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POWERING UP PRODUCTIVITY:
THE EFFECTS OF ELECTRIFICATION ON U.S. MANUFACTURING

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ABSTRACT

We use 1890-1940 sector-county level data to identify the impact of electricity on manufacturing industries, exploiting pre-electrification variation in energy intensity across industries combined with variation across locations in proximity to early hydroelectric power plants. We find that labor productivity gains from electricity were rapid and long-lasting, in contrast with established narratives. Electrification was quickly accompanied by capital deepening and organizational changes that may have contributed to these gains. Impacts varied with market structure: productivity increased without expanding employment in sector-county cells with large initial firm size, while, in contrast, both output and employment increased in cells with small initial firm size.

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1 Introduction

Technological change is essential to economic growth, and understanding its nature is a perennial research topic. Technological change sometimes occurs as a wave of transformative innovation that sweeps across all economic activities. Such "general-purpose technologies" include the salient cases of steam engines, electricity, and computers that marked the First, Second, and Third Industrial Revolutions, respectively. Such transformations entail major investments, learning costs, and multiple complementary innovations, which may act as barriers that slow down the diffusion of productivity benefits, according to conventional narratives (David, 1990; Helpman, 1998; Jovanovic and Rousseau, 2005; Vidart, 2023). Yet, a simpler explanation for the slow arrival of productivity benefits of transformative technologies, not previously subject to rigorous examination, is that the net benefits of the new technology itself can be low early on for most potential adopters. In this paper, we explore this possibility in the case of industrial electrification, using the fact that its costs and benefits varied across potential users in its first decades.

We use a rich dataset of manufacturing industries across large urban counties in the US from 1890 to 1940, and leverage variation in the net benefits of electricity adoption coming from differences in energy intensity across industries before electrification, and differences across counties in access to hydropower. Our cross-industry cross-county approach exploits the interaction between these two sources of variation while controlling for industry and county fixed effects for each period. These fixed effects absorb industry-specific trends (e.g., faster technological change in leading sectors of the Second Industrial Revolution) and any direct effects of geography (e.g., natural advantages of hydropower-suitable sites). Identification comes from comparing the gaps in outcomes between industries with high and low energy intensity in counties with access to hydropower with the analogous gaps in counties without hydropower.

We start by showing that the two sources of variation used in our empirical strategy have strong predictive power for electricity adoption. Across sectors, electricity adoption was significantly affected by pre-determined energy intensity. Across cities, electricity rates were significantly affected by access to hydropower at the county level. The importance of pre-electrification power intensity is consistent with the findings of Woolf (1984), who shows that electricity substituted for other forms of power. Proximity to large hydropower stations was a key driver of variation in electricity adoption because transmission of power was technologically infeasible or too costly over long distances early on, in line with the patterns documented by Lewis (2018), Gaggl et al. (2021), and Severnini (2023). The interaction between these two sources of variation is a strong predictor of electricity adoption: by 1920, the gap in electricity use between industries in the 75th and 25th percentiles of pre-electrification energy intensity grew about 10% faster in areas within 70km of a hydropower plant compared to areas farther away. This variation in technology adoption, induced by geographic factors combined with cross-sectoral pre-determined features, is a salient feature of this historical transformation that we can leverage in our identification strategy.

We use the interaction of sector-level energy intensity and city-level access to hydropower to study the impacts of electricity adoption on manufacturing productivity over several decades. We find that productivity gains from electricity adoption were immediate, sizable, and long-lasting. Being within 70km of hydroelectric plant locations led to faster productivity growth in energy-intensive industries already by 1900. By 1920, proximity to hydropower was associated with a 10 percent faster increase in the productivity of an industry at the 75th percentile of energy intensity compared to one at the 25th percentile. Productivity gains only appear following the arrival of electricity to manufacturing in 1900, suggesting that our measure is not conflated with other advantages of locations with access to hydropower. Our findings are robust to considering different measures of access to hydropower and controlling for initial conditions.

The effect we document may have been largely the direct result of access to a cheaper source of energy through hydropower, in line with Woolf (1984)'s view that cost was a key driver of electrification in manufacturing. However, this is not the whole story. Consistent with narratives that highlight the reorganization of production driven by electrification (e.g., Crafts, 2002; David, 1991; Devine, 1983), we find substantive changes in the intensity of physical capital use, the skill composition of the workforce, and the complexity of the production process. What is different here is that we find such changes without the long lags suggested in the literature, indicating that barriers to change may have been lower than previously thought, a point we return to below.

