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LABOUR-FRIENDLY STEAM POWER: EVIDENCE FROM 19th-CENTURY FRANCE

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Abstract

This study examines the two earliest national industrial censuses from mid-nineteenth-century France and finds that the adoption of steam power was associated with both job creation and wage growth. To identify causal effects, we exploit plausibly exogenous variation in sectoral complementarity with steam technology and in local energy-cost incentives to substitute steam for water power. The results contrast prevailing views that early mechanisation displaced workers and suppressed pay.

Keywords: Capitalists, industrialisation, inequality, labour, mechanisation, productivity, technological progress, wages.

JEL Classifications: I15, J42, J31, L92, O14, O33

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1 Introduction

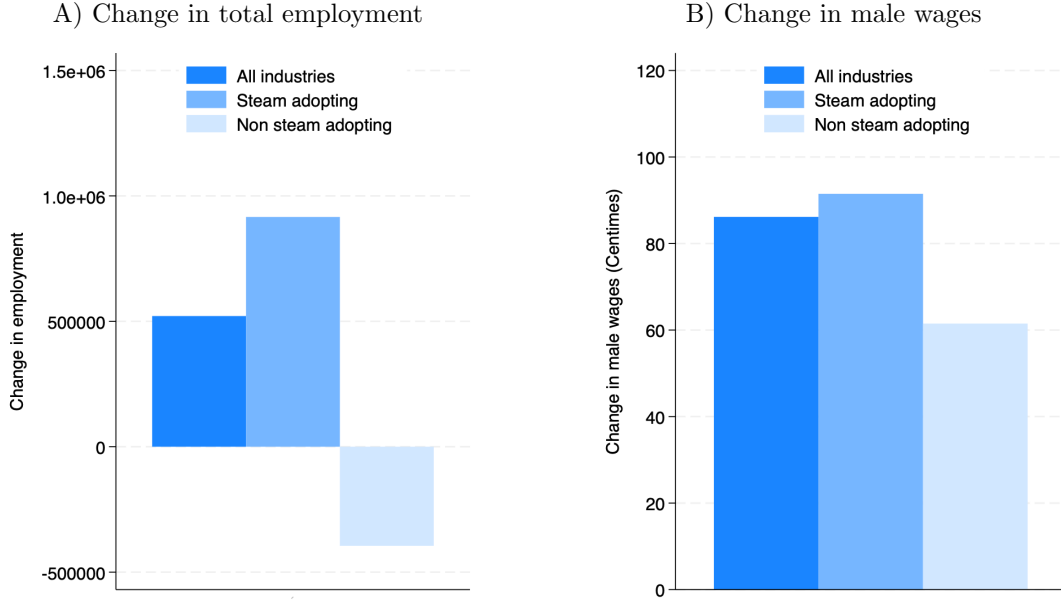
Mechanisation is regarded as a central driver of economic growth, yet it also raises concerns about its consequences for labour (e.g. [Aghion et al., 2021](#); [Johnson and Acemoglu, 2023](#)). These concerns draw heavily on interpretations of early industrialisation (e.g. [Mokyr et al., 2015](#); [Acemoglu and Johnson, 2024](#); [Küsters and Schneider, 2025](#)). Influential accounts have described historical episodes of mechanisation as labour-saving ([Habakkuk, 1962](#); [Allen, 2009a](#)), warned of labour displacement ([Marx, 1844](#); [Keynes, 1931](#)), argued that early industrial profits outpaced wages ([Engels, 1943](#); [Kuznets, 1955](#)), and pointed to machine-breaking riots as supporting evidence ([Nuvolari, 2002](#); [Caprettini and Voth, 2020](#)).

We assess these claims by examining one of the earliest and most prominent waves of mechanisation in history: the diffusion of steam power. While industrial statistics for England—the birthplace of the steam engine—were not systematically compiled during its early diffusion, the French authorities conducted two comprehensive national industrial censuses, in the 1840s and 1860s, at the height of the country’s steam expansion. These censuses provide detailed local information on technology use, employment, and wages during the spread of steam power, but before the subsequent wave of general-purpose technological change associated with electrification. The French data thus offer a unique opportunity to identify the labour-market effects of mechanisation during the formative stages of industrial development.

Figure 1 presents initial evidence that steam adoption was associated with improved labour conditions. Between the two censuses, total industrial employment in France increased by 521,013 workers. Over the same period, local subindustries that adopted steam expanded employment by 916,049 workers, overwhelmingly offsetting employment declines among comparable non-adopters. Wages display a similar pattern: average male earnings rose more rapidly in local subindustries that adopted steam than in their non-adopting counterparts. Taken together, these descriptive trends suggest that the diffusion of steam power was associated with net employment growth and stronger wage gains.

Our formal analyses corroborate these patterns. At the district–subindustry level, steam adoption was associated with stronger growth in employment and male wages relative to

Figure 1: Industrial steam use and labour changes in France, 1840s–1860s



Note: The bar charts show the average change in industrial employment and male wages in France between the 1840s and 1860s, broken down by steam- and non-steam-using firms. *Source:* [Chanut et al. \(2000\)](#).

non-adopters, both along the extensive margin (the installation of steam power) and the intensive margin (the scale of steam horsepower deployed). Using plausibly exogenous proxies for variation in sectoral complementarity with steam technology and in local energy-cost incentives to substitute between steam engines and traditional waterwheels, we find that these positive labour-market effects were causal. The results are robust across a wide range of alternative specifications. In particular, tests for aggregation bias show that the favourable labour-market dynamics observed at the district–subindustry level were also present at the establishment level. Survivorship analyses additionally indicate that entering and exiting local subindustries exhibited labour-market responses comparable to those of continuing subindustries.

Heterogeneity analyses further suggest that the positive labour-market effects of steam adoption persisted over several decades, although they attenuated over time. Steam adoption was associated with stronger wage growth in traditionally industrial regions than elsewhere. A similar pattern emerges in textiles—often central to debates on early mechanisation (e.g. [Broadberry and Gupta, 2009](#); [Squicciarini and Voigtländer, 2015](#))—although wage growth

was stronger and employment responses more modest there than in other sectors. Finally, evidence on technological substitution shows that subindustries transitioning from water to steam power experienced labour-market effects similar to those of other adopters, suggesting that *creative destruction* did not have distinct consequences for workers relative to other motive-power configurations. In combination, these findings support the view that mechanisation, as captured by steam adoption, improved local labour conditions in mid-nineteenth-century France.

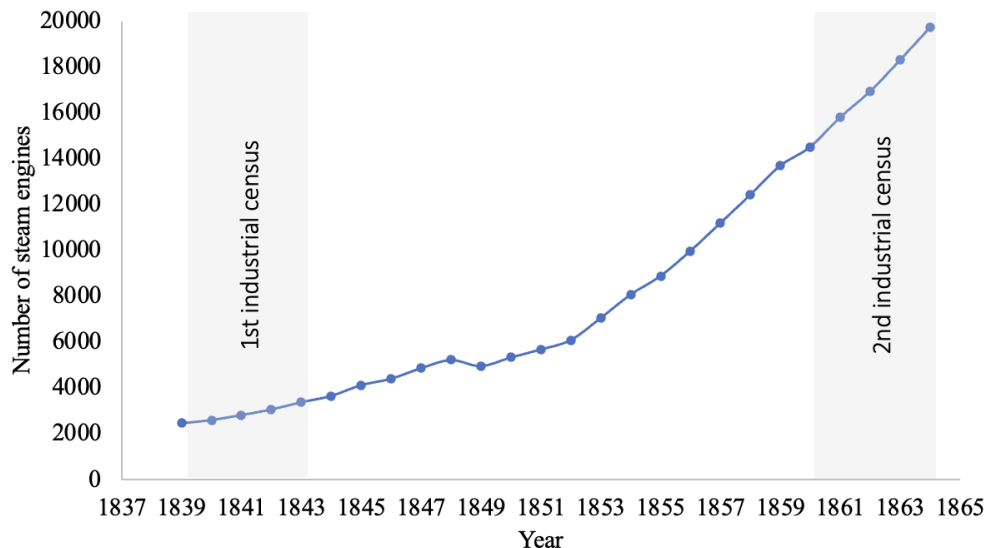
These results relate to a growing literature examining the labour-market consequences of automation and technological change (e.g. [Autor et al., 2003](#); [Acemoglu and Restrepo, 2018](#); [Bessen, 2019](#)). Recent work emphasises that new technologies may simultaneously displace labour from existing tasks while creating new sources of labour demand through productivity gains, lower prices, and output expansion. Whether employment rises or falls therefore depends on the relative strength of these opposing forces. Our results suggest that, during the diffusion of steam power, the demand-expansion effects of mechanisation outweighed any direct labour-displacing effects. In this respect, the findings are consistent with historical and theoretical accounts emphasising the role of productivity growth in generating labour demand (e.g. [Hicks, 1963](#); [Bessen, 2019](#)), and provide historical evidence that major technological transformations need not reduce employment or wages even when they fundamentally alter production processes.

The remainder of the paper is organised as follows. Section 2 provides historical background, while Section 3 describes the data. Section 4 outlines the empirical strategy and identification. Section 5 presents the main results. Section 6 reports robustness checks, and Section 7 examines heterogeneity. Section 8 concludes.

2 Background

The diffusion of steam power is widely regarded as the first major wave of general-purpose technological change in modern times (e.g. [Crafts, 2004](#); [Bresnahan, 2010](#)). Developed in England at the beginning of the eighteenth century, steam engines spread globally over the next two centuries, transforming production by enabling both mechanisation and greater

Figure 2: The total number of steam engines installed in France, 1837–1864



Source: [Direction générale des ponts et chaussées et des mines \(1864\)](#).

stability in output. For England, however, the industrial statistics required to examine labour-market outcomes comparable to those analysed here are only available from 1900 onward ([Smith and Penneck, 2009](#)), by which time steam power was already being displaced by electric motors ([Devine, 1983](#); [Goldin and Katz, 1998](#)). By contrast, the French industrial censuses underpinning our analysis predates the diffusion of electricity into industrial production by more than two decades, thereby allowing us to isolate the labour-market effects of steam power prior to electrification.

Access to coal is widely viewed as a key determinant of industrial modernisation (e.g. [Fernihough and O'Rourke, 2021](#); [Bartels et al., 2023](#)). [Allen \(2009a\)](#) highlights the importance of cheap coal in England's early steam adoption, whereas [Crouzet \(1974, 2003\)](#) argues that France's extensive reliance on waterwheels delayed the transition to steam power. Abundant water resources and the absence of a national railway network kept coal prices high outside mining regions until the mid-nineteenth century, strengthening the economic attractiveness of hydraulic power relative to steam ([Benoit, 2020](#)). Reflecting these conditions, early steam adoption in France was concentrated in locations where water power was scarce or inadequate ([Dubuc, 1952](#); [Benoit, 2020](#)). We exploit this geographic variation in the relative

attractiveness of steam and water power to identify the causal effects of steam adoption on labour outcomes.

Large-scale adoption of steam engines in France occurred only after the 1820s, in part because of disruptions associated with the Continental Blockade (Payen, 1969). Subsequent diffusion (see Figure 2) is commonly attributed to technical advances—most notably the low-fuel-consumption engines developed by Trevithick and Woolf—that made steam economically viable even where water power was abundant and coal relatively costly (Nuvolari, 2010). From an early diffusion point in Fresnes-sur-Escaut in northern France in the late 1830s, the Woolf engine spread gradually across much of the country over the following decades (e.g. Diebolt et al., 2021; Franck and Galor, 2021, 2022).

Steam adoption varied considerably across manufacturing sectors. The technology was particularly attractive in industries characterised by large-scale production, continuous operations, and substantial power requirements, where steam engines provided a reliable and scalable source of motive power (e.g. von Tunzelmann, 1978). Sectors such as textiles and metallurgy therefore adopted steam relatively early and extensively (e.g. Gutberlet, 2014). By contrast, steam power was less prevalent in industries relying on artisanal production methods, small workshops, or processes requiring limited mechanical energy (e.g. Nuvolari et al., 2011). As a result, some subindustries exhibited a systematically higher propensity to install steam power than others, reflecting differences in complementarity with the technology. We deploy this variation in our identification strategy.

3 Data

The first comprehensive national industrial census in France (see Chanut et al., 2000) was carried out in the 1840s, followed by a second in the 1860s (see Figure 2). Together, these surveys provide near-universal coverage of industrial production and report four key statistics: the type of motive power employed (water, wind, animal, steam); total employment, disaggregated by men, women, and children; average wages for each group; and the value of output net of raw material and fuel costs.

The two censuses differ in their unit of observation. Whereas the first census reports data at the firm level, the second provides information only in aggregated form at the district–subindustry level. For the baseline analysis, we therefore aggregate firm-level observations from the first census to match the level of aggregation used in the second census, while controlling for the number of firms within each local subindustry to account for differences in industrial concentration. To address concerns arising from aggregation, we conduct robustness checks using firm-level information, where available, and show that aggregation bias does not drive the results. Furthermore, the second census records both the type of motive power and installed horsepower, enabling us to identify the labour-market effects of steam adoption along both the extensive and intensive margins.

The two industrial censuses jointly mention 82 subindustries across 356 districts. We observe 3,955 operating local subindustries in the 1840s and 6,763 in the 1860s. These figures exclude state-owned firms (0.3%), as well as districts that did not belong to France at the time or that appear in only one of the two censuses (1.9%). We also exclude subindustries with missing information on labour outcomes (2.4%). Of the 3,776 local subindustries recorded in the 1840s with relevant labour-market information, 2,543 are observed in both censuses, forming a balanced panel. Although excluded from the balanced sample, information on subindustry entry and exit is retained for the robustness analysis assessing potential survivorship bias.

Within the balanced panel, 21% of local subindustries had already adopted steam power prior to the first census, recorded in the 1840s. Our baseline regression sample is constructed by excluding these early adopters from the balanced panel in order to isolate the initial diffusion margin and avoid conflating pre-existing adoption with subsequent take-up. Instead, pre-1840s adopters are used in the IV analysis to construct a measure of sectoral steam complementarity, thereby contributing to identification without contaminating the baseline estimates. This restriction yields a baseline sample of 2,020 local subindustries, of which 32% adopted steam power between the 1840s and 1860s. The baseline sample covers 72 of the 82 subindustries and 315 of the 356 districts mentioned in the censuses. Summary statistics are reported in Table A.2.

3.1 Steam adoption

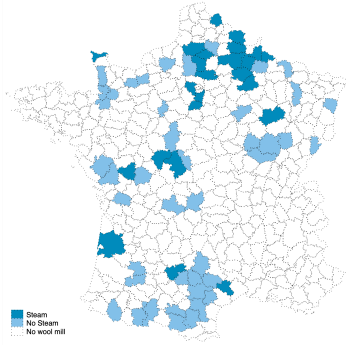
The baseline analysis captures mechanisation by examining steam adoption at the extensive margin. This is measured by a binary indicator equal to one if a local subindustry adopted steam power between the 1840s and the 1860s. The robustness section captures steam adoption at the intensive margin, measured by the level of steam horsepower installed by the 1860s, conditional on adoption between the two censuses. Distinguishing between these two margins allows us to examine both the presence and the intensity of steam use in relation to the labour outcome variables described below.

Historically, the textile industry was among the first sectors to mechanise. We thus illustrate the geographical diffusion of steam adoption in our sample using wool milling as a representative case across both the balanced and baseline samples. Panel A of Figure 3 maps all districts with wool-milling activity observed in both the 1840s and the 1860s (the balanced sample), thereby excluding districts with entering or exiting subindustries (shown separately in Panels D and E). Panel B presents the baseline sample in the 1840s, further excluding districts with continuing wool-milling industries that had already adopted steam by that date, marked in medium blue in Panel A. Panel C then maps the baseline districts in the 1860s, highlighting new steam adopters in dark blue. Equivalent maps can be constructed for all other subindustries recorded in the censuses.

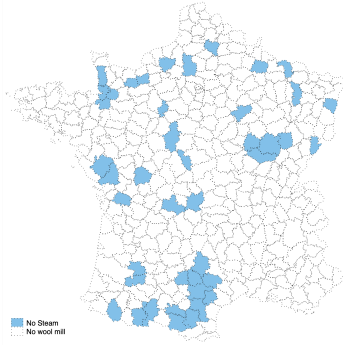
Table 1 presents the distribution of motive power across the balanced and baseline samples. Column 1 shows that 7.5% of subindustries in the balanced sample relied exclusively on steam power in the 1840s, while an additional 9.9% combined steam with other motive powers, primarily water (7.2%). Figure 4 shows that early steam use was concentrated in textiles and iron and steel production, and largely absent from sectors such as watchmaking, shoemaking, and cutlery. This heterogeneity underlies the prediction of sectoral steam complementarity in the IV analysis further below. Column 2 of Table 1 documents that the share of steam-using subindustries roughly doubled between the two censuses, reflecting the technology’s rapid diffusion (see also Figure 2). Columns 3–4 report adoption patterns for the baseline sample, while Columns 5–6 present corresponding figures for exiting and entering subindustries.

