Synthetic Control Methods and Customs Reform: An Application to Serbia's In-House Clearance Program

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Impact evaluation of trade facilitation projects is rare, despite large stakes

- Impact evaluation is common in many fields of development
  - Health, poverty reduction, education etc.
- Trade facilitation projects consume substantial financial resources
  - OECD reports US $373 million in official development assistance was disbursed in 2013.
- The WTO Trade Facilitation Agreement of 2013 should mean a significant push in the near future
  - We need to know what works and what does not.
- But there have been relatively few impact evaluations of trade facilitation projects
  - Growing literature on export promotion
    - Volpe and Carballo(2008,2010), Cadot et al (2012) Atkin et al (2015).
  - Almost nothing on customs reform
    - Fernandes et al (2015) study implementation of risk management in Albanian customs
    - Volpe Martincus et al currently investigating impact of a single window.
    - Fernandes et al currently investigating impact of risk management in technical agencies at the border.

While operational demands make randomization difficult, new techniques allow evaluation of many customs reforms

- Operational difficulties
  - It is difficult to maintain differential treatment for operationally equivalent firms over time spans that are long enough to observe meaningful changes.
  - Many interventions are IT solutions (risk management, single window), and differential treatment of equivalent firms can substantially raise costs of installation.
- Strengths of customs reform for evaluation
  - Heterogeneous treatment is normal part of reform
    - A “roll out” of reforms is common (e.g. one border post is treated as a pilot)
  - Often there are very high quality administrative data available
    - These allow the specific timing of the reforms to be identified, and impacts to be measured in real time
- These strengths mean that impact evaluation is possible, ex post, if the untreated units can be used to create a credible projection of what would have happened to treated units if there had been no customs reform.
  - We believe that synthetic control methods a la Abadie et al (2010) are extremely useful in this regard.

Synthetic control method

- Using an untreated unit as a control for a treated unit is problematic
  - Untreated units may differ on observables or unobservables, and this can bias effects.
    - Especially difficult issue is time-varying unobservables.
      - In the context of customs reforms, for example, treated firms may be differentially exposed to shocks in the countries from which they source imports.
      - There may also be differential exposure to products, and product-specific shocks.
    - Time-varying unobservables make difference-in-difference (D-in-D) or propensity score matching with D-in-D invalid
  - Under appropriate conditions synthetic control methods can handle unit-specific time-varying fixed effects
    - A “synthetic” unit, which is a weighted average on untreated unit, is constructed to minimize differences between the characteristics and the time path of the outcome variable for the treated and synthetic unit.
- We apply a new technique, pooled synthetic controls (Dube and Zipperer 2013) because our application has multiple treated units.

Application: In-house clearance program in Serbia

- Many customs agencies allow pre-qualified firms to by-pass standard clearance procedures, and to clear their goods at their own warehouse, rather than at the customs office.
- Serbian customs began a program of this type in 2011.
- We wish to know whether firms that adopted the program saw reductions in their median (monthly) clearance time and their monthly log import values.
- 21 firms adopted the program for imported goods, and used it continuously thereafter until the end of 2013.
  - We compare clearance times and firm level imports of these firms against constructed synthetic control firms

Data

- The Serbian customs agency provided us with detailed transaction level import data containing, among other variables…
  - the precise time of registration and clearance of the goods,
  - a commodity classification,
  - the country of origin,
  - special clearance codes, including a code designating in-house clearance.
- The data are comprehensive for the years 2010-2013.
  - The in-house clearance program came into use in July 2011.
- Our outcome variables are
  - the monthly median time to clear import customs
  - The log of monthly average import value
  - In both cases we construct 3-month moving averages to remove underlying volatility in the data. This is a conventional approach in this literature.

Model set-up

(1) $Y_{jt}^N = \delta_t + \pi_{jt}$ Model for untreated observation, Y_{jt}^N

(2) $Y_{jt}^I = \delta_t + \alpha_{jt} D_{jt} + \pi_{jt}$ Model for treated observation, Y_{jt}^I

$D_{jt} = 1$ for treated firm, post treatment

α_{jt} is period-specific treatment effect

(4) $\pi_{jt} = \boldsymbol{\theta}_t \boldsymbol{X}_j + \boldsymbol{\lambda}_t \boldsymbol{\mu}_j + \varepsilon_{jt}$

$\boldsymbol{\theta}_t$ Time varying coefficient

$\boldsymbol{X}_j$ Characteristics of unit j

$\boldsymbol{\lambda}_t$ Time varying factors

$\boldsymbol{\mu}_j$ Factor loadings

A consistent estimate of α_{jt} can be obtained by subtracting (2) from (1) if $\left(\boldsymbol{\lambda}_t^I - \boldsymbol{\lambda}_t^N\right)\boldsymbol{\mu}_j \approx \mathbf{0}$. This occurs in SCM under certain conditions.