Within ten years of electricity's arrival, energy-intensity industries in locations with access to hydropower became more capital-intensive, reduced the share of medium-skill workers, increased the share of low-skill workers, and expanded the variety of occupations. The response of capital is consistent with its complementarity with electricity, as emphasized by Du Boff (1967), Goldin and Katz (1998), and Goldin and Katz (2009). Electricity allowed for smaller machine sizes and lower fixed costs of using energy, a likely driver of capital deepening and productivity growth. The impacts on skill mix reflect a relative growth of production workers and a reduction in medium-skill craftsmen. These responses contrast with the idea that electricity destroyed low-skill jobs (Jerome, 1934), but are aligned with Gray (2013)'s finding that electrification deskilled production jobs.[1] It is also consistent with the idea that new sources of power may increase the division of labor (Atack et al., 2017). The rapid changes in how production was organized may have been aided by the surge of electricity-related innovation even before manufacturing firms began using electricity, evident in

[1]Using geographic, gender, and educational variation and focusing on the whole economy, Vidart (2023) finds that electricity increased women's return to education in younger generations, something we do not see with our cross-industry/cross-county strategy focused on manufacturing only, suggesting that female employment growth may have concentrated in services. Our focus is also on short-term effects, while she focuses on the incentives to invest in human capital, something that is likely driven by long-term expectations.

patenting trends shown in Petralia (2021).

To what extent were these productivity gains shared with workers? We find that the labor share decreased, at least early on in the process. This result echoes recent findings on the effects of technological change, in particular computerization. However, we find that, once we control for initial conditions, growth in productivity fueled by electricity adoption was, on average, linked to growth in both output and employment. New technologies can destroy jobs and have reinstatement effects (or increase employment through increasing the scale of production), with the overall impact depending on the strength of both forces (Acemoglu and Restrepo, 2019). Our results suggest that electricity created more jobs than it destroyed, though the new jobs were on net lower paying.

Finally, we argue that market structure mediated how the electricity-induced productivity gains were shared with consumers, echoing studies of more recent technological change (see Autor et al., 2020; De Loecker et al., 2016). Our thesis is captured by a simple model similar to Autor et al. (2020)'s, presented in the appendix: in markets with small firms, cheaper energy leads to higher output and employment; in markets with large firms, Marshall's second law of demand implies more inelastic product demand, inducing firms to increase markups instead of output in response to reduced energy prices; labor demand increases by less or even decreases. In line with our hypothesis, we show that productivity gains from electricity adoption were accompanied by employment growth in industry-county cells with below-median firm size, but not in those with above-median firm size. This may explain why Morin (2019) shows strong negative effects of electricity on employment in the cement sector, since this is one of the most concentrated ones in the US.

Related literature and contribution. This paper contributes to a large and growing literature on the effects of electrification on economic outcomes. A number of recent studies provide insights from developing countries in recent periods (e.g., Dinkelman, 2011; Fried and Lagakos, 2020; Lipscomb et al., 2013) as well as from contexts that overlap with our historical study of the U.S. offering a variety of perspectives, e.g. households and rural areas (Lewis, 2013, 2018; Lewis and Severnini, 2020), the task content of occupations (Gray, 2013), agglomeration economies (Severnini, 2023), female labor participation (Vidart, 2023), and structural change (Gaggl et al., 2021); see also Brey (2023) for a historical study of Switzerland. Our contribution centers on the manufacturing sector during the the Second Industrial Revolution in the US, where electrification was a major breakthrough innovation, aiming to shed new light on the timing and diffusion of productivity gains and how they related to changes in production organization.

Our insights about electricity's impacts on manufacturing are based on the novel application of a cross-industry cross-location approach. While some previous papers exploit geographic variation in access to electricity (e.g. Gaggl et al., 2021, 2016; Molinder et al., 2021; Severnini, 2023; Vidart, 2023) and others emphasize sectoral differences (e.g. Jovanovic and Rousseau, 2005), we are the first to leverage the combination of both dimensions for identification purposes. We lean on Ciccone and Papaioannou (2023)'s recent methodological contribution to this approach to explain its logic and advantages. We also address potential concerns related to agglomeration effects and within-county externalities between industries.

