Networks of Change: Infrastructure and the Spread of Steam Power in 19th-Century France

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Topic

Topic/i

Aims

The paper revisits France's industrialisation by analysing the spatial diffusion of steam power across departments (1840-1911), showing how transport infrastructure shaped regional adoption dynamics.

Motivations

- Steam engines as transformative GPT: UK/US diffusion is well studied → France remains under-explored, especially spatially.
- New panel dataset (1840–1910) at the department-year level
- 1840–1911: simultaneous rise of industrialisation and the expansion of canals and railways → France as a natural laboratory of shifting transport networks.
- Transport infrastructure shapes diffusion through market access and knowledge flows → mixed existing evidence.

Core findings

- Intense spatial heterogeneity in regional steam adoption
- Railways **systematically intensified** the adoption of steam engines in the department over time
- Navigable **canals** mattered *later on* (1880-1900)
- Complex relationship between rail- and waterways: *substitution* effects evident when considering the density in the departments over time

\+ Knowledge accessibility strongly predicts diffusion patterns

Background/i

French industrialisation: a different perspective

- Long decline (Grantham 1997); "*retardation-stagnation*", incomplete modernisation (Crouzet 2003)
- Different paths to prosperity, respectable but not brilliant (Crafts 1984; Crouzet 1974)

→ All previous analyses were carried out at the national level → this paper introduced a regional perspective

Steam engine diffusion: existing studies

- Steam engine diffusion & factor prices, resource endowment, power sources, institutions (USA: Atack et al. 1980, UK: Von Tunzelmann 1978; Nuvolari et al. 2011, Bel+Nl: Lintsen 1991, Swe: Berger and Ostermeyer 2025)
- For France, new study on time and spatial patterns, distance-decay (Le Chapelain and Wilke 2025) → panel used in this article

Background/ii

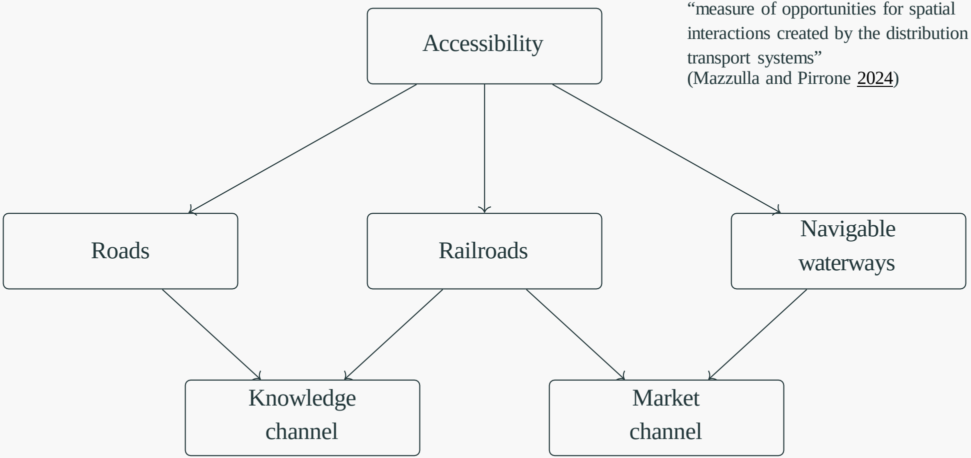
Why study the relation between infrastructure development and the diffusion of steam engines?

Infrastructure development & innovation diffusion

- **Railroads:** generally positive effects on technology adoption and innovative activity (Yamasaki 2025; Alvarez-Palau et al. 2025; Américo 2024; Komikado et al. 2021; Andersson et al. 2023; Tsiachtsiras 2025)
  - Channels: lower transport costs; improved market access; knowledge diffusion
  - But: quality of innovation sometimes limited (Martinez et al. 2025)
- **Waterways (canals, rivers):** more debated (Sokoloff 1988; Crompton 1993; Bogart et al. 2017; Rosevear et al. 2024)
  - Evidence of strong pre-rail contribution to industrialisation (Deane 1965)
  - Others: canals as stopgaps or highly localised; limits for market reach (Flinn 1984; Freeman 1984; Langton 1984)
  - Complementarity or substitution with railways (Beyer and Verhaeghe 2014; Mauret-Cribellier and León 2005)
- **Overall:** access to markets and access to knowledge are key mechanisms

→ No study links infrastructure to steam adoption in France (Closest: Tsiachtsiras 2025 on innovation creation, not adoption)

Proposed mechanisms: Knowledge and Market access



"measure of opportunities for spatial interactions created by the distribution of transport systems"
(Mazzulla and Pirrone 2024)

Grande écoles type "Ingénieur" → technical knowledge
Role of the *Corps des Mines*
(Jacqmin 1870; Mazzulla and Pirrone 2024; Komikado et al. 2021)

Coal supply

Data & Methods

Data I

1. Steam engines' panel (1840-1910):

- *Compte rendu des travaux des ingénieurs des mines* (1840-1847)
- *Statistique de l'industrie minérale et des appareils à vapeur* (1847-1910)

NB: *stationary* steam engines employed in *industries* + **department**-level data

Info on: No. machines, No. firms employing them, No. HP employed

+ robustness check with data from *Enquêtes industrielles* (1840-1847 & 1860-65) with **arrondissement**-level data: number of engines (1840-1847) and steam power installed (1860-1865)

Data II

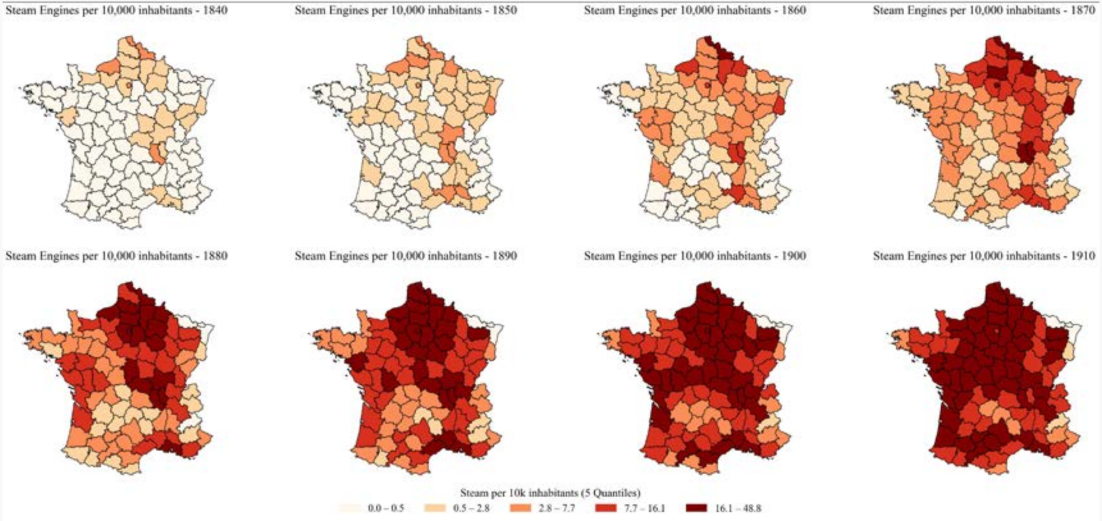


Figure 1: Steam engines per 10k inhabitants for selected years - own elaborations on steam engines' panel and census data (interpolation), map of 1870's departments from Gay 2020

2. COMMUNES project data

- First municipal-level historical GIS for France
- Commune boundaries changes + multi-modal transport network (rail- and waterways)

We got:

- Rail station GIS (opening, closing)
- Rail lines GIS (opening, closing, speed)
- Water lines GIS (navigable, type, service year)
- Ports coordinates (Litvine)

Data IV

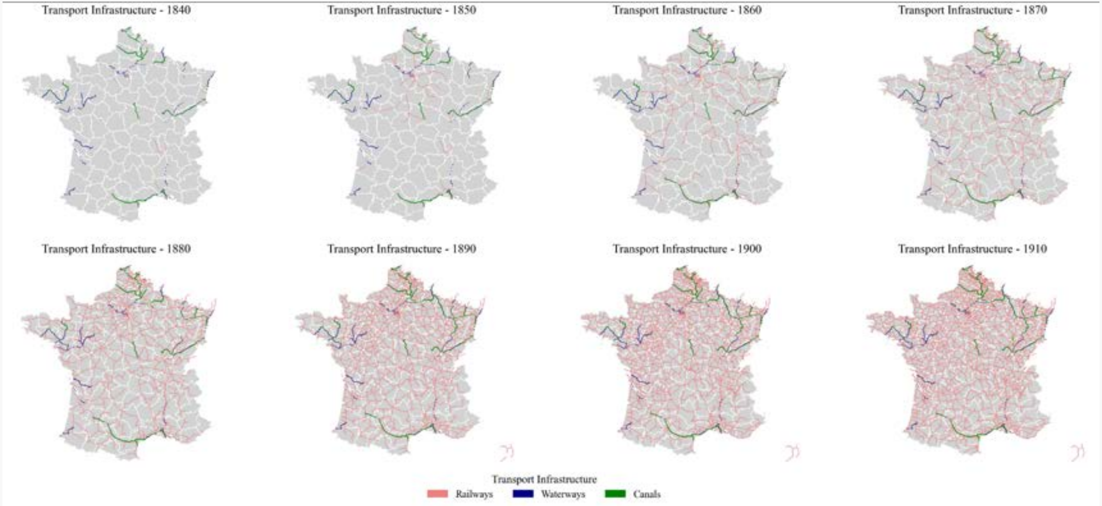


Figure 2: Transport infrastructure's development (railways and navigable waterways) for selected years - own elaborations on COMMUNES data, map of 1870's departments from Gay 2020

