling evidence that the Russian airspace closure had substantial localised trade impacts, several methodological and empirical considerations must be acknowledged. First, it is important to note that although the study reports p-values for the calculated RMSPE ratios, conventional statistical significance testing is not central to inference in the synthetic control method. As noted by Abade (2021), synthetic control inference relies on the comparative rarity of the observed effect among a distribution of placebo units, rather than traditional p-values. Therefore, results with p-values above conventional thresholds can still indicate meaningful effects if the treatment effect is unusually large compared to the placebo distribution. For results such as Finland-Japan, Finland-South Korea, and Denmark-Japan, the RMSPE-ratio is substantially larger than the placebo distribution (See Figures 1A, 2A), indicating a strong and robust treatment effect.

Second, the reliability of the SCM estimate depends on its ability to achieve a strong pre-treatment fit (Abadie, 2021). In cases such as Japan-Finland, South Korea-Norway, South Korea-Denmark, and Norway-South Korea, it proved difficult to construct a credible synthetic control, likely due to unique trade patters or unobserved features not well represented in the donor pool. This highlights a key limitation of the SCM, namely it's ability to construct a credible counterfactual when dealing with highly heterogeneous units, such as country-pairs, where unique bilateral characteristics or complex interdependent predictors can make it difficult to find suitable comparisons within the donor pool. Although Coarsened Exact Matching is used to attempt to address this, if the treated unit is highly dissimilar from all available donor units in a way that cannot be replicated through a weighted average of others, the SCM will fail to construct a credible counterfactual. This limitation signifies a broader challenge in terms of external validity. Results for country-pairs with strong synthetic controls can be treated as credible case-level estimates, but generalising these results beyond the studied pairs should be done with caution.

Furthermore, this study uses aggregate monthly level trade data on all goods and cannot differentiate between specific product or mode-of-transport level effects. A more granular analysis, for example examining only goods transported by air, could isolate the effect of increased air freight costs on trade in goods transported via air. Similarly, examining only goods shipped by sea could isolate the effect of reduced face-to-face interaction on bilateral trade.

Finally, a key assumption of the synthetic control method is that the treatment only impacts treated units, and not the donor pool (Abadie, 2021). In this paper, donor units were manually verified to ensure the bilateral pair did not rely on Russian airspace for travel between origin and destination, however, in the context of a global aviation disruption, this assumption may not fully hold. For example, the Russian airspace closure could have potentially affected control units through broader supply chain disruptions, rerouted flight paths, or increased shipping costs. If control units were partially exposed to treatment effects via these channels, this could bias the estimated effects.

Despite these constraints, the findings of large, credible effects in several key country-pairs lends confidence to the conclusion that the Russian airspace closure did have meaningful negative trade impacts.

VIII. CONCLUSION

In this study I examine the causal effect of the Russian airspace closure on bilateral trade flows between Nordic countries (excluding Iceland) and Japan, South Korea. Using CEM in combination with the SCM, I create unit-specific counterfactuals for sixteen country-pairs, which allow me to estimate the treatment effect at a country-pair level.

I find that multiple country-pairs saw a substantial decrease in trade relative to their synthetic control following the airspace closure. Most notably Sweden-Japan, Denmark-Japan, Finland-Japan and Japan-Norway, which saw an average reduction of -22.8%, -20.55%, -23.66% and -29.39% in trade flows respectively. The robustness of these results was verified using in-space placebo tests which strengthened their statistical validity. Furthermore, I observed directional asymmetry in treatment effects, with Nordic exports to Japan seeing a much larger effect than Japanese exports to Nordic countries overall, suggesting Nordic exporters were more vulnerable to the airspace closure.

The heterogeneity and directional differences found in the results presents several areas for future research. Using product level or mode-of-transport data in a similar analysis could allow for isolation of the effects of increased air shipping costs or reduced face-to-face interaction on trade. Furthermore, this study treats the airspace closure as a binary shock, future research could model treatment intensity continuously, either in terms of flight time or distance travelled, which could reveal if trade is impacted proportionally by treatment across country-pairs. Finally, adopting alternative matching or synthetic control techniques could improve the robustness of causal estimates in trade contexts where units exhibit high heterogeneity.

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X. APPENDIX

Table 1A: Summary statistics of final cleaned and merged dataset, pre CEM or SCM.