The findings on rapid productivity gains from electricity stand in contrast with a number of influential studies indicating sizable but slow productivity impacts. Using growth accounting methods, Crafts (2002) finds a sizable contribution of electricity to total factor productivity but only starting in 1920. David (1991) and David and Wright (2003) argue that adoption required time as innovations diffused progressively across different activities and types of firms. Jovanovic and Rousseau (2005) and Atkeson and Kehoe (2007) analyze the slow adoption process of electricity and other general-purpose technologies and their delayed effects on productivity. The idea of a slow adoption process echoes contemporaneous studies that noted that growth in energy use in manufacturing was below expectations and much slower than in transportation (Daugherty, 1933; Thorp, 1929).

In contrast to the established narrative of steep barriers to change, our study echoes examples of early adaptation to industrial electrification under the right conditions. Such examples include the rapid switch to unit drive in printing (Goldfarb, 2005), the invention of new machinery in glass-making (Nye, 1990), and the early electrification of textiles where power was cheap (Du Boff, 1967, p. 512). We show that our finding of rapid gains from electricity and the previous evidence of long lags can be reconciled empirically: when using cross-industry variation alone, we also find long lags, and only when using cross-industry cross-county variation we find significant and sizable impacts early on. Taken together, these results indicate that electricity's impacts were slow to arrive at the *national* level, but very fast to arrive at the *local* level insofar as there was access to hydropower.

This presence of rapid productivity gains, albeit only in areas with access to hydropower, echoes the argument by David and Wright (2003) that the UK lagged the US in productivity growth over the 1920s due to the gap in the availability of cheap purchased electric power for industrial districts. Geography played an important role in the First Industrial Revolution insofar as it determined which locations were suitable for water power and which ones had an advantage in adopting steam engines based on the availability of coal (see Fernihough and O'Rourke, 2021). Our paper shows that geography –here in the form of proximity to hydropower– also played a key role in the spatial distribution of manufacturing development during the Second Industrial Revolution.

The relevance of market structure in our analysis echoes contemporaneous concerns about "bigness" during and after the Great Merger Movement in the late 19th and early 20th centuries (as discussed by Adelman, 1951; Lamoreaux, 2019; Nutter and Einhorn, 1969; Smythe, 2010). The recent literature on the impacts of industrial robots mainly points to negative effects on employment, though not in all cases (see Acemoglu et al., 2020; Acemoglu and Restrepo, 2020; Aghion et al., 2020; Dauth et al., 2019; Graetz and Michaels, 2018), suggesting that the relationship between new technologies and jobs may depend on the context.

We point to some striking resemblances in the impacts of technology in the Second Industrial Revolution and recent decades—two technological epochs that appear sharply different at first sight. The fact that technological change required different types of workers hired and required simultaneous reorganization of the firm has been discussed in the context of IT (Bloom et al., 2012; Bresnahan et al., 2002). The hollowing out of the labor skill distribution that we discuss resembles recent trends toward polarization in labor markets (Autor et al., 2003; Goos and Manning, 2007). Our analysis of the role of market structure as a mediating factor echoes De Loecker et al. (2016), De Loecker et al. (2020) and Autor et al. (2020). Our findings on the impacts of new technologies on labor markets may thus go beyond the historical context of our empirical study.

Paper structure Section 2 describes the data that we use and our empirical strategy. Section 3 shows that electricity adoption was significantly influenced both by pre-determined energy intensity at the sector level and access to hydropower at the city level. Section 4 presents our analysis of the impacts of electricity on manufacturing productivity, employment, capital deepening, and the shares of different types of labor, as well as the heterogeneous effects by market structure. The last section concludes.

2 Data and Empirical Strategy

2.1 Data

Our data set combines information on energy intensity, access to hydropower, electricity adoption, industrial output, employment, and other outcomes for a panel of consistently defined countries and industrial sectors between 1890 and 1940.

We use data at the county-industry level from decennial Censuses of Manufactures 1890-1940. While not much micro-level data is available for the historical Census of Manufactures in the United States for the period we are interested in (the samples by Atack et al., 2008, end in 1880), summary tables by industry and city (or county, depending on the year) are available in the published paper versions for Census years and some intercensal periods. This is an extended version of the data digitized by Lafortune et al. (2019) from the Censuses of Manufactures, now focused on the post-1890 period and adding 1940 to capture long-term impacts of electricity diffusion. The key outcomes of interest are electricity and energy use, capital, labor, and output. The value of products and costs are available for the full period, which allows us to define value-added as our measure of output (Y). We use the total number of workers as our measure of employment (N) and compute labor productivity as value-added per worker or Y/N. We present summary statistics for these outcomes in Appendix Table A.1.[2]

Energy intensity, as proxied by horsepower use, is available at the city-industry level from 1910 to 1930. We use the prime movers as our definition of horsepower when measuring energy intensity (HP/Y), but we add to it the rented horsepower when calculating the fraction of horsepower that is electric in the industry. We also obtained an aggregate industry measures of horsepower use from 1890 to 1930. Unfortunately, data on electricity usage by city-industry is only available for 1920. For 1930, we have the electricity rented by firms which is a significant portion, but not all, of electricity used by firms at that moment.