Figure 3: Steam use in wool milling

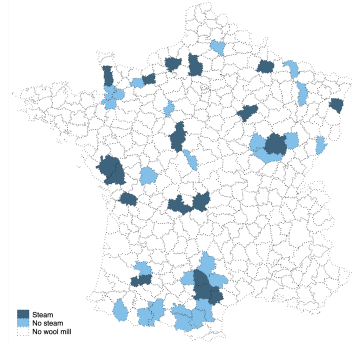
A) Balanced sample, 1840s



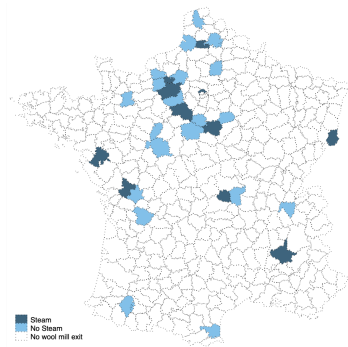
B) Baseline sample, 1840s



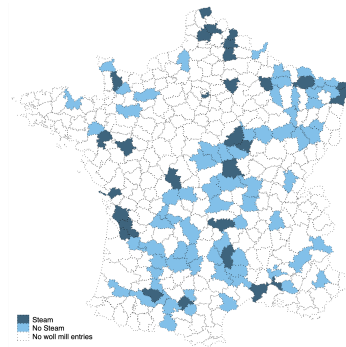
C) Baseline sample, 1860s



D) Exit districts, 1840s–60s



E) Entry districts, 1840s–60s



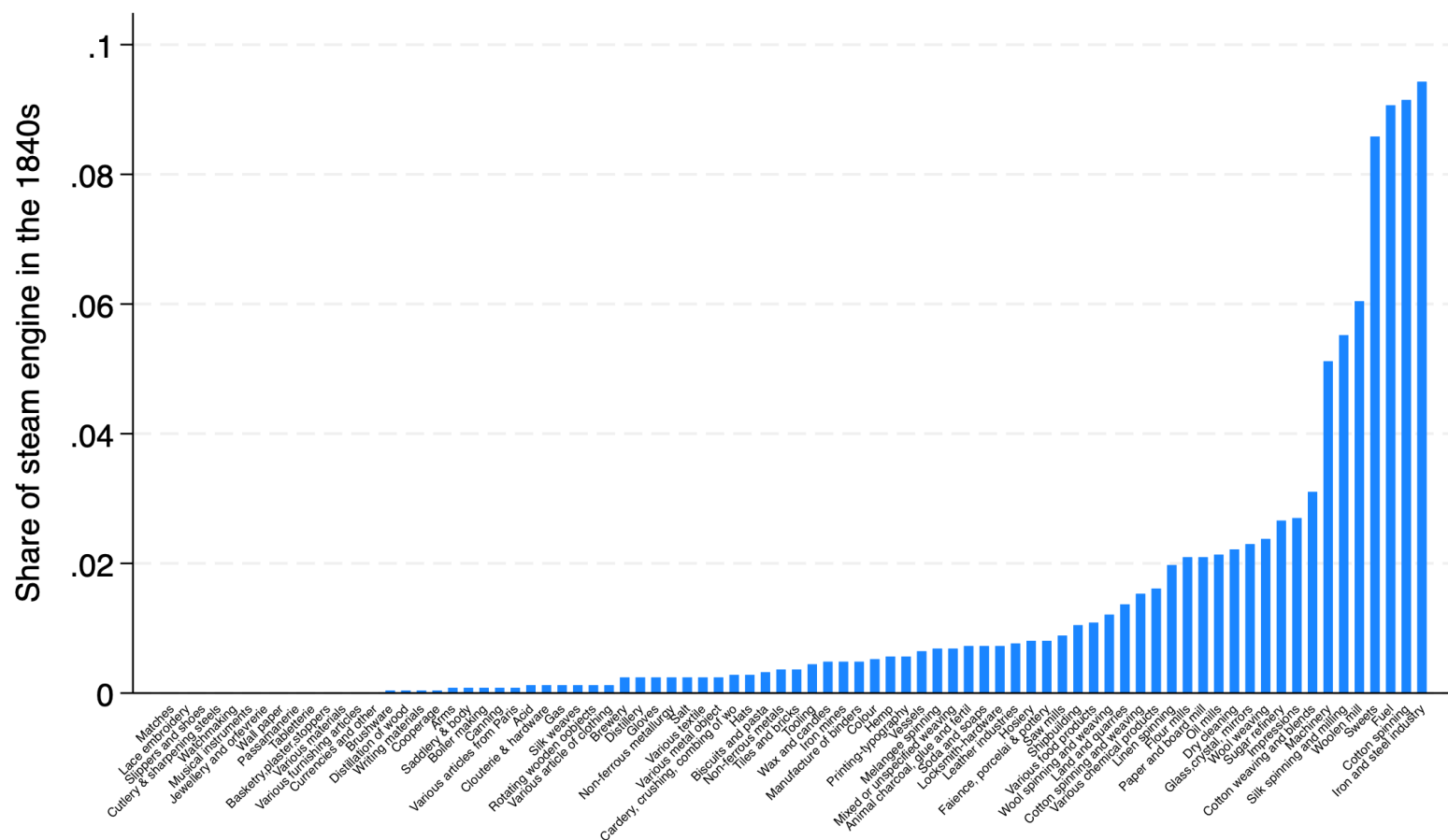
Notes: Panel A displays the balanced wool-milling subsample, consisting of districts where wool-milling industries were active in both censuses. These districts are further divided according to whether steam was already in use in the 1840s. Panel B presents the baseline wool-milling sample, derived by excluding from the balanced sample those districts that had adopted steam in the 1840s (shown as medium blue in Panel A). Panel C shows the baseline wool-milling districts in the 1860s, differentiated by whether steam was adopted between the 1840s and the 1860s. Panels D and E illustrate the geographical distribution of wool-milling industries that exited or entered between the two censuses. Equivalent sets of maps can be produced for all other subindustries recorded in the censuses and their steam-use status. *Source:* Chanut et al. (2000), *Minist'ere des Travaux Publiques, de l'Agriculture e du Commerce 1839*, and data.gouv.fr.

Table 1: The use of motive powers, 1840s–1860s

	(1)	(2)	(3)	(4)	(5)	(6)
Sample	Balanced sample	Baseline sample	Exits	Entries		
Type of power	1840s	1860s	1840s	1860s	1840s	1860s
No power	43.8%	32.4%	55.1%	38.3%	60.4%	50.3%
Water only	20.8%	12.7%	26.2%	14.7%	17.3%	15.4%
Animals only	7.2%	7.2%	9.1%	8.5%	5.3%	5.4%
Wind only	0.7%	0.4%	0.9%	0.5%	0.2%	0.2%
Steam only	7.5%	15.4%	0.0%	11.1%	7.6%	14.1%
Steam and water	7.2%	14.9%	0.0%	10.9%	4.7%	5.9%
Steam and animals	2.5%	4.8%	0.0%	4.4%	1.3%	2.1%
Steam and wind	0.2%	0.2%	0.0%	0.2%	0.2%	0.2%
Other (including steam)	10.1%	12.0%	8.7%	11.4%	3.0%	6.4%
Total %	100%	100%	100%	100%	100%	100%
Total N	2,543	2,543	2,020	2,020	1,221	3,839

Notes: The balanced sample includes all local (district) subindustries observed in both census registrations. The baseline sample excludes those that had adopted steam power by the time of the first registration.
Source: [Chanut et al. \(2000\)](#).

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Notes: The graph shows the contribution of steam engines by each subindustry to the total number of engines employed at the national level in France in the 1840s, calculated using the balanced and exit samples. *Source:* Chanut et al. (2000).

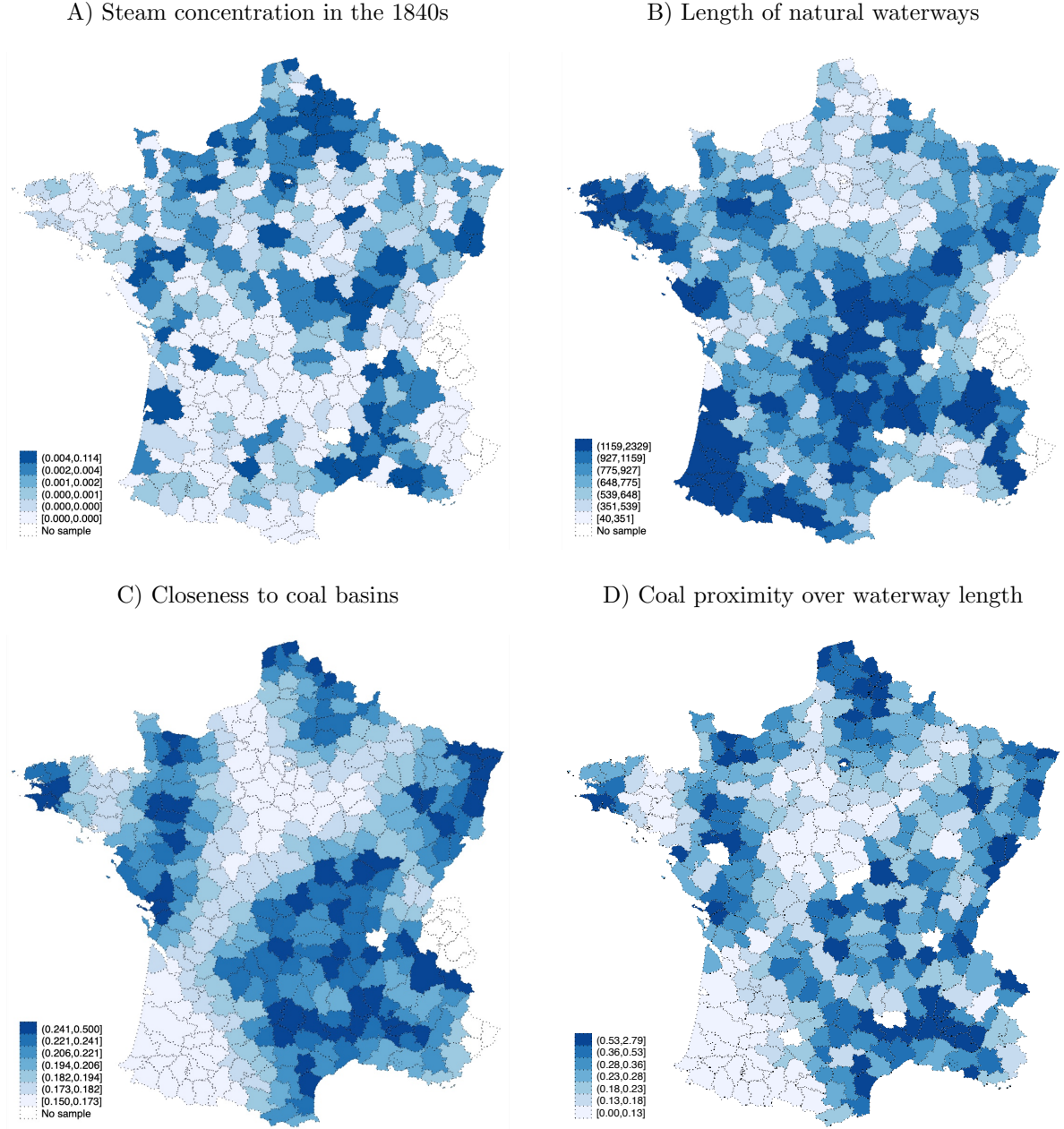
Steam adoption varied not only by sector but also by district. Panel A of Figure 5 shows the geographical distribution of steam engines used across French industries in the 1840s. Adoption tended to cluster in areas with limited waterways and closeness to coal (see Panels B and C). A prominent steam-use cluster was located in the coal-rich but water-poor Nord-Pas-de-Calais basin, including Fresnes-sur-Escaut, the first-ever site of steam adoption in France (e.g. [Franck and Galor, 2021](#)). By contrast, steam use was limited in Nouvelle-Aquitaine in the south-west of France, where abundant water coincided with scarce coal. Even coal-rich regions such as Auvergne in the Massif Central exhibited relatively low adoption, reflecting the region’s availability of hydraulic power. These patterns align with earlier accounts (e.g. [Dubuc, 1952](#); [Benoit, 2020](#)), emphasising that steam engines were adopted where water was insufficient and coal abundant. The relationship between steam adoption and the combined local availability of water and coal (shown in Panel D) provides an additional basis for the IV analysis presented later.

3.2 Labour outcomes

Our analysis considers three labour-related outcomes: total employment, male wages, and labour’s share. Total employment is the number of workers (including men, women, and children) in a local subindustry. Male wages are measured as the average daily wage of male workers. We focus on male wages because women and children were employed much less frequently than men, and their employment was concentrated in too few subindustries to support reliable statistical analysis.

Labour’s share is estimated as the ratio of total labour costs to the value of production. Total labour costs are calculated by multiplying the average wages of men, women, and children by their respective employment levels and summing across groups. Production values are reported net of raw material costs and are divided by 365 to ensure comparability with daily wages. This measure should be interpreted as an approximation of labour’s share: it captures the proportion of production value accruing to labour but excludes capital depreciation and therefore differs from the factor-income-based labour share measures typically used in national accounts (e.g. [Gollin, 2002](#); [Karabarbounis and Neiman, 2014](#)).

Figure 5: Steam use in the 1840s and access to industrial energy, by district



Notes: Panel A reports each district's share of steam engines relative to the national total, as recorded in the original census data. In Panel B, darker shading indicates a greater length of natural waterways, while in Panel C it denotes closer proximity to coal basins. Panel D combines these measures and is employed in our subsequent analysis as a district-level instrument, capturing proximity to coal relative to waterway length. Darker shading in Panel D therefore indicates districts where water is relatively scarce and coal relatively abundant, conditions under which steam adoption is potentially more attractive. The underlying calculations are detailed in Appendix A. *Source:* see Table A.1.

Labour patterns varied substantially across subindustries and regions. For example, in the 1840s, average male wages in printing typography were roughly twice those in shoemaking, while wages in flour milling—the most prevalent subindustry in France at the time—were

about three times higher on average in northern than in southern France. Similar heterogeneity is evident in employment and labour’s share: steel and textiles accounted for a large share of industrial employment, whereas labour’s share was considerably higher in shoemaking and watchmaking than in wool milling.

These differences underscore the importance of controlling for subindustry- and district-specific fixed effects to distinguish the relationship between steam adoption and labour outcomes from persistent structural variation across industries and regions.

3.3 Additional data

Our analysis also controls for a range of geographic characteristics that may have influenced both steam adoption and labour-market outcomes. These variables proxy for access to markets, trade infrastructure, technical expertise, administrative governance, and export activity. They include population and trade statistics as well as measures of the distance from each district centroid to the nearest coast, coal port, railway, national border, university, and to the capital city of Paris. Detailed information on the underlying sources is provided in Table A.1.

4 Empirical strategy

4.1 The OLS model

We begin by estimating the relationship between steam adoption and labour outcomes using an OLS estimator within a two-period panel framework. To address potential endogeneity concerns, we complement the baseline analysis with an instrumental-variable (IV) strategy, described below. Both approaches are based on the following linear specification:

$$Outcome_{ijt} = \alpha_0 + \alpha_t + \alpha_{ij} + \alpha_1 Steam_{ijt} + \beta' \mathbf{X}_{ijt} + \gamma' \mathbf{Z}_{it} + \delta' \mathbf{W}_{jt} + \epsilon_{ijt} \quad (1)$$

where $Outcome_{ijt}$ denotes the (log) value of the labour outcome variable in subindustry i in district j at time t (1840s or 1860s). Because labour outcomes are expressed in logs and the model is estimated on a two-period panel, the coefficients can be interpreted as approximate

growth rates between the two census years. The terms α_t and α_{ij} denote time and district–subindustry fixed effects, respectively. The vectors $\mathbf{X}_{ijt}$, $\mathbf{Z}_{it}$, and $\mathbf{W}_{jt}$ include control variables at the local-subindustry, district, and subindustry levels, respectively, multiplied by a *post* binary indicator. The variable ϵ_{ijt} is the error term.

$Steam_{ijt}$ captures steam adoption either along the extensive margin—measured as a binary indicator equal to one if adoption occurred between the two censuses—or along the intensive margin, measured as the log of steam horsepower installed in the 1860s. Because all baseline subindustries report zero steam horsepower in the 1840s, the continuous measure approximates growth in installed steam capacity over the period. As a robustness check, and given that the key explanatory variable in the extensive-margin analysis is binary, we later estimate the first stage of the IV specification described below using a probit model.

The key coefficient of interest, α_1 , captures the association between steam adoption and changes in labour outcomes. Conditional on fixed effects, the specification can be interpreted as a difference-in-differences design that exploits variation between adopters and non-adopters across the two censuses (e.g. [Angrist and Pischke, 2009](#); [Wooldridge, 2010](#)).

4.2 The IV model

The OLS estimates may be biased for two main reasons. First, the censuses do not reveal the precise timing of steam adoption relative to changes in labour, raising concerns about reverse causality. Second, unobserved time-varying factors may have jointly affected steam adoption and labour, leading to omitted-variable bias even after conditioning on fixed effects. To address these concerns, we implement an IV strategy exploiting two sources of plausibly exogenous variation in steam adoption at the subindustry and district levels, respectively. The two sources are combined to generate a total of three instruments, each interacted with a *post* binary indicator equal to one for observations in the 1860s.

The first instrument captures sector-specific complementarity with steam technology. The second proxies for the trade-off faced by industrial producers between steam engines and traditional waterwheels in terms of their local energy costs. The latter combines closeness to the nearest coal deposit—the principal fuel source for steam engines—with the extent of natural waterways within a district, determining the viability of water power. The third

instrument interacts these two components, thereby capturing district–subindustry variation in steam adoption arising from the interplay between subindustry-specific complementarity with steam technology and the relative costs of using steam rather than water power. We describe the construction of each instrument below and subsequently show that they provide credible sources of exogenous variation.

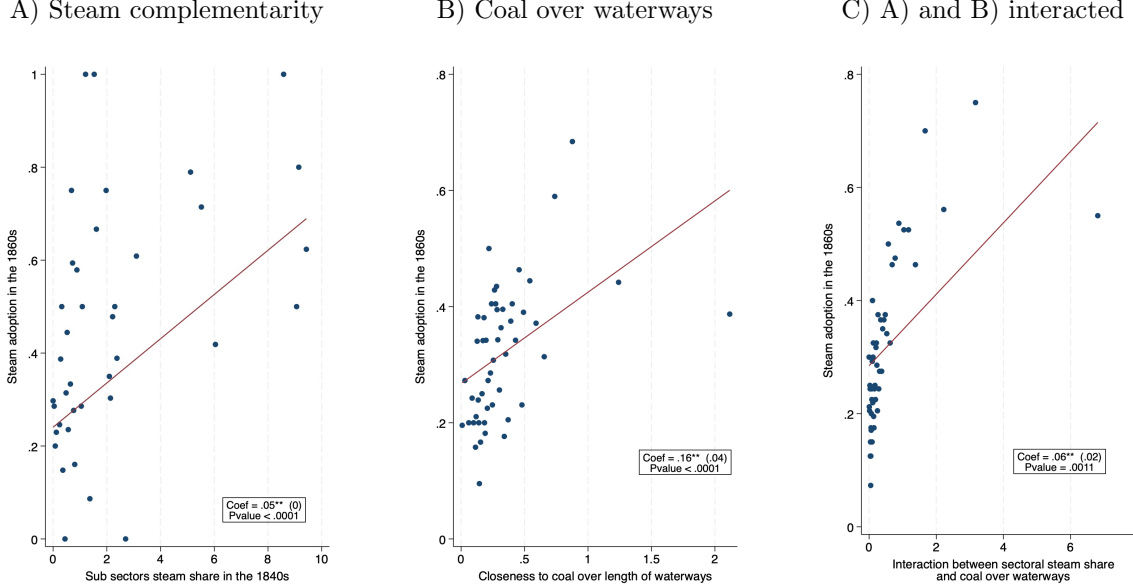
4.2.1 Sectoral steam complementarity

Some sectors exhibited greater complementarity with steam technology than others (e.g. [von Tunzelmann, 1978](#)). Our sector-specific instrumental variable captures this by measuring each subindustry’s share of steam engines in the national total at the time of the first census in the 1840s. Figure 4 above illustrated the distribution of these shares in the 1840s, revealing substantial sectoral heterogeneity in steam use. For instance, watchmaking did not employ steam technology at all, whereas wool milling used it relatively intensively, accounting for 6% of all steam engines. These shares are constructed using pre-1840s steam adopters recorded in the first census, which are excluded from the baseline sample (see Figure 3).