Other estimators such as D-in-D cannot difference out unit-specific time-varying effects.

To obtain synthetic control for a treated firm

Let V be a diagonal matrix with trace = 1. The elements of V are weights on firm characteristics.

1. Given V, choose elements of the W matrix w_j to minimize pretreatment gaps between characteristics of synthetic and treated units.

$$\min_{\boldsymbol{W}} \sqrt{(\boldsymbol{X}_1 - \boldsymbol{X}_j\boldsymbol{W})'\boldsymbol{V}(\boldsymbol{X}_1 - \boldsymbol{X}_j\boldsymbol{W})} \qquad \text{s.t.} \quad w_j \geq 0, \sum_{j\neq 1} w_j = 1$$

2. Given W, choose elements of V to best fit the pretreatment time path of the outcome variable Y.

$$min_{\boldsymbol{V}} \quad MSPE(Y) = \frac{1}{T_0}\sum_{t=1}^{T_0}\left(Y_{1t} - \sum_{j=2}^{J} w_j^*(V)Y_{jt}\right)^2$$

Iterate.

Characteristic variables, $\mathbf{X}_j$

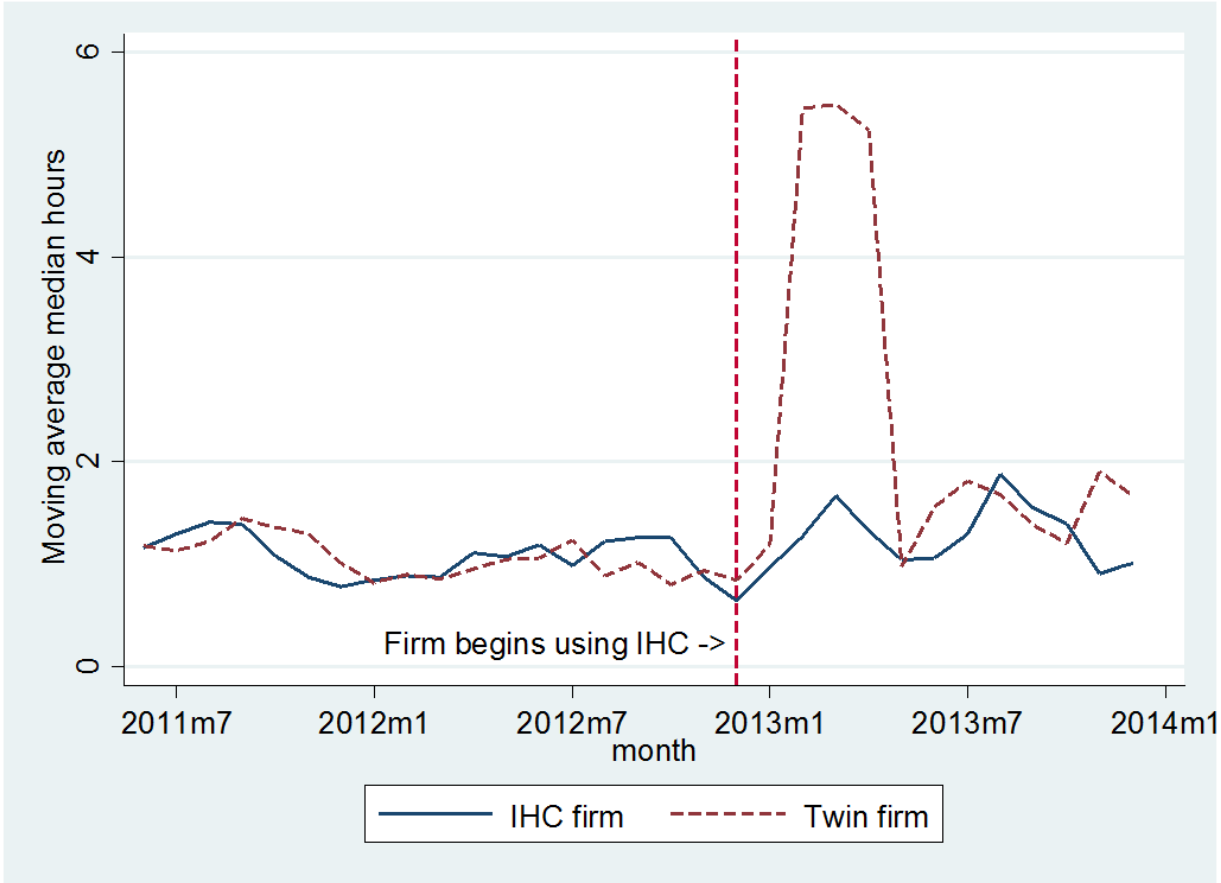
- Monthly average, for firm j, of……

    1. average share of imports in 10 commodity groups
    2. average share of imports from the European Union
    3. average share of imports entering under a special clearance code