The geographic coverage of the Manufacturing Census differs by year. The population threshold above which cities were included in each year changed over time. In 1890, the 165 largest cities were included. In 1900, there were 209 cities included: only cities with more than 20,000 inhabitants. In 1910 and 1920, only cities with more than 50,000 inhabitants were included. In 1930, the process was more complex and involved restricting cities to those that had a significant amount of manufacturing workers (10,000 was a typical cut-off, but it depended on other factors). Due to this change of geography, and because, with rare exceptions, cities are within county boundaries, we make "county" the unit of analysis, matching each city to the county they corresponded to.[3] We merged counties over time to ensure that borders were very similar between years, as described in Lafortune et al. (2019).

The map in Figure 1 shows the counties that enter into our sample (using 1920 county boundaries). The areas in our analysis are the largest metropolitan areas of the period (including counties whose population was 5 to 6 times that of an average US county).

Industry classifications changed significantly over the period. We use detailed information provided by the Census Bureau on the change in industry definitions over this period to generate groups that are consistent over the full period. This means that we lose some detail in how finely our industries are defined, but we are sure that we have the same industries included in each group in each period. Industries were matched across census tabulations using tabulated crosswalks in years after 1900, and by hand before that. Appendix Table C.18 gives our final set of industry crosswalks. We generate a balanced sample at the aggregate level from 1890 to 1940, including 156 industries consistently defined over the period.

[2]For all outcomes where we use a logarithmic transformation, we use $\log(1+x)$ instead of $\log(x)$ to avoid dropping observations that are available in the database but for which one input (labor, capital, electricity, etc) is equal to 0.

[3]The only significant exception to this is New York City, which spans multiple counties and whose county composition changes over time. We therefore construct New York City to cover the five "boroughs" (counties) that make it up at the end of the period. This aggregates together Brooklyn and New York City, which were reported as separate cities in earlier years.

At the industry-city level, some industries disappear since there is also a minimum “cell size” to be included (often at least 3 establishments per location-year are required). However, even with these reporting restrictions, there is “balancedness” in the sense that the industries detailed for each city often repeat, allowing us to use panel methods as described in the empirical methods section. In the industry-by-area analysis, we exclude the residual “All other industries” cells, as they are not comparable across years or areas. Merging all together, we obtain a panel including 17,409 industry-city-year observations. This includes 134 areas (more in some years than others) and 142 industries.[4] We capture between a third and half of all manufacturing activity in the United States, although this fraction is smaller for 1930 and 1940 than for earlier years.

We identify access to early hydropower using the Census of Central Electric Light and Power Stations and Street and Electric Railways of 1912. This edition of the Census provides a map of all hydroelectric central stations reporting water power of at least 1,000 horsepower. We digitized this map geocoding each power plant. Given the lack of clear consistent historical indications regarding exactly how far electricity could be transmitted at reasonable costs over the years, we (like previous papers) let the data determine how close to these power plants one needs to be to obtain benefits. Appendix Figures A.1 and A.2 show that there appears to be a benefit to being close to a power plant in terms of electricity prices and electricity usage until one is further than 70 km. We thus use as our main measure whether there are any hydropower plants within a radius of 70 km of the centroid of the county. Seventy kilometers also correspond to the median distance of counties if we consider only those with distances ranging between 2 and 450km. We also measured the distance of each centroid to the closest power plant on the map. We present this map in Figure 1. As an alternative measure, we use the 44 hydroelectric power stations identified in the 1900 Census of Manufactures and identify the county where each of them was located. This data, however, is of lower quality given the lack of exact geographic location and the unclear definition the Census of Manufactures employed to classify these stations.

We also use data on electricity prices. Our preferred source is the Census of Manufacturing 1947 which provides, for each county, the total cost of electricity and the number of KWh consumed by manufacturing firms. This is the only source we found with reliable price information for the manufacturing sector. Our analysis suggests, in line with Severnini (2023), that even by 1947 prices remained very local, as the distribution network was not yet well developed. We also show results using the National Electric Light Association (NELA) Rate Books from 1921, which provide information on residential rates for a subset of cities in our sample.

