Using Synthetic Control to Study the Economic Impact of the Brexit Referendum

Presentation by: Eddie (Yidi) Wu

Brown University

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Overview

1. Introduction
2. Previous Work
3. Methods
4. Results
5. Discussions

Brexit

- On June 23, 2016, the UK held a referendum to determine its membership status in the European Union, and to the surprise of many, 51.89% voted to leave the EU.
- Financial markets responses:
  - The global stock market fell around 5% on June 24
  - The pound depreciated sharply after the referendum against the US dollar, dropping from 1.5 to around 1.35.
  - Government bond yields and safe haven assets such as gold surged in prices
- Real income growth has stagnated and standard of living barely rose for average Britons over the past 15 years.

This Paper

- Uses synthetic control methods to estimate the impacts of Brexit on real GDP per capita and real gross disposable income per capita.
- Brief summary of results:
  - Per capita RGDP in the UK grew 8% in total between 2007 to 2023. In the counterfactual world, per capita RGDP would have grown 19%, representing a 9.2% shortfall.
  - 9% actual vs 30% counterfactual for real gross disposable income per capita.

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Literature Review

- Effects of Brexit on trade and productivity:
  - Bloom et al (2019): gradually reduced business investment by 11% over three years, reduced productivity by 2-5%.
  - Ahmad et al (2023): lowered services exports by 20 log points.
  - Broadbent et al (2023): tradable sector expands in the short run, while the non-tradable sector contracts.

Literature Review

- Effects on aggregate measures and investment:
  - Born et al (2017): costed the UK 1.3% of GDP by 2017Q3.
  - Sampson (2017), McGrattan and Waddle (2020): large negative impact on foreign direct investment and productivity for the UK; other EU countries suffered much smaller losses.
  - Opatrny (2020): no significant impact on FTSE100 index, significantly negative effect of 1.2 percentage points on 10 year bond yield.

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The original synthetic control

- For country i in period t, denote the observed outcome as y_{it}.
- Suppose there is only a single treated period T. Then UK's treated outcome can be expressed as

$$y_{UK,T} = y_{CF,T} + \tau_{UK,T}$$

where $y_{CF,T}$ is the counterfactual outcome and $\tau_{UK,T}$ is the treatment effect.

The original synthetic control

- The counterfactual outcome can be formed as a weighted average of the observed outcome of other countries:

$$y_{CF,T} = \sum_{i \neq UK} \hat{\gamma}_i^{scm} y_{i,T}$$

  where $\sum_{i \neq UK} \hat{\gamma}_i^{scm} = 1$ and $\hat{\gamma}_i^{scm} \geq 0 \ \ \forall \ i$
- Synthetic control assumes a stable relationship across countries in each period. $\hat{\gamma}_i^{scm}$ is calculated using all pre-treatment period predictors in $t < T$.

The augmented SCM

- The augmented SCM estimates the counterfactual outcome using

$$y_{CF,T} = \sum_{i \neq UK} \hat{\gamma}_i^{scm} y_{i,T} + (X_{UK} - \sum_{i \neq UK} \hat{\gamma}_i^{scm} X_i)^T \hat{\eta}_{ridge}$$

  where $\hat{\eta}_{ridge}$ is obtained from the ridge regression of regression $y_{i,T}$ onto the demeaned X_i for the untreated countries:

$$\min_{\eta} \sum_{i \neq UK} (y_{i,T} - \eta X_i)^2 + \lambda \|\eta\|_2^2$$

- There is no non-negativity restriction on the augmented SCM weights. The augmented SCM debiases the original SCM to improve quality of the counterfactual for UK.

Synthetic difference-in-differences (SDID)

- Arkhangelsky at al: SDID assumes homogeneous treatment effect and estimates it by:

$$(\hat{\tau}^{SDID}, \hat{\mu}, \hat{\alpha}, \hat{\beta}) =$$

$$argmin_{\tau,\mu,\alpha,\beta} \left\{ \sum_{i=1}^{N} \sum_{t=1}^{T} (Y_{it} - \mu - \alpha_i - \beta_t - W_{it}\tau)^2 \hat{\omega}_i^{SDID} \hat{\lambda}_t^{SDID} \right\}$$

- τ is the treatment effect.
- ω_i^{SDID} is the synthetic control weight that is estimated using the original SC method with a regularization term.
- λ_t^{SDID} is estimated by balancing pre-exposure time periods with post-exposure ones i.e. for each control country, the average post-treatment outcome differs by a constant from the weighted average of the pre-treatment outcomes.

