Does trade liberalization boost innovation? Evidence from French industrial sectors in the 19th century

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Outline

In a nutshell

The effect of trade openness on innovation

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- Case study: industrial follower (France) *relaxed import tariffs* from a technological leader (England) during the 1860s

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- Case study: industrial follower (France) *relaxed import tariffs* from a technological leader (England) during the 1860s
- *Diff-in-diff* approach
- Treatment: tariff reduction due to the *Cobden-Chevalier Treaty*

Results:

- Positive effect of trade openness on innovation
- Stronger in areas more exposed to competition

Motivation

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- How do *domestic* firms react to increased *international competition*?
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- How do *domestic* firms react to increased *international competition*?
- Coming from a technological *leader* country?
- Because trade-barriers are being *removed*?
- Investment in new technology (innovation)? Or give up?

Earlier works: trade openness on innovation

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- Positive effect
  - China competition on Europe innovation (Bloom et al 2016)
- Negative effect
  - US patents decline after Chinese competition (Dorn et al 2020)

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Most related to my work *(but different)*

- Effect of trade restriction
  - Increasing capacity in mechanized cotton spinning after Napoleonic blockade (Juhász 2018)

Why historical France?

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- Data superiority: especially for regional studies
- Trade openness shock to *technological follower country*

The Cobden-Chevalier Treaty of 1860

Anglo-French trade agreement

- 23 Jan 1860
- Removed trade barriers

Bright, Cobden and Chevalier 1860s

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- 23 Jan 1860
- Removed trade barriers
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- The negotiation was secret
  (French producers against free-trade with UK)

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Outcome variable: innovation

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  - Power use: steam vs old powers (water wind and animal)
  - Sub-industry level data
  - Other such as info as employment and wages
  - 377 districts *(arrondissements)*
  - 82 sub-industries from 16 macro-sectors (textile, iron, chemical etc)

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- French industrial censuses 1843 and 1863
  - Power use: steam vs old powers (water wind and animal)
  - Sub-industry level data
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  - 377 districts *(arrondissements)*
  - 82 sub-industries from 16 macro-sectors (textile, iron, chemical etc)

- Sample restriction (exclusion of)
  - Only one time period (50%)
  - State-owned (0.3%)
  - No power (38%)
    Note: robustness checks!

Outcome variable: innovation

$$Steam\ intensity_{it}\ (outcome) = \frac{steam_{it}}{(steam_{it} + water_{it} + wind_{it} + animal_{it})} \quad (1)$$

- i=1,..1281 where i=sub-sector x district
- t=1843,1863

Defining trade liberalization: treatment

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- The text of the Cobden-Chevalier Treaty
  - Tariff duties
  - Prohibited products
- I matched industrial and (product) tariff data
  - 58 out of 82 sub-sectors involved

$$Treatment(explained): tariff\ \ reduction\ \ or\ \ prohibition\ lifted, yes/no$$

Outline

Strategy

- *Diff-in-diff* approach
- Sample: 1281 local-sub-industries observed both time periods
- Period: 1843 (pre-Treaty) and 1863 (post-Treaty)
- Outcome: steam intensity
- Treatment: trade liberalization (tariff reduction or lifting prohibition) yes/no

Outline

Analysis

(i) Pre-Treaty differences

(ii) Baseline results

(iii) Pseudo pre-trends and post-trends

(iv) Alternative outcome

(v) + Robustness checks (in the Appendix!)

- Alternative treatments
- Propensity score matching
- Restricted sample

(i) Was the Treaty biased?

Table: **Pre-Treaty** differences

	Mean		
Pre-treatment variables	Treated	Control	p>|t|
Steam intensity	**0.37**	**0.44**	**0.369**
Labor productivity	8.19	8.13	0.824
N° of workers	618	409	0.481
Male wage	230	218	0.368
Closeness to coal	0.22	0.21	0.554
Distance from Fresnes	5.89	5.95	0.610
Distance from London	6.16	6.20	0.574
Water yes/no	0.33	0.20	0.124
Closeness to customs	0.29	0.29	0.956