Each subindustry’s share of steam engines in the national total serves as a proxy for its complementarity with steam technology and, consequently, for the propensity of initially non-adopting local subindustries to adopt steam power between the 1840s and 1860s. Panel A of Figure 6 plots the unconditional relationship between this measure of sectoral steam complementarity and changes in steam adoption at the local subindustry level between the two censuses. The estimated relationship is positive and statistically significant, supporting the relevance of the instrument. Panel A of Figure A.2 in the Appendix shows the corresponding relationship for steam adoption along the intensive margin.

Although the sectoral instrument appears to be time-invariant, it reflects the fact that all French subindustries began with zero steam engines in 1732 (e.g. [Franck and Galor, 2021, 2022](#)). The instrument therefore captures differential nationwide growth in steam adoption across subindustries between the 1730s and the 1840s. As mentioned above, temporal variation is introduced into the regression model by interacting the sectoral share with a *post* indicator equal to one in the 1860s. This construction yields a difference-in-difference style instrument that exploits cross-subindustry variation in technological complementarity over

Figure 6: Steam adoption and the instrumental variables: the extensive margin



Notes: The graphs report binned *scatterplots* based on the baseline sample. Each point represents the average value of the dependent variable within quantile-based bins of the instrumental variable.

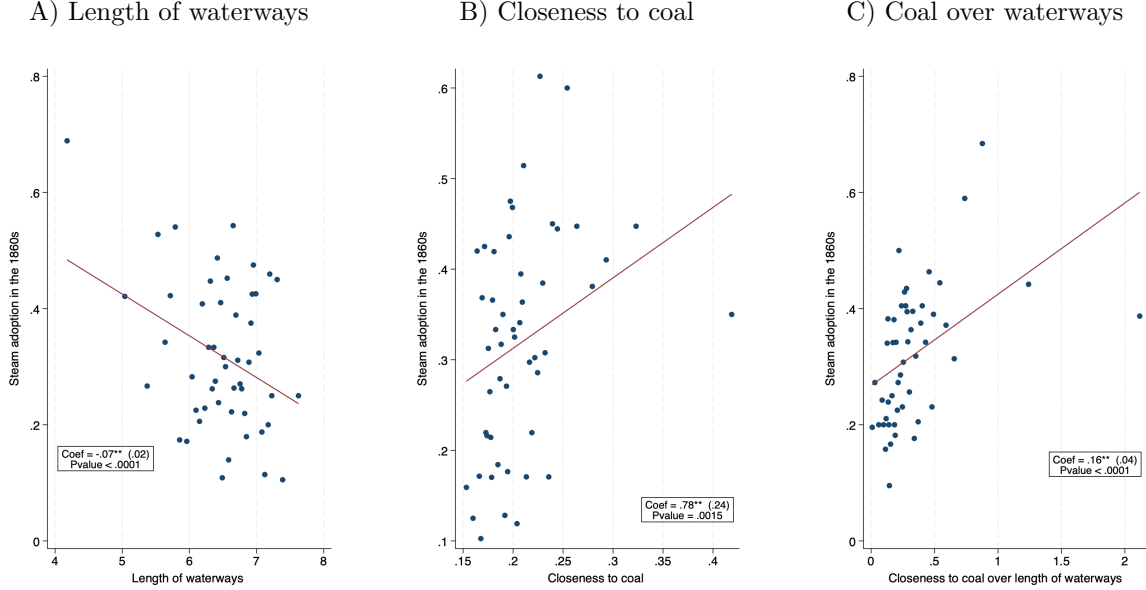
time, analogous to a share-shift instrument (e.g. [Goldsmith-Pinkham et al., 2020](#)). The baseline results reported below are robust to using the sectoral share of national steam engines in England instead of France.

4.2.2 Local relative energy costs

Our second instrumental variable captures the relative energy costs faced by local industrial producers when choosing between the two principal motive powers of the period—waterwheels and steam engines. The operating costs of these technologies depended crucially on access to two key energy inputs: water and coal. Waterwheels relied on hydraulic resources, whereas steam engines depended on coal as their essential fuel source.

More specifically, water power was the dominant source of industrial motive power when steam technology began to diffuse (see Table 1). Prior work suggests that France’s abundant water resources contributed to a slower uptake of steam relative to England ([Crouzet, 1974, 2003](#); [Benoit, 2020](#)). We capture this dimension using the length of natural waterways at the district level (see Panel B of Figure 5). The identifying assumption is that greater

Figure 7: Steam adoption by waterway length and coal proximity



Notes: The graphs report binned *scatterplots* based on the baseline sample. Each point represents the average value of the dependent variable within quantile-based bins of the instrumental variable.

waterway availability—by lowering the cost of water power—reduced the incentive to adopt steam. Panel A of Figure 7 confirms a negative correlation between local waterway length and steam adoption from the 1840s to the 1860s. This is consistent with evidence on the displacement of water power by steam in US manufacturing ([Hornbeck et al., 2024](#)).

Conversely, access to coal—the primary fuel used by steam engines—was a key determinant of early industrial mechanisation (e.g. [Allen, 2011](#)). In the absence of a dense railway network, coal prices increased steeply with distance from the nearest deposit (e.g. [Chevalier, 1842](#); [Benoit, 2020](#)). Because coal deposits were geologically determined and unevenly distributed across France (see Panel C of Figure 5), they provide a plausibly exogenous source of variation in access to industrial energy. Identification rests on the premise that districts located farther from coal basins faced higher effective energy costs and were therefore less likely to adopt steam power. Consistent with this interpretation, Panel B of Figure 7 reveals a positive relationship between coal proximity and steam adoption. Coal proximity is defined as the inverse of the logarithmic distance to the nearest coal basin, with higher values corresponding to greater access to coal.

By combining proximity to coal with the availability of natural waterways, our second instrument is intended to capture substitutability between waterwheels and steam power from an energy-cost perspective. The instrument is constructed as the ratio of min–max normalised coal proximity to min–max normalised waterway availability, both measured at the district level (see Panel D of Figure 5) and with a positive constant (equal to 0.10) added to waterway access to avoid extreme values in districts with limited waterways. While proximity to coal presumably reduced the cost of operating steam engines, abundant waterways likely increased the viability of waterwheels as an alternative source of power. The instrument therefore reflects the relative advantage of steam over traditional water-based technologies, taking higher values in districts that were closer to coal deposits and had more limited waterways. Panel C of Figure 7 shows a positive relationship between this measure and the propensity to adopt steam power between the two censuses. The baseline results reported below are robust to alternative specifications in which coal proximity and waterway availability enter either separately or interactively.

4.2.3 Steam complementarity and energy-cost incentives

The third and final instrumental variable interacts the two preceding measures. It thus combines sectoral steam complementarity with the local incentive to install steam power rather than relying on traditional waterwheels. Panel C of Figure 6 shows a statistically significant positive relationship between the interacted instrument and the probability of steam adoption between the two censuses. The interaction captures the idea that producers weighed sector-specific gains from steam against local conditions shaping the relative viability of steam and water power when deciding whether to adopt steam technology.

Archival evidence from eastern France shed light on the decision-making process. Two letters reproduced in Appendix B document the case of the *Usine de la Gouille*, an iron-casting foundry near Besançon whose waterwheels were powered by the Doubs River (Bouchot, 2023). In a letter dated 23 February 1835, the owner of the foundry, Mr. Bouchot, requested permission from the chief engineer of the Doubs River to construct a new water intake (a dam-like structure designed to channel water from the river onto the waterwheel blades) in order to sustain year-round production. The request was denied on the grounds

that it would lower the Doubs River’s level below navigable capacity. A subsequent letter reveals that Mr. Bouchot instead installed two steam engines with a combined capacity of 40 horsepower. The letter further reveals that the adoption of steam was accompanied by the hiring of eight additional blacksmiths, as well as a foreman and a supervising mechanic.

The correspondence highlights the trade-off presumably faced by many producers at the time: physical and regulatory constraints limited the scalability of water power, whereas steam offered a more flexible alternative (e.g. [Benoit, 2020](#)). The letters moreover suggest that steam adoption entailed both increased employment and higher wages, the latter reflecting additional demand for more highly trained workers and greater managerial oversight—consistent with our regression results showing higher employment and wages in steam-adopting subindustries.

4.2.4 Threats to identification

Identification relies on the assumption that the instruments affect labour outcomes only through their influence on steam adoption. A necessary condition is therefore that the instruments be uncorrelated with factors that independently affect both steam adoption and labour-market outcomes. We examine the most plausible threats to this assumption below.

Steam complementarity or industrial dynamism

Our sectoral instrument is intended to capture subindustry-specific complementarity with steam technology. A natural concern is that a high sectoral share of national steam engines in the 1840s mainly reflected unobserved differences in sectoral growth trajectories rather than technological suitability for steam. In principle, subindustries could have been equally compatible with steam technology but differed in the evolution of demand for their products. Sectors experiencing stronger demand growth could thus have been more likely to expand employment and wages and, for the same reason, more likely to adopt steam power. In this case, the instrument could capture underlying sectoral dynamism rather than complementarity with steam technology, thereby biasing the estimated effects of steam adoption.

Several considerations mitigate this concern. First, the baseline specification controls for a range of factors that may be correlated with both sectoral growth and steam adoption.

At the subindustry level, we account for the use of alternative motive powers (water, wind, and animal), whose prevalence may have varied systematically across sectors, as well as for the number of local establishments, which may proxy for the scale of local demand. At the district level, we control for proximity to coasts and railways, both of which facilitated access to expanding markets. The robustness analysis further incorporates measures of population density and population growth, together with sector-specific changes in exports, to account for additional variation in local and sectoral demand conditions. Finally, district–subindustry fixed effects absorb time-invariant local characteristics, while time fixed effects capture aggregate shocks common to all observations.

Second, if a high sectoral share of national steam engines primarily reflected superior growth prospects rather than steam complementarity, we would expect this instrument to be positively correlated with labour outcomes already in the 1840s. The cross-sectional evidence reported in Table C.1 does not support this view, showing no systematic relationship between the steam-share instrument and either wages or employment at the time of the first census. Third, if the steam-share instrument merely proxied sectoral dynamism, it should remain positively associated with labour outcomes even among local subindustries that never adopted steam. To assess this possibility, Table C.2 restrict the sample to non-adopters and examine the reduced-form relationship between the steam-share instrument and labour outcomes in the 1860s. The estimates reveal no consistent relationship between the two. Fourth, if the sectoral instrument primarily captured broader sectoral dynamism rather than steam complementarity, the estimated effects would disappear once we remove sectors normally associated with rapid industrial growth, including textiles, mining, metals, and iron products. Robustness results show this is not the case.

Local energy costs or industrial development

Defined as proximity to coal relative to the length of waterways of each district, our second instrument intends to capture variation in local incentives to substitute water with steam power. While identification relies on their ratio, we assess the instrument’s two components both separately and jointly.

Beginning with waterways, a plausible concern is that water endowments affected more than industrial energy costs. Waterways facilitated transport and market access, potentially raising employment and wages through increased trade, while at the same time possibly encouraging subindustries to adopt steam in response to higher demand. Equally, water resources enabled the use of waterwheels, so favourable endowments could have supported expanded industrial activity—raising profits as well as employment and wages—with higher profits in turn facilitating the adoption of steam power.

These channels, however, are unlikely to threaten our identification strategy. First, greater waterway endowments are associated with a *lower* likelihood of adopting steam, as shown in Panel A of Figure 7, and consistent with water acting as a substitute rather than a complement to steam technology. Consequently, if waterways independently promoted employment or wage growth, they would induce a negative correlation between steam adoption and labour outcomes, opposite to the positive relationship documented below. Any resulting bias would therefore attenuate the estimated effects of steam on employment and wages, implying that our estimates, if anything, understate its true impact. Second, our specifications control for the use of waterwheels at the district–subindustry level. Finally, district–subindustry fixed effects absorb time-invariant local characteristics, while time fixed effects capture aggregate shocks common to all observations.

Proximity to coal on the other hand may have positively influenced both steam adoption and labour-market outcomes through channels beyond the cost of steam fuel. A salient example is coal-mining activity, which typically paid above-average wages to compensate for physical risk and harsh working conditions (e.g. [Church, 1986](#); [Vanhaute, 1992](#); [Feinstein, 1998](#)). At the same time, mining profits may have relaxed local financing constraints for steam adoption. Proximity to coal—especially in districts with coal-mining industries—may therefore have been correlated with factors beyond steam energy costs that are themselves positively associated with both steam adoption and labour outcomes. This raises concerns about omitted-variable bias for proximity to coal and therefore for the ratio of coal proximity to waterway access.

Again, this concern is mitigated by the inclusion of district–subindustry and time fixed effects. Moreover, if proximity to coal affected labour-market outcomes through channels

other than steam adoption, as the preceding argument suggests, we would expect the instrument to be correlated with wage levels already in the 1840s. The cross-sectional evidence reported in Table C.3 provides little support for this interpretation. Distance to coal and the extent of waterways are both individually uncorrelated with wages in the 1840s. While the coal-over-waterways measure is positively associated with wages, Table C.4 shows that this statistically significant relationship disappears once mining-intensive sectors and districts close to coal deposits are excluded. Indeed, the robustness analysis indicates that removing these observations strengthens the estimated positive effects of steam on labour outcomes. These results suggest that the instrument does not simply capture pre-existing profits or labour-market advantages associated with coal-rich locations, particularly when the analysis is restricted to subindustries and districts situated away from coal mines.

Lastly, if the district-specific instrument primarily captured broader economic advantages associated with coal abundance or water availability, restricting the sample to areas without particularly favourable (or unfavourable) energy endowments should substantially weaken both instrument relevance and the estimated effects of steam adoption. The robustness analysis provides little support for this prediction. First-stage F-statistics remain strong, and the estimated labour-market effects are broadly unchanged relative to the baseline specification, as we show further below.

Taken together, these observations suggest that the instrumental variables used below do not simply reflect pre-existing economic advantages associated with dynamic sectors or coal-rich districts.

4.2.5 First-stage estimation

Having considered the plausibility of the identifying assumptions underlying our three instrumental variables, we now turn to the details of the IV specification. In the first stage of the IV model, the three instrumental variables described above are used to predict $Steam_{ijt}$ in equation (1). That is,

$$Steam_{ijt} = \beta_0 + \beta_t + \beta_{ij} + \beta_1 Z_{1it} + \beta_2 Z_{2jt} + \beta_3 Z_{1it} Z_{2jt} + \mu' \mathbf{X}_{ijt} + \nu' \mathbf{Z}_{it} + \rho' \mathbf{W}_{jt} + \omega_{ijt} \quad (2)$$

where β_t and β_{ij} denote time and district–subindustry fixed effects, respectively; the vectors $\mathbf{X}_{ijt}$, $\mathbf{Z}_{it}$, and $\mathbf{W}_{jt}$ are the same control vectors as in equation (1); and ω_{ijt} is an error term for subindustry i in district j at time t .

The instruments are defined as follows. The variable Z_{1it} measures the share of steam engines employed in subindustry i relative to the national total in the 1840s, proxying for sector-specific complementarity with steam technology. The variable Z_{2jt} is defined as the ratio of proximity to coal to the length of waterways in district j , capturing district-specific incentives to substitute between steam engines and waterwheels. Finally, the term $Z_{1it} Z_{2jt}$ denotes the interaction between the subindustry-specific and district-specific instruments. As noted above, all instruments, together with the time-invariant controls, are interacted with a *post* indicator equal to one in the 1860s.

5 Results

This section presents the baseline estimates of the relationship between steam adoption and labour outcomes. Subsequent sections assess the robustness of the results and examine heterogeneity in the estimated effects.

Table 2 reports OLS and IV estimates of the relationship between steam adoption and labour outcomes between the 1840s and 1860s at the extensive margin. The steam y/n indicator equals one if a local subindustry used steam power in the 1860s and zero otherwise. All specifications are estimated on the full baseline sample (see Figure 3) and include time and district–subindustry fixed effects. Standard errors are clustered at the district–subindustry level, allowing for unobserved within-cluster dependence. Table D.1 reports the reduced-form results, and Table D.2, Column (6), details the first-stage estimates.

The model controls for several plausible confounding factors, reported in Table E.1. These include a set of time-invariant district characteristics—captured by distances to the nearest

Table 2: The effect of steam on labour: the full baseline sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.014)	0.116* (0.065)	0.517*** (0.053)	0.790*** (0.262)	0.091*** (0.022)	0.221* (0.116)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.271	0.264	0.501	0.494	0.084	0.068
jp		0.433		0.241		0.499
K-P Wald F		29		29		29

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. The reduced form is reported in Table D.1 columns (1-3). The full table and the first stage are reported in Table E.1 and Table D.2.

coast, coal port, railway, university, and to Paris—all interacted with a *post* indicator. We further control for pre-existing reliance at the local subindustry level on water, wind, and animal power in the 1840s. Because some subindustries were more likely than others to rely on female labour, we also account for the share of female workers at the subindustry level.

Additionally, we control for the size of each subindustry in the 1840s, measured as its share of total industrial establishments in the first census. This variable captures differences in industrial structure and production organisation across sectors. Further to this, the analysis accounts for the number of establishments within each local subindustry, capturing changes in the local scale of production over time. These controls imply that the estimated effect of steam on labour outcomes is identified net of both pre-existing differences across subindustries and changes in local production scale.

The baseline IV estimates show that steam adoption was positively associated with labour outcomes. Male wages rose by 12%, total employment by 120%, and labour's share by 24% more among steam adopters than among non-adopters. These percentage effects are computed as $(\exp(\alpha) - 1) \times 100$. The large employment effect should be interpreted relative to the overall decline in employment among non-adopting subindustries over the same period

(see Figure 1). The OLS estimates are uniformly smaller, consistent both with omitted variables affecting steam adoption and with the IV specification identifying a Local Average Treatment Effect for subindustries at the margin of adoption (e.g. [Imbens and Angrist, 1994](#)). This pattern is also consistent with the control-function estimates reported in Table F.5 and discussed in the next section.