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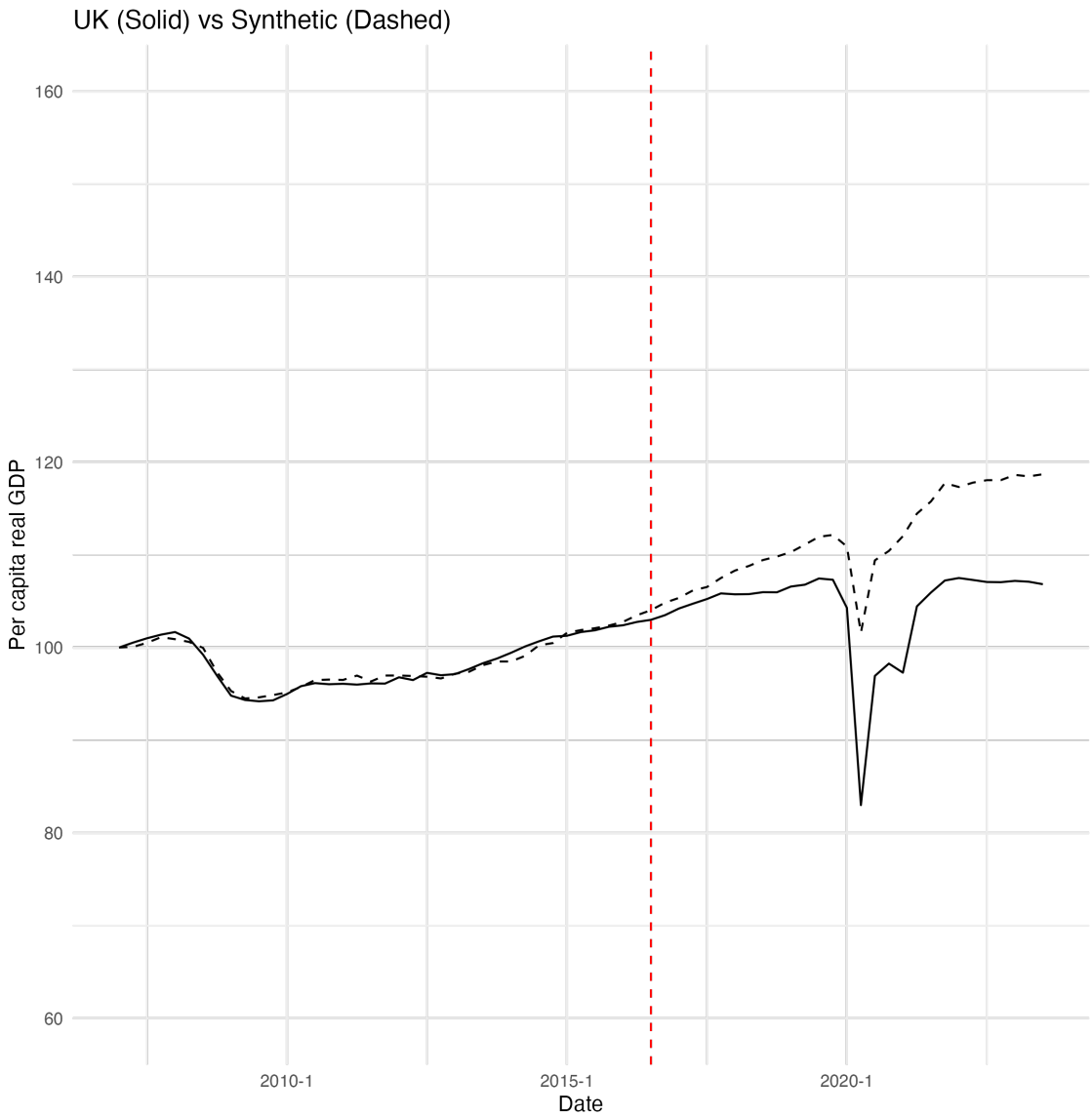
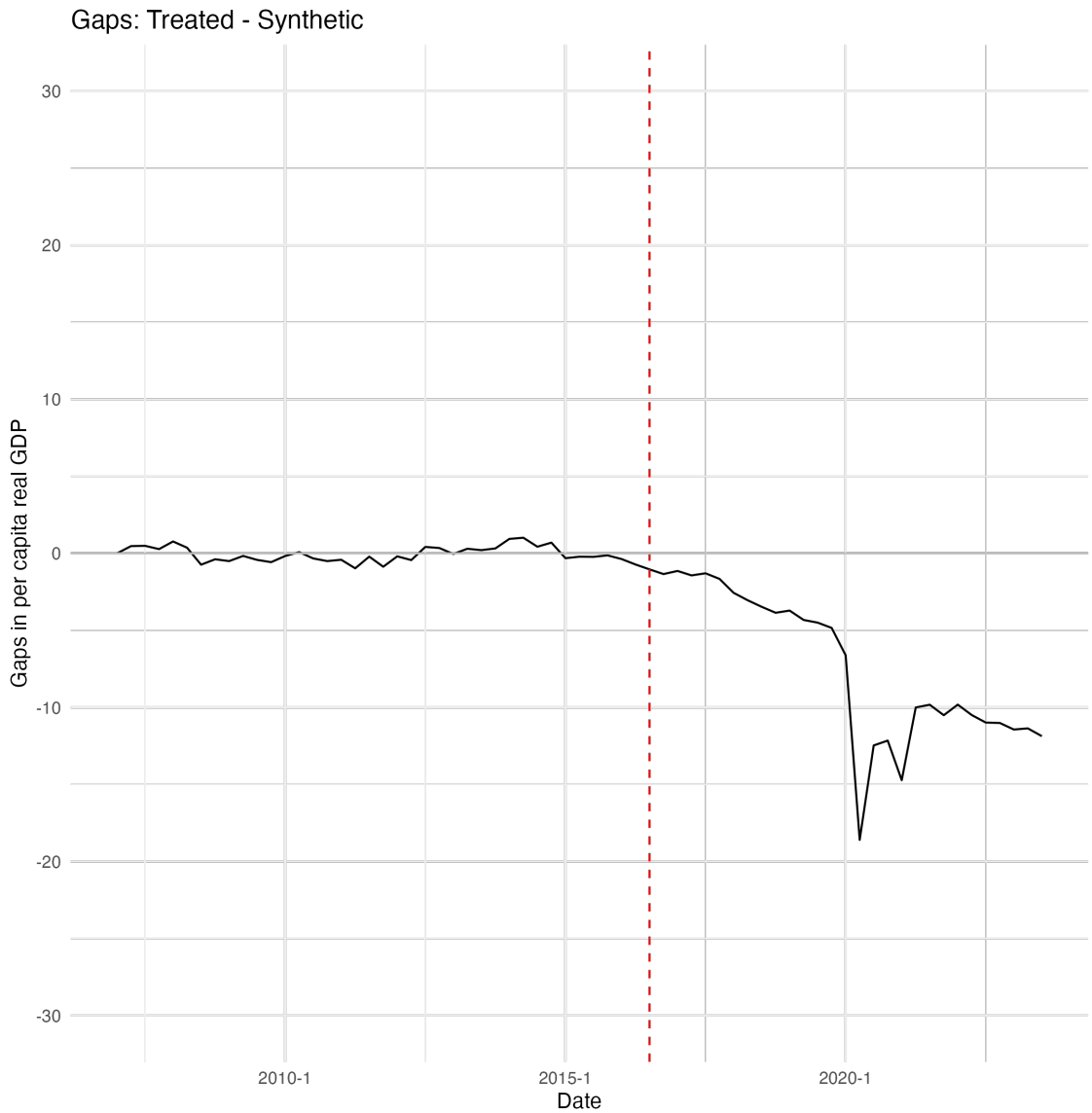
Predictors I use