Data V

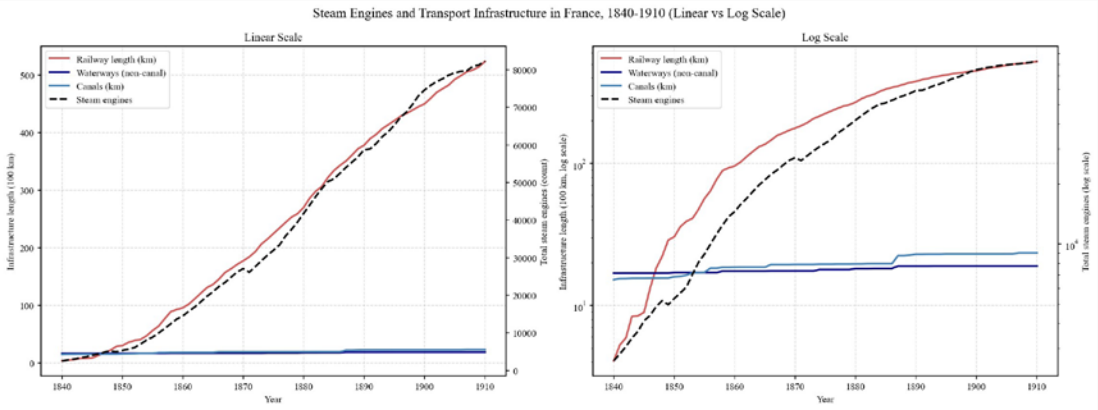


Figure 3: Railways, waterways, and steam engines' diffusion (1840-1910) - own elaborations on steam engines' panel and COMMUNES data

Data VI

3. Miscellaneous

- Population: *Annuaires Statistique de la France* then *Annuaire Statistique* from 1900 for census years (log-linear interpolation of gap years)
- Mines & coal areas: Litvine and Fernihough and O'Rourke 2021
- Grandes écoles - type 'Ing': website *Conférence des Grandes Ecoles* (date of creation, website, coordinates)

Methods/i - Two-Step Analysis

1. **Characterization of steam engine diffusion:**
   Analysis using diffusion curves (Logistic and Gompertz models)
2. **Impact of infrastructure development on diffusion:**
   Panel regression model:

$$
\begin{aligned}
\text{SteamEnginesPC}_{d,t} = \; & \underbrace{\beta_1(\text{RailStock}_{d,t-1} \cdot t)}_{\text{Km of rail line over time (100 km units)}} + \underbrace{\beta_2(\text{WaterwayStock}_{d,t-1} \cdot t)}_{\text{Km of water line over time (100 km units)}} + \\
& \underbrace{\beta_3(\text{RailStock}_{d,t-1} \cdot \text{WaterwayStock}_{d,t-1} \cdot t)}_{\text{Complementarity/substitution over time}} + \\
& + \beta_4 \text{RailDensity}_{d,t-1} + \beta_5 \text{WaterwayDensity}_{d,t-1} \\
& + \beta_6 \text{CitiesWithStations}_{d,t-1} + \beta_7 \text{CitiesWithPorts}_{d,t-1} \\
& + \beta_8 \ln(\text{pop}_{d,t-1}) + \gamma_t + \lambda_d + \epsilon_{d,t}
\end{aligned}
\quad (1)
$$

∗Lagged variables to avoid simultaneity (used also lags of 2, 5 and 7 y.)
∗Clustered std.err. (by department)
Period of estimation: 1850-1910

Methods/ii - The Endogeneity Issue

$$\text{SteamEnginesPC}_{d,t} = \beta_1 \text{Rail}_{d,t} + \text{etc.} + \gamma_t + \lambda_d + \epsilon \tag{2}$$

would capture:

- Rail development → engine adoption, **and**
- earlier engine adoption / industrialization → more infrastructure (*reverse effect*)

Our solution:

Straight-line connections instrument between cities and ports

(Tsiachtsiras 2025; Banerjee et al., 2020; Hodgson, 2018; Kats, 2018; Perlman, 2016; Atack et al., 2008)

Plan	Period	Objective
Legrand plan	1840–1860	Connect Paris to major cities (regional centres) and cities with port access
Migneret law	1865	Link all departmental seats (prefectures) to regional centres and ports
Freycinet plan	1878	Connect each sub-prefecture to its nearest point on the straight-line network

Diffusion Dynamics across French Departments

Diffusion dynamics: main take-aways

Regional heterogeneity in steam power adoption

- France: rate of adoption growth of 7.57% and *take-off* year in 1848, BUT **strong variation** in diffusion patterns across departments:
  - Late adopters: southern and rural departments on the West-side.
  - Adoption speeds varied significantly (e.g. 10–90% saturation: 13 to 70+ years).

Infrastructure and the Geography of Diffusion

- Early-connected departments (e.g., Seine, Rhône, Vaucluse, Marne) → faster adoption.
- Western departments and poorly connected areas → delayed adoption.
- Take-off year on average 7y after first 100km of rail installed

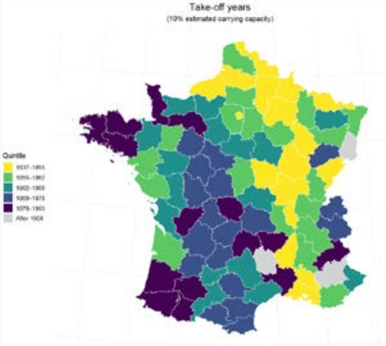


Figure 4: Take off years across departments - own elaborations on steam engines panel, map of 1870's departments from Gay 2020

Role of Infrastructure in Steam Engine Adoption

Role of Infrastructure in Steam Engine Adoption - year-specific results

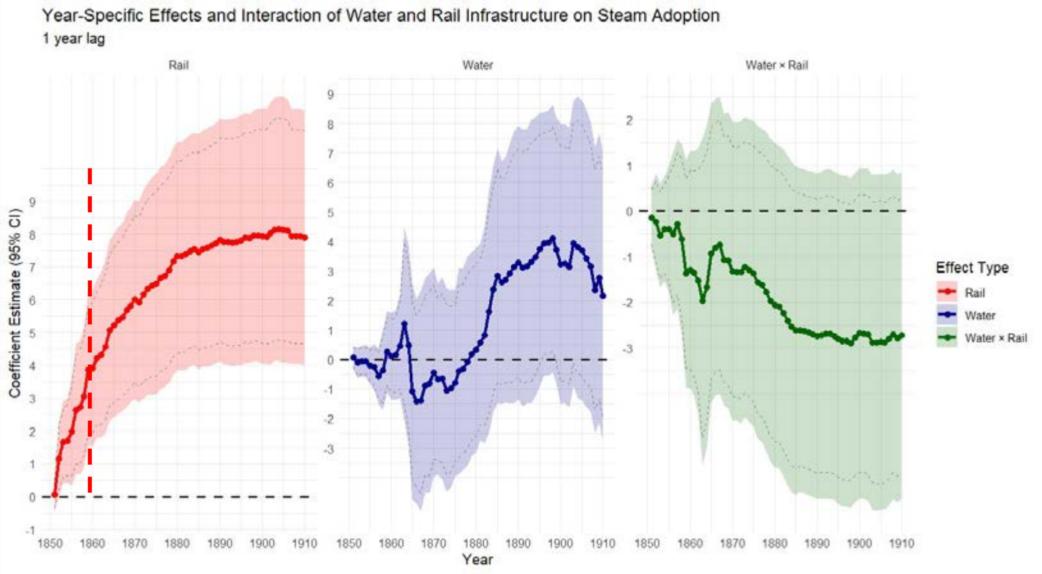


Figure 5: Preliminary but robust results of year specific effects of Rail (100 km u.), Waterways (100 km u.) and their interaction (1y lag) - own estimation on panel and COMMUNES data, overall effects in Appendix, naive estimation (no instrument), clustered std.err. (dep-level)

But if we use only navigable canals...

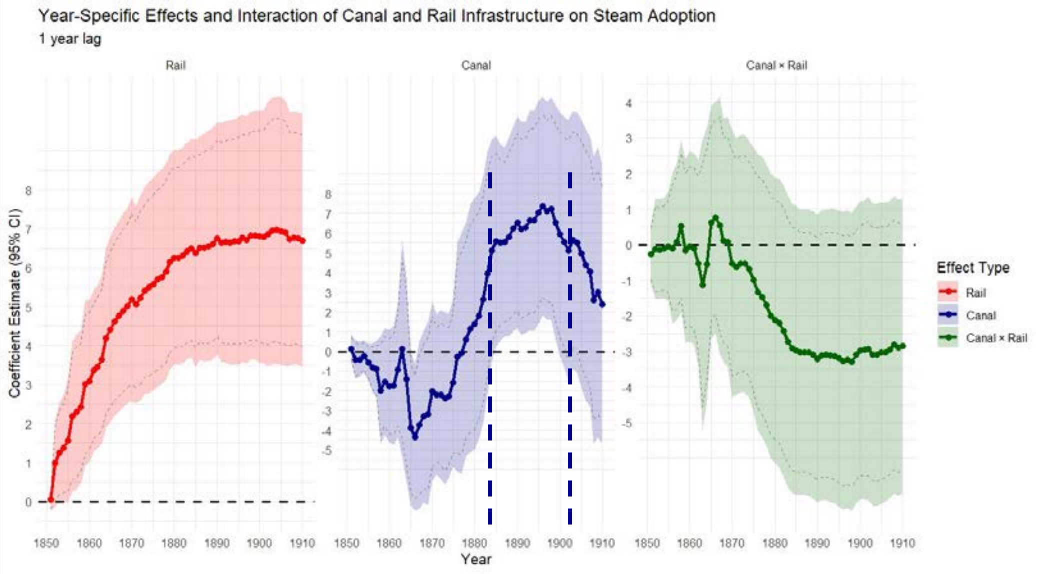


Figure 6: Preliminary but robust results of year specific effects of Rail (100 km u.), Canals (100 km u.) and their interaction (1y lag) - own estimation on panel and COMMUNES data, overall effects in Appendix, naive estimation (no instrument), clustered std.err. (dep-level)