6 Robustness

This section further assesses the robustness of the baseline results through a series of complementary checks. We vary the clustering of standard errors to examine sensitivity to alternative inference assumptions, estimate the first stage of steam adoption using a probit model to test functional-form robustness, and introduce additional controls and alternative instrumentation specifications to assess the stability of the estimates.

We also conduct a survivorship analysis to determine whether entering and exiting local subindustries exhibited labour-market responses comparable to those of continuing subindustries. We test for aggregation bias, verifying that the results are not driven by subindustry- and district-specific composition. Finally, we examine steam use at the intensive margin by analysing whether stronger labour-market gains were associated with higher levels of installed steam horsepower.

Taken together, these exercises suggest that the baseline findings are robust across a broad range of alternative identification and specifications strategies.

6.1 Alternative specifications

Before turning to potential survivorship and aggregation biases, we present a series of sensitivity analyses based on alternative specifications.

Inference and fixed-effects sensitivity

Tables F.1 and F.2 show that the results are robust to alternative inference procedures, including specifications with double clustering and heteroskedasticity- and autocorrelation-consistent (Conley) standard errors allowing for spatial correlation within a 100 km radius of

each district centroid. Tables F.3 and F.4 further show that the estimates remain broadly unchanged when district and subindustry fixed effects are entered separately. The employment effects become smaller and less precisely estimated once additional controls are included, suggesting that a substantial part of the baseline effect is driven by within district–subindustry variation.

Functional form robustness

The baseline specification estimated the effect of steam adoption on labour using OLS. Because the key explanatory variable is binary (steam y/n), a probit model provides a natural alternative estimator. Table F.5 shows that the estimated effects of steam on labour outcomes remain consistent with the baseline results. Moreover, the coefficient on the control-function residual, $\hat{v}$, is negative and statistically significant, indicating the presence of a downward bias in the OLS estimates, in line with our baseline results.

Instrumentation sensitivity

Turning to robustness concerning the instrumentation procedure, Figure F.1 reports a randomisation inference exercise based on 1,000 random reallocations of the subindustry- and district-specific components of the instrument. The observed first-stage F-statistic broadly lies well above the placebo distributions, suggesting that the predictive power of the instruments is not driven by arbitrary subindustry- and district-specific variation.

Table F.6 further illustrates that the results remain robust when the instrumental variables are standardised instead of normalised. Table F.7 shows that the estimates are similar when allowing for a quadratic specification of waterway access. Further, since the district-specific instrument is constructed as a ratio of distance to coal over the length of waterways, a positive constant (ϵ) is added to the denominator to account for very short or zero waterway length. Table F.8 shows the results are robust to alternative ϵ values.

Finally, Table F.9 assesses the sensitivity of the results to replacing the steam complementarity instrument—originally constructed using the national share of subindustry-specific steam engines in France—with an alternative measure based on the corresponding national shares in England during 1781–1800 (see Figure A.1). Moreover, Table F.10 shows that our

results remain robust to controlling for distance to Fresnes-sur-Escaut in northern France, the site of the first commercial steam engine installed in France in 1732, and used as an instrumental variable in [Franck and Galor \(2021, 2022\)](#).

Alternative controls and sample restrictions

We next report a range of alternative control specifications. Some remove baseline controls, others introduce additional variables or replace existing ones, whereas still others restrict the sample size.

Table F.11 shows that the results remain robust when excluding the full set of baseline controls. Table F.12 reports estimates that do not condition on the number of establishments within each subindustry. While the results for wages and labour’s share remain similar to the baseline, the employment coefficients increase in magnitude in both the OLS and IV specifications. This pattern is consistent with the interpretation that steam adoption was associated not only with higher employment within establishments, but also with an expansion in the overall scale of local industrial activity.

We also account for three vital factors that may plausibly have influenced both steam adoption and labour-market outcomes. In Table F.13, Panel A controls for market-expansion potential by including population growth between 1801 and 1836 and population density in 1836. Panel B examines the role of local financial access by controlling for the number of banks in the 1840s, while Panel C accounts for sector-specific demand dynamics by including changes in the value of subindustry exports between 1841 and 1859. Panel D includes all three sets of controls simultaneously. Across all specifications, the estimated effects remain similar in magnitude and statistical significance.

A matter discussed in the previous sections is that coal-mining industries, or proximity to coal deposits more generally, may be associated both with a higher likelihood of steam adoption and improved labour conditions for reasons unrelated to industrial energy costs. Table F.14 addresses this concern by excluding mining sectors from the sample and removing districts above the 75th percentile in terms of proximity to coal basins. The baseline results remain robust to this sample restriction.

A broader question is whether the baseline results are driven by rapidly industrialising sectors, such as textiles, mining, and metals and iron production, or by districts with particularly favourable (or unfavourable) access to industrial energy sources. Table F.15 addresses this concern by re-estimating the baseline specification after excluding these industries or districts in the top quartile of proximity to coal deposits, coal ports, or either of these coal-related advantages, as well as districts with unusually high or low access to waterways.

Overall, the checks above indicate that the results are insensitive to the choice of error structure or model or control specification, reinforcing the credibility of the baseline findings.

6.2 Survivorship bias

The baseline empirical strategy relied on local subindustries observed in both censuses. Excluding exiters may overstate average performance if weaker units are more likely to disappear, while omitting entrants may bias estimates if new subindustries differ systematically from incumbents (e.g. [Brown et al., 1992](#)). To address these concerns, we extend the analysis through robustness checks that explicitly incorporate exits and entries, comparing each group with the continuing subindustries that form the baseline sample. The results indicate that survivorship bias is unlikely to materially affect our findings.

We implement the tests using cross-sectional regressions that augment the balanced sample with either exiting or entering subindustries, interacting an indicator for exit or entry with the steam-adoption variable. The 1840s census allows us to check whether subindustries that exited before the 1860s differed systematically from those that survived, while the 1860s census provides a corresponding comparison for entrants. Figure 3 shows the approach for the wool-milling industry, illustrating how exiting and entering subindustries (Panels D and E) can be incorporated alongside the continuing (balanced) sample (Panel A).

Columns 1–3 of Table 3 compare surviving and exiting subindustries. Exiting subindustries employed significantly fewer workers and, among steam users, paid significantly higher wages—patterns that may be consistent with factors associated with their exit. Columns 4–6 present the analogous comparison between survivors and entrants. Entrants also employed fewer workers than surviving subindustries, including among steam adopters, but—unlike

Table 3: Cross-sectional analysis including exits (1840s) and entries (1860s)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS					
	1840s			1860s		
	Male wage	Employment	Labour's share	Male wage	Employment	Labour's share
Steam y/n	0.065*** (0.013)	0.746*** (0.056)	-0.056*** (0.016)	0.044*** (0.009)	0.862*** (0.047)	0.090*** (0.015)
Steam y/n × exit/entry	0.074*** (0.026)	0.158† (0.110)	-0.047* (0.027)	0.006 (0.011)	0.224*** (0.059)	0.057*** (0.020)
Exit/entry	-0.014 (0.011)	-0.453*** (0.048)	0.017 (0.016)	0.003 (0.007)	-0.410*** (0.038)	-0.013 (0.012)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District
N	3,764	3,764	3,764	6,382	6,382	6,382
R2	0.554	0.749	0.321	0.568	0.740	0.338

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The model relies on the balanced sample (see Panel A of Figure 3) and includes binaries equal to one if the local subindustry exited before the 1860s (Columns 1–3) or entered after 1840s (Columns 4–6). For the 1860s, the model further includes a binary equal to one if steam was adopted prior to the 1840s. Standard errors are robust.

exiting subindustries—entrants paid lower wages relative to survivors, a configuration that may be associated with their entry success.

Beyond these differences, the results consistently indicate that steam-using subindustries—whether exiting, entering, or surviving—paid higher wages and employed more labour than non-steam users. One possible explanation for the negative association between steam adoption and labour's share in the cross-sectional analysis is that early steam adoption was concentrated in relatively capital-intensive sectors, where labour costs accounted for a smaller share of production value.

The test above relied on the balanced panel (Panel A of Figure 3). Because part of this panel is used to construct the sectoral steam-complementarity instrument, the preceding analysis did not report IV estimates. By augmenting the baseline sample (Panel B of Figure 3) with entering subindustries (Panel E of Figure 3), we can instead implement a cross-sectional analysis for the 1860s that applies the baseline IV approach to predict steam

Table 4: Cross-sectional analysis including entries (1860s) using an IV approach

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.071*** (0.009)	0.132** (0.055)	1.068*** (0.049)	3.436*** (0.469)	0.103*** (0.015)	0.174† (0.118)
Steam y/n × entry	0.002 (0.012)	-0.019 (0.053)	0.200*** (0.064)	-1.712*** (0.412)	0.058*** (0.020)	0.043 (0.121)
Entry	-0.016** (0.008)	-0.007 (0.019)	-0.424*** (0.039)	0.254* (0.142)	0.007 (0.011)	0.015 (0.039)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subsector	Subsector	Subsector	Subsector	Subsector	Subsector
	Department	Department	Department	Department	Department	Department
N	6,382	6,382	6,382	6,382	6,382	6,382
R2	0.421	0.416	0.651	0.525	0.248	0.243
jp		0.001		0.089		0.677
K-P Wald F		9		9		9

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The sample includes a binary equal to one if the local subindustry had already steam in the 1840s. Standard errors are robust.

adoption among entrants. Table 4 reports the results. Relative to surviving steam adopters, entrants employed fewer workers and paid lower wages on average. Nevertheless, in line with the baseline findings, steam-adopting entrants employed more labour and paid higher wages than non-adopting entrants, both in the OLS and IV specifications.

Taken together, these exercises suggest that entry and exit—were they to be incorporated—would not alter the baseline findings. If anything, the patterns observed for both entrants and exiting subindustries are broadly consistent with the interpretation that steam adoption was associated with relatively more labour-intensive and better-paid outcomes, regardless of whether subindustries persisted across both censuses.

6.3 Aggregation bias

While the 1840s census reports statistics at the establishment level, the 1860s census provides data only at the district–subindustry level. For the baseline analysis, we therefore aggregated firm-level observations to the district–subindustry level. This step, however, raises potential

Table 5: Firm-level cross-sectional analysis for the 1840s

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS					
	Firm level			Post aggregation		
	Male wage	Employment	Labour's share	Male wage	Employment	Labour's share
Steam y/n	0.067*** (0.008)	0.888*** (0.039)	-0.019* (0.012)	0.063*** (0.013)	0.813*** (0.059)	-0.050*** (0.016)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District
N	10,554	10,554	10,554	2,543	2,543	2,543
R2	0.501	0.518	0.257	0.603	0.780	0.370

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors. The sample includes firms in local subindustries from the balanced sample.

concerns about aggregation bias, whereby relationships operating at the establishment level may be obscured or distorted when data are collapsed into broader units (e.g. [Deaton, 1985](#)). In our context, such bias would arise if the observed relationships were driven by within-subindustry heterogeneity that is not captured at the aggregated level.

We address the issue in two ways. First, using firm-level data from the 1840s census, we compare labour conditions of steam and non-steam firms within the same district-subindustry. We also test whether outcomes differ between single- and multi-firm subindustries. Second, noting that single-establishment firms are statistically similar to multi-firm ones in this regard, we mark out single-establishment subindustries in the 1860s aggregated data to approximate firm-level behaviour. Both exercises dismiss the idea that our baseline results are driven by aggregation.

We begin by examining the firm-level information provided in the 1840s census. These data allow us to assess whether the relationship between steam adoption and labour conditions differs before and after aggregation at the district-subindustry level. Table 5 compares labour outcomes before and after aggregation. To ensure comparability between steam and non-steam users in the 1840s, we rely on the balanced sample (see Panel A of Figure 3).

Table 6: Within-district pairwise firm-level analysis for the 1840s

	(1)	(2)	(3)
	OLS		
	Male wage	Employment	Labour's share
Steam y/n	0.038** (0.019)	0.830*** (0.081)	-0.005 (0.031)
FE	Subindustry & District	Subindustry & District	Subindustry & District
N	290	290	290
R2	0.884	0.864	0.714

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors.

Columns 1–3 report cross-sectional OLS estimates, showing that steam-using firms employed significantly more workers and paid higher wages than non-users. Columns 4–6 report estimates from the corresponding district–subindustry specification, which are qualitatively similar and suggest that aggregation does not introduce systematic bias. Indeed, Wald tests fail to reject the null hypothesis of coefficient equality across the two specifications.

Continuing with the 1840s census data, we take a further step to assess potential aggregation bias at the district level. Table 6 reports cross-sectional OLS estimates for a restricted sample limited to districts that include both steam and non-steam users within a given subindustry, constructing for each district the average labour outcomes by group. This within-district comparison is again consistent with the pattern that steam-using firms employed more workers and paid higher wages than their non-using counterparts.

Although the 1860s census does not return firm-level data, some local subindustries consisted of a single establishment, approximating a firm-level setting. Introducing a binary indicator for such single-establishment subindustries and interacting it with steam adoption in a cross-sectional model, Table 7 shows that their wage effects aligned with those of multi-establishment peers, while they absorbed more labour and exhibited a higher labour share.

Lastly, an attempt to explore the causal effect of steam on labour (employment) using firm-level data comes from re-estimating the baseline model on a restricted sample of single district-level establishment subindustries. Because this restricted sample size is too small

Table 7: Cross-sectional analysis for the 1860s

	(1)	(2)	(3)
	OLS		
	Male wage	Employment	Labour's share
Steam y/n	0.050*** (0.010)	0.793*** (0.054)	0.092*** (0.018)
Steam y/n × single establishment	-0.003 (0.025)	0.708*** (0.143)	0.122*** (0.041)
Single establishment	-0.023 (0.018)	-0.369*** (0.087)	-0.011 (0.025)
Controls	Yes	Yes	Yes
FE	Subindustry & District	Subindustry & District	Subindustry & District
N	2,543	2,543	2,543
R2	0.659	0.792	0.472

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Robust standard errors.

to support IV estimation, we further include subindustries that entered between the two censuses (Panel E in Figure 3). Entrants are included under the assumption that these had zero employment in the 1840s. A binary variable distinguishes these entrants from local subindustries that continued across both censuses (i.e. survivors).

Columns 1–2 of Table 8 report the estimated effect of steam adoption on employment for the full sample of single- and multiple-establishment subindustries, while Columns 3–4 restrict the analysis to single-establishment cases. Both models confirm that steam adoption was labour-absorbing. As in Table 7, however, the stronger responses among steam-adopting single-establishment subindustries suggest that aggregation, if anything, may understate the true labour-absorbing effects of steam.

Taken together, the results of the aggregation-bias checks strengthen confidence that steam adoption was both labour-absorbing and wage-enhancing at the individual firm level, and that our baseline findings are not artifacts of sectoral or regional aggregation.

Table 8: The effect of steam on total employment: the extensive margin including entries

	(1)	(2)	(3)	(4)
	Second stage			
	OLS	IV	OLS	IV
	Full sample		One establishment	
	Employment			
Steam y/n	0.955*** (0.065)	0.808*** (0.294)	1.414*** (0.109)	1.074** (0.480)
Controls	Yes	Yes	Yes	Yes
N	5,859	5,859	1,450	1,450
R2	0.078	0.077	0.135	0.127
jp		0.000		0.745
K-P Wald F		77		23

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district-subindustry level. The full sample includes the baseline sample plus entrants between the two censuses. Employment among entrants is set to zero in the 1840s. The 'One establishment' sample restricts the full sample to local subindustries with only one establishment.

6.4 The intensive margin

The baseline analysis focused on steam adoption at the extensive margin, that is, the impact on labour outcomes of adopting steam power versus not using it. Table 9 instead reports OLS and IV estimates of the relationship between installed steam horsepower and labour outcomes, conditional on steam being adopted between the 1840s and 1860s. All specifications include the same controls and fixed effects as in the extensive-margin analysis. In contrast to the extensive margin, however, the first-stage estimates—reported in Column 6 of Table D.3—suggest that sectoral steam complementarity is the main determinant of installed steam horsepower once steam adoption has occurred.

The intensive-margin IV estimates indicate sizeable effects of steam on labour outcomes. Subindustries at the 75th percentile of steam horsepower exhibit 12% higher male wages, 55% greater employment, and a 26% higher labour share than those at the 25th percentile. These effects are computed using the interquartile range of installed horsepower. OLS estimates are again uniformly smaller, consistent with attenuation bias due to omitted variables or reverse causality. As in the extensive-margin analysis, the IV estimates admit a Local Average Treatment Effect interpretation, capturing the response of subindustries whose intensity of

Table 9: The effect of steam horsepower on labour

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam HP	0.034*** (0.010)	0.075** (0.033)	0.289*** (0.041)	0.303** (0.128)	0.010 (0.017)	0.159** (0.065)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	1,290	1,290	1,290	1,290	1,290	1,290
R2	0.404	0.387	0.569	0.569	0.032	-0.095
jp		0.022		0.631		0.086
K-P Wald F		16		16		16

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The sample is restricted to local subindustries that adopted steam power between the 1840s and the 1860s. The standard errors are clustered at the district subindustry level. The reduced form is reported in Appendix Table D.1 columns (4-6). The full table and the first stage are reported in Appendix Tables D.3.

steam use was most affected by the instruments. Table E.2 in the Appendix reports the full set of estimates, while Table D.1 presents the corresponding reduced-form results.

Notably, there is no statistically significant relationship between waterways or closeness to coal (or their interaction) and steam horsepower (see Figures A.2 and A.3). This suggests that, once steam power was installed, the amount of horsepower used in production was largely independent of local hydraulic or coal-proximity conditions and instead depended primarily on technological complementarity with steam power.

Taken together, the extensive- and intensive-margin estimates indicate that both the diffusion of steam power and the intensification of its use were associated with improved labour conditions.

7 Heterogeneity

The baseline analysis suggests that steam adoption was associated with higher wages, greater employment, and a higher labour share. Yet this does not necessarily imply that the mechanical modernisation of industry, through the installation of steam power, uniformly expanded labour demand and compensation. This section examines whether the observed labour-market benefits were concentrated in particular regions, industries, or configurations of motive power. It also explores, albeit in a crude manner, whether the baseline effects persisted over time.