- Consumer price index
- Short term interest rate
- Stock market index
- Consumer confidence
- Unemployment rate
- Labor underemployment rate: working fewer hours than is necessary, or working in an undesired field.
- Real household final consumption expenditure per capita
- Household indebtedness level
- Household savings level
- Household networth

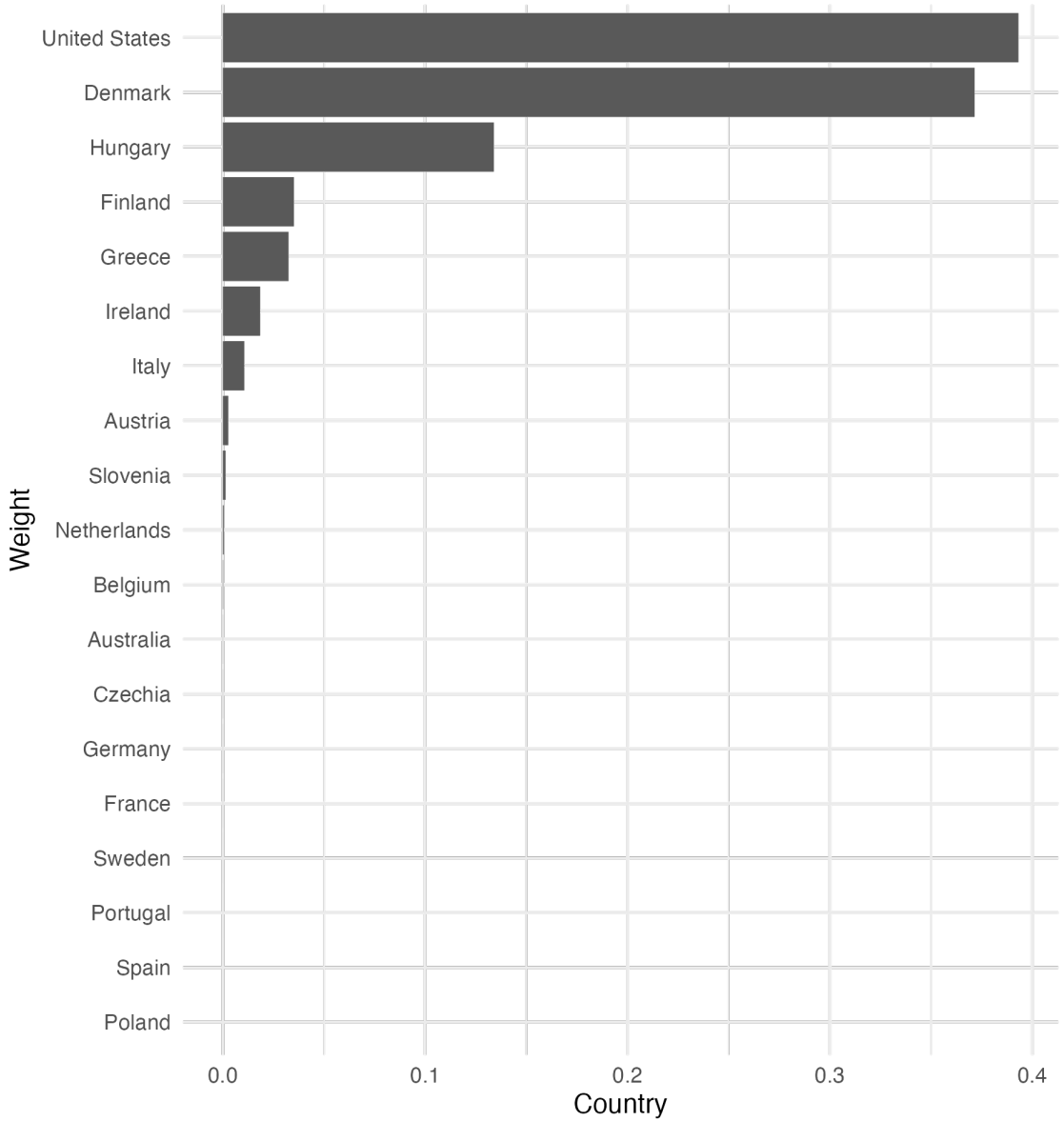
Real GDP per capita