Variable	Mean (treated)	Mean (control)	Std. dev.	Min	Max
Log Trade	16.903	15.317	2.874	0	24.722
Log GDP	20.438	19.806	1.800	11.930	24.172
Log GDP per capita	3.732	3.145	0.978	0.133	11.060
Distance	8307.985	6934.443	4455.995	18	19661
Contiguity	0	0.029	0.168	0	1
Common Language	0	0.138	0.343	0	1
Colonial Dependent	0	0.024	0.151	0	1
Free Trade Agreement	0.759	0.363	0.482	0	1

Tables 2A-9A: Unit weights in Nordic exporting synthetic controls.

2A: SWE-JPN

Weight	Country-pair
0.033	CAN-ITA
0.019	CAN-KOR
0.124	CHE-SGP
0.169	CHL-CAN
0.090	CHL-ITA
0.151	CHL-JPN
0.033	CHL-KOR
0.074	CHL-NLD
0.043	CHL-USA
0.028	GBR-ROU
0.001	SGP-CHE
0.061	SGP-JPN
0.030	SWE-CAN
0.131	TUR-CHE
0.014	USA-CHL

3A: SWE-KOR

Weight	Country-pair
0.119	CAN-CHL
0.003	CHE-ISR
0.047	CHE-TUR
0.029	CHL-CAN
0.046	CHL-CHE
0.118	CHL-ITA
0.137	CHL-JPN
0.019	ESP-NOR
0.047	FRA-TUR
0.062	ROU-ESP
0.077	SGP-CHE
0.036	TUR-CHE
0.072	TUR-IRL
0.186	TUR-KOR

4A: NOR-JPN

Weight	Country-pair
0.069	BGR-USA
0.057	FIN-USA
0.063	HKG-AUT
0.108	HKG-BEL
0.400	HKG-CZE
0.028	HKG-RUS
0.064	ISR-JPN
0.036	LTU-USA
0.049	QAT-ITA
0.070	QAT-JPN
0.056	QAT-KOR

5A: FIN-JPN

Weight	Country-pair
0.169	BHR-USA
0.011	BRN-AUS
0.028	FIN-ITA
0.023	FIN-TUR
0.148	GRC-ESP
0.095	GRC-NLD
0.008	ISL-NLD
0.064	ISR-DEU
0.134	ISR-FRA
0.048	NOR-CAN
0.097	NZL-KOR
0.027	NZL-MYS
0.147	PRT-DEU

6A: DNK-JPN

Weight	Country-pair
0.027	BGR-ESP
0.094	BHR-USA
0.101	FIN-ESP
0.006	FIN-ITA
0.016	GRC-FRA
0.112	GRC-GBR
0.232	ISR-DEU
0.084	ISR-ESP
0.059	ISR-FRA
0.096	ISR-NLD
0.081	NZL-MYS
0.092	PRT-DEU

7A: DNK-KOR

0.027	BGR-GBR
0.051	DNK-CAN
0.020	FIN-ITA
0.092	FIN-TUR
0.043	GRC-FRA
0.068	GRC-NLD
0.053	ISR-ESP
0.035	NOR-TUR
0.048	NZL-KOR
0.256	NZL-MYS
0.306	PRT-TUR

8A: FIN-KOR

Weight	Country-pair
0.198	BGR-ESP
0.359	BGR-GBR
0.015	BHR-USA
0.198	DNK-CAN
0.083	GRC-GBR
0.100	NZL-KOR
0.046	NZL-MYS

9A: NOR-KOR

Weight	Country-pair
0.123	BRN-JPN
0.088	FIN-ITA
0.151	GRC-FRA
0.685	ISL-NLD

Tables 10A-17A: Unit weights in Japanese and South Korean exporting synthetic controls.