[4] Thus, we “lose” 14 industries that do not have enough consistent local observability to contribute to the analysis feasibly. They are: industry 26 (felt goods), industry 49 (wood preserving), industry 63 (turpentine and rosin), industry 65 (explosives), industry 74 (fireworks), industry 80 (fuel), industry 81 (rubber boots and shoes), industry 92 (emery), industry 94 (graphite), industry 99 (wire), industry 108 (doors and shutters), industry 122 (tin foil), industry 132 (bicycles), and industry 155 (fire extinguishers).

For labor related outcomes, we exploit data from the Census of Population with IPUMS microdata from 1900 to 1940 full counts (Ruggles et al., 2019). We obtain information regarding the number of workers and their characteristics by county and industry. Since the Census of Population data uses IND1950 as an industry classification, we generate a crosswalk between the Census of Manufacturing and the Census of Population. Given that our classification is finer than that provided in the Census, sometimes one IND1950 is matched to multiple industries in our database, as shown in Appendix Table C.18.

2.2 Empirical strategy

Using our detailed data at the sector-county level every decade in the period 1890-1940, we use a difference-in-difference estimator to exploit variation in energy intensity across industries and variation in access to cheap electricity across locations. This approach is essentially the cross-country cross-industry design pioneered by Rajan and Zingales (1998) and adopted in many subsequent studies (see Ciccone and Papaioannou, 2023, for a review of economic applications of this approach and an insightful discussion). In our case, the geographic variation is across cities rather than countries. We run regressions for outcomes at different points in time, focusing on observed patterns before and after the arrival of electricity. This time variation is an additional layer that, in intuitive terms, implies we adopt a triple-difference approach.

We estimate the following equation:

$$\Delta log(y)_{ict} = \gamma_t \cdot HP_{i,0} \cdot Prox_c + \theta_{it} + \theta_{ct} + \varepsilon_{ict}, \quad (1)$$

where i denotes an industry, c a county and t a time period. We estimate the regression separately for each year. This lets all the coefficients estimated in this model change by year. We control for fixed effects by industry (θ_{it}) and by county(θ_{ct}) separately, for each year in our sample. $\Delta log(y)_{ict}$ corresponds to outcomes related to either growth in employment or output or productivity between year t and year 1890, which pre-dates the diffusion of electricity in manufacturing. In some specifications, we also include a control for the 1890 value of the outcome variable at the industry-city level, thus allowing for differential trends across years by initial levels. Regressions are weighted by the number of establishments in each sector-county cell.

Our parameter of interest is γ_t, which measures the differential impact of the arrival of electricity on a given sector given its location. $HP_{i,0}$ measures an industry's initial horsepower usage per unit of output in 1890 at the *national* level. This attempts to compare sectors with high versus low energy needs *before* the widespread adoption of electricity. As discussed below, this is a strong predictor of electricity adoption.

We interact sector-level energy intensity with a city-level proxy for access to electricity: the availability of a hydroelectric plant in a near vicinity. Electricity generation was developed before the technological innovations that allowed its distribution over long distances. Moreover, hydroelectric power produced much cheaper electricity than (mostly thermal) alternatives. Using information on the geographic location of all large hydroelectric plants in 1912, we define $Prox_c$ as a dummy for whether there were any hydropower plant within 70km or the inverse distance to the nearest plant. We also obtained a list of all large hydroelectric plants in 1900 and marked all counties that had a plant in 1900 as having access to electricity. Thus, this interaction allows us to add another "difference" to the empirical strategy comparing two counties that differed in their access to hydroelectric power.[5]

Ciccone and Papaioannou (2023) offers an insightful way to think about this research design, considering a breakdown of the cross-location cross-industry specification into two steps: first, a cross-industry regression in which outcomes across industries within a county are regressed on industry characteristics (in our context, energy intensity), yielding a regression slope for each location (for us, each county); second, a regression of the county-specific slope coefficients from the first step on county-level features (for us, proximity to hydropower). This way of thinking about the empirical approach highlights its similarity to a difference-in-differences approach: we are examining how the gaps in outcomes between high energy-intensity and low energy-intensity industries differ in counties with access to hydropower and those that do not.