(ii) Baseline result: graphically

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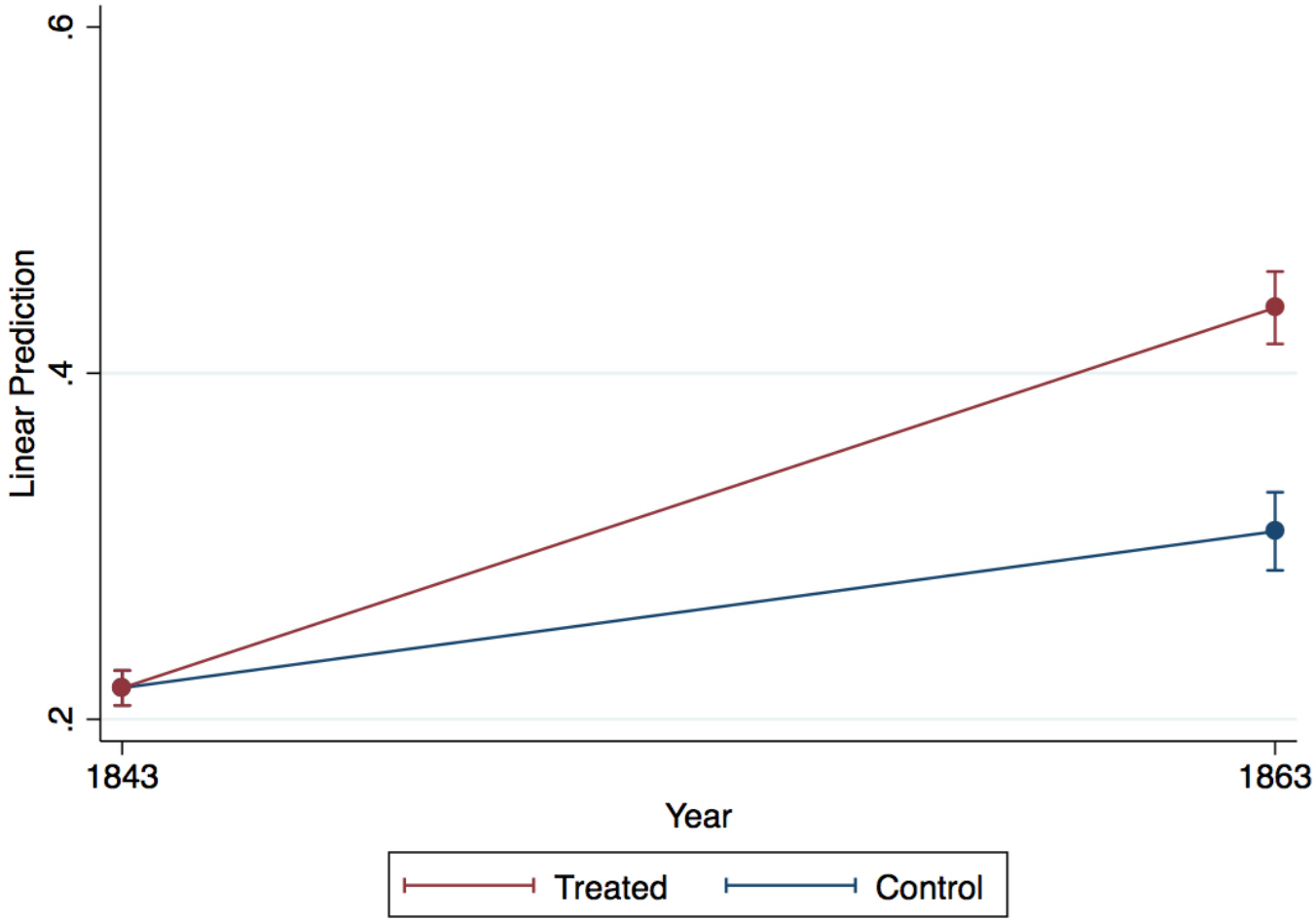
Figure: Steam intensity pre and post trade liberalization



(ii) Baseline results + Pre-Treaty controls

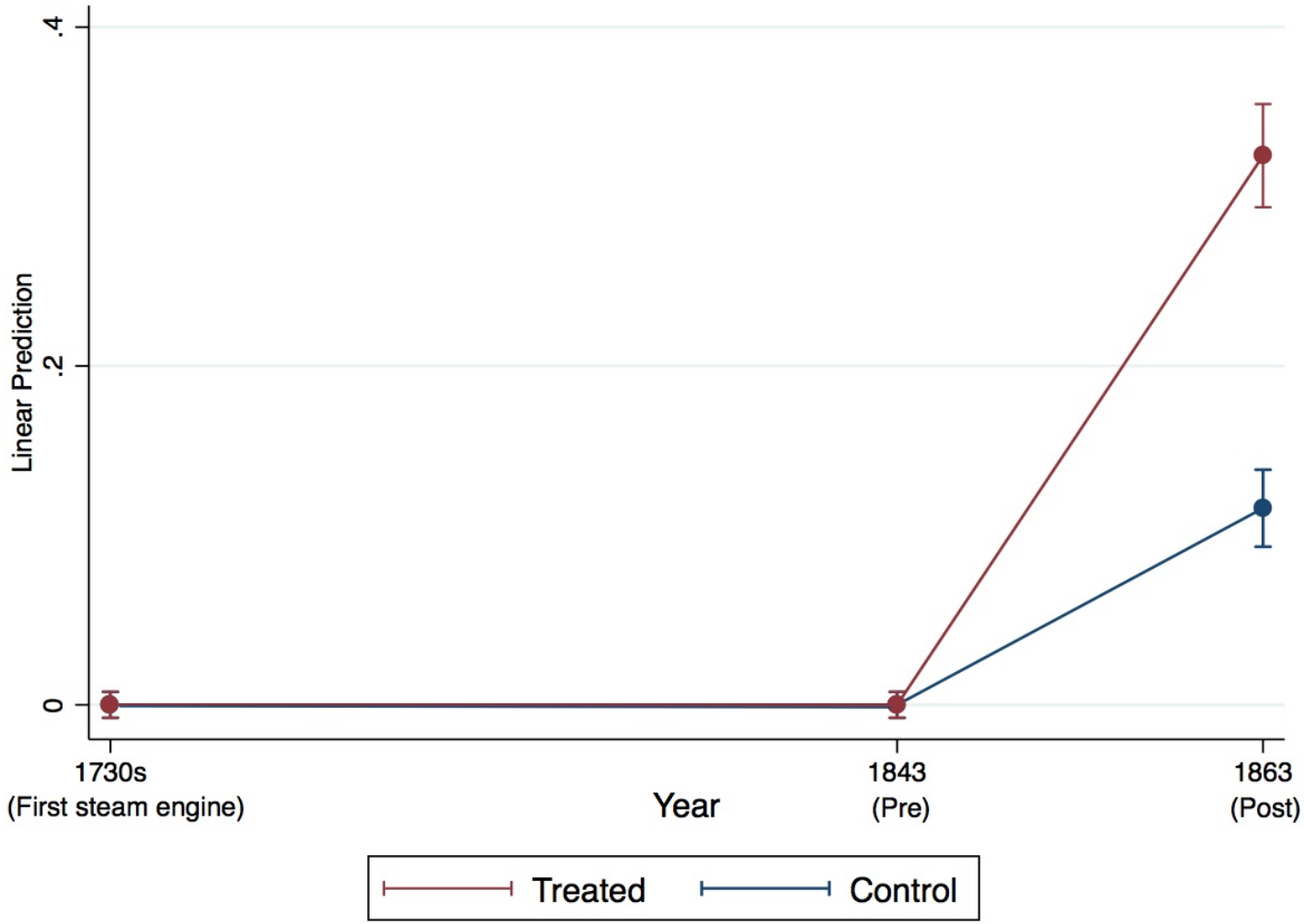
Table: The role of trade liberalization on innovation