Mechanisms

Knowledge channel

From a commune-level perspective:

$$\text{Access}_{i,t} = \begin{cases} \dfrac{d_{i,g}}{v_w}, & \text{if no rail path to } g, \\ \min\left(\dfrac{d_{i,g}}{v_w}, \dfrac{d_{i,s}}{v_w} + \text{RailTime}_{s\to g}\right), & \text{otherwise.} \end{cases} \quad (3)$$

To a department-level, year-normalised score:

$$\text{Accessibility}_{d,t} = \frac{\sum_{i\in d} \text{Pop}_{i,t} \cdot \text{Access}_{i,t}}{\sum_{i\in d} \text{Pop}_{i,t}}. \quad (4)$$

$$\text{Norm Score}_{d,t} = \frac{\text{Accessibility}_{d,t} - \min_d \text{Accessibility}_{d,t}}{\max_d \text{Accessibility}_{d,t} - \min_d \text{Accessibility}_{d,t}} \cdot 100 \quad (5)$$

- i: commune
- t: year
- g: nearest grande école open at time t
- s: nearest active station to commune i
- $d_{i,g}$: Euclidean distance from commune i to grande école g
- $d_{i,s}$: Euclidean distance from commune i to station s
- $d_{s,g}$: least-cost path distance from station s to station near grande école g
- v_w: walking speed (4 km/h)
- v_r: rail speed (variable)

From a commune-level perspective

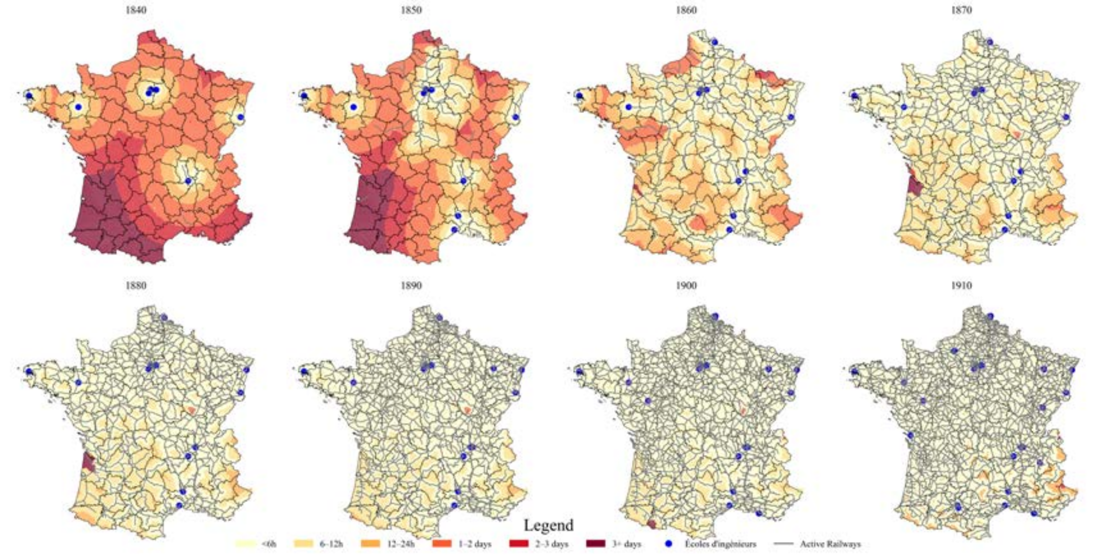


Figure 7: Multi-modal access: hours from any commune to closest Ingénieur grande école for selected years - own elaborations on CGE and COMMUNES data

To a department-level...

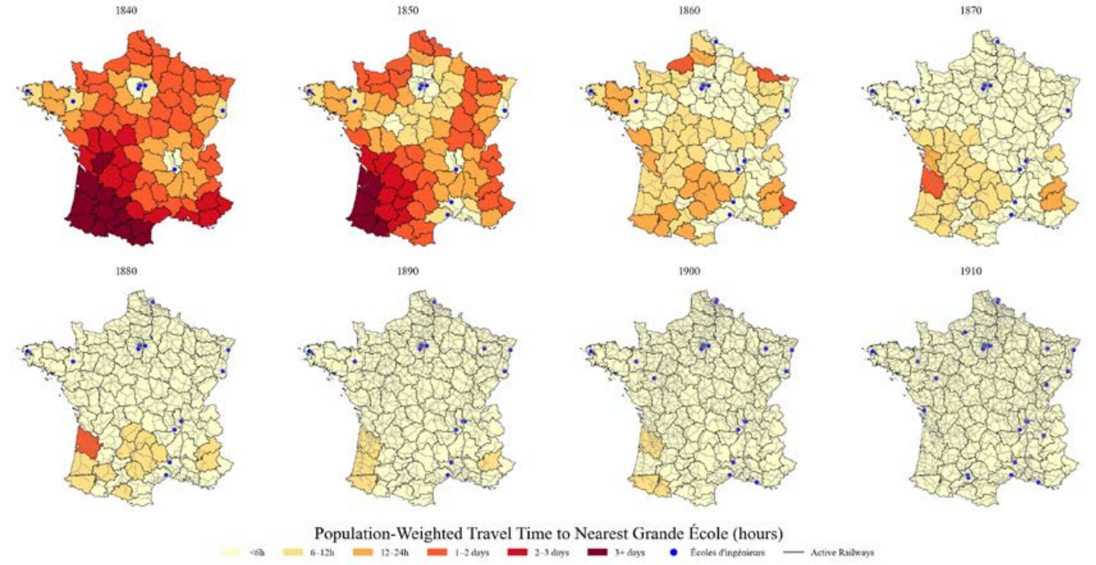


Figure 8: Multi-modal access: weighted hours to closest Ingénieur grande école for selected years - own elaborations on CGE and COMMUNES data, 1870's department boundaries from Gay 2020

Year-normalised score

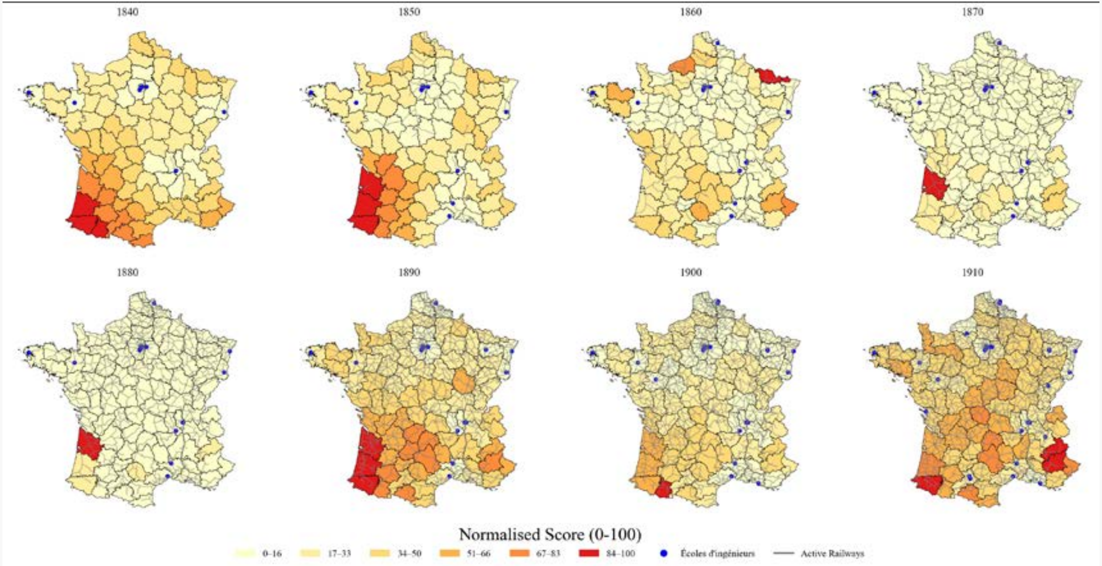


Figure 9: Multi-modal access: normalised knowledge accessibility score for selected years - own elaborations on CGE and COMMUNES data, 1870's department boundaries from Gay 2020

Knowledge access score - resulting estimation

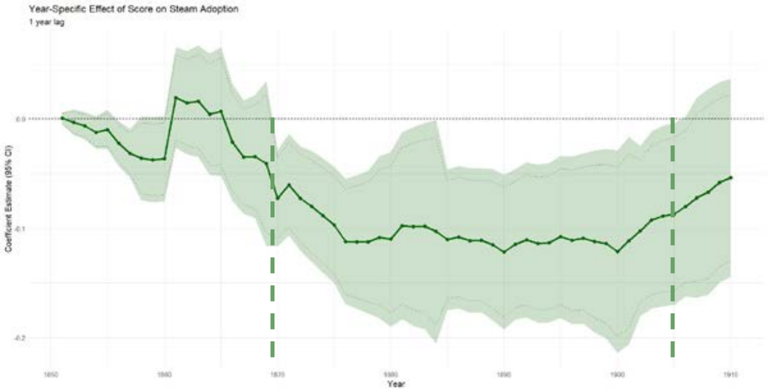


Figure 10: Year-specific effects of the normalised accessibility score on steam engine adoption - own elaborations, overall effects in Appendix, naive estimation (no instrument), clustered std.err. (dep-level), all controls as previous estimations

Higher values of the normalised scores (i.e. more time with respect to other dep to arrive to G.E.) → ↓ intense steam engine adoption

Main Takeaways and Future Steps

Main Takeaways

- France as a natural laboratory of competing networks (water vs rail)
- Infrastructures shaping both **market access and knowledge flows**, fundamental in tech adoption across regions
- Conceptual framework is *transferable* to other GPTs (electricity, etc.)
- Additional analyses in Appendix:
  - Temporal evolution of the relative importance of railway and waterway *densities*.
  - Alternative time lags to explore dynamic effects.