These examinations would ideally be addressed by disaggregating the sample and estimating the baseline model separately across periods, districts, subindustries, and motive-power combinations. In practice, the available data and the complexity of the IV strategy constrain the degree of sample partitioning. By relaxing certain requirements, it is nevertheless possible to conduct a rudimentary assessment of whether the effects of steam varied over time; whether traditional industrialised regions registered alternative labour outcomes; whether textiles—one of the earliest sectors to mechanise—experienced distinct impacts relative to other sectors; and whether technological substitution—notably *creative destruction* captured by the replacement of water with steam power—generated differential effects on labour.

7.1 Persistence: early versus later adopters

The estimates reported above capture the average labour-market effects of steam adoption over a period of up to two decades. A natural question is whether these effects persisted over longer horizons or gradually diminished over time. While the available census data do not permit a precise analysis of long-run persistence, information on steam installations predating the first census nonetheless allows us to construct a rough proxy for the duration of these effects

To this end, we return to the balanced sample (see Panel A of Figure 3) and reintroduce local subindustries that had already adopted steam by the 1840s into the baseline specification. While this extension comes at the cost of weaker identification, it allows us to compare changes in labour outcomes between the 1840s and 1860s for early adopters, later adopters,

Table 10: Shorter- and longer-term effects of steam on labour

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam in 1840s	0.028* (0.016)	0.052*** (0.019)	0.399*** (0.060)	0.503*** (0.069)	0.145*** (0.028)	0.192*** (0.037)
Steam in 1860s	0.060*** (0.013)	0.094*** (0.015)	0.542*** (0.052)	0.625*** (0.064)	0.086*** (0.022)	0.138*** (0.028)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	5,086	5,086	5,086	5,086	5,086	5,086
r ²	0.274	0.273	0.487	0.486	0.077	0.074
jP		0.226		0.027		0.083
K-P Wald F		375		375		375

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. .

and non-adopters. Specifically, we introduce an indicator equal to one for subindustries that adopted steam between the 1840s and 1860s (and zero for those that had already adopted by the 1840s) and interact it with the baseline steam-adoption variable, normalised to zero in the initial period. This specification enables us to distinguish the shorter-run effects of steam adoption from its longer-run impact on labour outcomes.

Table 10 reports changes in the three outcome variables between the two censuses. Both the OLS and IV estimates indicate that the effects on male wages and employment were stronger in the shorter run, whereas increases in labour's share were more pronounced over longer horizons. At the same time, the earlier cross-sectional analysis shows that local subindustries that had already adopted steam by the 1840s paid higher wages and employed more workers than non-adopters (see Table 4). The weaker subsequent growth observed among early adopters may therefore reflect that part of the labour-market benefits of steam adoption had already been realised before the first census, leaving less scope for further gains between the 1840s and 1860s.

Table 11: Short- versus long-term effects of steam on labour

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam in 1860s x later	0.042** (0.017)	0.089*** (0.020)	0.194*** (0.062)	0.297*** (0.089)	-0.062** (0.030)	0.010 (0.041)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	2,136	2,136	2,136	2,136	2,136	2,136
R2	0.378	0.373	0.501	0.499	0.044	0.038
jp		0.237		0.391		0.143
K-P Wald F		311		311		311

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. The sample includes only steam adopters in the 1840s or 1860s.

Table 11 further restricts the sample by excluding never-adopting subindustries, thereby facilitating a direct comparison between early and later steam adopters. The results indicate that later adopters experienced stronger growth in employment and wages between the 1840s and the 1860s, again consistent with the view that some of the labour-market gains associated with early steam adoption had already been realised before the first census.

7.2 Regional differences: north versus other regions

Did the labour-market effects of steam adoption differ between established industrial regions and areas that industrialised more recently? To address this question, we exploit regional variation by comparing districts in northern France—historically among the country's leading industrial regions—with those in the rest of the country.

Table 12 indicates that the effects of steam adoption on employment and labour's share did not differ significantly between northern France and the rest of the country. However, compared with much of the rest of France, the industrial north experienced tighter labour

Table 12: The effect of steam on labour: northern France vs other regions

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.045*** (0.014)	0.103 [†] (0.069)	0.506*** (0.054)	0.761*** (0.278)	0.083*** (0.022)	0.221* (0.123)
Steam y/n x the north	0.160*** (0.039)	0.185*** (0.062)	0.207 (0.187)	0.237 (0.240)	0.153* (0.087)	0.074 (0.105)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.275	0.269	0.501	0.495	0.086	0.069
jp		0.049		0.159		0.465
K-P Wald F		14		14		14

Notes: [†] $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. The northern sample includes the arrondissements of Avesnes, Cambrai, Douai, Dunkerque, Hazebrouck, Lille, and Valenciennes.

markets during the nineteenth century, as rapid industrial expansion outpaced local population growth and encouraged pioneering forms of cross-border labour migration, particularly from Belgium (e.g. [Schor, 1985](#); [Caron, 1995](#)). These historical patterns are consistent with the significantly larger wage effects observed in the north, suggesting either stronger pass-through of productivity gains to wages in more industrialised areas or the particular prominence of textile production in the region—a point to which we return below.

7.3 Sectoral differences: textiles versus other sectors

As one of the earliest manufacturing sectors to industrialise, textiles occupy a central place in debates over the effects of early mechanisation (e.g. [Allen, 2009b](#); [Squicciarini and Voigtländer, 2015](#); [Kawaguchi et al., 2025](#)). We therefore examine whether the labour-market effects of steam adoption differed in textiles relative to other industries.

Table 13 reports the results of re-estimating the baseline specification with a binary indicator that separates the effects of steam adoption in textiles from those in other industrial

Table 13: The effect of steam on labour: textile vs other sectors

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.041*** (0.015)	0.082 (0.072)	0.516*** (0.055)	0.807*** (0.277)	0.099*** (0.024)	0.297** (0.131)
Steam y/n x textile	0.079*** (0.030)	0.107** (0.051)	0.008 (0.129)	-0.113 (0.239)	-0.048 (0.042)	-0.163** (0.072)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.274	0.270	0.501	0.494	0.085	0.052
jp		0.607		0.404		0.268
K-P Wald F		13		13		13

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level.

sectors. The estimates suggest that steam adoption generated larger wage gains in textiles, but smaller increases in labour's share, relative to other steam-adopting industries.

7.4 Motive-power configurations: creative destruction or not

A central question in assessing the labour-market consequences of technological progress concerns the role of *creative destruction* (e.g. [Aghion and Howitt, 1994](#); [Mortensen and Pissarides, 1998](#); [Green et al., 2025](#)). Prior to the diffusion of steam power, waterwheels were by far the dominant source of motive power (see Table 1). This provides a useful setting in which to examine technological substitution, as cases where water-powered production was replaced by steam allow us to isolate the labour-market consequences of the transition from an incumbent to a superior technology.

Table 14 reports estimates from a re-specified baseline model that isolates steam adoption in local subindustries initially reliant on water power but transitioning exclusively to

Table 14: The effect of steam on labour: creative destruction (cd) vs other formats

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.054*** (0.014)	0.117* (0.067)	0.521*** (0.055)	0.779*** (0.265)	0.094*** (0.022)	0.205* (0.118)
Steam y/n x cd	-0.013 (0.032)	-0.034 (0.051)	-0.058 (0.157)	-0.147 (0.226)	-0.037 (0.070)	-0.066 (0.105)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.271	0.265	0.501	0.495	0.085	0.073
jp		0.747		0.502		0.533
K-P Wald F		15		15		15

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level.

steam by the second census. The results indicate that labour-market effects in this *creative-destruction* scenario were statistically indistinguishable from those observed in other steam-adopting subindustries. These findings provide little support for the view that technological substitution entailed disproportionate labour displacement. Instead, they suggest that steam adoption operated primarily through labour-augmenting channels, with broadly similar effects regardless of the initial motive-power configuration.

8 Conclusion

We revisited one of the most significant episodes of mechanisation in history—the diffusion of steam power—and examined its consequences for labour. Using the two earliest national industrial censuses for nineteenth-century France, we showed that steam adoption, at both the extensive and intensive margins, increased employment and wages. In most specifications, it also raised our proxy for labour's share. These findings speak directly to long-standing

debates on the labour-market consequences of industrialisation, which have often emphasised labour displacement and the redistribution of gains away from workers. By contrast, our results suggest that steam power was broadly labour-friendly, increasing both the demand for workers and their compensation. A wide range of robustness checks, including tests for aggregation bias and survivorship, reinforces the credibility of these findings. While our data do not allow us to identify the precise mechanism, the results are consistent with productivity gains from mechanisation generating sufficient demand expansion to offset labour-displacing effects.

The heterogeneity analysis suggests that these effects were not uniform across time, regions, or sectors. While both early and late adopters experienced labour-market gains associated with steam adoption, the effects were more pronounced in the more immediate aftermath of installation. In traditionally industrial regions, such as parts of northern France, steam adoption was associated with stronger wage growth than elsewhere. A similar pattern emerges in textiles, although this sector experienced more modest increases in labour's share than other industries. By contrast, transitions from exclusive reliance on water power to steam did not generate distinct labour-market outcomes, suggesting that even this particularly stark form of creative destruction was not systematically associated with adverse consequences for labour.

One avenue for future research is to examine distributional outcomes more closely, particularly differences across gender and skill groups (e.g. [Becker and Hornung, 2025](#)), which our census data capture only imperfectly. Another is to explore comparative settings—such as Britain, Germany, or Japan—to assess the external validity of our findings and better understand how institutional environments shaped the labour-market consequences of steam adoption. Further, the study of historical mechanisation episodes using linked microdata can inform contemporary debates on automation by providing a long-run perspective on how technological change reshapes labour demand and compensation. In this respect, the diffusion of steam power offers a valuable benchmark for understanding the challenges and opportunities associated with the current wave of AI-driven technological change (e.g. [Acemoglu and Restrepo, 2018, 2019, 2020](#)).

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A List of sources and descriptive statistics

Table A.1: Additional sources used

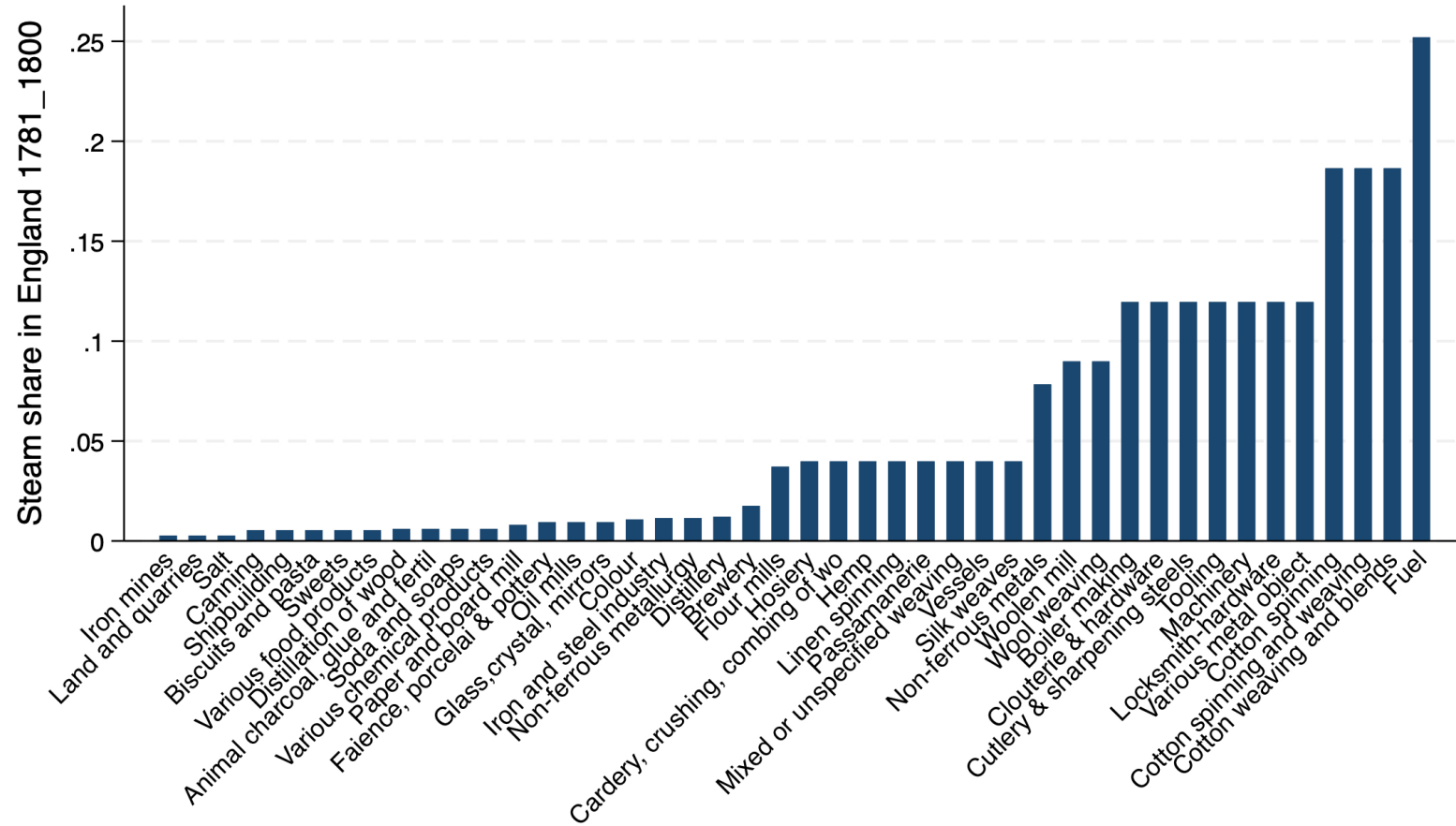
<i>Variables</i>	<i>Sources</i>
Longitude and latitude	mapsofworld.com/lat-long/france-lat-long
Shapefile of France (historical borders)	Gay (2021)
Coal ports and deposits	Ministère des Travaux Publiques, de l'Agriculture e du Commerce 1839
Length of permanent natural waterways	data.gouv.fr
Coastlines and navigable rivers	french-waterways.com/waterways/canals-rivers-france
Railroads in the 1840s	commons.wikimedia.org/wiki/map of rails
Distance to universities in the 1840s	en.wikipedia.org/wiki/List of modern universities in Europe (1801–1945)
Population Data	<i>Données historiques de la Statistique générale de France, 1801, 1836.</i> https://www.insee.fr/fr/accueil
Export Data	<i>Tableau général du commerce de la France avec ses colonies et les puissances étrangères,</i> 1841,1859

Table A.2: Descriptive statistics of the subindustry-specific variables of the baseline sample

<i>Variables</i>	<i>Mean</i>		<i>Std. Dev</i>		<i>Min</i>		<i>Max</i>		<i>N</i>	
	<i>1840s</i>	<i>1860s</i>	<i>1840s</i>	<i>1860s</i>	<i>1840s</i>	<i>1860s</i>	<i>1840s</i>	<i>1860s</i>	<i>1840s</i>	<i>1860s</i>
Total employment	178	234	876	1,115	1	1	32,500	39,835	2,020	2,020
Total number of establishment	23	24	60	62	1	1	779	1,240	2,020	2,020
Value of output (1,000 Franc)	20	71	67	216	0.014	0.025	1,890	5,298	2,020	2,020
Male wages in centimes	194	225	64	61	70	47	550	500	2,020	2,020
Labour's share	0.80	0.69	1.12	1.1	0.01	0.00	29.2	19	2,020	2,020
Steam y/n	0.00	0.32	0.00	0.47	0	0	0	1	2,020	2,020
Water y/n	0.34	0.37	0.48	0.48	0	0	1	1	2,020	2,020
Wind y/n	0.07	0.07	0.25	0.26	0	0	1	1	2,020	2,020
Animal y/n	0.13	0.19	0.34	0.39	0	0	1	1	2,020	2,020
Steam horsepower	0.00	36	0.00	83	0.00	1	0.0	928	645	645
Steam-use share (France)	0.0	0.02	0.0	0.02	0.0	0.0	0.0	0.09	2,020	2,020
Steam-use share (England)	0.0	0.04	0.0	0.05	0.0	0.0	0.0	0.25	1,374	1,374
Distance to coal (km)	0.0	71	0.0	52	0.0	1.71	0.0	284	2,020	2,020
Length of water (km)	0.0	762	0.0	401	0.0	40.24	0.0	2,329	2,020	2,020
Distance to Fresnes (km)	0.0	468	0.0	227	0.0	10	0.0	881	2,020	2,020
Sectoral steam share (Z_1)	0.00	1.66	0.00	2.28	0.00	0.00	0.00	9.43	2,020	2,020
Coal over waterways (Z_2)	0.00	0.33	0.00	0.32	0.00	0.00	0.00	2.79	2,020	2,020
Steam-use share $\times$ coal over waterways ($Z_1 \times Z_2$)	0.00	0.55	0.00	1.23	0.00	0.00	0.00	25.27	2,020	2,020
Distance to French coast (km)	0.0	140	0.0	116	0.0	0.49	0.0	473	2,020	2,020
Distance to Paris (km)	0.0	340	0.0	183	0.0	6.29	0.0	699	2,020	2,020
Distance to coal port (km)	0.0	135	0.0	112	0.0	2.42	0.0	488	2,020	2,020
Distance to university (km)	0.0	85	0.0	51	0.0	0.0	0.0	256	2,020	2,020
Distance to border (km)	0.0	200	0.0	135	0.0	4.14	0.0	572	2,020	2,020
Distance to railways in the 1840s (km)	0.0	174	0.0	111	0.0	2.55	0.0	484	2,020	2,020
Subsector establishment share in the 1840s	0.0	0.07	0.0	0.14	0.0	0.0	0.0	0.47	2,020	2,020
Female employment share	0.0	0.123	0.0	0.134	0.0	0.0	0.0	0.846	2,020	2,020
Total Export (Franc)	3,272	14,947	6,553	27,271	3	21	78,800	207,000	1,781	1,781
Population growth, 1801–1836	0.0	-0.2	0.0	0.2	0.0	-1.0	0.0	0.6	2,020	2,020
Population density, 1836	0.0	76.5	0.0	61.1	0.0	16.9	0.0	668.9	2,020	2,000
Number of banks in the 1840s	0.0	2.6	0.0	3.2	0.0	0.0	0.0	18.0	2,020	2,020

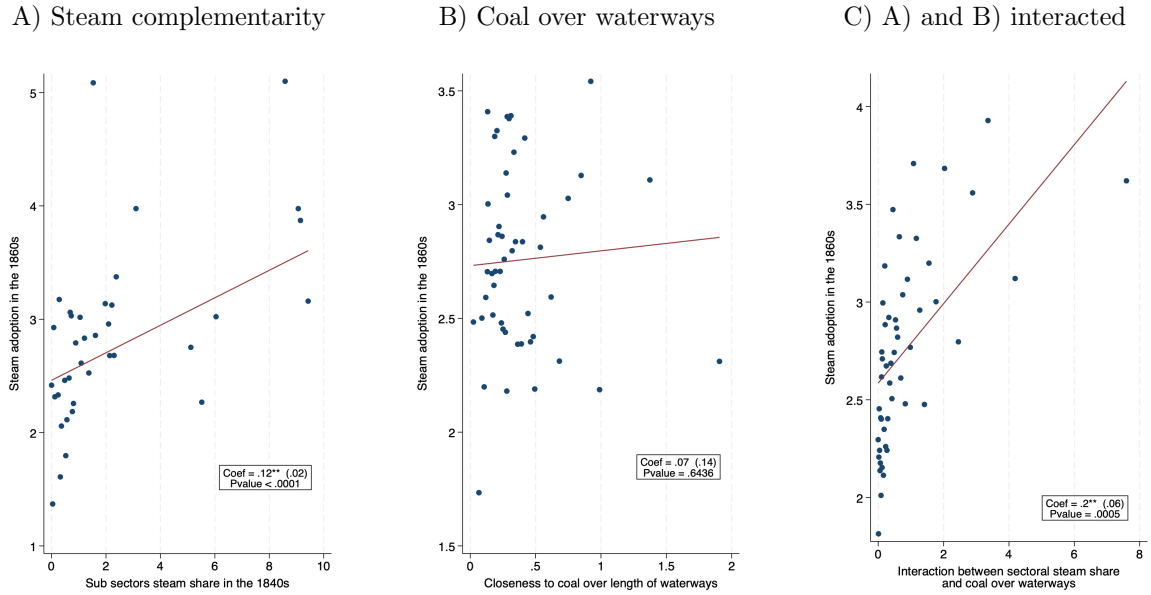
Notes: The total value of production is measured in 1,000 *francs*. Wages are measured in *centimes*. Labour's share is defined as total labour costs divided by the net value of daily output. Steam horsepower is reported only for subindustries that adopted steam by the 1860s. Time-invariant controls and instrumental variables are set equal to zero in the 1840s by construction, as they are interacted with the post indicator in the panel regressions. Total exports are by subsector and are measured in 1,000 *francs*. *Source:* See the previous table for additional sources.