	Steam intensity									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade liberalization	**0.129*** **	**0.114*** **	**0.127*** **	**0.128*** **	**0.122*** **	**0.126*** **	**0.124*** **	**0.125*** **	**0.136*** **	**0.103*** **
	(0.0199)	(0.0220)	(0.0206)	(0.0198)	(0.0200)	(0.0197)	(0.0201)	(0.0199)	(0.0199)	(0.0231)
Labor productivity x 1863		-0.0208**								-0.0262***
		(0.00875)								(0.00894)
Male wage x 1863			0.0139							0.00521
			(0.0350)							(0.0369)
Closeness to coal x 1863				0.240***						0.205***
				(0.0679)						(0.0692)
Railways x 1863					0.0874***					0.0618***
					(0.0207)					(0.0227)
Riverways x 1863						0.0661***				0.0470**
						(0.0211)				(0.0233)
Machine sector in dep x 1863							0.110			0.0946
							(0.0716)			(0.0737)
Closeness to custom x 1863								0.108*		0.0657
								(0.0617)		(0.0675)
Only water powered x 1863									0.0663***	0.0934***
									(0.0200)	(0.0200)
r2	0.191	0.195	0.191	0.199	0.202	0.198	0.193	0.194	0.197	0.226
N	2562	2562	2562	2562	2562	2562	2562	2562	2562	2562

* p<0.05, ** p<0.01, *** p<0.001
Clustered standard errors in parentheses. Pre-treaty controls are equal to zero if year=1843. *Time* and *local-sub-industry* fixed effects are included.