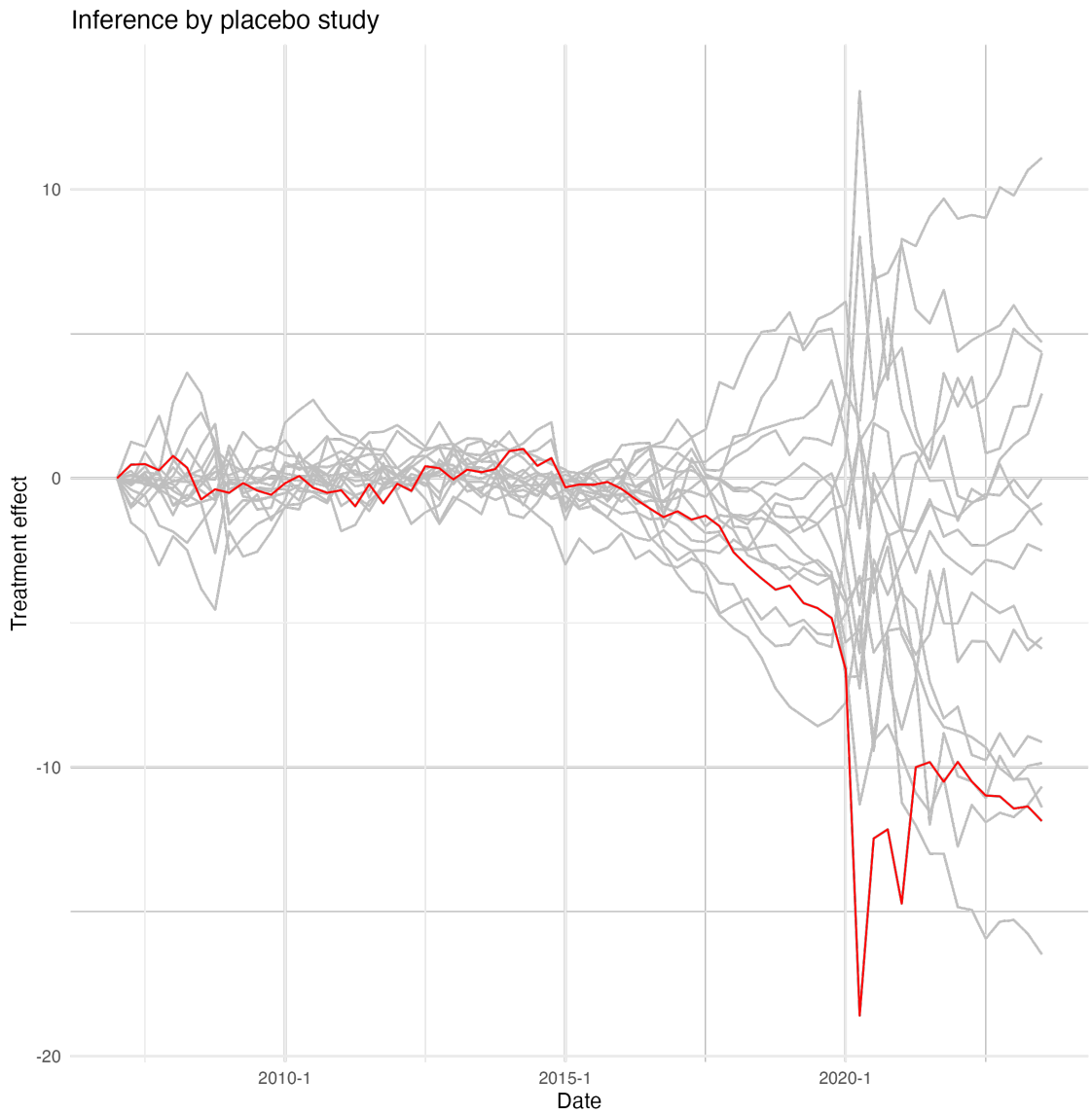
Gaps in real GDP per capita



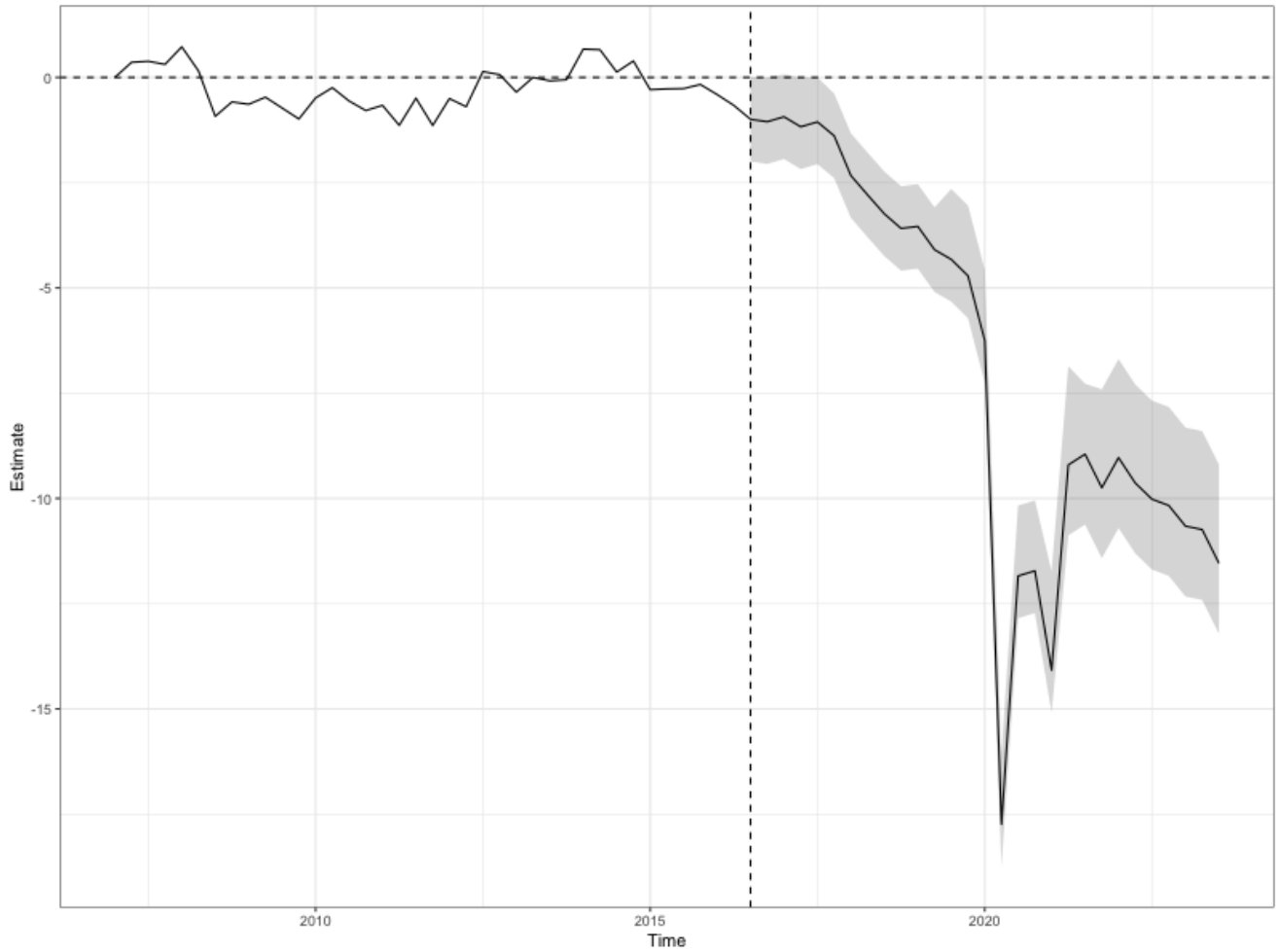
Weights distribution by country



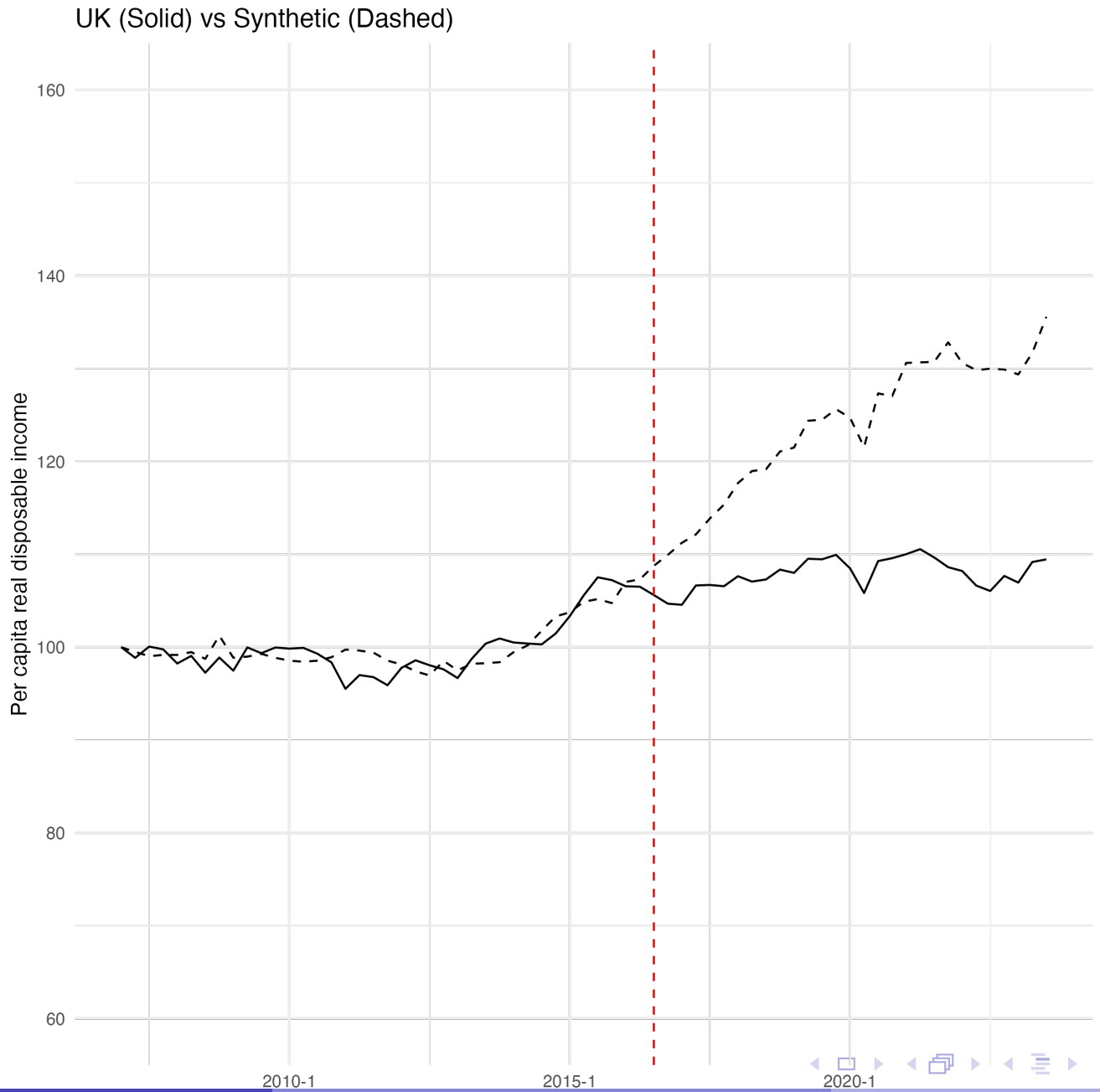