10A: JPN-SWE

Weight	Country-pair
0.062	CAN-CHL
0.006	CAN-ESP
0.168	CHE-ISR
0.038	CHE-TUR
0.042	CHL-CAN
0.047	CHL-CHE
0.014	CHL-ITA
0.084	CHL-NLD
0.164	FRA-CHL
0.147	GBR-ROU
0.072	IRL-TUR
0.037	NLD-CAN
0.049	POL-PRT
0.031	SWE-CAN
0.040	TUR-CHE

11A: JPN-NOR

Weight	Country-pair
0.0295	AUS-BEL
0.0355	AUS-FRA
0.0185	AUS-SAU
0.1375	CHE-MYS
0.0185	DEU-KAZ
0.0535	IRL-SAU
0.0325	JPN-ISR
0.1985	JPN-SAU
0.0955	KAZ-GBR
0.1325	POL-SAU
0.0525	RUS-HKG
0.0845	SAU-DEU
0.0265	SAU-NLD
0.0585	TUR-SAU
0.0255	USA-ROU

12A: JPN-FIN

Weight	Country-pair
0.654	DEU-ISL
0.152	ITA-EST
0.194	TUR-FIN

13A: JPN-DNK

Weight	Country-pair
0.050	AUT-ISR
0.037	BEL-CHL
0.062	CAN-DNK
0.028	CAN-SWE
0.197	CHL-GBR
0.067	CHL-SWE
0.113	GBR-CHL
0.123	IRL-ROU
0.171	NLD-CHL
0.122	SGP-TUR
0.030	TUR-SGP

14A: KOR-SWE

Weight	Country-pair
0.059	CAN-CHL
0.103	CAN-ESP
0.045	CAN-KOR
0.188	CAN-MYS
0.099	CHL-ITA
0.125	FRA-CHL
0.053	FRA-TUR
0.138	POL-PRT
0.190	TUR-IRL

15A: KOR-NOR

Weight	Country-pair
0.017	CHE-TUR
0.296	CHL-CHE
0.510	GBR-ROU
0.031	ROU-GBR
0.035	TUR-DNK
0.112	TUR-NOR

16A: KOR-FIN

Weight	Country-pair
0.095	CAN-FIN
0.004	CAN-GRC
0.015	CAN-LVA
0.005	CHL-BGR
0.051	DEU-CYP
0.341	DEU-ISL
0.004	ESP-BHS
0.119	FRA-EST
0.027	ITA-PAN
0.006	NLD-BHS
0.042	NLD-CYP
0.291	TUR-FIN

17A: KOR-DNK

Weight	Country-pair
0.264	BEL-CHL
0.058	CAN-POL
0.151	CHL-GBR
0.056	IRL-ROU
0.055	NLD-CHL
0.015	ROU-PRT
0.277	SGP-TUR
0.122	TUR-SGP

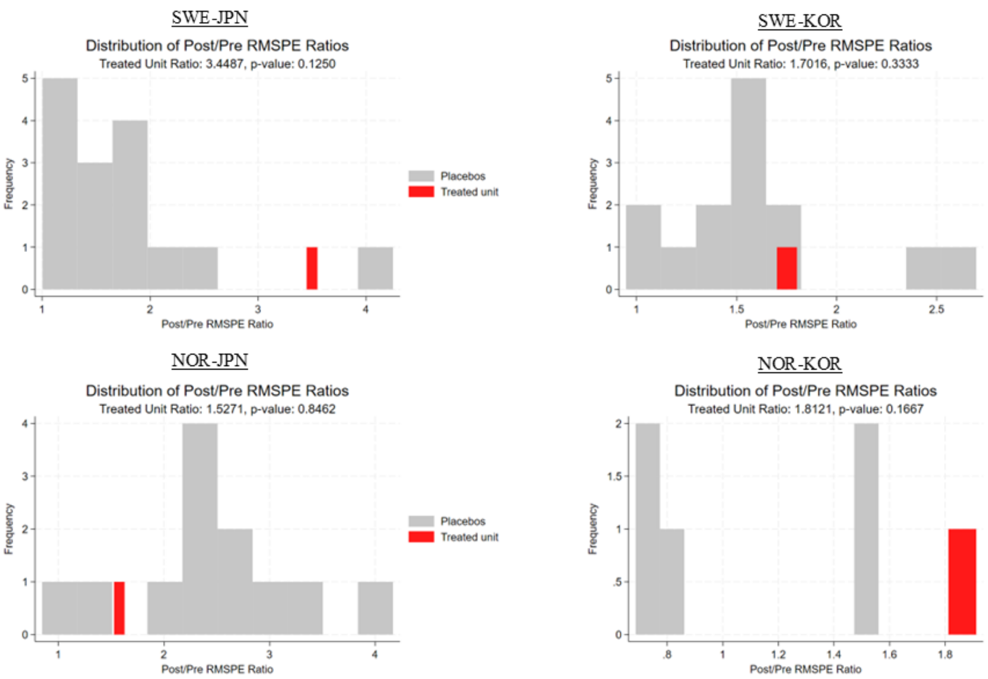

Figure 1A. Distribution of actual and placebo RMSPE ratios for Sweden & Norway exporting pairs.