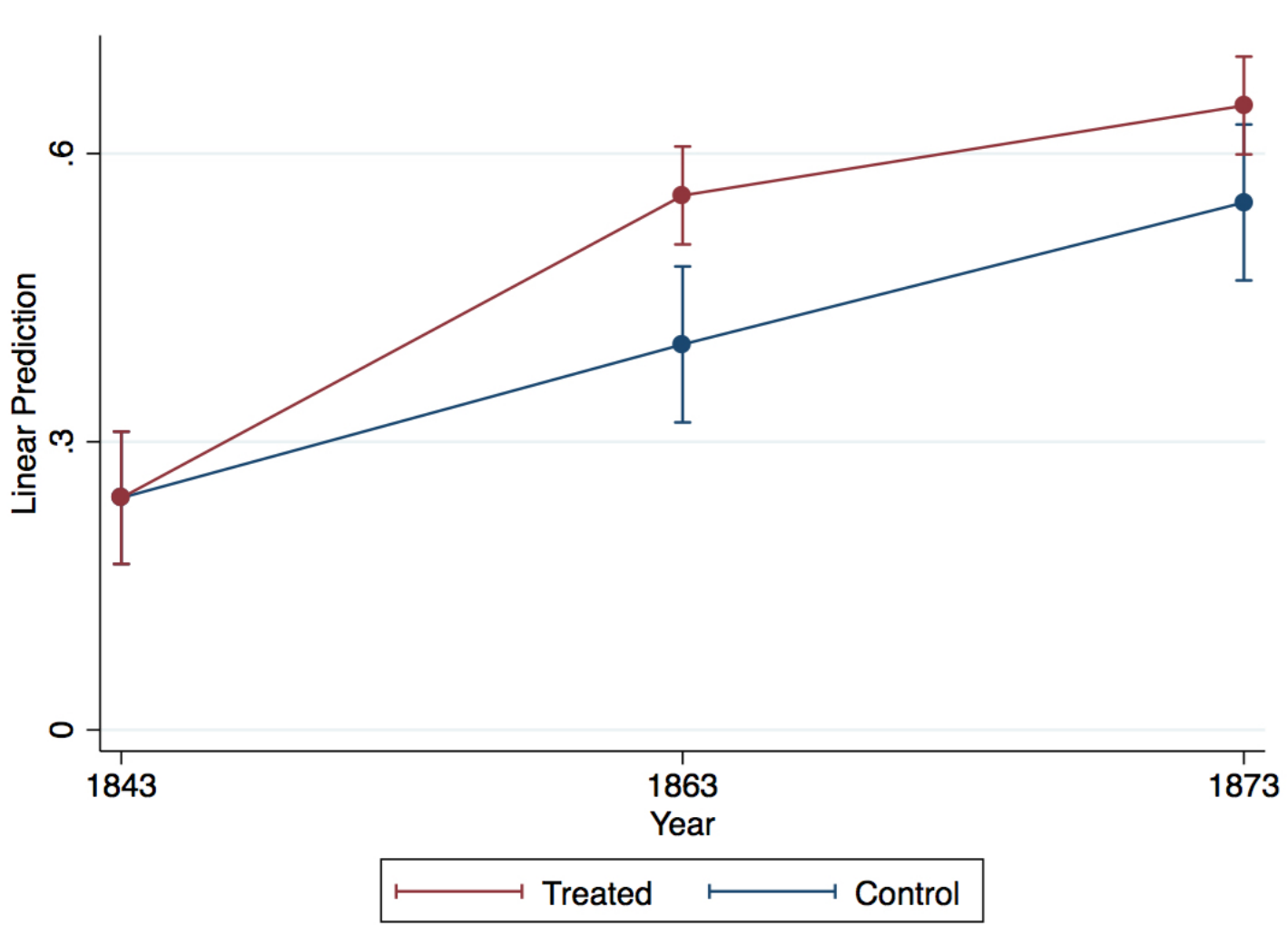
(iii) *Pseudo* pre-trends

Figure: Steam intensity pre and post trade liberalization: no-steam in 1843



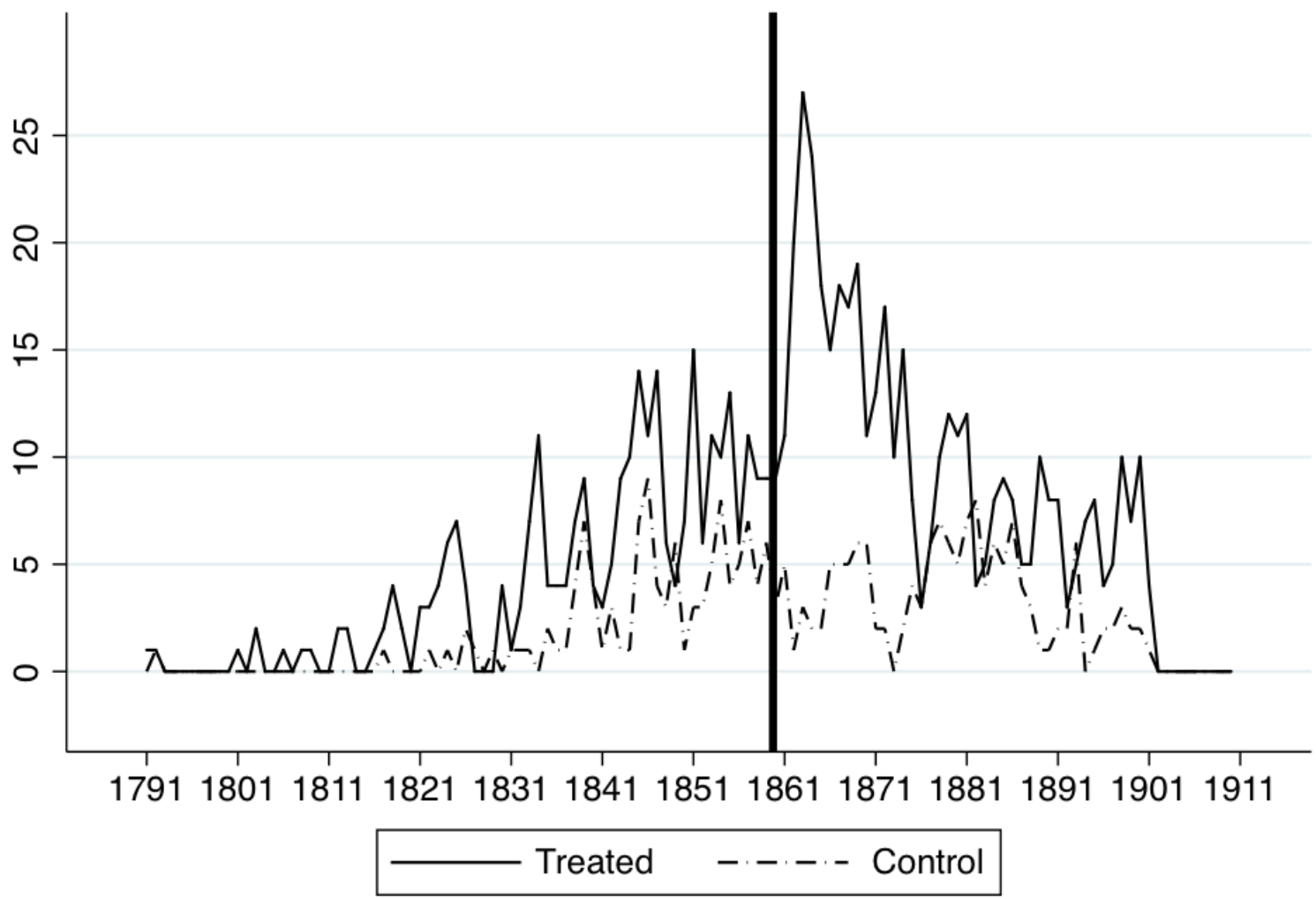
(iii) Post-trends

Figure: Steam intensity pre and post trade liberalization: two post periods



(iv) Alternative outcome: Patents

Figure: N of patents in cotton (Treated) and flour mills (Control) 1791-1910



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The mechanism

- Producers *increase (fast)* the use of new technology
- *to face* the *potential* reduction of domestic demand
- *caused by* the increasing foreign-competition