Next Steps

- Use of **historical straight-line instrument** leveraging the Legrand / Migneret / Freycinet plans.
- Add occupation-related controls and finalise rail and canal accessibility scores.
- Test for *spatial dependence* and assess its impact on estimates.
- Evaluate whether mechanisms hold at the arrondissement level.

French industrialization is not a story of *delay* but a story of **geography**: steam follows the networks, and the networks follow access to knowledge.

Thank you!

Any question/suggestion/comment?

↓

Bonus slides

Distribution of steam engines per 10k inhabitants through time

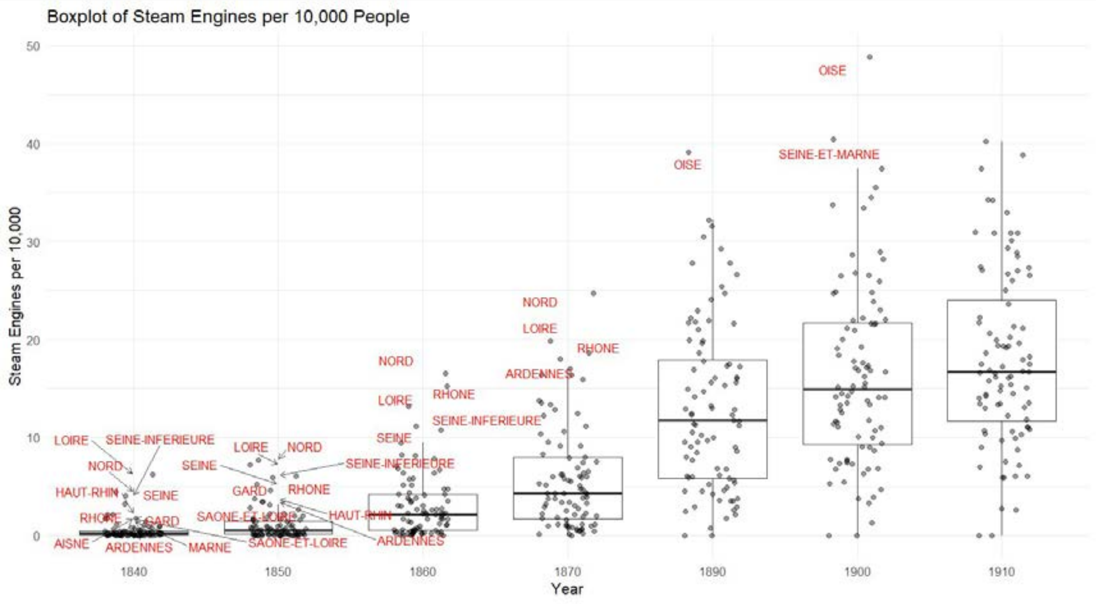


Figure 11: Boxplot of steam engine per 10k inhabitants over time - own elaborations on panel data

Estimation result: rail and waterways - overall effects

Dependent Variable:	Steam engines per 10k inhabitants			
Model:	(1y lag)	(2y lag)	(5y lag)	(7y lag)
Variables				
Water	9.185	10.15	11.18	11.00
	(10.50)	(10.78)	(12.06)	(12.73)
Rail	-6.641***	-5.798**	-6.273**	-6.263*
	(2.326)	(2.322)	(3.142)	(3.304)
Rail Density	0.0133	0.0131	0.0036	-0.0150
	(0.2907)	(0.2697)	(0.2266)	(0.2115)
Water Density	-7.392	-7.885	-8.974	-8.865
	(6.050)	(6.232)	(7.055)	(7.481)
Communes Served Ratio	3.192	2.373	1.369	1.950
	(8.698)	(8.608)	(8.313)	(8.178)
Population (log)	-5.617	-5.604	-5.158	-4.924
	(5.699)	(5.668)	(5.595)	(5.547)
Water × Rail	2.501	1.844	5.535	5.800
	(1.974)	(1.945)	(3.579)	(3.910)
Fixed-effects				
Department	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	5,368	5,368	5,368	5,368
R^2	0.88049	0.88048	0.87922	0.87834
Within R^2	0.78199	0.78196	0.77966	0.77805

Clustered (dep) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 1: Estimation results of the overall effects of railways and waterways effects - own elaborations on panel and

Year-specific effects and interaction of water and rail infrastructure - 2y. lag

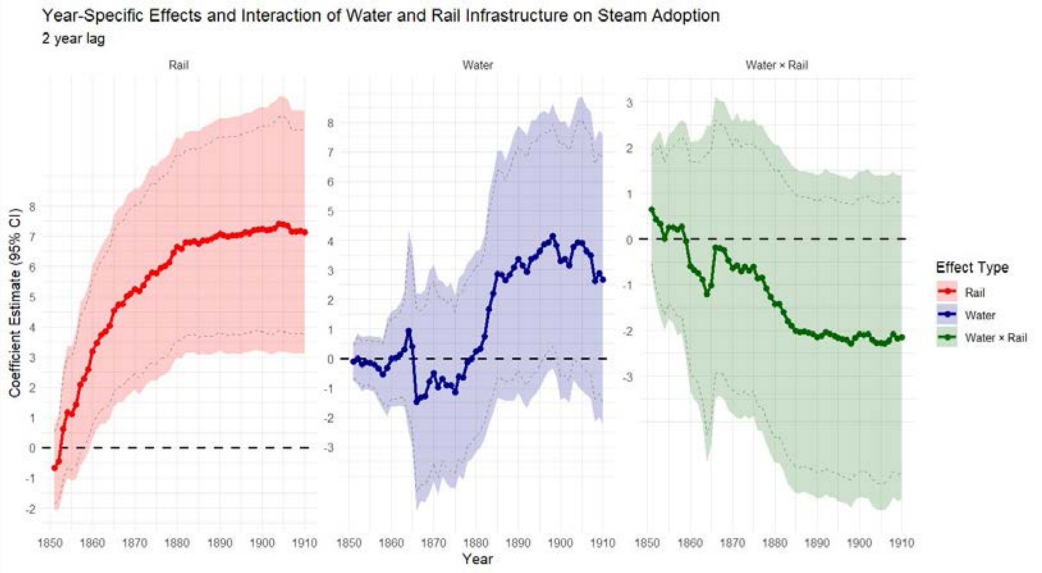


Figure 12: Year specific effects of Rail (100 km u.), Waterways (100 km u.) and their interaction (2y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of water and rail infrastructure - 5y. lag

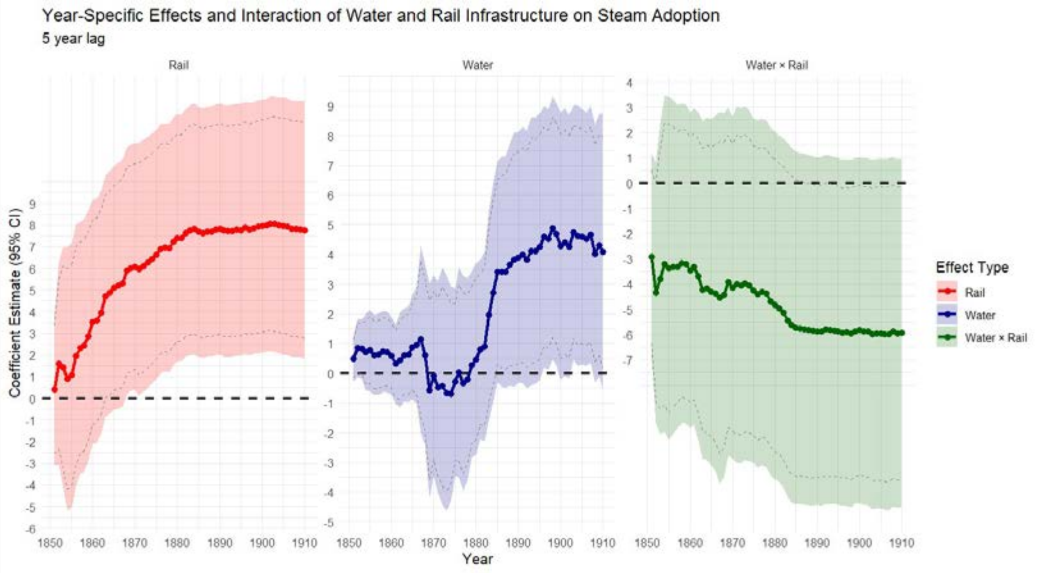


Figure 13: Year specific effects of Rail (100 km u.), Waterways (100 km u.) and their interaction (5y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of water and rail infrastructure - 7y. lag

