Causal Inference with Synthetic Controls: Estimating the Economic Costs of Conflict

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- Spain is organized into 17 ”autonomous communities”
- Each community holds a large degree of government power
  - Greater power still deferred to ”historical nationalities”: Galicia, Basque Country, Catalonia
- Catalonia and the Basque Country have seen major separatist movements


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- Euskadi Ta Askatasuna (ETA) formed to support Basque separatism
- Beginning in 1960s, begin terrorist activities

TABLE 1—CHRONOLOGY OF ETA'S TERRORIST ACTIVITY

Year	Killings	Kidnappings	Event
1968	2	0	First victim of ETA
1969	1	0	
1970	0	1	
1971	0	0	
1972	1	1	
1973	6	1	ETA kills Franco's Prime Minister Admiral Carrero-Blanco
1974	19	0	
1975	16	0	Dictator Franco dies
1976	17	4	
1977	11	1	First democratic elections in Spain after Franco's death
1978	67	6	Spanish Constitution approved in referendun
1979	76	13	Regional Autonomy Statute for the Basque Country approved
1980	92	13	
1981	30	10	Attempted military coup. Spain joins NATO

1982	37	8	
1983	32	5	
1984	32	0	
1985	37	3	
1986	41	3	Spain joins European Community
1987	52	1	
1988	19	1	
1989	19	1	
1990	25	0	
1991	46	0	
1992	26	0	Barcelona hosts the Summer Olympic Games
1993	14	1	
1994	13	0	
1995	15	1	
1996	5	2	
1997	13	1	
1998	6	0	ETA declares indefinite cease-fire starting on September 18

- Question: What was the impact of terrorism on the people of the Basque Region?

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- Less ambitious
  - What was the **economic** impact of terrorism on the people of the Basque Region?

  - Can we quantify this effect?

Roadmap of Talk

Empirical considerations

Methods

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Software

Empirical considerations

A few stylized facts:

- Terrorist activities took place in Basque country at a higher frequency than rest of Spain
  - Deaths per 1 million inhabitants per year: 8.17 Basque Country, 0.22 Rest of Spain (1968-1997)

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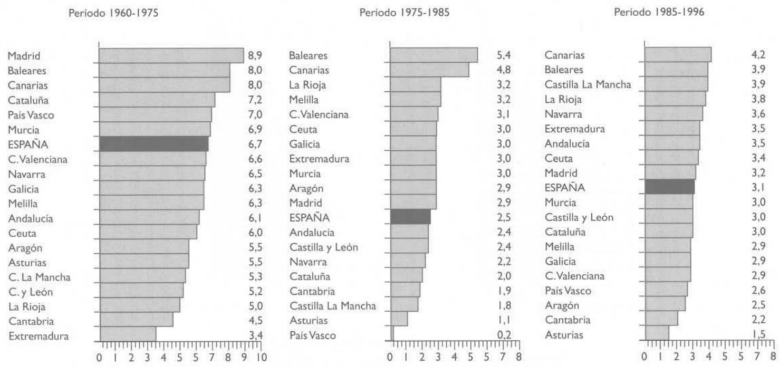
- The Basque conflict had ”no direct economic motivation” (Abadie and Gardeazabal, 2003, pp. 114)
- The Basque region experienced less growth than other Spanish regions

Empirical considerations

GRAFICO N.º 2

EVOLUCION DEL PIB A PRECIOS CONSTANTES. AÑOS 1960 A 1996

TASAS DE VARIACION MEDIA ANUAL DEL PERIODO



Source: BBV, 1999

Empirical considerations

How do we quantify the effect of terrorism?

- A naïve comparison of means before and after terrorism
  - ignores time-varying dynamics that are independent of terrorism
  - e.g. Business cycle variations in macroeconomic aggregates
- Comparing Basque country to other regions of Spain
  - Concentration of terrorism in Basque country supports this method

Empirical considerations

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Compare the outcomes of Basque country to other regions that are similar.

Issue: we can't just compare it to the rest of Spain.