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- Railways
- Closeness to London

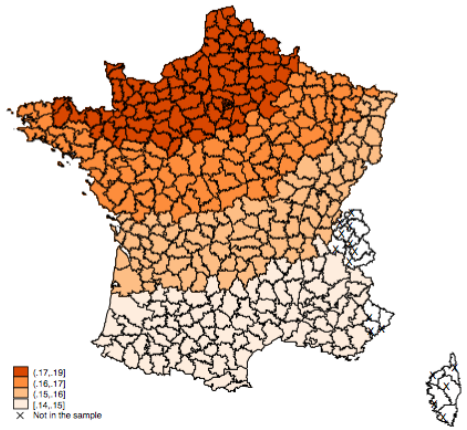

Table: Trade liberalization interacted with exposition to trade

	Steam intensity			
	(1)	(2)	(3)	(4)
Effect × railways (yes)	**0.0981*** **	**0.0655** **		
	(0.0308)	(0.0331)		
Effect × closeness to London			**3.052** **	**2.901** **
			(1.329)	(1.374)
			*0.0834***	*0.0793***
Effect	0.0628**	0.0629**	-0.331	-0.333
	(0.0283)	(0.0317)	(0.201)	(0.208)
Controls x 1863	no	yes	no	yes
r2	0.199	0.226	0.195	0.229
N	2562	2562	2562	2562

* p<0.05, ** p<0.01, *** p<0.001
Clustered standard errors in parentheses;*fixed effect* included.Standardized coeff in Italics.