Placebo study for real GDP per capita



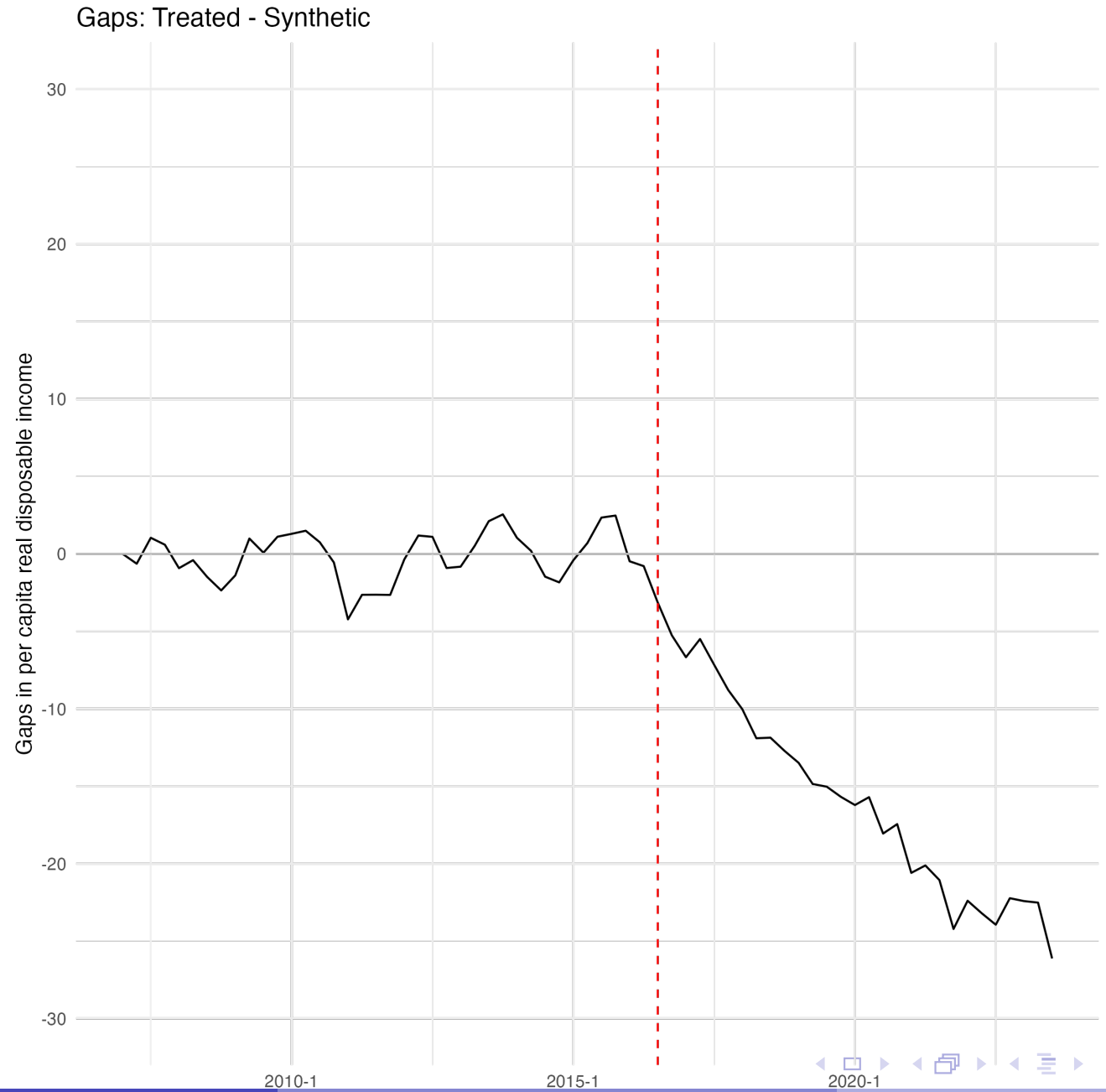
Conformal inference in augmented SC for RGDP



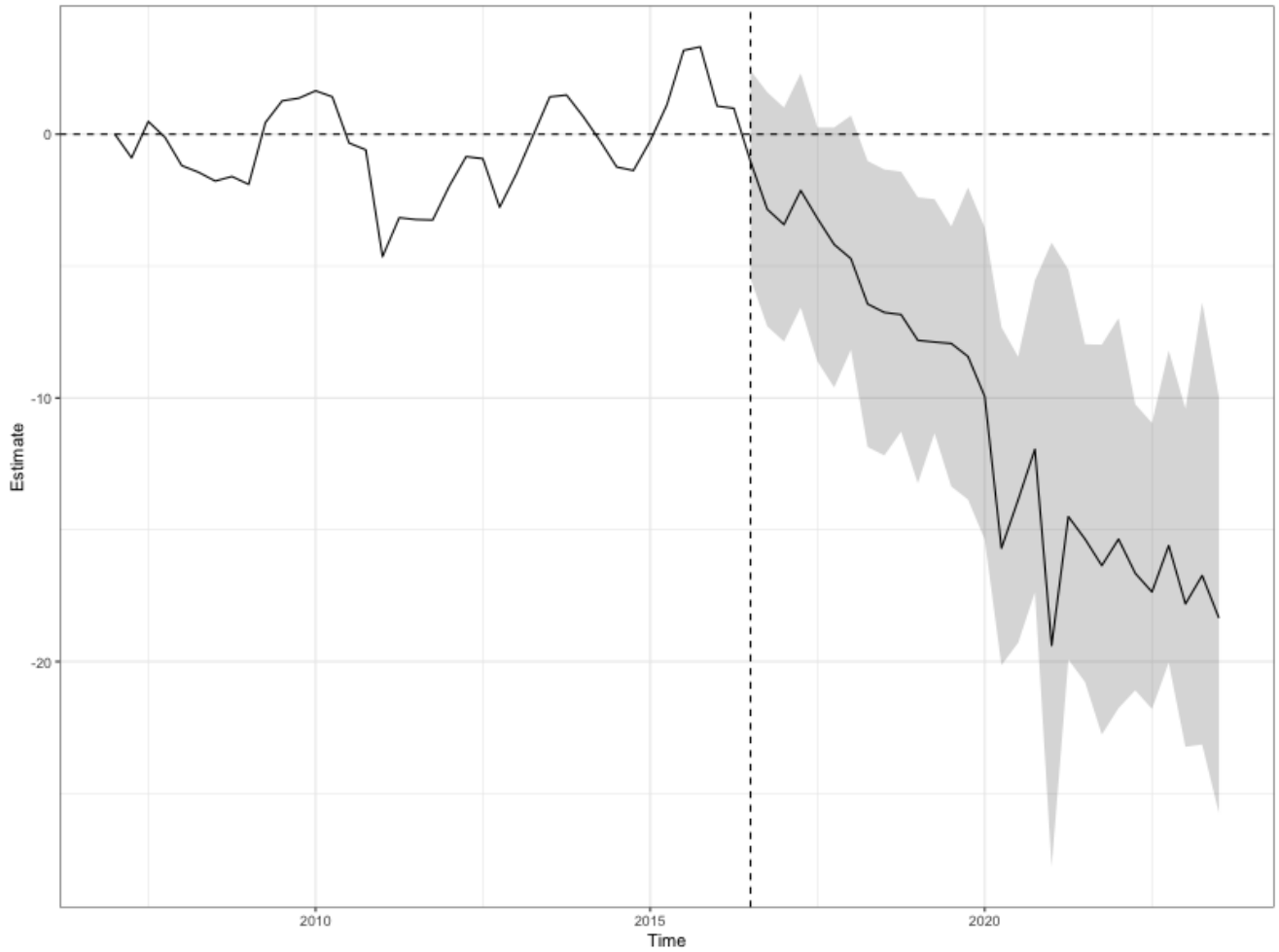
Original SC for real gross disposable income