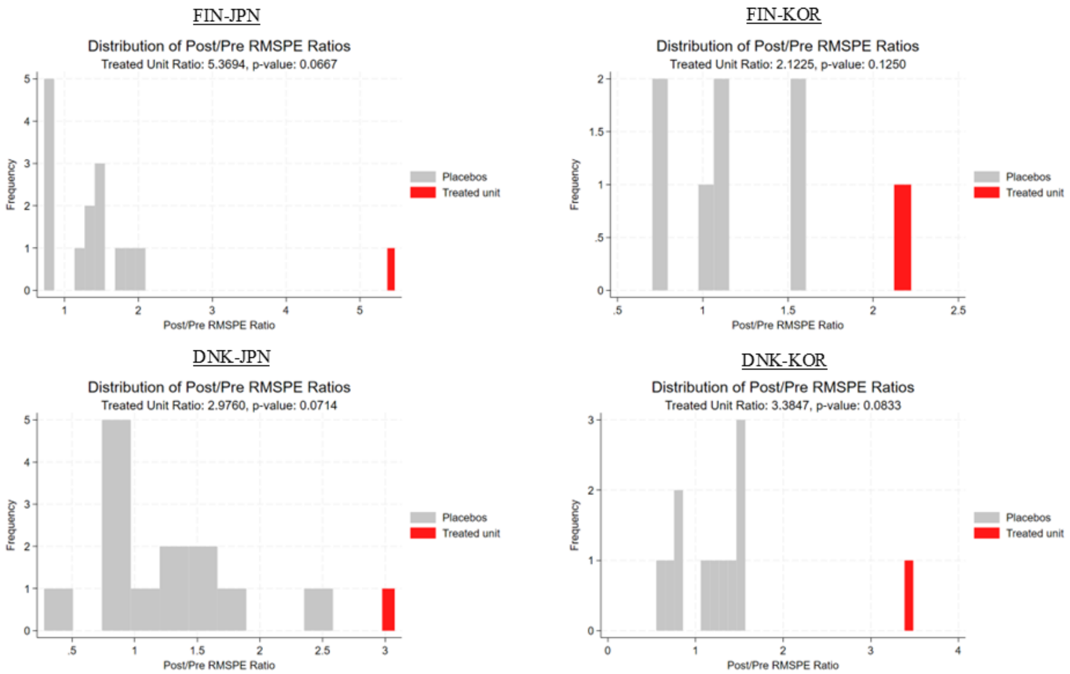

Figure 2A. Distribution of actual and placebo RMSPE ratios for Finland & Denmark exporting pairs.