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Preliminary findings

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- Trade liberalization had a *positive* and *profound* (up to 60%) effect on technical change
  - *Probably* response to increased *foreign competition*
  - *More* exposed to competition *more* steam technology

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  - Key to the contrasting: outcome?

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  - *Probably* response to increased *foreign competition*
  - *More* exposed to competition *more* steam technology

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  - Key to the contrasting: outcome?

- Differently from Juhász (2018) that focuses on *infant* industries, my work speaks to *all industries*

Thank you!

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Outline

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Outline

Unbalance panel

Table: The role of trade liberalization on innovation

	Steam intensity									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade liberalization	0.131***	0.115***	0.129***	0.130***	0.124***	0.127***	0.125***	0.126***	0.137***	0.105***
	(0.0199)	(0.0220)	(0.0206)	(0.0198)	(0.0200)	(0.0197)	(0.0201)	(0.0200)	(0.0200)	(0.0231)
Labor productivity x 1863		-0.0207**								-0.0258***
		(0.00875)								(0.00893)
Male wage x 1863			0.0129							0.00327
			(0.0350)							(0.0369)
Closeness to coal x 1863				0.232***						0.196***
				(0.0683)						(0.0696)
Railways x 1863					0.0884***					0.0634***
					(0.0207)					(0.0226)
Riverways x 1863						0.0663***				0.0463**
						(0.0212)				(0.0233)
Machine sector in department x 1863							0.109			0.0928
							(0.0716)			(0.0736)
Closeness to custom x 1863								0.109*		0.0644
								(0.0619)		(0.0677)
Only water powered x 1863									0.0629***	0.0898***
									(0.0200)	(0.0200)
r2	0.193	0.197	0.193	0.201	0.204	0.200	0.195	0.196	0.199	0.227
N	5458	5458	5458	5458	5458	5458	5458	5458	5458	5458

* p<0.05, ** p<0.01, *** p<0.001

Clustered standard errors in parentheses. Pre-treaty controls are equal to zero if year=1843. *Time* and *local-sub-industry* fixed effects are included.

Including no power

Table: The role of trade liberalization on innovation: including no power

	Steam intensity			
	Balance		Unbalance	
	(1)	(2)	(3)	(4)
Trade liberalization	0.0511***	0.0320**	0.0511***	0.0320**
	(0.0156)	(0.0162)	(0.0156)	(0.0162)
Controls x 1863	no	yes	no	yes
r2	0.137	0.187	0.137	0.187
N	5174	5174	10012	6392

* p<0.05, ** p<0.01, *** p<0.001.
Clustered standard errors in parentheses. *Time* and *local-sub-industry* fixed effects are included.

(v) Alternative treatment

Alternative *treatment* variables:

- Prohibited y/n
- Tariff reduction (continuous diff-in-diff) where

$$Tariff\ \ reduction = \frac{Tariff_{1860} - Tariff_{1859}}{Tariff_{1859}} x(-1) \tag{2}$$

Table: The role of trade liberalization on innovation

	Steam intensity				Only textile	
	(1)	(2)	(3)	(4)	(5)	(6)
Trade liberalization:						
Prohibited y/n	0.141***	0.112***				
	(0.0212)	(0.0250)				
Tariff reduction			0.157***	0.125***	0.248**	0.245**
			(0.0251)	(0.0290)	(0.124)	(0.122)
			*0.145****	*0.116****	*0.229***	*0.226**
Controls x 1863	no	yes	no	yes	no	yes
r2	0.204	0.241	0.188	0.222	0.244	0.366
N	2180	2180	2487	2487	484	484

* p<0.05, ** p<0.01, *** p<0.001
Clustered standard errors in parentheses;*fixed effect* included.Standardized coeff in Italics.

Table: Likelihood of disappear or appear by trade liberalization

	Disappeared after 1843 y/n		Appeared in 1863 y/n	
	(1)	(2)	(3)	(4)
Trade liberalization	**0.531*** **	**0.440*** **	**-0.0857**	**-0.221*** **
	(0.114)	(0.117)	(0.0607)	(0.0646)
	[0.145]	[0.117]	[-0.0294]	[-0.0738]
Controls x 1863	no	yes	no	yes
Pseudo R2	0.131	0.150	0.131	0.152
N	1899	1884	3538	3526

* p<0.05, ** p<0.01, *** p<0.001. Probit model
Clustered standard errors in parentheses. dy/dx in square brackets. *Time* and *local-sub-industry* fixed effects are included.

Alternative controls

	Steam intensity									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade liberalization	0.129***	0.114***	0.127***	0.126***	0.122***	0.126***	0.123***	0.125***	0.136***	0.0986***
	(0.0199)	(0.0220)	(0.0206)	(0.0200)	(0.0200)	(0.0197)	(0.0205)	(0.0199)	(0.0199)	(0.0237)
Δ Banks x 1863	0.00636									0.00439
	(0.0147)									(0.0149)
Labor productivity x 1863		-0.0208**								-0.0285***
		(0.00875)								(0.00913)
Male wage x 1863			0.0139							-0.000925
			(0.0350)							(0.0374)
Δ Coal x 1863				-0.0503*						-0.0271
				(0.0289)						(0.0303)
Railways x 1863					0.0874***					0.0772***
					(0.0207)					(0.0235)
Riverways x 1863						0.0661***				0.0442*
						(0.0211)				(0.0240)
Secondary school/Surface x 1863							0.387			0.360
							(0.280)			(0.305)
Closeness to custom x 1863								0.108*		0.0342
								(0.0617)		(0.0698)
Only water powered x 1863									0.0663***	0.0888***
									(0.0200)	(0.0206)
Constant	0.218***	0.218***	0.218***	0.219***	0.218***	0.218***	0.216***	0.218***	0.218***	0.216***
	(0.00515)	(0.00514)	(0.00515)	(0.00515)	(0.00512)	(0.00513)	(0.00513)	(0.00514)	(0.00513)	(0.00505)
r2	0.191	0.195	0.191	0.194	0.202	0.198	0.191	0.194	0.197	0.221
N	2562	2562	2562	2554	2562	2562	2513	2562	2562	2505

* p<0.05, ** p<0.01, *** p<0.001

Clustered standard errors in parentheses. Pre-treaty controls are equal to zero if year=1843. *Time* and *local-sub-industry* fixed effects are included.