A key feature of the cross-county cross-industry approach is that the fixed effects absorb any factor that varies only at the industry or location level. For each time period, θ_{ct} absorbs any effects induced by industry-level characteristics that may be correlated with (but distinct from) energy intensity, and θ_{it} takes care of any geographic advantages of counties with hydroelectric potential (e.g., waterways that favor water power or decrease transportation costs).[6] In terms of the two-step breakdown of the cross-county cross-industry approach, if there are county-level characteristics correlated with proximity to hydropower that shift productivity across all activities, the empirical approach is effective: these shifters do not affect the *slopes* and thus do not contaminate the coefficient estimate for the interaction term.

The argument above implies that the location of hydropower close to large or rapidly growing

[5]Our results are similar, though noisier when using the measure of hydropower potential from Gaggl et al. (2016), which the authors generously shared. This measure is based on unexploited potential as of the 1990s, while ours captures historical hydropower capacity.

[6]One important aspect of the geography of hydropower plant placement is that it was far from uniform and did not necessarily reflect a consistent type of "geographic advantage." The set of early hydropower plants discussed by U.S. Department of Interior, United States Census Office (1902) illustrates the point: one of the stations in Niagara Falls benefited from the large drop of water placing the turbines in the gorge, but this made the operation hard, while another plant used a canal that split from the river just above the fall, reducing the speed and volume of water but making the operation easier; in California, hydropower plants relied on much smaller bodies of water but relied on water coming from much higher altitudes –e.g., the plant at Colgate that was located at the base of a high hill. A different, peculiar setup was the plant in Snoqualmie Falls, Washington, which was placed on a large cavern below the surface because the spray from the fall on the surface was too strong.

urban centers would not be an issue, since the location fixed-effects would absorb variation in the regressor and outcomes along this dimension, with cross-industry variation providing the required identifying variation. A remaining threat to identification is that power plants may have located in areas where manufacturing would have otherwise (that is for reasons *other than* the availability of electric power) increased its growth rate, not overall, but differentially in historically power-intensive industries. It seems unlikely that this was a primary driver of power plant location: in the early 20th century, manufacturing still relied heavily on other power sources (water and especially steam), while in many locations, the leading sources of demand for purchased electricity were street lightning and urban transportation (see, e.g., U.S. Department of Interior, United States Census Office (1913) p. 331; U.S. Department of Interior, United States Census Office (1902), p. cccxxix). Consistent with these observations, we find no clear indication that energy-intensive industries had any substantive advantages in output, employment, or productivity by 1880 in counties that later had hydropower stations.

Another possible concern is that hydropower may induce agglomeration forces that affect some sectors more than others. If these differences are orthogonal to sector-level energy intensity, then it will make the estimations noisier, but in terms of the two-step breakdown of the cross-county cross-industry approach, it would not affect the county-level slopes. If these industry-level shifts are correlated with energy intensity, there could be bias in either direction. If proximity to hydropower favors agglomeration, and the latter favors energy-intensive sectors, these would create a bias. To address this concern, some of our robustness checks add controls for the size of manufacturing production and population growth rates.

A somewhat related potential issue based on externalities is that energy-intensive sectors could be key suppliers of other energy-intensive sectors, making the estimates capture the direct effect of access to hydropower plus an indirect amplification through input-output linkages. For this to explain our estimates, we would need energy-intensive sectors to be very dependent on the sale of their products to other local lower-energy sectors. Looking at Table A.2, it is not evident that the most energy-intensive sectors are more likely to produce intermediate rather than final goods, nor that the intermediate goods that would be produced are likely to be differentially used by less energy-intensive sectors. Furthermore, manufacturing inputs are usually considered tradable goods, making it unlikely that their market would be limited to local buyers.

Finally, a key concern about cross-location cross-industry designs, highlighted and studied in detail by Ciccone and Papaioannou (2023), relates to the measurement of industry-level characteristics. In cross-country studies, the industry-level variable of interest is usually proxied by measures from a benchmark country. Insofar as technological heterogeneity across countries exists, this could lead to attenuation bias due to classical measurement error. The bigger concern is that the technological similarity of different countries with the benchmark country may be correlated with other country characteristics. This could bias the results in any direction. This important point seems less of a concern in our cross-*county* study, where the industry-level measure is the average horsepower intensity at the national level. While there could certainly be heterogeneity across locations in horsepower intensity for a given industry, in a context of high mobility of labor and capital across locations, national averages are more reliable proxies for the technologies that firms have access to.

3 Energy Intensity, Access to Hydropower, and Electricity Adoption

This section establishes the building blocks of our empirical strategy to identify the impacts of electricity adoption on manufacturing production. Our strategy is based on combining two sources of variation in electricity adoption: cross-sectoral variation in energy intensity (before the diffusion of electricity) and cross-county variation in access to hydropower.