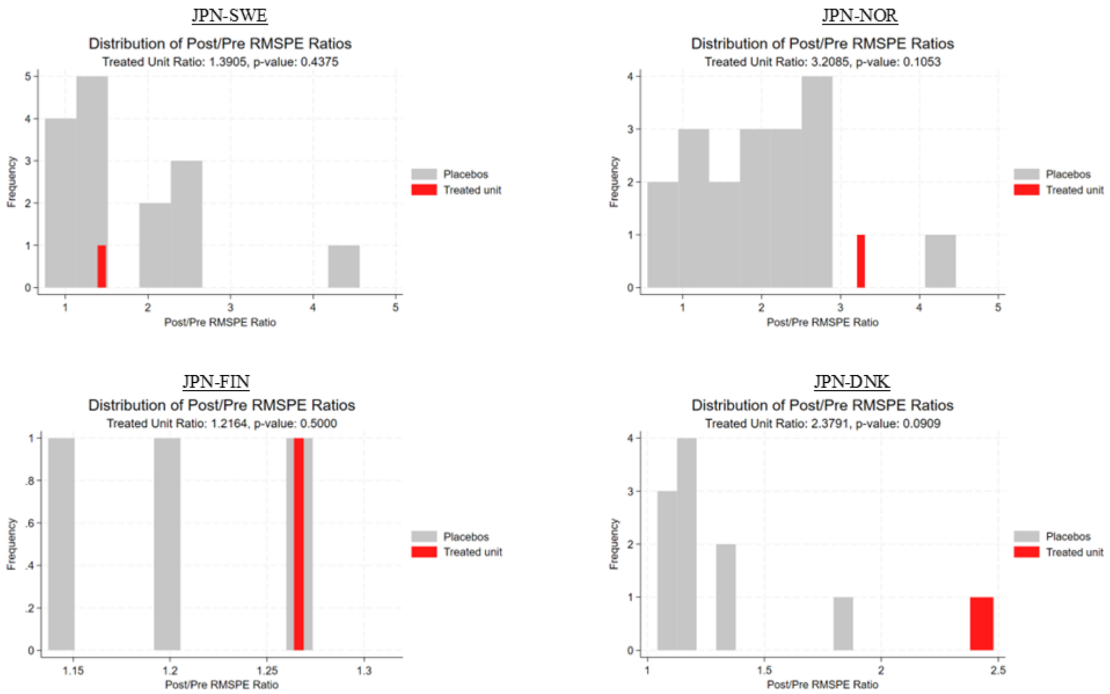

Figure 3A. Distribution of actual and placebo RMSPE ratios for Japanese exporting pairs.

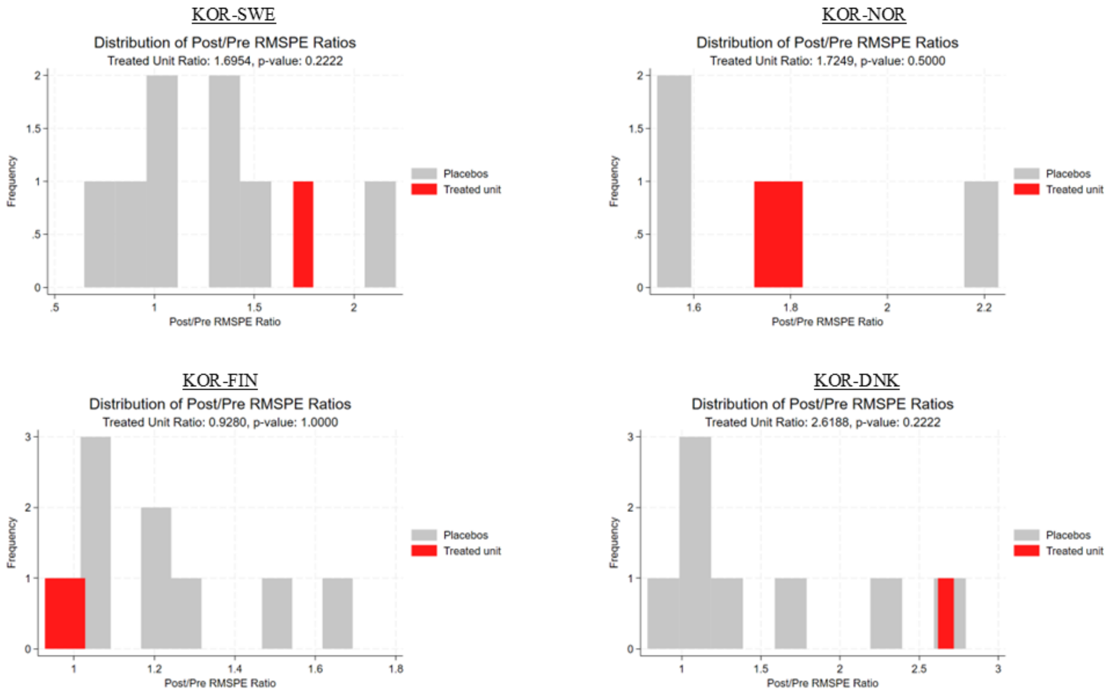

Figure 4A. Distribution of actual and placebo RMSPE ratios for Korean exporting pairs.

A. AI Usage statement

Tools: ChatGPT, Claude
Use: Generative AI tools were used in this paper to improve sentence structure, grammar, and shorten specific sections. In the Introduction, Background, Discussion, and Conclusion sections, GenAI tools were used to suggest rephrasing that better conveyed key points trying to be made.