Splitted

Steam was very uncommon in 1843, so I split the sample:

- No-steam 1843 (63%) → "New-entry in tech"
- Already-steam in 1843 (37%) → "Continuous in tech"

Table: The role of trade liberalization on innovation

	Steam intensity								
	Full sample			No steam in 1843			Steam in 1843		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Trade liberalization	**0.129*** **	**0.103*** **	**0.0808*** **	**0.208*** **	**0.113*** **	**0.154*** **	**0.0677***	**0.0797*** **	**0.122*** **
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)
Controls x 1863	no	yes	yes	no	yes	yes	no	yes	yes
Matched	no	no	yes	no	no	yes	no	no	yes
r2	0.191	0.226	0.205	0.362	0.465	0.429	0.0354	0.0541	0.0269
N	2562	2562	2104	1606	1606	1202	956	956	886

* p<0.05, ** p<0.01, *** p<0.001. Clustered standard errors in parentheses
Pre-treaty controls (as Table 2) are equal to zero if year=1843. *Time* and *local-sub-industry* fixed effects are included.
Propensity score matching using Nearest-neighbour matching procedure (kernel matching in appendix).

Including nopower

	(1) intensity	(2) intensity	(3) intensity	(4) intensity
effect=1	-0.0780***	-0.0839***	-0.0771***	-0.0753***
	(0.0126)	(0.0142)	(0.0125)	(0.0126)
effect=1 × power=1	0.189***	0.193***	0.185***	0.186***
	(0.0156)	(0.0161)	(0.0158)	(0.0156)
r2	0.325	0.326	0.326	0.331
N	5158	5158	5158	5158

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.010

Full table pre-treatment Control and treated

Table: Differences in mean between Treated and Controls before treament

Pre-treatment variables	Mean		
	Treated	Control	p>|t|
Steam intensity	0.37	0.44	0.369
Steam machines	1.61	2.07	0.430
Labor productivity	8.19	8.13	0.824
Value of production	2200000	1500000	0.468
N° of workers	617.76	408.81	0.481
N° of male workers	339.28	235.56	0.444
N° female workers	204.48	100.29	0.460
N° child workers	74.00	72.96	0.979
Male wage	229.90	218.19	0.368
Female wage	101.99	99.53	0.685
Child wage	51.05	45.85	0.436
Closeness to coal	0.22	0.21	0.554
Coastline	0.21	0.18	0.630
Railways	0.72	0.72	0.989
Population density	133.02	123.18	0.713
Rivers	0.54	0.55	0.852
Machine sector in the department	0.02	0.00	0.538
Distance from Fresnes	5.89	5.95	0.610
Closeness to customs	0.29	0.29	0.956
Water yes/no	0.33	0.20	0.124
Distance from London	6.16	6.20	0.574

Results 1 standardized coeff

Table: The role of trade liberalization on innovation

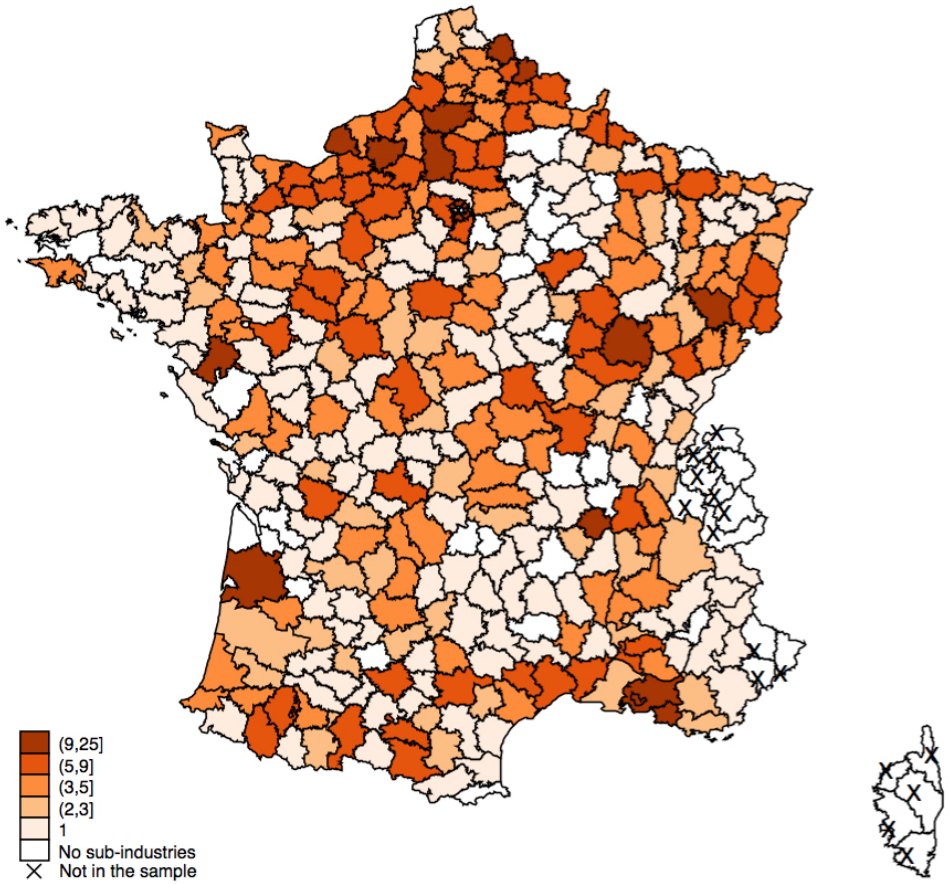
	Steam intensity									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Trade liberalization	0.326***	0.283***	0.321***	0.323***	0.310***	0.319***	0.312***	0.317***	0.345***	0.260***
	(0.0519)	(0.0571)	(0.0538)	(0.0518)	(0.0521)	(0.0516)	(0.0525)	(0.0522)	(0.0520)	(0.0600)
*b*Labor productivity		-0.244**								-0.297***
		(0.0969)								(0.0995)
*b*Male wage			0.0907							0.0389
			(0.240)							(0.254)
*b*Closeness to coal				0.0906***						0.0734***
				(0.0273)						(0.0278)
Railways					0.226***					0.167***
					(0.0543)					(0.0599)
Riverways						0.158***				0.113*
						(0.0554)				(0.0611)
Machine sector in department							0.297			0.254
							(0.193)			(0.197)
*b*Closeness to custom								0.0369		0.0196
								(0.0278)		(0.0303)
Only water powered									0.170***	0.232***
									(0.0523)	(0.0523)
r2	0.192	0.195	0.192	0.199	0.202	0.197	0.194	0.193	0.198	0.225
N	2498	2498	2498	2498	2498	2498	2498	2498	2498	2498