We start by showing that energy intensity before the arrival of electricity is a good predictor of electricity intensity once electricity has been implemented. We do that by regressing electricity use in 1920 (this is the only year in our county-industry data where we have all the required data to compute these values) on the industry-level energy intensity in 1890, prior to the diffusion of electricity in manufacturing.[7] We include county-level fixed effects to capture any factor related to the location of these industries across the United States.[8] The results are presented in Table 1. In the first column, we use electric horsepower per worker as our measure of electricity use while in the next column, we employ electric horsepower per value added.

We find a strong and robust relationship between how energy intensive an industry was in 1890 (either by using horsepower per worker or per unit of output) and the intensity in the use of electricity of that industry in subsequent years. A one percent increase in horsepower per unit of output in 1890 is associated with 0.63 percent higher electric horsepower per worker and 0.67 percent higher electricity per unit of output in 1920. A one percent increase in horsepower per worker in 1890 is associated with 0.53 percent higher electricity per worker and 0.58 percent higher electricity per unit of output in 1920.

We now address the concern that these results may not reflect the role of energy-intensity but rather some other industry-level characteristic that was correlated with energy-intensity and with electricity adoption. First, note that our measure of energy-intensity does not just capture established versus new industries. Appendix Table A.2 shows the list of sectors that were more and less energy-intensive before the arrival of electricity. While some of the most energy-intensive

[7] This section does not include a control for the outcome variable in 1890 since we do not have electricity at the city-industry level for that year.

[8] However, results are very similar when excluding these controls. Results are available upon request.

industries are the ones that led the Second Industrial Revolution (e.g., iron and steel, electrical machinery), others are more traditional industries (e.g., flouring, ice).

We explore the relationship of energy adoption and various of industry-level characteristics (early adoption, capital intensity, human capital intensity, complexity) in Appendix Table A.3. The first panel shows that the few industries that started employing electricity in 1890 were not those that ended up using it more intensively. Early adoption of electricity is actually associated with lower electricity intensity in subsequent years.

One could be worried that energy-intensity is simply a proxy for "heavy industries." We explore this using measures of capital intensity in Panel B. We find that capital-labor ratios in 1890 are negatively correlated with electricity intensity in 1920, although capital output ratios in 1890 are positively correlated with electricity intensity in 1920. This suggests that energy-intensity was more correlated with higher capital-output ratios than capital-labor ratios. Overall, the results suggest that our measure of energy-intensity is not the same as capital intensity.

Panel C turns to variables related to human capital. Lafortune et al. (2019) suggest that the Second Industrial Revolution led to skill becoming complementary with capital and the arrival of electricity could have played a role in that transformation. This would suggest that higher skill ratios would have been essential for the adoption of electricity. However, the results presented in this panel do not support this hypothesis, which is not surprising since electricity is one of the last changes to occur during the Second Industrial Revolution. We first use the average literacy of workers who report working in that industry in the Census of Population in 1900. We find no evidence that industries that were more literate in 1900 at the national level had higher electricity intensity in 1920. If anything, the results suggest a negative relationship between literacy and electricity intensity.

The results above could be imperfect since we have to merge industry categories in order to match to industry categories available in the census, introducing noise in the analysis. The next set of results use the number of white-collars per blue-collars in the Census of Manufactures in 1890. This has the advantage of being in our database and thus can be generated for all industries in our classification directly. However, it is less clearly a measure of skill than literacy, since blue-collar workers may have also been "skilled." The results presented in Table A.3 show that a similar conclusion as when using literacy can be drawn: industries with more high-skill workers are less likely to have adopted electricity, contrary to our hypothesis.

We finally include measures of industry complexity since some authors argue that the arrival of electricity was particularly relevant for allowing a better division of labor through a change in floor organization. We find no evidence that proxies of complexity such as the number of occupations employed in an industry or the Herfindahl index of occupations are positively correlated with more use of electricity.

In sum, the results show that energy intensity in 1890 (*before* the diffusion of electricity in manufacturing) is a good predictor of electricity intensity a few decades later, and that this does to simply mask a pattern related to other variables.