Figure A.1: The share of steam engines by subindustry in England 1781-1800



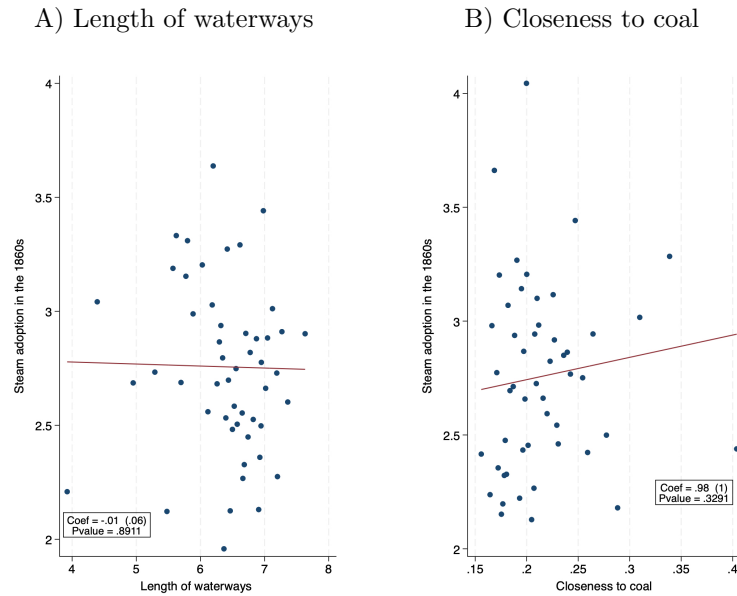
Notes: The graph shows the contribution of steam engines by each subindustry to the total number of engines employed at the national level in England, 1781-1800, calculated using Table 6 in [Kanefsky and Robey \(1980\)](#).

Figure A.2: Steam adoption and the instrumental variables: the intensive margin



Note: The graphs report binned *scatterplots* based on the baseline sample. Each point represents the average value of the dependent variable within quantile-based bins of the instrumental variable.

Figure A.3: Steam adoption and coal vs water: the intensive margin



Notes: The plots report binned *scatterplots* based on the baseline sample. Each point represents the average value of the dependent variable within quantile-based bins of the instrumental variable.

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C The exclusion restriction

The exclusion restriction commands that the instruments should affect our labour outcomes only indirectly through the installation of steam power. This section provides a series of placebo-style and decomposition exercises designed to assess this assumption. We first examine whether the instruments are systematically correlated with level labour outcomes in the 1840s, prior to the wave of steam adoption in the baseline sample (Table C.1). Since the only pre-treatment association concerns male wages, we then separately decompose the district-specific component of the IV strategy and evaluate whether this relationship is driven by mining-intensive sectors or districts located close to coal deposits (Tables C.3 and C.4). We also report placebo reduced-form estimates for local subindustries that never adopted steam power (Tables C.2 and C.5). Finally, Table F.15 re-estimates the baseline specification after excluding sectors and districts most likely to combine steam adoption with favourable labour-market conditions. These restrictions include mining, textiles, metals and iron products, the Nord department, coal-rich districts, and areas with unusually high or low access to waterways. The stability of the estimates suggests that the baseline results are not driven by a small number of highly industrialised sectors or locations.

Table C.1: The instruments explaining level outcomes in the 1840s

	(1)	(2)	(3)
	OLS		
	Male wage	Employment	Labour's share
Sectoral steam share in the 1840s	0.003 (0.006)	0.035 (0.030)	0.000 (0.008)
Closeness to coal over length of waterways	0.037* (0.019)	-0.004 (0.052)	0.025 (0.036)
Sectoral steam share in the 1840s $\times$ closeness to coal over length of waterways	-0.001 (0.005)	0.028 [†] (0.018)	0.004 (0.005)
Controls	Yes	Yes	Yes
FE	Yes	Yes	Yes
Clustering	Sector $\times$ Dep	Sector $\times$ Dep	Sector $\times$ Dep
N	2,020	2,020	2,020
R2	0.47	0.69	0.24

Notes: [†] $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All specifications include the full set of controls and fixed effects (macro-sector and department). Standard errors are clustered at the district-subindustry level.

Table C.2: Placebo reduced form never steam adopters

	(1)	(2)	(3)
	OLS		
	Male wage	Employment	Labour's share
Subsector steam share in the 1840s	-0.006 (0.007)	-0.014 (0.023)	-0.012 (0.010)
Closeness to coal over length of water	-0.042† (0.028)	0.187* (0.096)	-0.001 (0.047)
Subsector steam share in the 1840s * Closeness to coal over length of water	0.006 (0.007)	-0.060** (0.024)	0.006 (0.014)
Post	0.349*** (0.115)	-0.339 (0.410)	-0.215 (0.155)
Water y/n in the 1840s	0.013 (0.022)	-0.187** (0.080)	0.070** (0.034)
Wind y/n in the 1840s	0.065* (0.038)	-0.196* (0.112)	0.026 (0.049)
Animal y/n in the 1840s	-0.004 (0.022)	-0.225*** (0.078)	0.026 (0.039)
Distance to coast	-0.039*** (0.014)	0.047 (0.038)	0.012 (0.019)
Distance to Paris	-0.062*** (0.012)	0.051 (0.049)	-0.010 (0.017)
Distance to coal port	0.030* (0.016)	-0.091* (0.048)	0.023 (0.022)
Distance to university	-0.001 (0.007)	-0.025 (0.020)	0.007 (0.009)
Distance to borders	0.022** (0.009)	0.053* (0.031)	0.037** (0.015)
Distance to railways in the 1840s	0.015† (0.010)	0.019 (0.040)	-0.027† (0.017)
Subsector establishment share in the 1840s	0.117* (0.067)	0.014 (0.228)	-0.730*** (0.100)
Subsector gender share in the 1840s	0.072 (0.063)	-0.537* (0.324)	-0.327*** (0.085)
Number of establishment	-0.010† (0.006)	0.761*** (0.025)	0.026*** (0.010)
Constant	5.215*** (0.011)	2.312*** (0.044)	0.478*** (0.018)
N	2,750	2,750	2,750
R2	0.236	0.497	0.118

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares. The sample includes localsubindustries that never adopt steam.

Table C.3: Decomposing instruments for level outcomes in the 1840s:

	(1)	(2)	(3)	(4)	(5)
	OLS				
	Male wage				
Subsectoral steam share in the 1840s	0.003 (0.005)				
Closeness to coal over Length of waterways		0.036*** (0.012)			
Subsectoral steam share in the 1840s x Closeness to coal over Length of waterways			0.005 (0.004)		
Closeness to coal				0.019 (0.074)	
Length of waterways					-0.012 (0.012)
Controls	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes
Clustering	Sector × Dep	Sector × Dep	Sector × Dep	Sector × Dep	Sector × Dep
N	2,020	2,020	2,020	2,020	2,020
R2	0.47	0.47	0.47	0.47	0.47

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All specifications include baseline controls, macro-sector and department fixed effects. Standard errors are two-way clustered by subsector and district. Coal proximity and water access are in logarithm scale.

Table C.4: Decomposing instruments for level outcomes in the 1840s: restricted sample

	(1)	(2)	(3)	(4)	(5)
	OLS				
	Male wage				
Subsectoral steam share in the 1840s	0.005 (0.007)				
Closeness to coal over Length of waterways		0.034 (0.068)			
Subsectoral steam share in the 1840s × Closeness to coal over Length of waterways			0.001 (0.030)		
Closeness to coal				0.197 (0.817)	
Length of waterways					0.008 (0.016)
Controls	Yes	Yes	Yes	Yes	Yes
FE	Yes	Yes	Yes	Yes	Yes
Clustering	Sector × Dep	Sector × Dep	Sector × Dep	Sector × Dep	Sector × Dep
N	1,557	1,557	1,557	1,557	1,557
R2	0.485	0.485	0.485	0.485	0.485

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All specifications include baseline controls together with macro-sector and department fixed effects. Standard errors are two-way clustered by subsector and district. The sample excludes mining-intensive sectors and districts above the 75th percentile in closeness to coal. Coal proximity and water access are measured in logarithms.

Table C.5: Decomposing the geographic instrument: employment (Placebo, 1840s)

	(1)	(2)	(3)	(4)	(5)
	Employment				
Subindustry steam share in the 1840s	-0.034*				
	(0.021)				
Closeness to coal over length of waterways		0.070			
		(0.084)			
Subindustry steam share $\times$ Closeness to coal over length of waterways			-0.046**		
			(0.021)		
Closeness to coal				0.696	
				(0.654)	
Length of waterways					0.007
					(0.061)
Controls	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
FE	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District
N	2,750	2,750	2,750	2,750	2,750
R2	0.909	0.908	0.909	0.908	0.908

Notes: $\dagger p < 0.15$, $* p < 0.1$, $** p < 0.05$, $*** p < 0.01$. Each column reports a separate regression of employment on a single instrument or component. The sample is restricted to never-adopters of steam technology. Standard errors are clustered at the local subindustry level. Closeness to coal and length of waterways are measured in logarithms.

D Reduced form and first stage

Table D.1: The reduced form for baseline analysis: extensive and intensive margins

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	Extensive			Intensive		
	Male wage	Employment	Labour's share	Male wage	Employment	Labour's share
Sectoral steam share in the 1840s	0.008* (0.004)	0.048*** (0.016)	0.015** (0.007)	0.021*** (0.005)	0.040 (0.025)	0.042*** (0.013)
Closeness to coal over length of waterways	0.008 (0.022)	0.244*** (0.084)	0.052 (0.038)	0.090** (0.035)	0.130 (0.157)	0.107* (0.064)
Sectoral steam share in the 1840s * Closeness to coal over length of waterways	-0.007 (0.006)	-0.060** (0.028)	-0.019 (0.013)	-0.034*** (0.012)	-0.014 (0.054)	-0.067** (0.029)
Post	0.281*** (0.088)	0.210 (0.314)	-0.083 (0.126)	-0.032 (0.139)	0.071 (0.482)	-0.081 (0.203)
Water y/n in the 1840s	-0.004 (0.016)	-0.223*** (0.065)	0.050* (0.026)	-0.048* (0.025)	-0.411*** (0.104)	0.004 (0.040)
Wind y/n in the 1840s	0.069** (0.029)	-0.067 (0.095)	0.011 (0.036)	0.115*** (0.044)	0.124 (0.160)	-0.068 (0.043)
Animal y/n in the 1840s	0.015 (0.017)	-0.200*** (0.062)	0.000 (0.030)	0.033 (0.027)	-0.263*** (0.100)	-0.034 (0.050)
Distance to coast	-0.025** (0.012)	0.065* (0.033)	0.027 (0.017)	0.020 (0.018)	0.083 (0.069)	0.050 (0.032)
Distance to Paris	-0.048*** (0.010)	-0.022 (0.037)	-0.024* (0.014)	0.002 (0.015)	-0.005 (0.059)	-0.006 (0.023)
Distance to coal port	0.024* (0.013)	-0.108*** (0.040)	-0.010 (0.020)	-0.002 (0.018)	-0.077 (0.073)	-0.057 (0.035)
Distance to university	0.001 (0.005)	-0.044** (0.018)	0.007 (0.008)	0.003 (0.007)	-0.046 (0.033)	0.014 (0.016)
Distance to borders	0.013* (0.007)	0.036 (0.024)	0.022** (0.011)	0.004 (0.010)	0.066* (0.040)	0.008 (0.016)
Distance to railways in the 1840s	0.013* (0.008)	0.030 (0.032)	-0.009 (0.013)	0.008 (0.011)	0.048 (0.052)	0.005 (0.020)
Subsector establishment share in the 1840s	0.039 (0.056)	-0.312 (0.193)	-0.654*** (0.076)	-0.093 (0.109)	-0.602 (0.367)	-0.333*** (0.099)
Subsector gender share in the 1840s	0.122** (0.050)	-0.267 (0.252)	-0.344*** (0.071)	0.234*** (0.079)	0.186 (0.342)	-0.339*** (0.129)
Number of establishment	-0.008 (0.005)	0.755*** (0.021)	0.030*** (0.008)	-0.009 (0.009)	0.682*** (0.036)	0.023* (0.013)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
N	District	District	District	District	District	District
R2	4,040	4,040	4,040	1,290	1,290	1,290
	0.268	0.479	0.079	0.404	0.531	0.058

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares. Controls and instrument are multiplied by the post variable equal to 0 in the 1840s.

Table D.2: The first stage: extensive margin

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
							std
Subsector steam share in the 1840s		0.048*** (0.005)		0.058*** (0.007)	0.047*** (0.007)	0.047*** (0.007)	0.041*** (0.005)
Closeness to coal over length of water	0.157*** (0.037)			0.209*** (0.045)	0.168*** (0.044)	0.162*** (0.043)	0.000 (0.001)
Subsector steam share in the 1840s * Closeness to coal over length of water			0.063*** (0.019)	-0.030** (0.015)	-0.019 (0.015)	-0.020 (0.014)	0.000* (0.000)
Post	0.267*** (0.015)	0.240*** (0.012)	0.285*** (0.014)	0.171*** (0.018)	1.164*** (0.137)	1.089*** (0.137)	1.262*** (0.131)
Water y/n in the 1840s					0.109*** (0.027)	0.107*** (0.026)	0.105*** (0.026)
Wind y/n in the 1840s					0.077† (0.049)	0.086* (0.048)	0.078† (0.049)
Animal y/n in the 1840s					0.097*** (0.031)	0.080** (0.031)	0.084*** (0.031)
Distance to french coast					0.018 (0.017)	0.020 (0.017)	0.017 (0.017)
Distance to Paris					-0.103*** (0.015)	-0.101*** (0.015)	-0.096*** (0.015)
Distance to coal port					-0.046** (0.021)	-0.047** (0.020)	-0.054*** (0.020)
Distance to universities					-0.020** (0.009)	-0.019** (0.009)	-0.022** (0.009)
Distance to borders					-0.053*** (0.011)	-0.047*** (0.011)	-0.055*** (0.011)
Distance to railroads in the 1840s					0.008 (0.013)	0.012 (0.013)	0.001 (0.013)
Subsector establishment share in the 1840s					-0.285*** (0.093)	-0.296*** (0.091)	-0.286*** (0.091)
Subsector gender share in the 1840s					0.080 (0.080)	0.068 (0.079)	0.053 (0.079)
Number of establishment						0.044*** (0.008)	0.045*** (0.008)
FE	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District
N	4,040	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.327	0.356	0.338	0.366	0.406	0.416	0.411

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table D.3: The first stage: intensive margin

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	std						
Subsector steam share in the 1840s		0.121*** (0.017)		0.122*** (0.029)	0.109*** (0.027)	0.111*** (0.027)	0.116*** (0.017)
Closeness to coal over length of water	0.065 (0.141)			0.156 (0.182)	-0.023 (0.175)	-0.032 (0.175)	0.003** (0.0101)
Subsector steam share in the 1840s * Closeness to coal over Length of water			0.203*** (0.058)	0.001 (0.084)	0.016 (0.077)	0.012 (0.078)	-0.001** (0.000)
Post	2.732*** (0.067)	2.462*** (0.053)	2.585*** (0.058)	2.398*** (0.081)	4.179*** (0.488)	4.002*** (0.484)	3.980*** (0.461)
Water y/n in the 1840s					0.168† (0.104)	0.149† (0.102)	0.153† (0.103)
Wind y/n in the 1840s					0.061 (0.185)	0.165 (0.192)	0.160 (0.192)
Animal y/n in the 1840s					0.137 (0.106)	0.078 (0.107)	0.081 (0.109)
Distance to coast					-0.044 (0.081)	-0.026 (0.081)	-0.027 (0.081)
Distance to Paris					-0.010 (0.057)	-0.017 (0.056)	-0.015 (0.057)
Distance to coal port					-0.059 (0.087)	-0.075 (0.084)	-0.074 (0.084)
Distance to university					0.014 (0.030)	0.010 (0.029)	0.010 (0.029)
Distance to borders					-0.231*** (0.044)	-0.211*** (0.043)	-0.211*** (0.043)
Distance to railways in the 1840s					-0.097** (0.048)	-0.080† (0.048)	-0.081† (0.050)
Subsector establishment share in the 1840s					0.742* (0.381)	0.529 (0.387)	0.529 (0.388)
Subsector gender share in the 1840s					1.330*** (0.323)	1.325*** (0.321)	1.338*** (0.321)
Number of establishment						0.126*** (0.037)	0.125*** (0.037)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
N	District	District	District	District	District	District	District
R2	1,290	1,290	1,290	1,290	1,290	1,290	1,290
	0.854	0.868	0.863	0.869	0.882	0.884	0.884