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.010

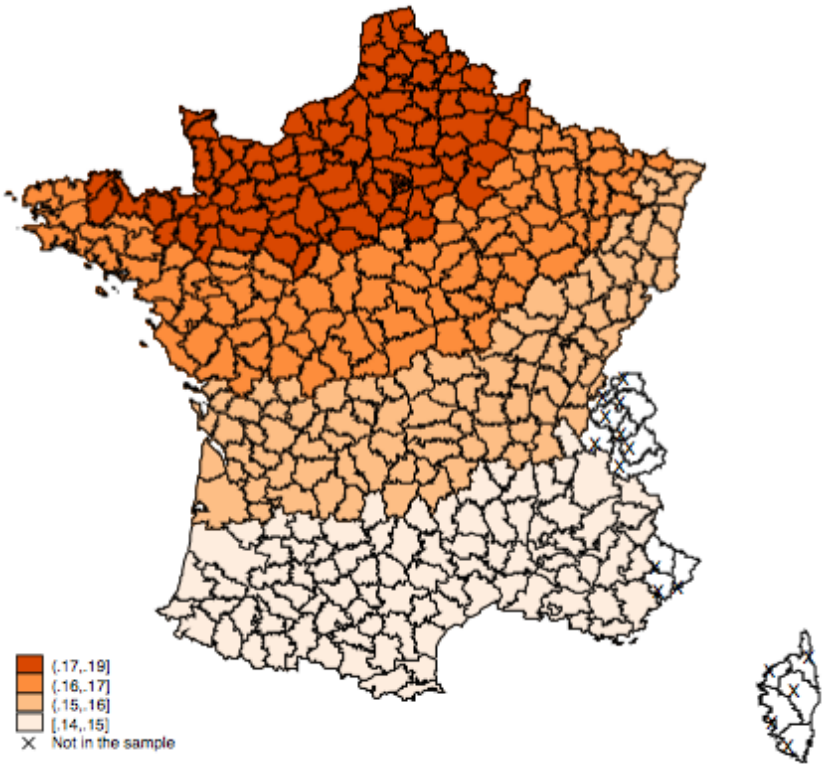
Industrial data

Figure: Number of sub-sectors by district



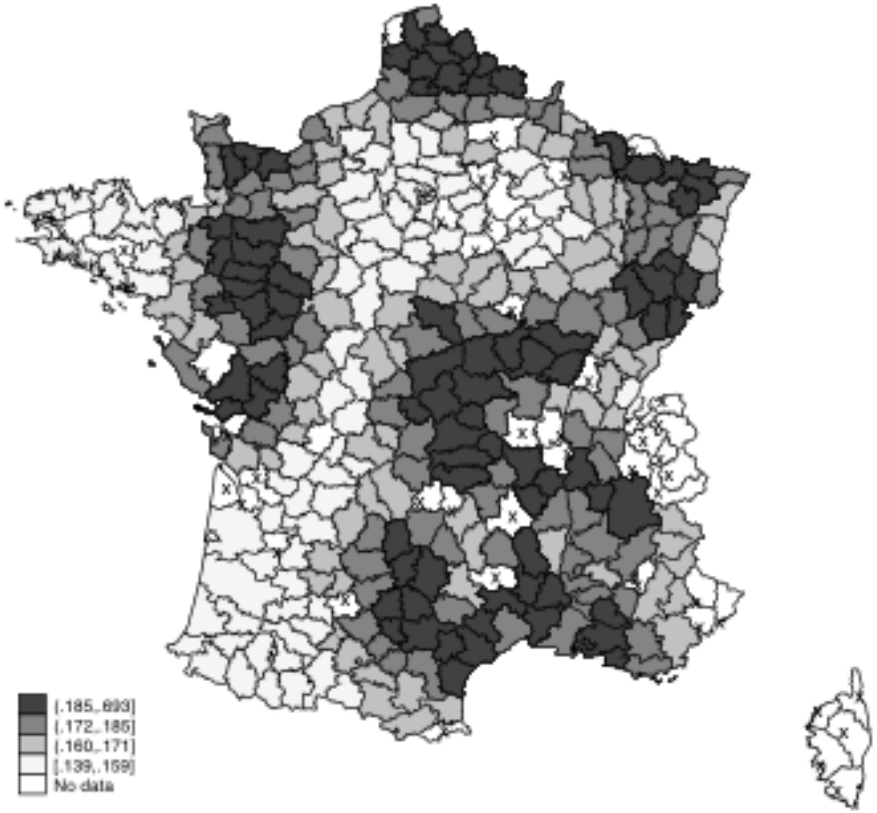
Maps

Figure: Closeness to London



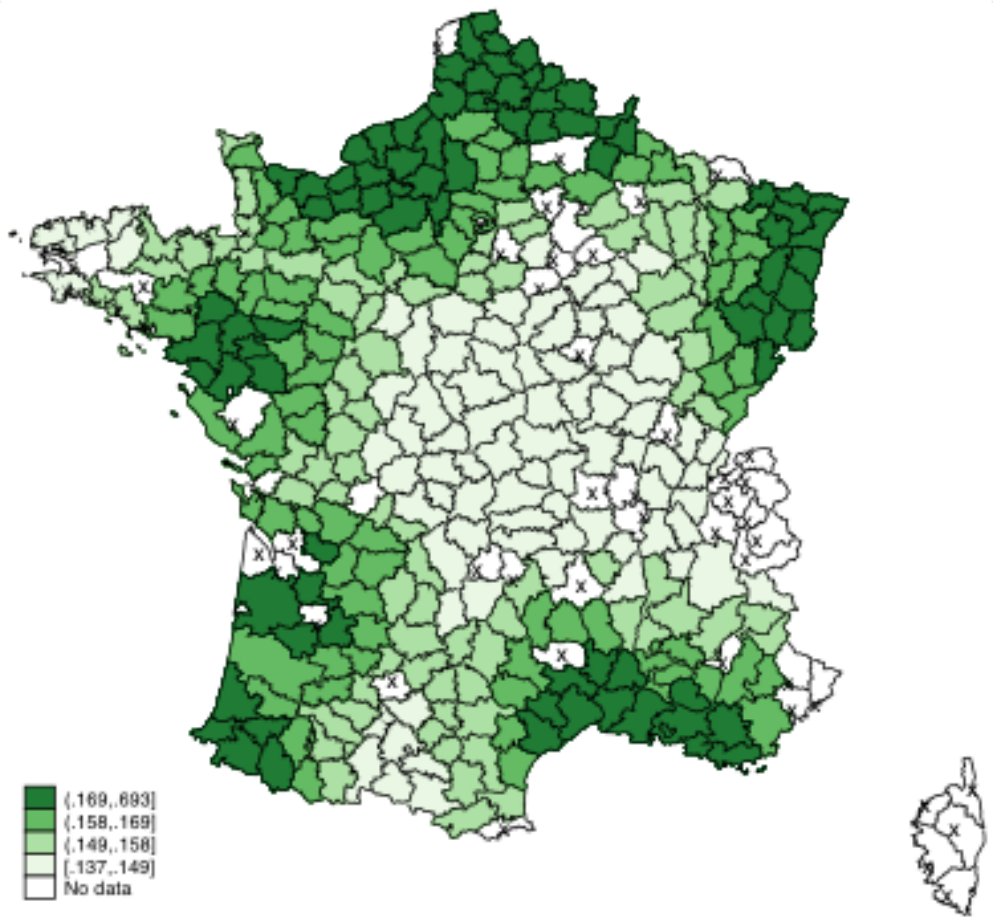
Maps

Figure: Closeness to Coal



Maps

Figure: Closeness to Customs



The model

$$Y_{it} = \alpha_i + \delta_t + Treated_i * Post_t + \epsilon_{it} \quad (3)$$

where:

- Y_{it} steam intensity in local-sub-industry i
- α_i local-sub-industry *fixed effect*
- δ_t time shock
- $Post_t\, Treated_i$ is the diff-in-diff coeff

Summary statistics

Summary statistics

Summary statistics

Variable	Mean	Std	Min	Max
Treated yes/no	0.60	0.49	0	1
Steam intensity 1843	0.22	0.35	0	1
Steam intensity 1863	0.39	0.41	0	1
Number of male workers 1843	296	873	1	15411
Number of female workers 1843	124	685	0	18000
Number of child workers 1843	66	252	0	4926
Male daily wage (centimes) 1843	201	68	70	650
Value of production 1843 in Francs	2191831	5013760	900	63800000
Tariff reduction	0.45	0.40	0	1
Railway yes/no	0.64	0.48	0	1
River way yes/no	0.42	0.49	0	1
Machine sector yes/no	0.03	0.17	0	1
Only water powered in 1843 yes/no	0.38	0.48	0	1
Distance from London (Km)	546	237	176	1038
Distance from customs (Km)	111	78	0	330
Distance from coal (Km)	84	57	0	296

Outline

Did trade liberalization start *before* the Treaty of 1860?

Did trade liberalization start *before* the Treaty of 1860?

- Tariff rates started to decrease in 1850 (Accominotti et al 2008)
- *But* not in manufactured product (Lampe 2009)
- Trade liberalization in 1850 *but* very high in 1860 (Tena-Junguito et al 2012)

$=>$ *Spoiler* : Data on manufacturing and 1843 as pre-Treaty

French industrialization

- Traditional view: Incomplete industrialization (Clapham 1921)

French industrialization

- Traditional view: Incomplete industrialization (Clapham 1921)
- Revisionist view: *different* but not so inferior to Britain (Crouzet 2003)
  - Natural resources (lack of coal)
  - Labor market (low wage)
  - Trade policies

French trade policies in 19th