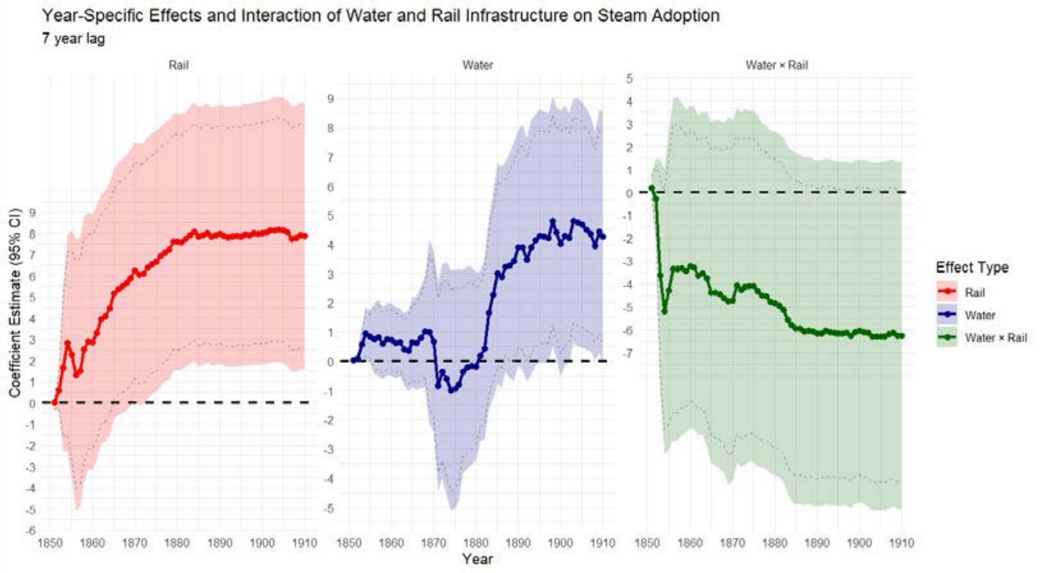


Figure 14: Year specific effects of Rail (100 km u.), Waterways (100 km u.) and their interaction (5y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Estimation result: rail and canals - overall effects

Dependent Variable:	Steam engines per 10k inhabitants			
Model:	(1y lag)	(2y lag)	(5y lag)	(7y lag)
Variables				
Canal	4.093	5.152	6.535	6.907
	(11.51)	(11.70)	(12.95)	(13.57)
Rail	-5.653***	-5.404***	-5.599***	-5.622***
	(2.034)	(1.914)	(1.818)	(1.915)
Rail Density	-0.0287	-0.0228	-0.0217	-0.0380
	(0.3153)	(0.2929)	(0.2468)	(0.2296)
Canal Density	-602.4	-666.8	-810.0	-822.5
	(656.5)	(673.4)	(755.5)	(795.3)
Communes Served Ratio	4.317	3.508	2.695	3.442
	(9.034)	(8.934)	(8.620)	(8.455)
Population (log)	-6.027	-6.016	-5.630	-5.393
	(5.736)	(5.711)	(5.623)	(5.535)
Canal × Rail	2.922	3.157	12.65**	15.02*
	(2.330)	(2.026)	(5.198)	(8.188)
Fixed-effects				
Department	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	5,368	5,368	5,368	5,368
R^2	0.88229	0.88229	0.88143	0.88090
Within R^2	0.78526	0.78526	0.78370	0.78273

Clustered (dep) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 2: Estimation results of the overall effects of railways and canals effects - own elaborations on panel and COMMUNES data

Year-specific effects and interaction of canal and rail infrastructure - 2y. lag

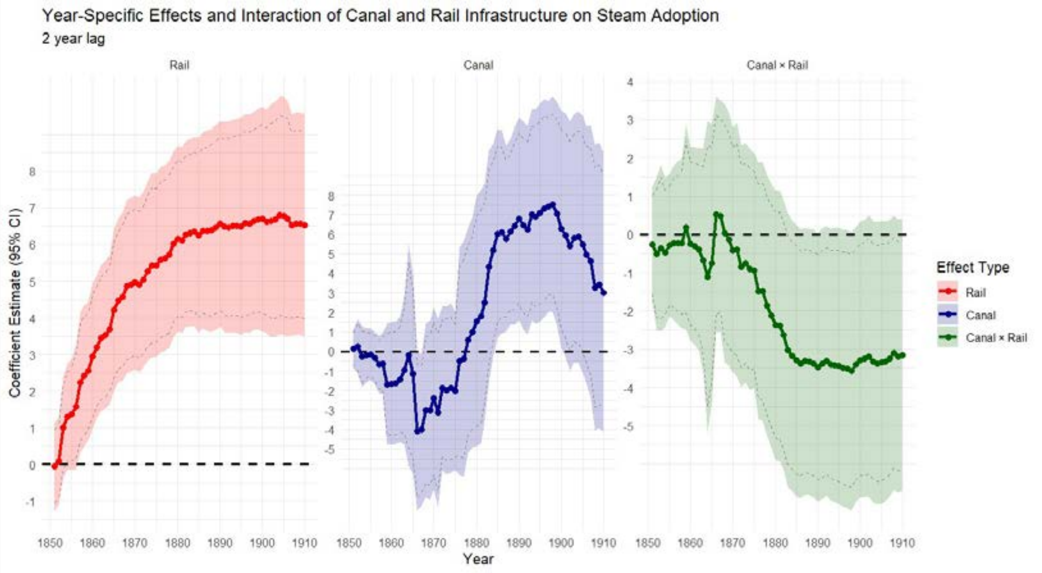


Figure 15: Year specific effects of Rail (100 km u.), Canals (100 km u.) and their interaction (2y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of canal and rail infrastructure - 5y. lag

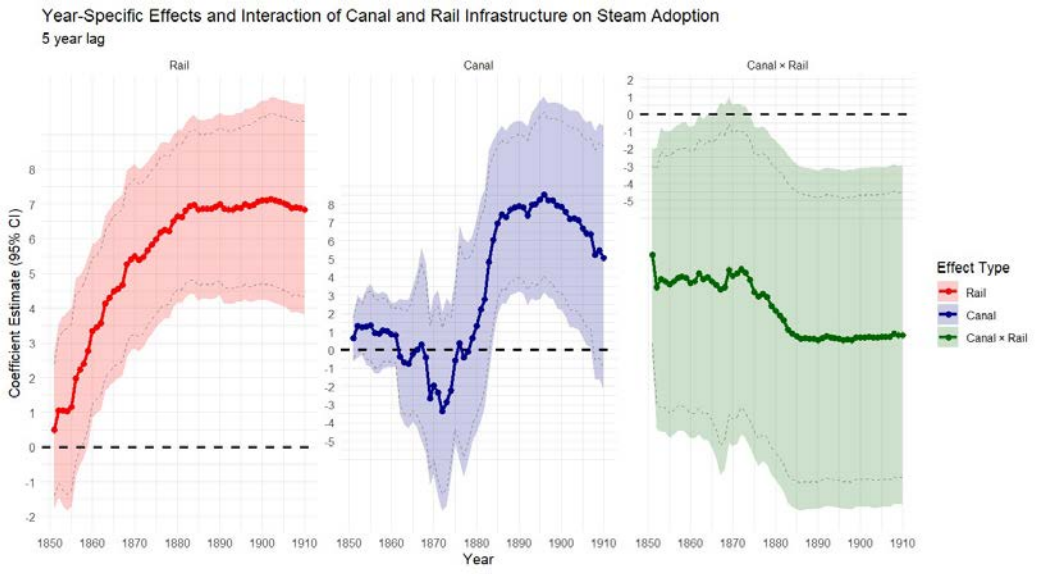


Figure 16: Year specific effects of Rail (100 km u.), Canals (100 km u.) and their interaction (5y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of canal and rail infrastructure - 7y. lag

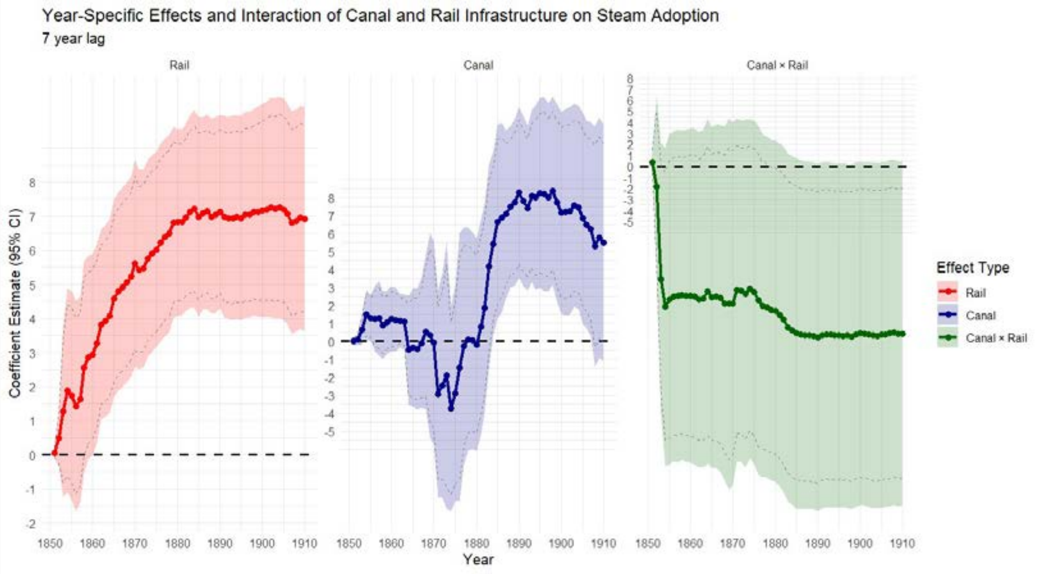


Figure 17: Year specific effects of Rail (100 km u.), Canals (100 km u.) and their interaction (5y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Estimation result: rail and water densities - overall effects