Empirical considerations

TABLE 3—PRE-TERRORISM CHARACTERISTICS, 1960'S

	Basque Country (1)	Spain (2)
Real per capita GDP[a]	5,285.46	3,633.25
Investment ratio (percentage)[b]	24.65	21.79
Population density[c]	246.89	66.34
Sectoral shares (percentage)[d]		
Agriculture, forestry, and fishing	6.84	16.34
Energy and water	4.11	4.32
Industry	45.08	26.60
Construction and engineering	6.15	7.25
Marketable services	33.75	38.53
Nonmarketable services	4.07	6.97
Human capital (percentage)[e]		
Illiterates	3.32	11.66
Primary or without studies	85.97	80.15
High school	7.46	5.49
More than high school	3.26	2.70

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Any experimental control group of this form will be a weighted average of the options available.

- Comparing to rest of spain gives equal weights
- A difference-in-differences approach would set the weight to 1 for the control regions of interest
- We can choose the weights more carefully: **synthetic control**

Empirical considerations

TABLE 3—PRE-TERRORISM CHARACTERISTICS, 1960'S

	Basque Country (1)	Spain (2)	"Synthetic" Basque Country (3)
Real per capita GDP[a]	5,285.46	3,633.25	5,270.80
Investment ratio (percentage)[b]	24.65	21.79	21.58
Population density[c]	246.89	66.34	196.28
Sectoral shares (percentage)[d]			
Agriculture, forestry, and fishing	6.84	16.34	6.18
Energy and water	4.11	4.32	2.76
Industry	45.08	26.60	37.64
Construction and engineering	6.15	7.25	6.96
Marketable services	33.75	38.53	41.10
Nonmarketable services	4.07	6.97	5.37
Human capital (percentage)[e]			
Illiterates	3.32	11.66	7.65
Primary or without studies	85.97	80.15	82.33
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Sources: Authors' computations from Matilde Mas et al. (1998) and Fundación BBV (1999).

[a] 1986 USD, average for 1960–1969.

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Methods

”The synthetic control approach developed by Abadie et al., 2010 and Abadie and Gardeazabal, 2003 is *arguably the most important innovation* in the policy evaluation literature in the last 15 years.”

–Athey and Imbens, 2017

Methods

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- Suppose there are J potential control regions.
- Let $W = (w_1, \ldots, w_J)' \in \mathbb{R}^J$ be the weights. Each W corresponds to a different synthetic control region.
- Goal: Choose W such that the synthetic control region resembles the actual region.
  - Let $X_1 \in \mathbb{R}^K$ be the vector of pre-treatment observables.
  - Let $X_0 \in \mathbb{R}^{K \times J}$ be the matrix of pre-treatment observables for all regions.
  - We want to minimize $\|X_1 - X_0 W\|$

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- Operationalize this by letting $V \in \mathbb{R}^{K \times K}$ be diagonal (more generally, positive semi-definite, see Abadie et al., 2010). For each $k \in K$, V_{kk} represents the relative weight that we give to the observable pre-treatment variable indexed by k.

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- We can but don't need to impose some constraints on the weights as well
  - (W1) $\forall j$, $w_j \in [0, 1]$ (No extrapolation - convex hull)
  - (W2) $w_1 + w_2 + \cdots + w_J = 1$
- What should we choose for V?

Methods

- In principle, V is the relative importance of pre-treatment observables.
- We may have some priors based on prior literature
  - E.g. we are using macroeconomic variables advanced by Barro and Sala-i-Martin, 2004.

Methods

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$$W^*(V) = \text{argmin}_{W \in \mathcal{W}} (X_1 - X_0 W)' V (X_1 - X_0 W)$$

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- Let $Z_1 \in \mathbb{R}^{10}$ be the per capita gdp in Basque Country for the ten years prior to intervention.
- Let $Z_0 \in \mathbb{R}^{10 \times J}$ be the same, but for the potential control regions.

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- Let $Z_1 \in \mathbb{R}^{10}$ be the per capita gdp in Basque Country for the ten years prior to intervention.
- Let $Z_0 \in \mathbb{R}^{10 \times J}$ be the same, but for the potential control regions.
- Now choose V to minimize the sum of squared error between the true values Z_1 and the synthetic region's values $Z_0 W^*(V)$.

$$V^* = \text{argmin}_{V \in \mathcal{V}} (Z_1 - Z_0 W^*(V))' (Z_1 - Z_0 W^*(V))$$

where $\mathcal{V}$ is the set of all diagonal (positive semi-definite) matrices over $\mathbb{R}$.