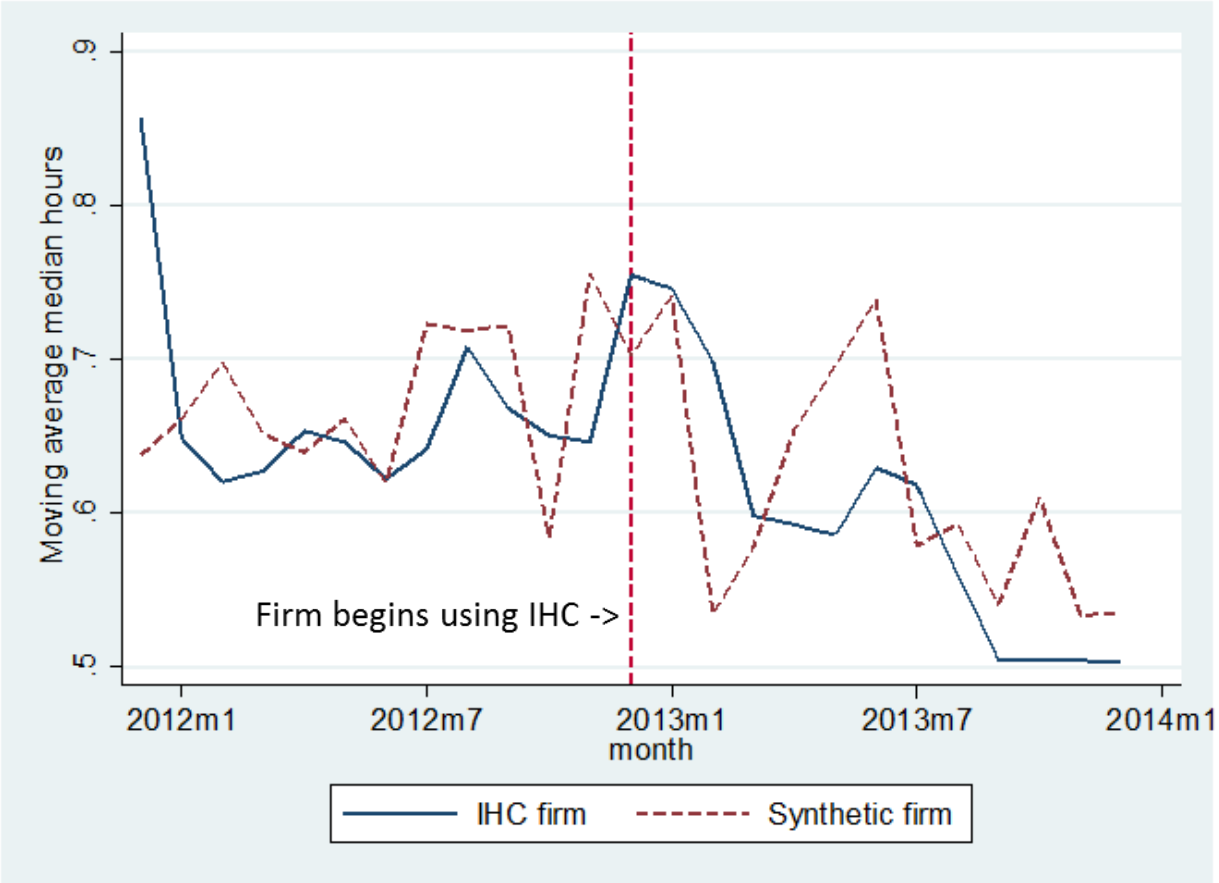
- Lagged value of outcome variable in 1^{st}, 10^{th}, and 18^{th} pretreatment months.