Dependent Variable:	Steam engines per 10k inhabitants			
Model:	(1y lag)	(2y lag)	(5y lag)	(7y lag)
Variables				
Water Density	-2.512*	-2.496*	-2.860*	-2.932*
	(1.407)	(1.448)	(1.606)	(1.676)
Rail Density	-4.504***	-4.029***	-2.472	-2.393
	(1.392)	(1.434)	(1.901)	(1.991)
Communes Served Ratio	7.523	7.001	5.670	5.781
	(12.41)	(12.33)	(12.27)	(12.33)
Population (log)	-8.065	-8.073	-7.297	-6.681
	(7.252)	(7.279)	(7.322)	(7.322)
Water × Rail (density)	1.361***	1.237**	1.038	1.085
	(0.3931)	(0.5103)	(0.6895)	(0.6667)
Fixed-effects				
Department	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	5,368	5,368	5,368	5,368
R^2	0.87193	0.87156	0.86949	0.86839
Within R^2	0.76636	0.76569	0.76191	0.75991

Clustered (dep) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 3: Estimation results of the overall effects of railways and waterways (use of densities interaction with time) – own elaborations on panel and COMMUNES data

Year-specific effects and interaction of water and rail densities - 1y. lag

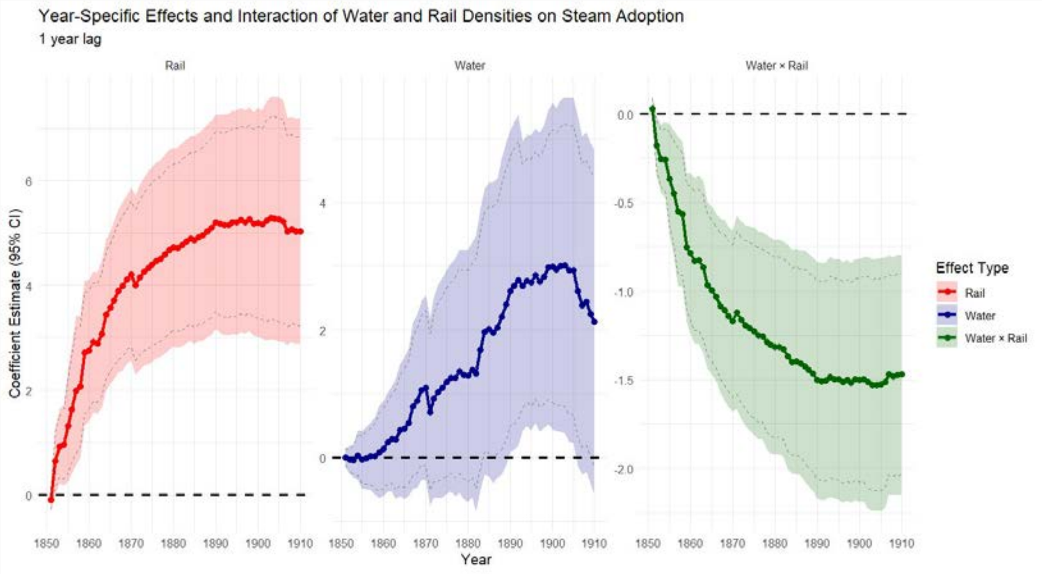


Figure 18: Year specific effects of Rail (density), Waterways (density) and their interaction (1y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of water and rail densities - 2y. lag

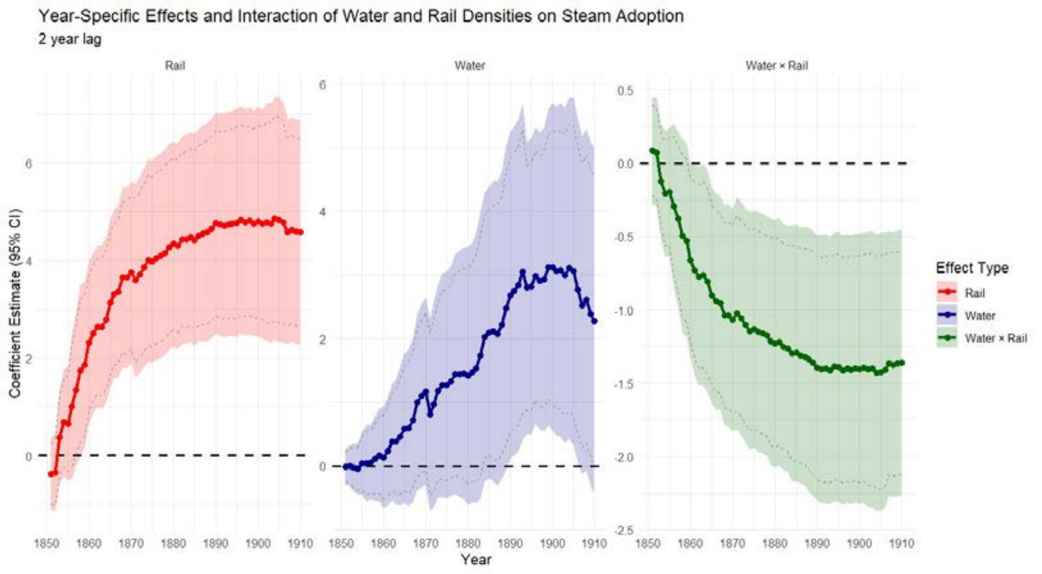


Figure 19: Year specific effects of Rail (density), Waterways (density) and their interaction (2y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of water and rail densities - 5y. lag

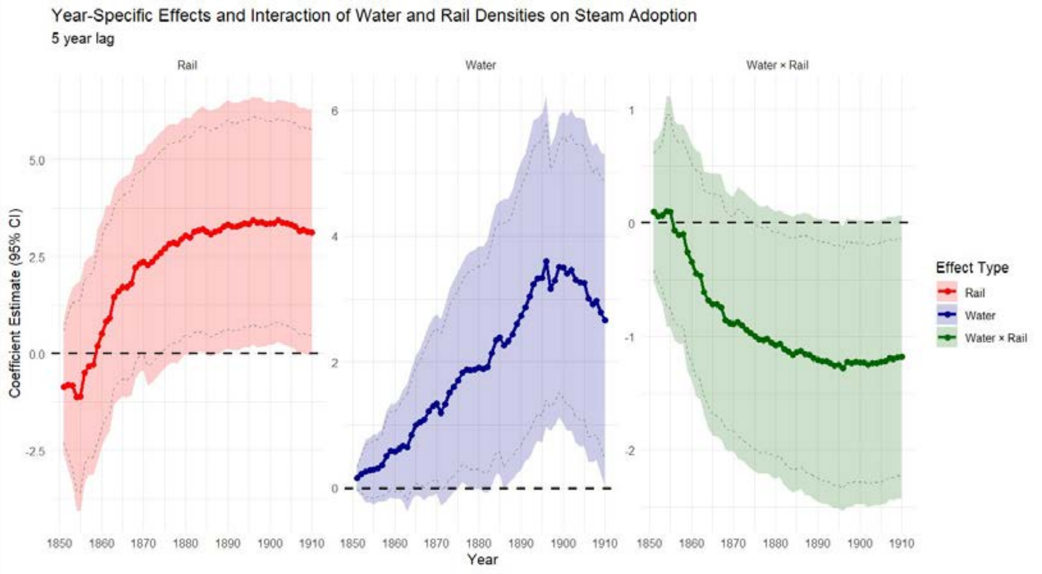


Figure 20: Year specific effects of Rail (density), Waterways (density) and their interaction (2y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Year-specific effects and interaction of water and rail densities - 7y. lag

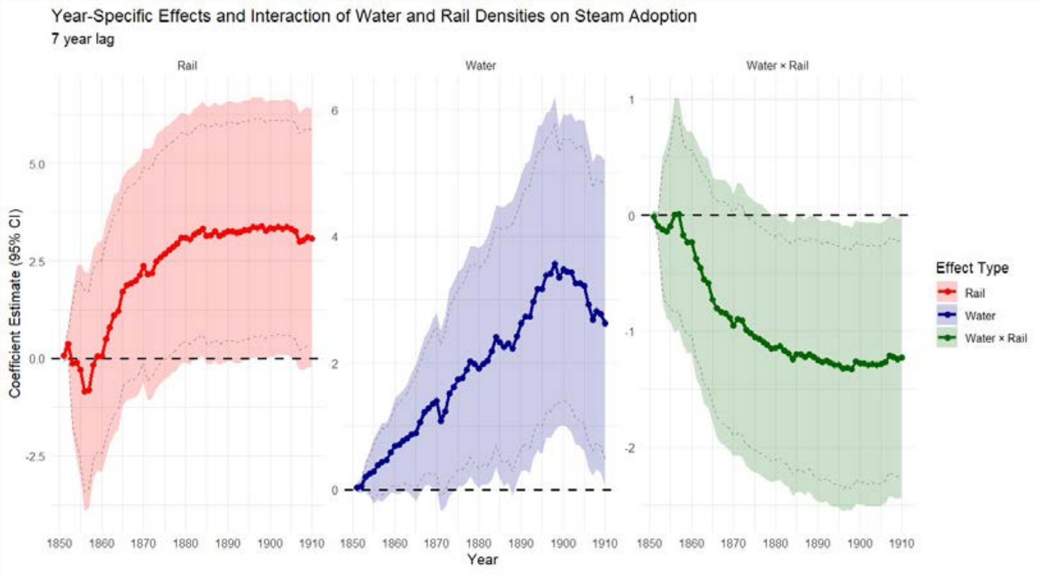


Figure 21: Year specific effects of Rail (density), Waterways (density) and their interaction (2y lag) - own estimation on panel and COMMUNES data, naive estimation (no instrument)