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

E Full specifications

Table E.1: The effect of steam on labour: the extensive margin (full table)

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.014)	0.116* (0.065)	0.517*** (0.053)	0.790*** (0.262)	0.091*** (0.022)	0.221* (0.116)
Post	0.217** (0.086)	0.139 (0.120)	-0.215 (0.304)	-0.557 (0.448)	-0.156 (0.121)	-0.319* (0.194)
Water y/n in the 1840s	-0.002 (0.016)	-0.013 (0.019)	-0.262*** (0.061)	-0.311*** (0.076)	0.052** (0.026)	0.028 (0.031)
Wind y/n in the 1840s	0.067** (0.029)	0.060** (0.030)	-0.110 (0.091)	-0.138† (0.095)	0.006 (0.037)	-0.007 (0.038)
Animal y/n in the 1840s	0.010 (0.017)	0.005 (0.017)	-0.240*** (0.061)	-0.263*** (0.067)	-0.007 (0.031)	-0.018 (0.032)
Distance to coast	-0.026** (0.012)	-0.027** (0.012)	0.053† (0.034)	0.048 (0.036)	0.025 (0.017)	0.022 (0.017)
Distance to Paris	-0.043*** (0.010)	-0.038*** (0.012)	0.032 (0.037)	0.057 (0.043)	-0.015 (0.014)	-0.003 (0.018)
Distance to coal port	0.026** (0.013)	0.030** (0.013)	-0.088** (0.040)	-0.073* (0.044)	-0.006 (0.019)	0.001 (0.020)
Distance to university	0.002 (0.005)	0.003 (0.005)	-0.035* (0.018)	-0.029† (0.018)	0.009 (0.008)	0.012 (0.009)
Distance to national borders	0.016** (0.007)	0.019** (0.008)	0.055** (0.024)	0.069** (0.029)	0.025** (0.011)	0.032** (0.013)
Distance to railways in the 1840s	0.013* (0.007)	0.013* (0.007)	0.018 (0.030)	0.018 (0.030)	-0.010 (0.012)	-0.010 (0.012)
Subsector establishment share in the 1840s	0.044 (0.057)	0.068 (0.062)	-0.176 (0.191)	-0.070 (0.213)	-0.643*** (0.079)	-0.592*** (0.085)
Subindustry gender share in the 1840s	0.122** (0.049)	0.117** (0.050)	-0.302 (0.244)	-0.323 (0.244)	-0.346*** (0.070)	-0.356*** (0.073)
Local subindustry establishments	-0.011** (0.005)	-0.013** (0.006)	0.732*** (0.021)	0.720*** (0.023)	0.026*** (0.008)	0.020** (0.009)
FE	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.271	0.264	0.501	0.494	0.084	0.068
jp		0.433		0.241		0.499
K-P Wald F		29		29		29

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. Subindustry size is measured as the share of establishments belonging to a given subindustry in the census of the 1840s, calculated relative to the total number of establishments recorded nationally. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table E.2: The effect of steam on labour: the intensive margin (full table)

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam horsepower in 1860s	0.034*** (0.010)	0.075** (0.033)	0.289*** (0.041)	0.303** (0.128)	0.010 (0.017)	0.159** (0.065)
Post	-0.085 (0.136)	-0.243 (0.188)	-0.922** (0.435)	-0.979 (0.650)	-0.052 (0.197)	-0.631* (0.328)
Water y/n in the 1840s	-0.041* (0.024)	-0.056** (0.027)	-0.453*** (0.098)	-0.459*** (0.107)	0.046 (0.041)	-0.010 (0.047)
Wind y/n in the 1840s	0.114** (0.045)	0.104** (0.048)	0.077 (0.166)	0.073 (0.169)	-0.054 (0.046)	-0.091 (0.055)
Animal y/n in the 1840s	0.025 (0.027)	0.023 (0.028)	-0.284*** (0.094)	-0.285*** (0.095)	-0.048 (0.051)	-0.057 (0.054)
Distance to coast	0.016 (0.018)	0.017 (0.019)	0.084 (0.070)	0.085 (0.070)	0.045 (0.032)	0.049 (0.037)
Distance to Paris	0.000 (0.015)	-0.000 (0.016)	0.003 (0.056)	0.003 (0.056)	-0.013 (0.024)	-0.013 (0.026)
Distance to coal port	0.002 (0.019)	0.005 (0.019)	-0.058 (0.073)	-0.057 (0.074)	-0.050 (0.035)	-0.041 (0.040)
Distance to university	0.004 (0.007)	0.003 (0.007)	-0.050 (0.031)	-0.050 (0.032)	0.017 (0.016)	0.013 (0.016)
Distance to borders	0.009 (0.010)	0.016 (0.011)	0.118*** (0.037)	0.121*** (0.043)	0.011 (0.017)	0.038* (0.022)
Distance to railways in the 1840s	0.010 (0.012)	0.014 (0.012)	0.064 (0.048)	0.066 (0.049)	0.010 (0.020)	0.023 (0.022)
Subsector establishment share in the 1840s	-0.147 (0.107)	-0.147 (0.108)	-0.767** (0.361)	-0.767** (0.362)	-0.449*** (0.107)	-0.446*** (0.121)
Subsector gender share in the 1840s	0.181** (0.080)	0.127 (0.093)	-0.218 (0.347)	-0.238 (0.370)	-0.353** (0.138)	-0.551*** (0.178)
Number of establishment	-0.014 (0.009)	-0.019* (0.010)	0.646*** (0.034)	0.645*** (0.038)	0.020 (0.014)	0.002 (0.016)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	1,290	1,290	1,290	1,290	1,290	1,290
R2	0.404	0.387	0.569	0.569	0.032	-0.095
jp		0.022		0.631		0.086
K-P Wald F		16		16		16

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

F Robustness checks

Table F.1: The effect of steam on labour: double clustering

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.019)	0.116* (0.059)	0.517*** (0.086)	0.790** (0.302)	0.091** (0.037)	0.221 (0.202)
Post	0.217† (0.146)	0.139 (0.139)	-0.215 (0.417)	-0.557 (0.548)	-0.156 (0.169)	-0.319 (0.302)
Water y/n in the 1840s	-0.002 (0.016)	-0.013 (0.018)	-0.262*** (0.071)	-0.311*** (0.092)	0.052 (0.054)	0.028 (0.043)
Wind y/n in the 1840s	0.067*** (0.020)	0.060*** (0.019)	-0.110 (0.096)	-0.138 (0.112)	0.006 (0.027)	-0.007 (0.027)
Animal y/n in the 1840s	0.010 (0.016)	0.005 (0.016)	-0.240*** (0.090)	-0.263*** (0.097)	-0.007 (0.033)	-0.018 (0.036)
Distance to coast	-0.026† (0.017)	-0.027† (0.017)	0.053† (0.035)	0.048 (0.036)	0.025† (0.016)	0.022 (0.017)
Distance to Paris	-0.043*** (0.015)	-0.038*** (0.014)	0.032 (0.043)	0.057 (0.051)	-0.015 (0.013)	-0.003 (0.021)
Distance to coal port	0.026 (0.019)	0.030† (0.019)	-0.088** (0.038)	-0.073* (0.043)	-0.006 (0.015)	0.001 (0.020)
Distance to university	0.002 (0.007)	0.003 (0.006)	-0.035* (0.018)	-0.029* (0.017)	0.009 (0.009)	0.012 (0.011)
Distance to borders	0.016† (0.010)	0.019** (0.009)	0.055** (0.025)	0.069* (0.035)	0.025 (0.018)	0.032* (0.018)
Distance to railways in the 1840s	0.013 (0.010)	0.013 (0.010)	0.018 (0.024)	0.018 (0.025)	-0.010 (0.013)	-0.010 (0.014)
Subsector establishment share in the 1840s	0.044 (0.033)	0.068 (0.048)	-0.176 (0.188)	-0.070 (0.225)	-0.643*** (0.131)	-0.592*** (0.118)
Subsector gender share in the 1840s	0.122† (0.074)	0.117† (0.074)	-0.302 (0.373)	-0.323 (0.357)	-0.346** (0.136)	-0.356*** (0.134)
Number of establishment	-0.011* (0.005)	-0.013** (0.006)	0.732*** (0.033)	0.720*** (0.034)	0.026** (0.010)	0.020† (0.013)
FE	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.783	0.264	0.910	0.494	0.646	0.068
K-P Wald F		27		27		27

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are double clustered at the district and subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares. The Hansen J statistic is not reported for this specification.

Table F.2: The effect of steam on labour: with Conley standard errors

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.010)	0.116** (0.046)	0.517*** (0.035)	0.790*** (0.166)	0.091*** (0.017)	0.221** (0.093)
Post	0.217* (0.119)	0.139 (0.130)	-0.215 (0.255)	-0.557* (0.338)	-0.156 (0.118)	-0.319* (0.166)
Water y/n in the 1840s	-0.002 (0.013)	-0.013 (0.015)	-0.262*** (0.039)	-0.311*** (0.051)	0.052*** (0.019)	0.028 (0.023)
Wind y/n in the 1840s	0.067*** (0.026)	0.060** (0.027)	-0.110 (0.083)	-0.138 (0.084)	0.006 (0.028)	-0.007 (0.026)
Animal y/n in the 1840s	0.010 (0.013)	0.005 (0.013)	-0.240*** (0.041)	-0.263*** (0.046)	-0.007 (0.020)	-0.018 (0.021)
Distance to coast	-0.026*** (0.008)	-0.027*** (0.007)	0.053** (0.022)	0.048** (0.024)	0.025** (0.010)	0.022** (0.011)
Distance to Paris	-0.043*** (0.013)	-0.038*** (0.013)	0.032 (0.034)	0.057† (0.038)	-0.015 (0.013)	-0.003 (0.015)
Distance to coal port	0.026*** (0.010)	0.030*** (0.010)	-0.088*** (0.027)	-0.073** (0.030)	-0.006 (0.012)	0.001 (0.013)
Distance to university	0.002 (0.005)	0.003 (0.005)	-0.035** (0.014)	-0.029** (0.013)	0.009 (0.007)	0.012 (0.008)
Distance to borders	0.016* (0.008)	0.019** (0.008)	0.055*** (0.017)	0.069*** (0.023)	0.025*** (0.008)	0.032*** (0.009)
Distance to railways in the 1840s	0.013 (0.008)	0.013* (0.008)	0.018 (0.020)	0.018 (0.020)	-0.010 (0.009)	-0.010 (0.009)
Subsector n of establishment in the 1840s	0.044 (0.041)	0.068† (0.046)	-0.176 (0.150)	-0.070 (0.162)	-0.643*** (0.072)	-0.592*** (0.067)
Subsector gender share in the 1840s	0.122*** (0.036)	0.117*** (0.036)	-0.302* (0.169)	-0.323* (0.167)	-0.346*** (0.052)	-0.356*** (0.055)
Number of establishment	-0.011*** (0.004)	-0.013*** (0.004)	0.732*** (0.015)	0.720*** (0.017)	0.026*** (0.006)	0.020*** (0.008)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.271	0.264	0.501	0.494	0.084	0.068
jp						
K-P Wald F		46		46		46

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. Conley 100km

Table F.3: The effect of steam on labour: district and subindustry fixed effects separated

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.057*** (0.010)	0.083† (0.056)	1.030*** (0.064)	0.629** (0.258)	0.104*** (0.017)	0.180* (0.103)
Post	0.145*** (0.008)	0.136*** (0.019)	-0.146*** (0.040)	-0.017 (0.088)	-0.112*** (0.012)	-0.136*** (0.034)
Controls	No	No	No	No	No	No
FE	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.580	0.151	0.493	0.056	0.352	0.022
jp		0.044		0.000		0.950
K-P Wald F		39		39		39

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level.

Table F.4: The effect of steam on labour: district and subindustry fixed effects separated (full)

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.059*** (0.010)	0.097† (0.066)	0.721*** (0.051)	0.313 (0.273)	0.098*** (0.018)	0.264** (0.121)
Post	0.238*** (0.090)	0.188† (0.126)	-0.807** (0.319)	-0.276 (0.477)	-0.154 (0.126)	-0.371* (0.208)
Water y/n in the 1840s	0.014 (0.013)	0.008 (0.015)	0.040 (0.061)	0.098 (0.074)	0.001 (0.022)	-0.023 (0.026)
Wind y/n in the 1840s	0.012 (0.019)	0.010 (0.020)	-0.076 (0.082)	-0.047 (0.085)	-0.019 (0.028)	-0.031 (0.029)
Animal y/n in the 1840s	0.014 (0.013)	0.011 (0.014)	0.073 (0.061)	0.105† (0.066)	0.015 (0.022)	0.002 (0.024)
Distance to coast	-0.028** (0.012)	-0.029** (0.012)	0.044 (0.038)	0.052 (0.037)	0.025 (0.018)	0.022 (0.018)
Distance to Paris	-0.044*** (0.010)	-0.040*** (0.012)	0.057† (0.039)	0.019 (0.046)	-0.015 (0.015)	0.001 (0.019)
Distance to coal port	0.026** (0.013)	0.028** (0.014)	-0.076* (0.044)	-0.098** (0.047)	-0.005 (0.020)	0.004 (0.021)
Distance to university	0.002 (0.005)	0.003 (0.006)	-0.030† (0.019)	-0.038* (0.020)	0.010 (0.009)	0.013 (0.009)
Distance to borders	0.014** (0.007)	0.016** (0.008)	0.090*** (0.026)	0.067** (0.030)	0.024** (0.012)	0.033** (0.014)
Distance to railways in the 1840s	0.013* (0.008)	0.013* (0.008)	0.036 (0.033)	0.035 (0.033)	-0.012 (0.013)	-0.011 (0.013)
Subsector establishment share in the 1840s	0.069 (0.055)	0.080 (0.058)	-0.656*** (0.194)	-0.777*** (0.206)	-0.530*** (0.072)	-0.480*** (0.077)
Subsector gender share in the 1840s	0.110** (0.051)	0.105** (0.052)	-0.607** (0.245)	-0.558** (0.253)	-0.293*** (0.072)	-0.313*** (0.077)
Number of establishment	-0.019*** (0.003)	-0.020*** (0.004)	0.811*** (0.015)	0.821*** (0.017)	0.016*** (0.005)	0.012** (0.006)
FE	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District	Subindustry & District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.590	0.169	0.745	0.521	0.368	0.027
jp		0.655		0.119		0.815
K-P Wald F		27		27		27

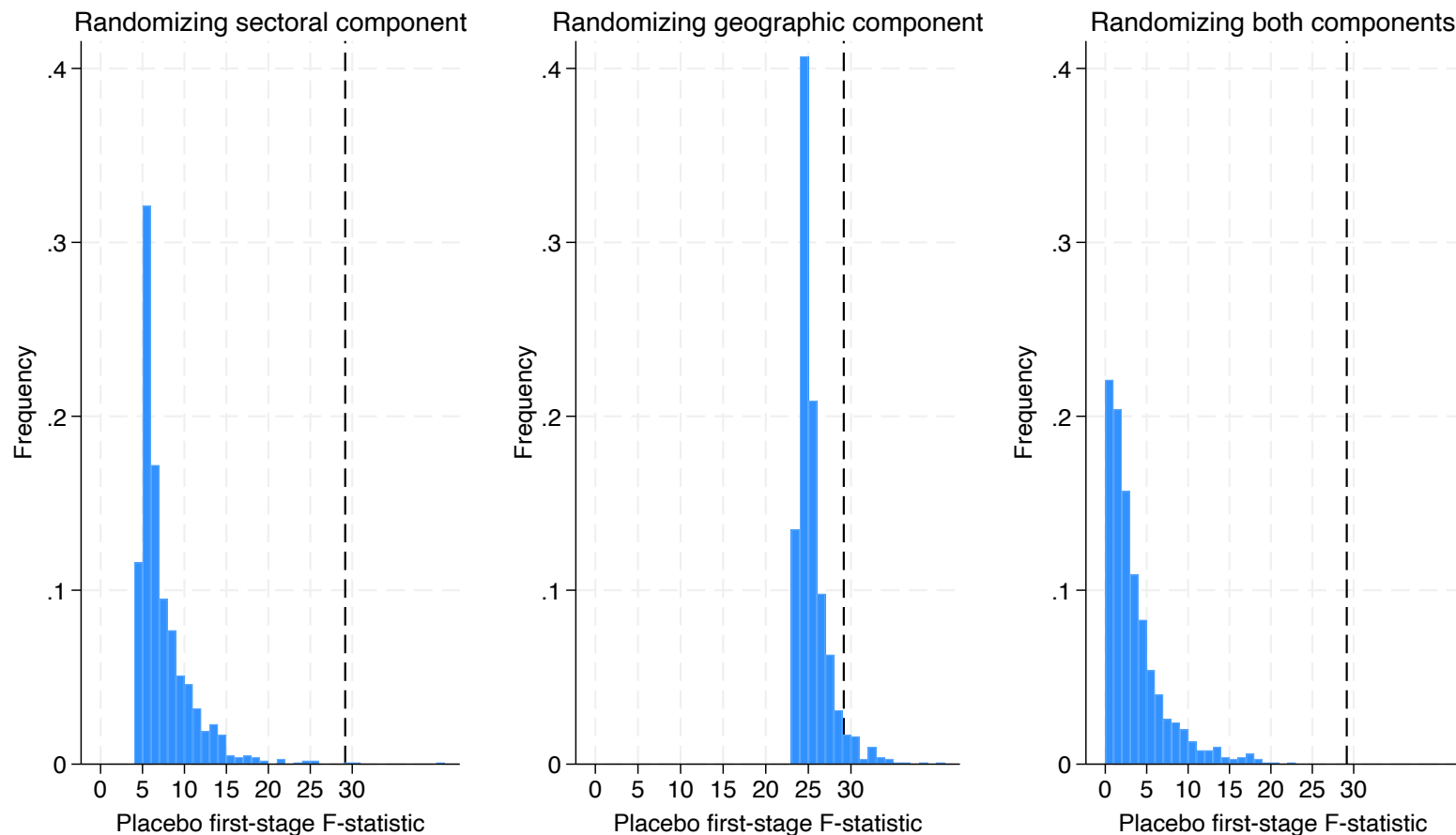
Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table F.5: Probit first stage (control function)

	(1)	(2)	(3)	(4)
	Second stage		Probit First stage	
	Male wage	Employment	Labour's share	Steam y/n in the 1860s
Steam in 1860s	0.263*** (0.053)	0.608*** (0.207)	0.326*** (0.095)	
Control function residual	-0.132*** (0.032)	-0.058 (0.128)	-0.148** (0.059)	
Subsector steam share in the 1840s				0.145*** (0.020)
Closeness to coal over length of water				0.497*** (0.120)
Subsector steam share in the 1840s * Closeness to coal over length of water				-0.059† (0.039)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	
FE	Subindustry District	Subindustry District	Subindustry District	
N	4,040	4,040	4,040	2,020
R2	0.28	0.50	0.09	

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. Control-function estimates are obtained using a two-step procedure. Steam adoption is first estimated with a probit using the excluded instruments and controls. The generalized residual from this first stage is then included in the fixed-effects outcome equation, and set to zero in the pre-period so that the correction applies only to post-period adoption. Standard errors are clustered at the local subindustry level.