Examples for clearance times

Example Firm 1

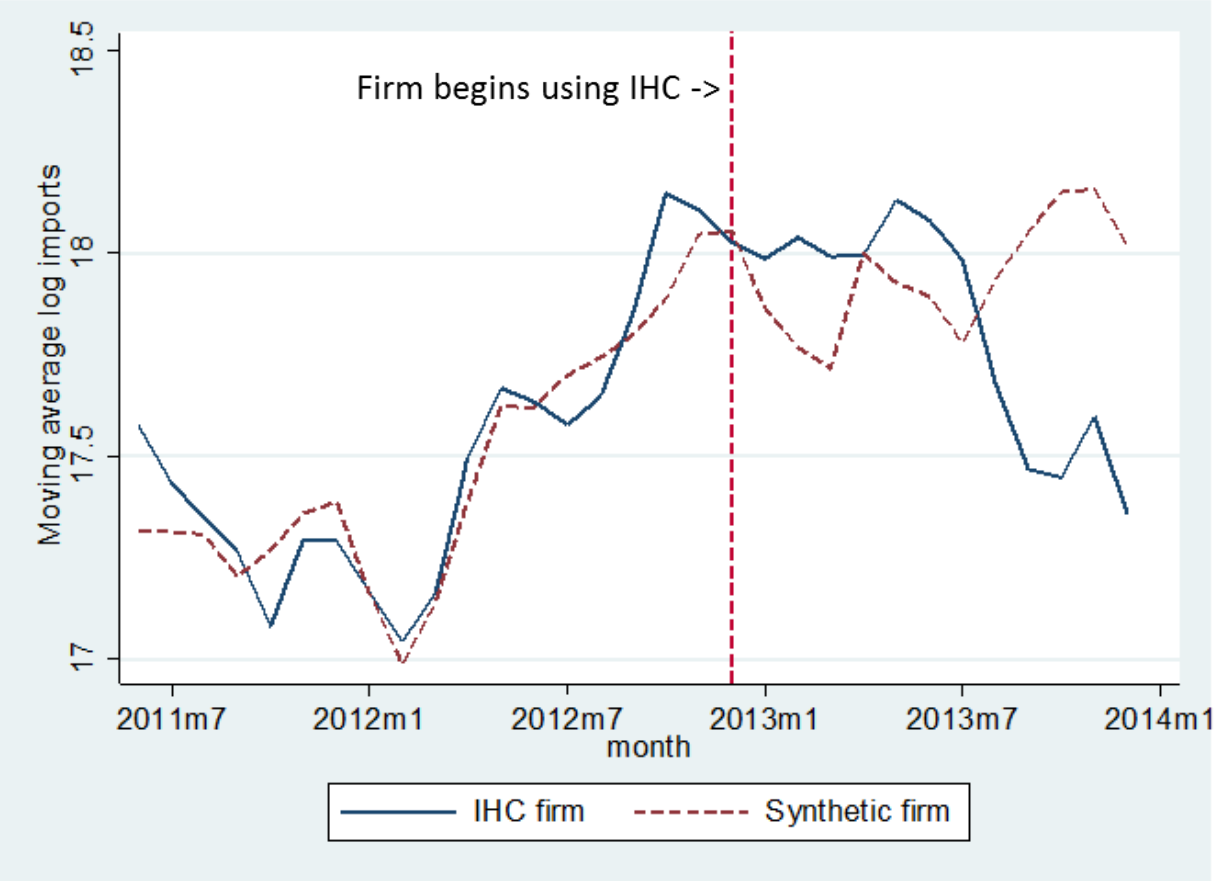


Example Firm 2

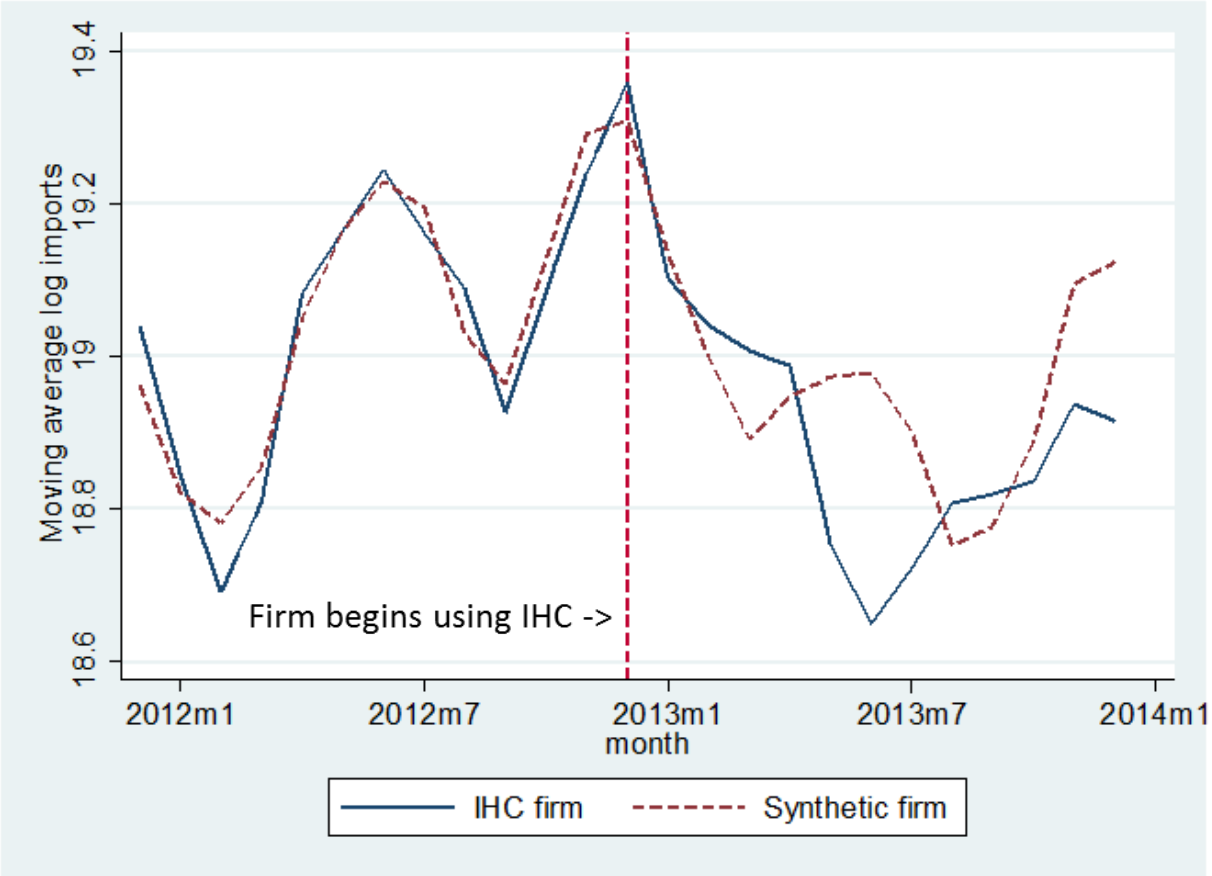


Examples for log imports

Example Firm 1

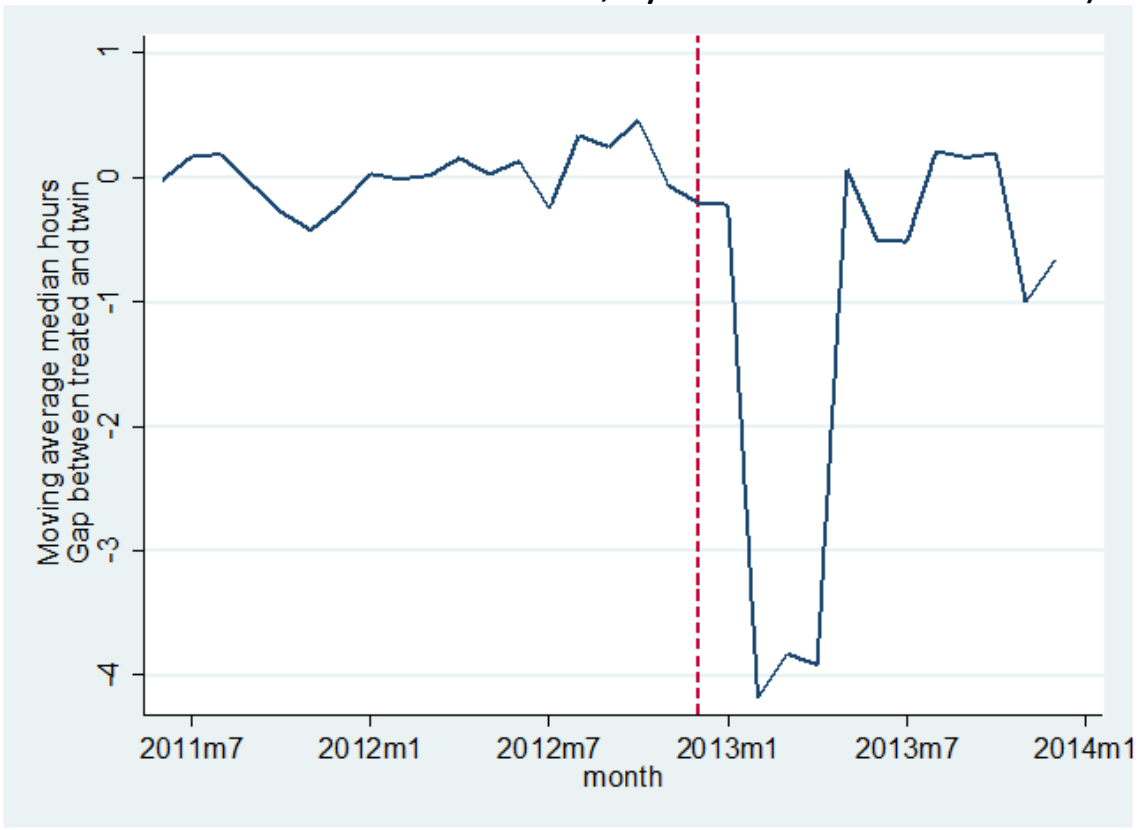


Example Firm 2

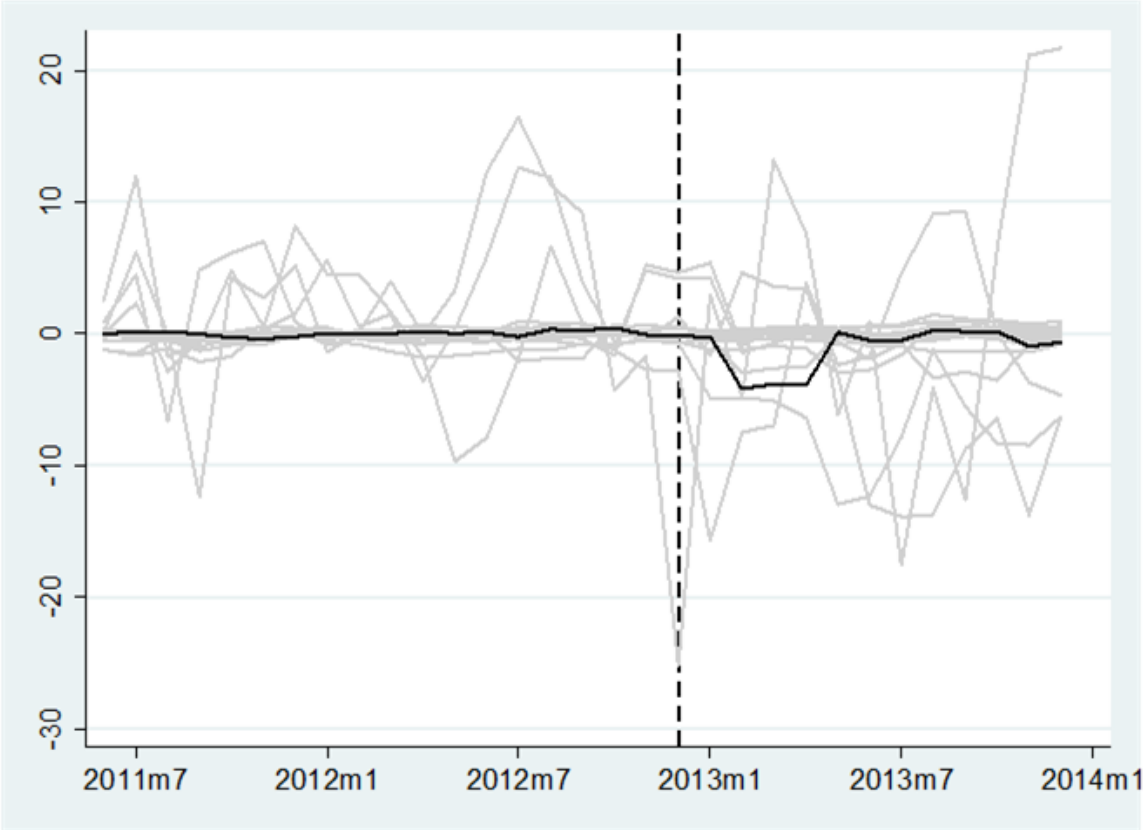


Statistical significance for the single firm case

Example Firm 1
Difference in clearance times, synthetic minus treated)



Difference in clearance times: treated and placebo firms



Treated firm's gap lies below the center of the distribution, but not outside it. No statistically significant effect observed.

Statistics for hypothesis testing and pooling across treated firms

Estimated treatment effect:

Average monthly gap in outcome Y between treated and synthetic firms.

Calculated for treated firm and for placebos.

$$\hat{\beta}_j = \frac{1}{(T - T_0)} \sum_{t=T_0+1}^{T} \left(Y_{1t} - \sum_{j=2}^{N} w_j Y_{jt} \right)$$

Statistic for hypothesis testing:

Percentile rank of $\widehat{\beta_f}$ among $\hat{\beta}$ for 20 placebo firms:

$$p_f = \frac{rank_{\widehat{\beta_f}}}{20 + 1}$$

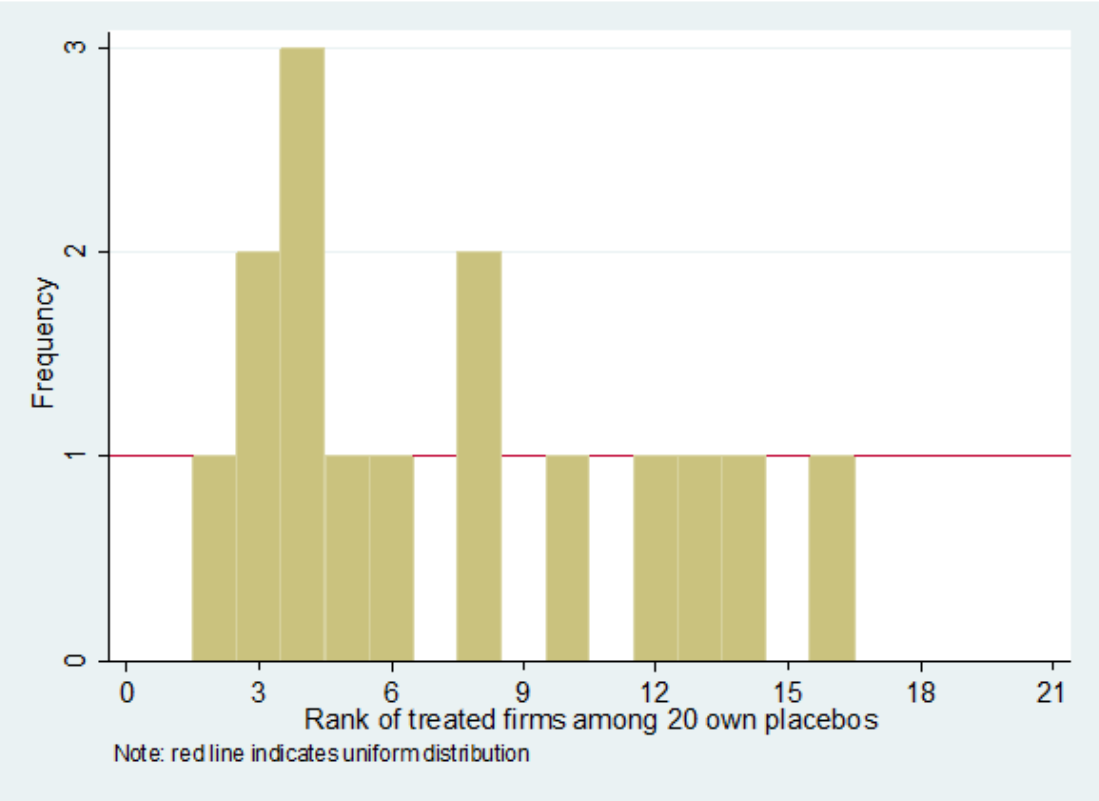
Under the null hypothesis of no treatment effect p_f is distributed uniformly for a single firm.

The sum of uniformly distributed variables $\sum_f p_f$ is distributed according to the Irwin-Hall distribution.

An exact distribution gives precise critical values.

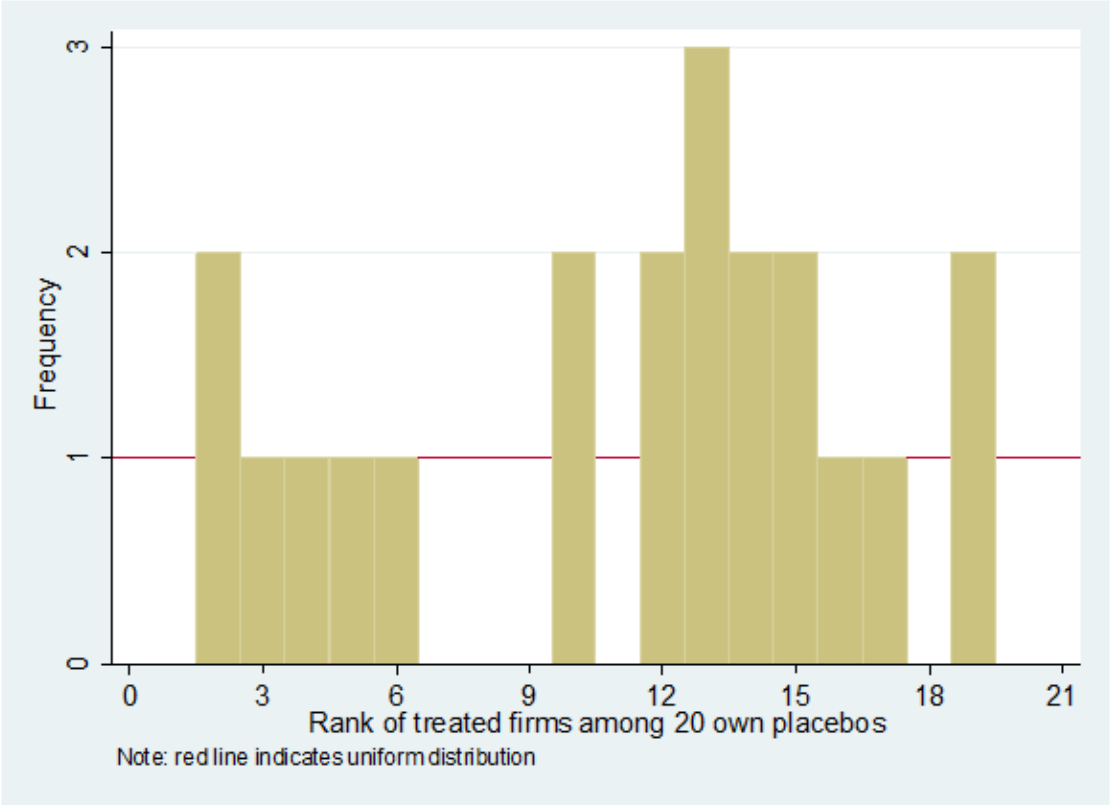
Graphical representation of percentile rank