Methods

Performing this method tells us that

$$\texttt{Basque} = 0.8508(\texttt{Catalonia}) + 0.1492(\texttt{Madrid})$$

Based on the construction, we expect that

- pre-intervention observables of Basque region and synthetic Basque region are close, and

- pre-intervention per capita GDP time series for Basque and synthetic Basque regiones are close

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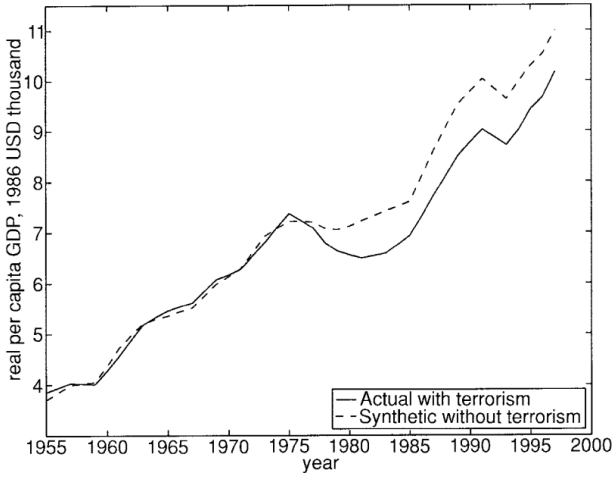
real per capita GDP, 1986 USD thousand
11
10
9
8
7
6
5
4
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
year
Actual with terrorism
Synthetic without terrorism

Roadmap of Talk

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Estimating costs of Basque conflict

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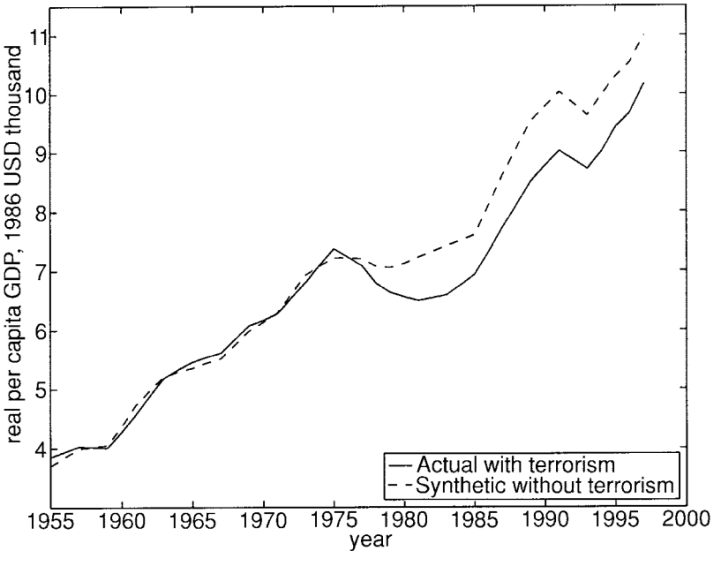
Estimating costs of Basque conflict

- Now we simply compare the outcomes of the treatment and control groups after the treatment period.

Estimating costs of Basque conflict



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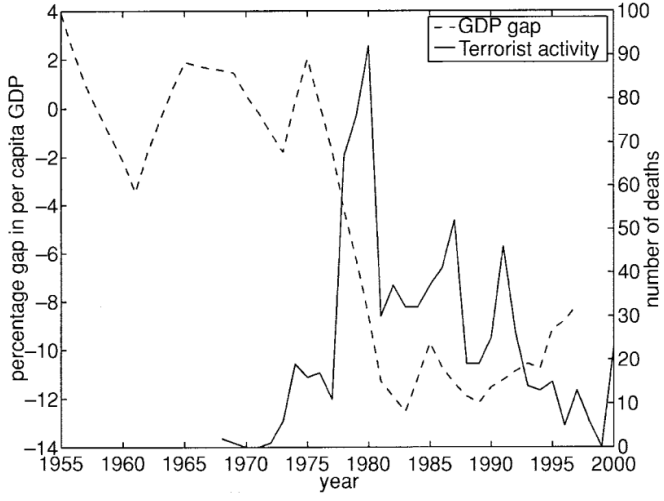

Estimating costs of Basque conflict

It is also interesting to note that Catalonia hosted the olympic games in 1992.