Original SC for real gross disposable income



Augmented SC for real gross disposable income



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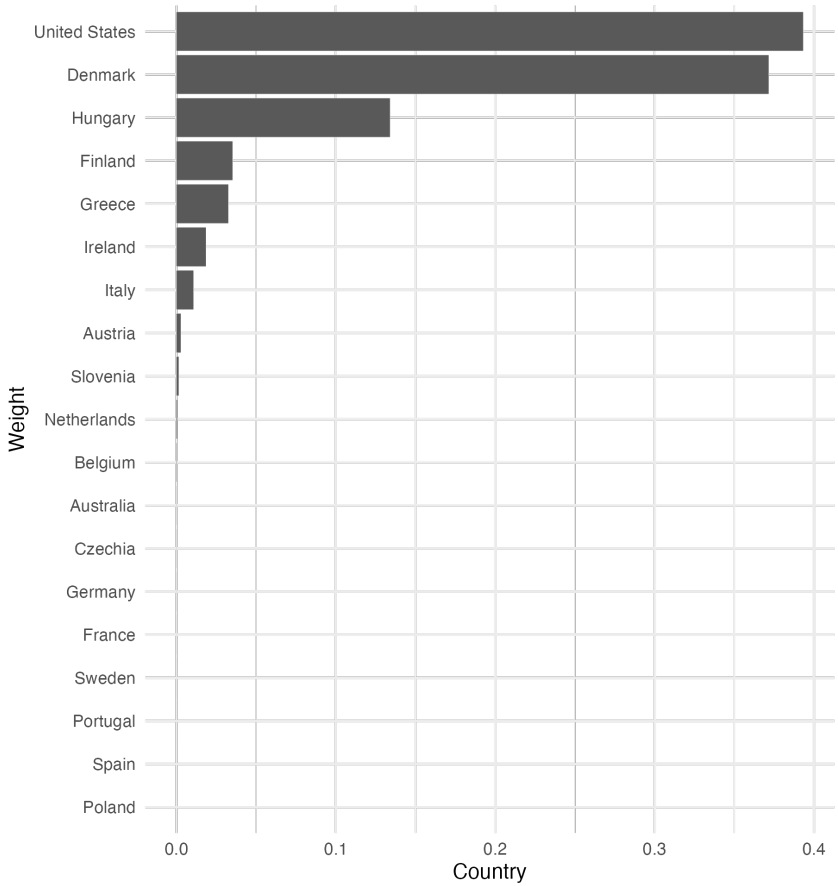
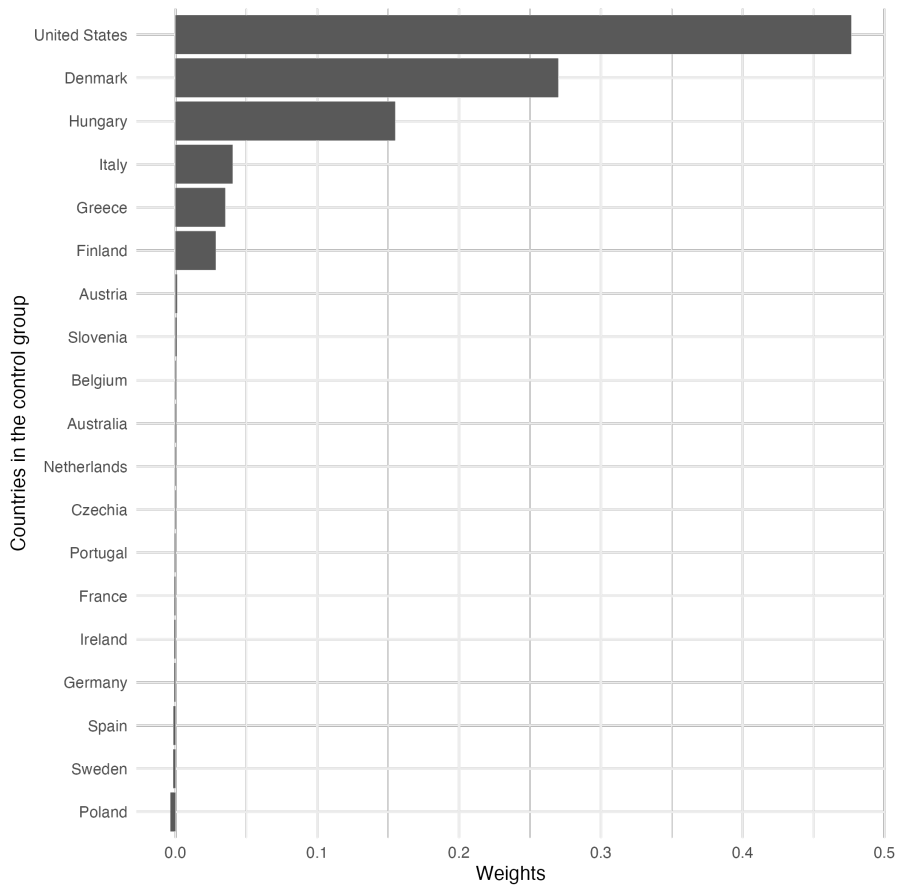
Comparison of results