Distribution of (lagged) normalised score through time

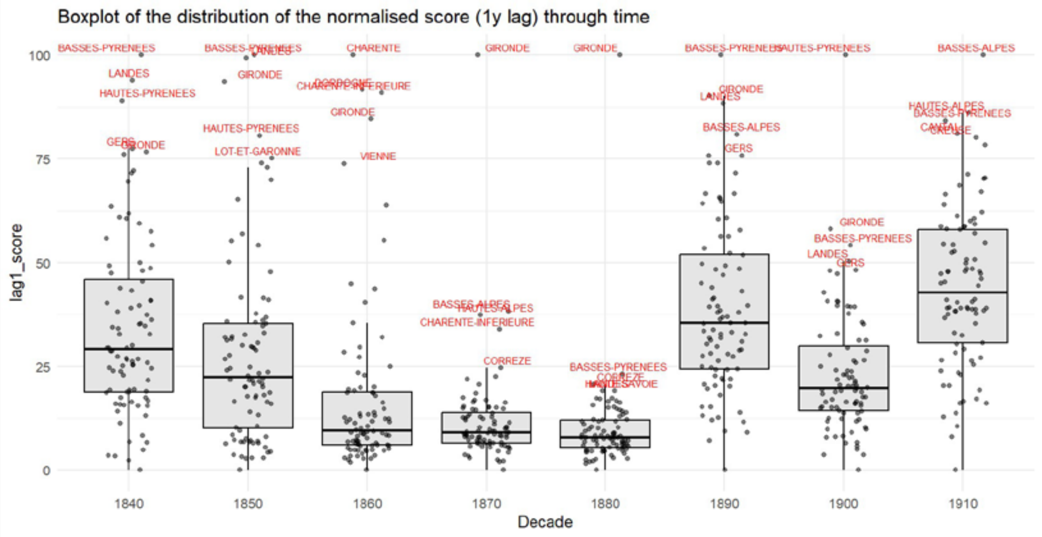


Figure 22: Boxplot of knowledge accessibility score (1y lag) over time - own elaborations on COMMUNES and CGE data

Why the *Grandes Écoles*?

In the late 1860s and early 1870s, the focus of the G.E. shifted toward viewing the "machine" as an *outil*:

> *[...] à un point de vue plus spécial, celui de leur emploi, soit dans l'industrie, soit dans les travaux publics, soit surtout dans la grande industrie des transports [...] voulut bien nous dire que le moment d'étudier la machine à vapeur au point de vue purement scientifique était passé, qu'il fallait désormais s'attacher à en vulgariser l'emploi et à montrer le rôle qu'elle remplissait comme instrument de transformation et de progrès.*

(Jacqmin 1870, p. I-III: lectures for the *École Impériale des Ponts et Chaussées*)

- Beyond theoretical knowledge: emphasis on **technical and practical** training
- Application highlighted in **industry**, public works, and transport

→ Grandes écoles as key sites for diffusing knowledge useful to **industrial adoption**

Mechanisms: knowledge access score estimation - overall effects

Dependent Variable:	Steam Engines per 10k inhabitants			
Model:	(1y Lag)	(2y Lag)	(5y Lag)	(7y Lag)
Variables				
Score	0.0765***	0.0420**	0.0427**	0.0439**
	(0.0211)	(0.0188)	(0.0193)	(0.0202)
Water Density	-1.112	-1.099	-1.065	-0.9949
	(1.405)	(1.416)	(1.489)	(1.533)
Rail Density	0.3594	0.3411	0.2763	0.2140
	(0.3250)	(0.3207)	(0.3102)	(0.3030)
Communes Served Ratio	7.332	7.935	10.73*	13.03**
	(6.008)	(5.945)	(5.636)	(5.374)
Population (log)	-6.643	-6.516	-5.984	-5.621
	(6.118)	(6.130)	(6.122)	(6.091)
Fixed-effects				
Department	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Fit statistics				
Observations	5,368	5,368	5,368	5,368
R^2	0.85404	0.85352	0.85318	0.85339
Within R^2	0.73373	0.73278	0.73216	0.73254

Clustered (dep) standard-errors in parentheses
*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

Table 4: Estimation results of the overall effects of the model with the Knowledge Acccess Score – own elaborations on panel, CGE and COMMUNES data

Year-specific effects of knowledge access score - 2y. lag

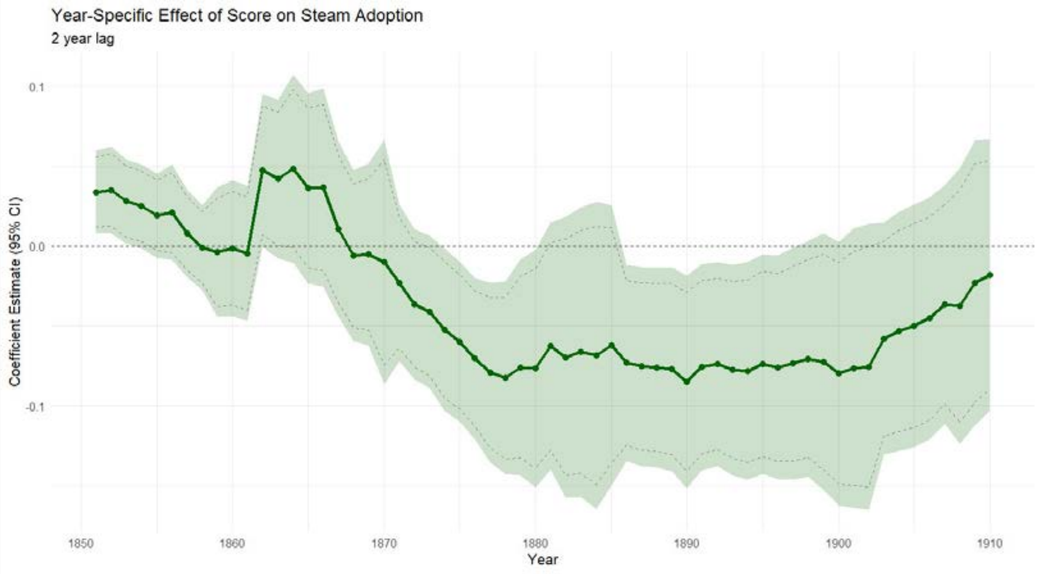


Figure 23: Year-specific effects of the normalised accessibility score on steam engine adoption (2y lag) - own elaborations, overall effects in Appendix, naive estimation (no instrument)

Year-specific effects of knowledge access score - 5y. lag

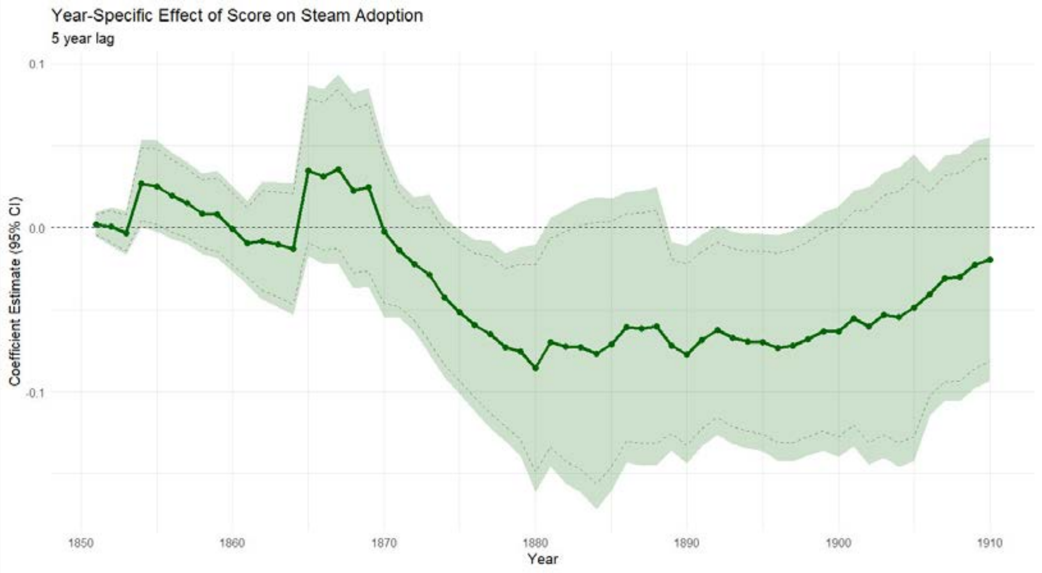


Figure 24: Year-specific effects of the normalised accessibility score on steam engine adoption (5y lag) - own elaborations, overall effects in Appendix, naive estimation (no instrument)