- We expect this to increase per capita GDP relative to non-hosting regions.
- Hence we expect the gap between synthetic and real Basque region to be larger than estimated.

Estimating costs of Basque conflict

Takeaways from this exercise:

- The actual Basque region grows below the control Basque region
- Larger deviations from control are associated with terrorist activity
- The magnitude of the effect is about 10%
- We should check with ”placebo” studies and other robustness checks

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Applications - Overview

Synthetic control methods have found been applied widely in fields such as:

- Economics: Gautier et al., 2009 Billmeier and Nannicini, 2013, Cavallo et al., 2013
- Political Science: Abadie et al., 2010, Abadie et al., 2015
- Health Policy: Kreif et al., 2016 Li and Toll, 2021
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Applications: Abadie et al. (2010)

- In 1988, California voters passed **1988 Proposition 99**
- The law included a 25-cent excise tax per carton of cigarettes
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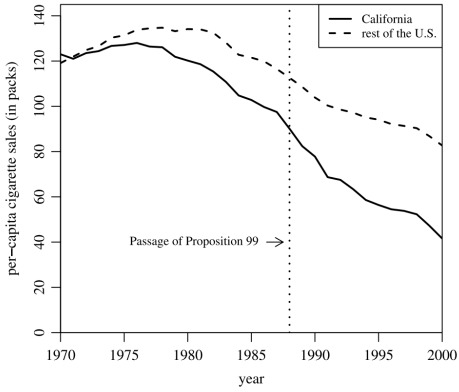
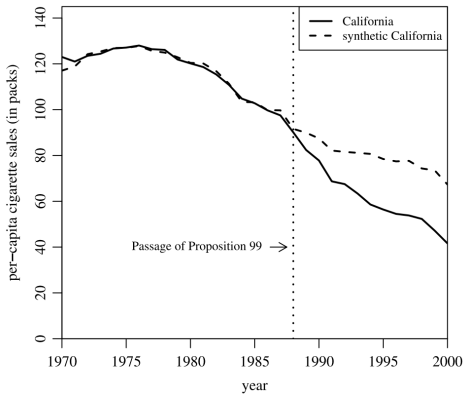
$$\texttt{CA} = 0.164(\texttt{CO}) + 0.069(\texttt{CT}) + 0.199(\texttt{MT}) + 0.234(\texttt{NV}) + 0.334(\texttt{UT})$$

Applications: Abadie et al. (2010)





Headline: CA cigarette sales p.c. were **26 packs lower** because of Proposition 99.

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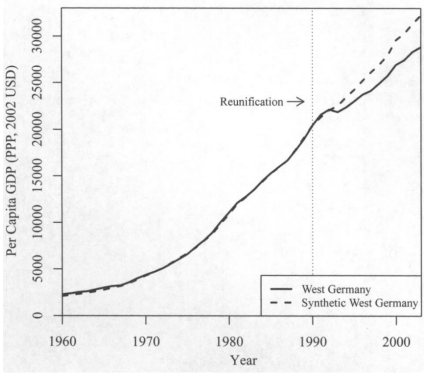
Applications: Abadie et al. (2015)

- On November 9, 1989, the Berlin Wall fell
- West German GDP per capita was triple that of East Germany
- Question: What was the effect of integration on the West German economy?

Applications: Abadie et al. (2015)

FIGURE 2 Trends in per Capita GDP: West Germany versus Synthetic West Germany



Headline: 2003 per capita GDP in synthetic W. Germany is 12% higher than in reality

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Active community building software

Focusing on R:

- `synth` (Diamond, Hainmueller, originally 2007): classic implementation
  - includes data sets Basque data set from Abadie and Gardeazabal, 2003
- `tidysynth` (Dunford, 2021): a tidy implementation of sc conducive to piping
- `gsynth` (Xu, Liu 2021): generalized synthetic control methods
- `scpi` (Cattaneo et al., October 2022): uncertainty quantification for synthetic control methods

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