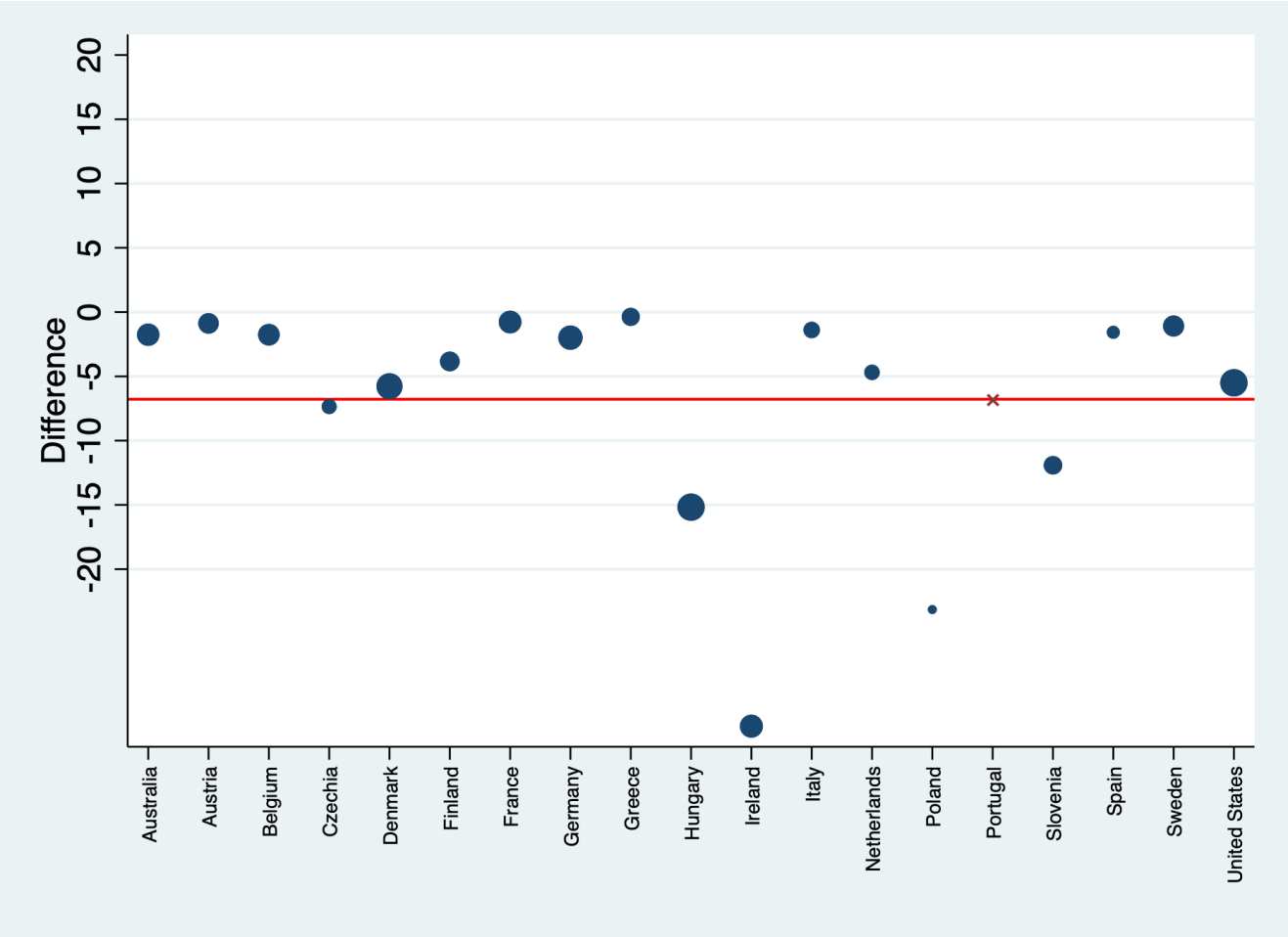
Estimate	(GDP) SC	(GDP) ASC	(GDP) SDID	(GDI) SC	(GDI) ASC	(GDI) SDID
τ			-6.781			-9.366
			(5.892)			(6.581)
2017Q2	-1.432	-1.174**		-5.497	-2.134	
		(-2.18, 0.00)			(-7.23, 0.61)	
2018Q2	-3.041	-2.793***		-11.903	-6.437***	
		(-3.80, -1.79)			(-11.86, -1.02)	
2019Q2	-4.323	-4.093***		-14.858	-7.883***	
		(-5.10, -3.09)			(-11.33, -2.46)	
2020Q2	-18.598	-17.739***		-15.707	-15.699***	
		(-18.74, -16.07)			(-22.11, -6.34)	
2021Q2	-10.001	-9.204***		-20.116	-14.501***	
		(-10.88, -6.87)			(-20.91, -7.11)	
2022Q2	-10.497	-9.635***		-23.199	-16.650***	
		(-11.31, -7.30)			(-21.09, -8.27)	
2023Q2	-11.360	-10.740***		-22.515	-16.735***	
		(-12.41, -8.40)			(-22.16, -6.39)	

Comparing SC and ASC weights





SDID weights



Context requirements

- “Large” treatment effect: as shown in previous literature.
- Donor pool: SUTVA (might be violated to a small extent), and unaffected by large idiosyncratic shocks.
- No anticipation: defined treatment to take place in 2016Q3.
- Convex hull condition: ASC shows that the condition is likely to be satisfied.
- Length of the pre-intervention period: long enough starting from 2007Q1.

Thank you.