Clearance times



Distribution of ranks left skewed, treatment effect observed.

Log imports



Distribution of ranks not skewed, no treatment effect.

Effects of IHC on clearance times for each firm, and pooled

IHC Firm #	6-month average reduction in median hours ($\widehat{\beta\_hrs}_j$)	Number of donor firms used for synthetic firm	Rank of IHC firm relative to own 20 placebos	Percentile rank statistic (rank/21)
1	-0.172	13	6	0.286
2	-0.747	11	4	0.190
3	-0.458	9	8	0.381
4	-0.003	10	12	0.571
5	-0.307	10	8	0.381
6	0.093	5	16	0.762
7	-0.083	21	14	0.667
8	-6.730	9	3	0.143
9	-1.875	20	2	0.095
10	-0.051	10	13	0.619
11	-4.322	10	3	0.143
12	-0.471	11	6	0.286
13	-0.077	12	10	0.476
14	-0.675	12	5	0.238
15	-2.046	13	4	0.190
16	-0.102	5	5	0.238
17	-10.297	7	1	0.048
18	-0.138	5	15	0.714
19	16.783	1	19	0.905
20	-0.046	6	10	0.476
21	-0.351	8	3	0.143

	Median estimated 6-month average reduction in median hours = 0.307	Sum of percentile rank test statistic	7.952
	Average estimated 6-month average reduction in median hours = 0.575	Critical value for time reduction (p = 0.05)	8.322
		Critical value for time increase (p = 0.95)	12.678

Note: The critical values shown are from the Irwin-Hall distribution assuming 21 draws from a uniform [0,1] distribution.

Effects of IHC for log imports for each firm, and pooled

IHC Firm #	6-month average increase in log imports ($\widehat{\beta\_imp_j}$)	Number of donor firms used for synthetic firm	Rank of IHC firm relative to own 20 placebos	Percentile rank statistic (rank/21)
1	0.253	9	17	0.810
2	0.099	11	15	0.714
3	0.058	8	12	0.571
4	0.052	7	13	0.619
5	0.184	7	14	0.667
6	0.134	6	13	0.619
7	0.563	10	19	0.905
8	-0.334	7	3	0.143
9	0.340	8	16	0.762
10	-0.385	11	4	0.190
11	0.180	6	15	0.714
12	-0.149	7	6	0.286
13	-0.615	7	2	0.095
14	-0.344	10	5	0.238
15	0.140	7	14	0.667
16	0.742	8	19	0.905
17	-0.016	8	10	0.476
18	0.064	5	12	0.571
19	-0.874	9	2	0.095
20	-0.104	8	10	0.476
21	0.041	9	13	0.619
	Median estimated 6-month average increase in log imports = 0.058		Sum of percentile rank statistics	11.143
	Average estimated 6-month average increase in log imports = 0.004		Critical value for reduction in imports (p = 0.05)	8.322
			Critical value for increase in imports (p = 0.95)	12.678

Note: The critical values shown are from the Irwin-Hall distribution assuming 21 draws from a uniform [0,1] distribution.

Conclusion

- Trade facilitation is an important area of development policy with a dearth of impact evaluation studies
- Although randomization often conflicts with operational goals of the custom agency, high quality administrative data and differential treatment across units offer some advantages for evaluation
- Synthetic control methods seem to be particularly useful in this setting
- We adopt a pooled synthetic control technique to evaluate the impact of the in-house clearance program on clearance times and log imports for firms that adopted the program for imports into Serbia.
- We find that the program reduced median clearance times, but did not affect firm imports during the 6 months following adoption of the program.