Figure F.1: Randomization inference for instrument relevance



Notes: The figure reports placebo distributions obtained from 1,000 random reallocations of the sectoral component (Z_i), the district-specific component (Z_c), and both components simultaneously. For each replication, we re-estimate the first-stage regression and record the corresponding F-statistic. The dashed vertical line indicates the first-stage F-statistic obtained using the actual instruments ($F = 29.2$). The observed statistic lies well above the placebo distributions, particularly when the sectoral component or both components are randomized, suggesting that instrument relevance is not driven by arbitrary subindustry- and district-specific variation.

Table F.6: The effect of steam on labour: standardised IVs

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage		Second stage		Second stage	
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.014)	0.141** (0.071)	0.517*** (0.053)	0.699** (0.318)	0.091*** (0.022)	0.225* (0.128)
Post	0.217** (0.086)	0.107 (0.125)	-0.215 (0.304)	-0.443 (0.508)	-0.156 (0.121)	-0.324† (0.206)
Water y/n in the 1840s	-0.002 (0.016)	-0.018 (0.020)	-0.262*** (0.061)	-0.295*** (0.080)	0.052** (0.026)	0.027 (0.032)
Wind y/n in the 1840s	0.067** (0.029)	0.058* (0.030)	-0.110 (0.091)	-0.129 (0.096)	0.006 (0.037)	-0.007 (0.038)
Animal y/n in the 1840s	0.010 (0.017)	0.003 (0.018)	-0.240*** (0.061)	-0.256*** (0.068)	-0.007 (0.031)	-0.018 (0.032)
Distance to coast	-0.026** (0.012)	-0.028** (0.012)	0.053† (0.034)	0.049 (0.035)	0.025† (0.017)	0.022 (0.017)
Distance to Paris	-0.043*** (0.010)	-0.035*** (0.012)	0.032 (0.037)	0.048 (0.047)	-0.015 (0.014)	-0.003 (0.019)
Distance to coal port	0.026** (0.013)	0.031** (0.013)	-0.088** (0.040)	-0.078* (0.045)	-0.006 (0.019)	0.001 (0.020)
Distance to university	0.002 (0.005)	0.004 (0.005)	-0.035* (0.018)	-0.031* (0.018)	0.009 (0.008)	0.012 (0.009)
Distance to borders	0.016** (0.007)	0.020*** (0.008)	0.055** (0.024)	0.065** (0.031)	0.025** (0.011)	0.032** (0.013)
Distance to railways in the 1840s	0.013* (0.007)	0.013* (0.007)	0.018 (0.030)	0.018 (0.030)	-0.010 (0.012)	-0.010 (0.012)
Subsector establishment share in the 1840s	0.044 (0.057)	0.078 (0.063)	-0.176 (0.191)	-0.105 (0.219)	-0.643*** (0.079)	-0.590*** (0.085)
Subsector gender share in the 1840s	0.122** (0.049)	0.115** (0.050)	-0.302 (0.244)	-0.316 (0.246)	-0.346*** (0.070)	-0.356*** (0.073)
Number of establishment	-0.011** (0.005)	-0.014** (0.006)	0.732*** (0.021)	0.724*** (0.025)	0.026*** (0.008)	0.020** (0.010)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
N	District	District	District	District	District	District
R2	4,040	4,040	4,040	4,040	4,040	4,040
jp		0.257		0.657		0.545
K-P Wald F		27		27		27

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. Instruments are standardized instead of min-max normalization. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table F.7: The effect of steam on labour: quadratic specification of waterway access

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.053*** (0.014)	0.132** (0.066)	0.517*** (0.053)	0.797*** (0.267)	0.091*** (0.022)	0.227* (0.118)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.271	0.260	0.501	0.494	0.084	0.067
jp		0.433		0.241		0.499
K-P Wald F		29		29		29

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the district–subindustry level. The district instrument uses a quadratic transformation of the normalised waterway measure, allowing for non-linearities in waterway access.

Table F.8: The effect of steam on labour: sensitivity to the smoothing parameter

Epsilon	Male wage	Employment	Labour's share	K-P Wald F
0.05	0.106†	0.776***	0.223*	28.8
0.10 (Baseline)	0.116*	0.790***	0.221*	29.2
0.20	0.124*	0.789***	0.217*	29.6
0.30	0.127**	0.785***	0.213*	29.8
0.50	0.130**	0.778***	0.209*	29.9

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table reports IV estimates obtained using alternative values of the smoothing parameter ϵ in the construction of the geographic component of the instrument, $\frac{\text{Coal proximity}}{\text{Water access} + \epsilon}$. The baseline specification uses $\epsilon = 0.10$. Entries report the coefficient on *Steam y/n in 1860s*. The final column reports the Kleibergen–Paap Wald F-statistic. All specifications include the full set of baseline controls and district–subindustry fixed effects. Standard errors are clustered at the district–subindustry level.

Table F.9: The effect of steam on labour: British steam shares IV

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.060*** (0.017)	0.318*** (0.105)	0.603*** (0.066)	1.188*** (0.407)	0.081*** (0.026)	-0.029 (0.155)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	2,748	2,748	2,748	2,748	2,748	2748
R2	0.264	0.150	0.498	0.465	0.123	0.111
jp		0.137		0.159		0.146
K-P Wald F		11		11		11

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. The sample is restricted to subindustries that matched those reported in Table 6 in [Kanefsky and Robey \(1980\)](#).

Table F.10: The effect of steam on labour: controlling for distance to Fresnes-sur-Escaut

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage		Second stage		Second stage	
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.039*** (0.014)	0.106† (0.071)	0.518*** (0.054)	0.766*** (0.287)	0.084*** (0.022)	0.217* (0.126)
Post	0.358*** (0.078)	0.259** (0.131)	-0.161 (0.295)	-0.526 (0.517)	-0.071 (0.126)	-0.268 (0.226)
Water y/n in the 1840s	0.002 (0.016)	-0.010 (0.020)	-0.262*** (0.061)	-0.307*** (0.078)	0.054** (0.026)	0.029 (0.032)
Wind y/n in the 1840s	0.070** (0.029)	0.063** (0.030)	-0.114 (0.091)	-0.140† (0.096)	0.008 (0.037)	-0.007 (0.038)
Animal y/n in the 1840s	0.009 (0.017)	0.004 (0.017)	-0.240*** (0.061)	-0.260*** (0.067)	-0.007 (0.030)	-0.018 (0.032)
Distance to coast	-0.028** (0.011)	-0.029** (0.012)	0.049† (0.034)	0.045 (0.035)	0.023 (0.017)	0.021 (0.016)
Distance to coal port	0.031** (0.012)	0.034*** (0.013)	-0.085** (0.040)	-0.074* (0.043)	-0.003 (0.019)	0.003 (0.020)
Distance to university	0.001 (0.005)	0.002 (0.005)	-0.035** (0.018)	-0.029† (0.018)	0.009 (0.008)	0.011 (0.009)
Distance to borders	0.037*** (0.007)	0.037*** (0.007)	0.045* (0.024)	0.048* (0.025)	0.034*** (0.011)	0.035*** (0.011)
Distance to railways in the 1840s	0.003 (0.007)	0.005 (0.007)	0.027 (0.028)	0.033 (0.029)	-0.013 (0.011)	-0.011 (0.011)
Subsector establishment share in the 1840s	0.042 (0.057)	0.068 (0.062)	-0.176 (0.191)	-0.081 (0.215)	-0.643*** (0.079)	-0.592*** (0.085)
Subsector gender share in the 1840s	0.128*** (0.049)	0.122** (0.049)	-0.306 (0.243)	-0.328 (0.245)	-0.344*** (0.070)	-0.356*** (0.073)
Number of establishment	-0.012** (0.005)	-0.015** (0.006)	0.733*** (0.021)	0.723*** (0.023)	0.025*** (0.008)	0.019** (0.009)
Distance to Fresnes	-0.075*** (0.009)	-0.065*** (0.014)	0.023 (0.036)	0.059 (0.055)	-0.033** (0.015)	-0.014 (0.024)
N	4,040	4,040	4,040	4,040	4,040	4,040
R2	0.285	0.277	0.501	0.495	0.086	0.070
jp		0.041		0.144		0.516
K-P Wald F		27		27		27

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered at the district-subindustry level. Distance to Paris is excluded from the set of controls due to its high correlation with distance to Fresnes-sur-Escaut. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table F.11: The effect of steam on labour: no controls

	(1)	(2)	(3)	(4)	(5)	(6)
			Second stage			
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.055*** (0.013)	0.087* (0.053)	0.750*** (0.064)	0.628*** (0.243)	0.107*** (0.021)	0.195** (0.096)
Post	0.145*** (0.008)	0.135*** (0.018)	-0.056 (0.038)	-0.017 (0.083)	-0.113*** (0.012)	-0.141*** (0.032)
Controls	No	No	No	No	No	No
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	4,040	4,040	4,040	4,040	4,040	4,040
r2	0.250	0.248	0.077	0.075	0.042	0.034
jp		0.038		0.000		0.670
K-P Wald F		44		44		44

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level.

Table F.12: The effect of steam on labour: no control for the number of establishment

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.050*** (0.014)	0.112* (0.064)	0.774*** (0.068)	0.940*** (0.307)	0.100*** (0.022)	0.224* (0.115)
Post	0.202** (0.086)	0.119 (0.123)	0.826* (0.423)	0.604 (0.597)	-0.119 (0.122)	-0.285 (0.200)
Water y/n in the 1840s	-0.002 (0.016)	-0.013 (0.019)	-0.272*** (0.079)	-0.302*** (0.096)	0.051** (0.026)	0.029 (0.031)
Wind y/n in the 1840s	0.069** (0.029)	0.064** (0.030)	-0.290** (0.133)	-0.305** (0.136)	0.000 (0.038)	-0.011 (0.038)
Animal y/n in the 1840s	0.006 (0.017)	0.000 (0.018)	0.022 (0.079)	0.005 (0.084)	0.002 (0.031)	-0.011 (0.033)
Distance to coast	-0.026** (0.012)	-0.027** (0.012)	0.009 (0.046)	0.006 (0.047)	0.023 (0.017)	0.021 (0.017)
Distance to Paris	-0.043*** (0.010)	-0.037*** (0.012)	0.023 (0.049)	0.038 (0.057)	-0.015 (0.014)	-0.004 (0.018)
Distance to coal port	0.026** (0.013)	0.029** (0.013)	-0.050 (0.057)	-0.041 (0.060)	-0.005 (0.019)	0.002 (0.020)
Distance to university	0.002 (0.005)	0.003 (0.005)	-0.043* (0.025)	-0.039† (0.026)	0.009 (0.008)	0.012 (0.009)
Distance to borders	0.017** (0.007)	0.021*** (0.008)	-0.046 (0.034)	-0.036 (0.040)	0.022** (0.011)	0.029** (0.013)
Distance to railways in the 1840s	0.014** (0.007)	0.015** (0.007)	-0.064* (0.037)	-0.063* (0.037)	-0.013 (0.012)	-0.013 (0.012)
Subsector establishment share in the 1840s	0.040 (0.058)	0.063 (0.062)	0.114 (0.326)	0.176 (0.344)	-0.632*** (0.080)	-0.586*** (0.085)
Subsector gender share in the 1840s	0.120** (0.049)	0.114** (0.050)	-0.145 (0.300)	-0.159 (0.302)	-0.341*** (0.071)	-0.352*** (0.073)
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
N	District	District	District	District	District	District
R2	4,040	4,040	4,040	4,040	4,040	4,040
jp	0.270	0.263	0.095	0.092	0.080	0.065
K-P Wald F		0.368		0.141		0.526
		29		29		29

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. All variables are expressed in natural logarithms, except dummy variables, instruments, and shares.

Table F.13: The effect of steam on labour: alternative control specifications

	(1)	(2)	(3)	(4)	(5)	(6)
			Second stage			
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Panel A. Population						
Steam y/n	0.051*** (0.014)	0.120* (0.068)	0.509*** (0.054)	0.765*** (0.273)	0.086*** (0.023)	0.216* (0.122)
Population growth, 1801–1836	0.099** (0.046)	0.101** (0.047)	0.118 (0.173)	0.126 (0.172)	0.023 (0.089)	0.027 (0.088)
Population density, 1836	0.021* (0.011)	0.015 (0.013)	0.059 (0.055)	0.034 (0.059)	0.033* (0.018)	0.020 (0.021)
N	4,040	4,040	4,040	4,040	4,040	4,040
R ²	0.274	0.265	0.502	0.495	0.086	0.070
jp		0.365		0.263		0.485
K-P Wald F		27.0		27.0		27.0
Panel B. Banking development						
Steam y/n	0.052*** (0.014)	0.117* (0.064)	0.517*** (0.053)	0.784*** (0.258)	0.092*** (0.022)	0.216* (0.114)
Number of banks in the 1840s	0.008 (0.008)	0.005 (0.009)	0.001 (0.029)	-0.013 (0.033)	-0.007 (0.013)	-0.013 (0.014)
N	4,040	4,040	4,040	4,040	4,040	4,040
R ²	0.272	0.264	0.501	0.494	0.085	0.070
jp		0.445		0.238		0.484
K-P Wald F		30.0		30.0		30.0
Panel C. Exports						
Steam y/n	0.049*** (0.015)	0.128* (0.071)	0.496*** (0.056)	0.728*** (0.273)	0.085*** (0.024)	0.269** (0.132)
Subindustry exports, 1841–1859	0.015** (0.007)	0.014** (0.007)	0.036 (0.026)	0.034 (0.027)	-0.050*** (0.013)	-0.052*** (0.013)
N	3,562	3,562	3,562	3,562	3,562	3,562
R ²	0.251	0.240	0.507	0.502	0.084	0.054
jp		0.561		0.405		0.431
K-P Wald F		26.8		26.8		26.8
Panel D. All controls						
Steam y/n	0.045*** (0.015)	0.128* (0.074)	0.495*** (0.057)	0.720** (0.284)	0.081*** (0.025)	0.261* (0.139)
Population growth, 1801–1836	0.100** (0.047)	0.107** (0.048)	0.114 (0.179)	0.134 (0.180)	0.007 (0.101)	0.022 (0.099)
Population density, 1836	0.024** (0.012)	0.016 (0.014)	0.018 (0.048)	-0.003 (0.053)	0.032† (0.020)	0.015 (0.024)
Number of banks in the 1840s	0.006 (0.009)	0.002 (0.010)	0.004 (0.031)	-0.008 (0.035)	-0.008 (0.014)	-0.018 (0.016)
Subindustry exports, 1841–1859	0.015** (0.007)	0.014** (0.007)	0.036 (0.027)	0.034 (0.027)	-0.051*** (0.013)	-0.052*** (0.013)
N	3,562	3,562	3,562	3,562	3,562	3,562
R ²	0.254	0.242	0.507	0.502	0.086	0.057
jp		0.527		0.382		0.397
K-P Wald F		25.0		25.0		25.0
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District	Subindustry District

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table reports OLS and IV estimates obtained by adding alternative sets of controls to the baseline specification. Panel A controls for population growth and (ln) population density; Panel B controls for (ln) number of banks; Panel C controls for (ln) subindustry exports; and Panel D includes all additional controls simultaneously. All specifications include the baseline controls and district–subindustry fixed effects. Standard errors, clustered at the district–subindustry level, are reported in parentheses. The sample is restricted to subindustries with available export data.

Table F.14: The effect of steam: excluding mining sectors and districts close to coal

	(1)	(2)	(3)	(4)	(5)	(6)
	Second stage					
	OLS	IV	OLS	IV	OLS	IV
	Male wage		Employment		Labour's share	
Steam y/n	0.047*** (0.016)	0.188** (0.074)	0.529*** (0.064)	0.652** (0.291)	0.099*** (0.026)	0.341** (0.133)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
FE	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry	Subindustry
	District	District	District	District	District	District
N	3,114	3,114	3,114	3,114	3,114	3,114
R2	0.280	0.248	0.488	0.487	0.084	0.033
jp		0.150		0.989		0.730
K-P Wald F		23		23		23

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The standard errors are clustered at the district subindustry level. The sample excludes coal-mining subindustries and districts in the top quartile (75th percentile and above) of the coal proximity distribution.

Table F.15: The effect of steam on labour: robustness to alternative sample restrictions

Sample	Male wage	Employment	Labour's share	K-P Wald F
Baseline	0.116*	0.790***	0.221*	29.2
No textile sectors	0.072	0.643**	0.249*	23.9
No mining sectors	0.121*	0.657**	0.254**	31.8
No metals and iron sectors	0.177**	1.224***	0.066	18.4
No Nord department	0.110†	0.733***	0.223*	27.0
No coal districts near	0.181***	0.808***	0.320**	26.3
No coal-ports districts near	0.172**	0.846***	0.215*	24.0
No coal-advantaged districts near	0.290***	0.969***	0.341**	16.0
No long-waterway districts	0.046	0.774**	0.127	18.9
No short-waterway districts	0.119†	0.950***	0.246*	22.0

Notes: † $p < 0.15$, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table reports IV estimates obtained after progressively excluding observations most likely to combine steam adoption. Entries report the coefficient on *Steam y/n in 1860s*. The final column reports the Kleibergen–Paap Wald F-statistic. All specifications include the full set of baseline controls and district–subindustry fixed effects. Standard errors are clustered at the district–subindustry level.