Year-specific effects of knowledge access score - 7y. lag

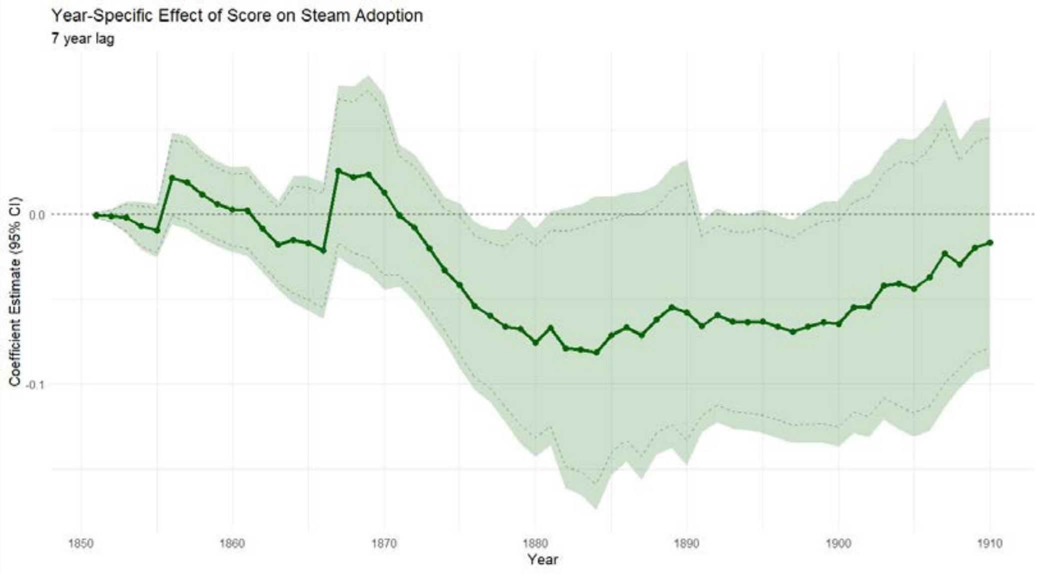


Figure 25: Year-specific effects of the normalised accessibility score on steam engine adoption (5y lag) - own elaborations, overall effects in Appendix, naive estimation (no instrument)

References

References i

- Alvarez-Palau, Eduard J et al. (Apr. 2025). **"Transport and urban growth in the First Industrial Revolution".** en. In: *The Economic Journal* 135.668, pp. 1191–1228. ISSN: 0013-0133, 1468-0297. DOI: 10.1093/ej/ueae111.
- Américo, Pedro (2024). ***The Industrialization Path: Railroads, Technology Adoption, and Structural Transformation in Brazil*.** en. DOI: 10.2139/ssrn.4942062.
- Andersson, David et al. (Mar. 2023). **"Making a Market: Infrastructure, Integration, and the Rise of Innovation".** In: *The Review of Economics and Statistics* 105.2, pp. 258–274. ISSN: 0034-6535. DOI: 10.1162/rest_a_01067.
- Atack, Jeremy et al. (June 1980). **"The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing".** en. In: *The Journal of Economic History* 40.2, pp. 281–308. ISSN: 0022-0507, 1471-6372. DOI: 10.1017/S0022050700108216.
- Berger, Thor and Ostermeyer, Vinzent (Aug. 2025). **"Institutional Innovation and the Adoption of New Technologies: The Case of Steam".** en. In: *The Journal of Economic History*, pp. 1–30. ISSN: 0022-0507, 1471-6372. DOI: 10.1017/S0022050725100855.
- Beyer, Antoine and Verhaeghe, Laetitia (Apr. 2014). **"Cooperation between Waterways and Railways, an Unnatural Alliance: Rail Strategic Development of River Ports in the Greater Paris Region".** In: *TRA - Transport Research Arena*. France, 10 p.
- Bogart, Dan et al. (2017). **"Transport networks and the adoption of steam engines in England and Wales, 1761-1800".** en. In.

- Crafts, N. F. R. (1984). **“Economic Growth in France and Britain, 1830-1910: A Review of the Evidence”.** In: *The Journal of Economic History* 44.1, pp. 49–67. issn: 0022-0507.
- Crompton, G. W. (Sept. 1993). **“Canals and the Industrial Revolution”.** en. In: *The Journal of Transport History* 14.2, pp. 93–110. issn: 0022-5266, 1759-3999. doi: 10.1177/002252669301400203.
- Crouzet, François (2003). **“The Historiography of French Economic Growth in the Nineteenth Century”.** In: *The Economic History Review* 56.2, pp. 215–242. issn: 0013-0117.
- Crouzet, FranOis (1974). **“French Economic Growth in the Nineteenth Century Reconsidered”.** In: *History* 59.196, pp. 167–179. issn: 0018-2648.
- Deane, Phyllis (1965). ***The first industrial revolution.*** eng. Cambridge University Press. isbn: 978-0-521-09363-7.
- Fernihough, Alan and O’Rourke, Kevin Hjortshøj (Apr. 2021). **“Coal and the European Industrial Revolution”.** In: *The Economic Journal* 131.635, pp. 1135–1149. issn: 0013-0133. doi: 10.1093/ej/ueaa117.
- Flinn (1984). ***The History of the British coal industry.*** eng. Oxford [England] : Clarendon Press ; New York : Oxford University Press. isbn: 978-0-19-828283-9 978-0-19-828282-2 978-0-19-828295-2 978-0-19-828294-5 978-0-19-828284-6.
- Freeman, Michael (1984). **“The Industrial Revolution and the Regional Geography of England: A Comment”.** en. In: *Transactions of the Institute of British Geographers* 9.4, p. 507. issn: 00202754. doi: 10.2307/621784.

- Gay, Victor (Oct. 2020). ***Mapping the Third Republic. A Geographic Information System of France (1870–1940).*** en. SSRN Scholarly Paper. Rochester, NY. doi: 10.2139/ssrn.3704185.
- Grantham, G. (Dec. 1997). **“The French cliometric revolution: A survey of cliometric contributions to French economic history”.** en. In: *European Review of Economic History* 1.3, pp. 353–405. issn: 1361-4916, 1474-0044. doi: 10.1017/S1361491697000166.
- Jacqmin, François Prosper (1870). ***Des machines à vapeur: Leçons faites en 1869-1870 à l’École impériale des ponts et chaussées.*** fr. Garnier frères.
- Komikado, Hiroshi et al. (June 2021). **“High-speed rail, inter-regional accessibility, and regional innovation: Evidence from Japan”.** In: *Technological Forecasting and Social Change* 167, p. 120697. issn: 0040-1625. doi: 10.1016/j.techfore.2021.120697.
- Langton, John (1984). **“The Industrial Revolution and the Regional Geography of England”.** In: *Transactions of the Institute of British Geographers* 9.2, pp. 145–167. issn: 0020-2754. doi: 10.2307/622166.
- Le Chapelain, Charlotte and Wilke, Ralf A. (Jan. 2025). **“Spatial patterns of steam technology diffusion in nineteenth-century France”.** en. In: *Cliometrica*. issn: 1863-2505, 1863-2513. doi: 10.1007/s11698-024-00302-6.
- Lintsen, Harry (1991). **“Steam and Polders Belgium and the Netherlands 1790-1850”.** en. In: *Tractrix. Yearbook for History of Science, Medicine, Technology and Mathematics* 3, pp. 121–147.

- Martinez, Marco et al. (Sept. 2025). **“Rails of Progress? Exploring the nexus between railroad access and innovation in Italy (19th20th centuries)”.** In: *Explorations in Economic History*, p. 101718. ISSN: 0014-4983. DOI: 10.1016/j.eeh.2025.101718.
- Mauret-Cribellier, Valérie and Léon, Patrick (Sept. 2005). **“Un paysage de l’industrie : canaux et usines en Val de Germigny (Cher)”.** fr. In: *In Situ. Revue des patrimoines* 6. ISSN: 1630-7305. DOI: 10.4000/insitu.8278.
- Mazzulla, Gabriella and Pirrone, Carlo Giuseppe (Dec. 2024). **“Accessibility Measures: From a Literature Review to a Classification Framework”.** en. In: *ISPRS International Journal of Geo-Information* 13.12, p. 450. ISSN: 2220-9964. DOI: 10.3390/ijgi13120450.
- Nuvolari, Alessandro et al. (Oct. 2011). **“The early diffusion of the steam engine in Britain, 1700–1800: a reappraisal”.** en. In: *Cliometrica* 5.3, pp. 291–321. ISSN: 1863-2505, 1863-2513. DOI: 10.1007/s11698-011-0063-6.
- Rosevear, Alan et al. (Aug. 2024). **“Government, trusts, and the making of better roads in early nineteenth century England and Wales”.** In: *European Review of Economic History* 28.3, pp. 399–423. ISSN: 1361-4916. DOI: 10.1093/ereh/head030.
- Sokoloff, Kenneth L (1988). **“Inventive Activity in Early Industrial America: Evidence From Patent Records, 1790-1846”.** en. In.
- Tsiachtsiras, Georgios (Dec. 2025). **“Changing the perception of time: railroads, inventor access and innovation in 19th-century France”.** In: *Regional Studies* 59.1, p. 2511710. ISSN: 0034-3404. DOI: 10.1080/00343404.2025.2511710.

- Von Tunzelmann, G. N. (1978). ***Steam power and British industrialization to 1860.*** eng. Oxford [Eng.] ; New York : Clarendon Press. ISBN: 978-0-19-828273-0.
- Yamasaki, Junichi (July 2025). **"Railroads and technology adoption in Meiji Japan".** In: *Explorations in Economic History* 97, p. 101683. ISSN: 0014-4983. DOI: 10.1016/j.eeh.2025.101683.