When did the difference by energy intensity arise and was it long lasting? To answer this question, we must rely on cross-industry variation only, since we do not have measures of electricity usage at the industry-city level for years other than 1920. Thus, our sample consists of 156 industries, and we cannot control for differences in location patterns across industries. We regress our three measures of electric intensity at the industry-year level on our measure of energy intensity in 1890 separately for each year. To show the results graphically, we predicted what the electric intensity was for the industries at the 10th, 50th and 90th percentile of initial energy-intensity. This is presented in Figure 2 where the dependent variable is in difference of log for each outcome. The pattern of the industry at the median is reflective of the typical "S-shape" adoption curve of new technology. From our data, in 1890, the average industry used less than 0.005 electric horsepower per worker in a given year, that number jumped to 0.07 in 1900 and then to 0.5 in 1910, virtually being multiplied by 100 over 20 years. It then increased to 0.6 in 1920 to then continue growing at a slower rate in the following decades, reaching 1.8 by 1940. This is visible in our graph as a change between 6 and 8 log points between 1890 to 1940 but much more rapid between 1890 to 1910 than after. This figure shows that initial energy intensity strongly influenced adoption of electricity as early as 1900 with the gap increasing until 1930. By 1940, initial energy-intensity is not a good predictor of electricity per worker or per unit of output. Coefficients used to obtained the predicted measures for each year are presented in Appendix Table A.4. Thus, the results suggests that energy intensive industries became more electricity intensive from 1900 onward and that this relationship became stronger as electricity spread more widely.

We now turn to show that cross-county differences in access to hydropower were also a key determinant of electricity adoption. This is the second building block of our empirical strategy. We measure this using proximity to large hydroelectric plants. In Table 2, we show how the presence of hydroelectric power plants in 1912 or 1900 are correlated with lower electricity prices, obtained from our preferred measure which employs manufacturing rates for 1947. We explore the correlation between the level (in the first three columns) and the logarithm (in the last 3 columns) of the rates and 3 different measures of proximity to a hydroelectric plant. Our first measure is the number of power plants within a 70km radius of the centroid of the county in 1912. Our second is the inverse distance of the centroid of the country to the nearest hydroelectric power plant in 1912. Finally, our last measure is a dummy for the presence of a large hydroelectric power plant in 1900.

The results in Table 2 show that our three measures of proximity are all significantly correlated with lower manufacturing electricity prices in 1947. Appendix Figure A.1 Panel A displays the effects of distance to 1912 hydropower stations on 1947 prices. The results show that being further than 70km from hydropower is associated with an increase of 1 cent per KW/h—over one standard deviation and about half of the mean price for that period. In Appendix Table A.5, we examine an alternative measure of electricity prices - residential rates for 1920. This table shows in general a negative correlation between proximity and electricity prices but it is only significant for the earliest power plants. Residential electricity prices were likely to be different from those paid by manufacturing firms which may explain the difference. Overall, these results indicate that electricity prices paid by manufacturing firms were likely to be significantly lower when they were located closer to a large power plant.

Having established that both industry-level energy intensity and county-level access to hydropower were relevant determinants of electricity adoption, we now show that the interaction between these two factors is also a strong predictor of electricity adoption even controlling for industry and city fixed effects. We do this in Table 3, where each panel corresponds to a different way of measuring proximity. In the first panel, we use a dummy for the presence of a power plant within a 70km radius of the centroid of the county. We find that industries that were more energy-intensive in 1890 and were located in counties with a power plant had substantial increases in electricity intensity as measured by electricity per worker by 1920. Electricity per unit of output is noisier. Appendix Figure A.2 shows that the benefit of proximity for electricity intensity appears to fade exactly past 70km as in the case of prices.

The next panel uses the inverse of the distance to the nearest power plant in 1912. We find a weaker relationship between the interaction between the inverse distance and the energy intensity of the industry in 1890. Finally, the last panel uses a more demanding specification using a simple dummy for whether the county had one of the 44 power stations already in existence in 1900. This is a very small number of counties but where the location of the power plant may have been particularly driven by topological characteristics that favored the production of hydro-electricity. Consistent with previous results, we find that industries with high energy-intensity in 1890 that were located in one of these counties had larger increases in electricity-intensity by 1920, as measured by electric horsepower per worker or per unit of output.[9]

In the above regression, we weight our regressions by the number of establishments represented for each industry-county cell in our sample. We do this for two reasons. First, while we do not have firm-level data, we wish our results to be representative of the impact of electricity on an average firm. Second, the variables for sector-county cells with fewer establishments are likely to be noisier, so weighting can increase the precision of the estimates. This is particularly true since the number

[9]We are unable to conduct similar exercises for other years because of data availability. For 1930 we have information on rented electric power, which does not include electricity produced in-house by manufacturing plants (a sizable source over this period), but it is still informative. Results using this measure (available on request) show weaker but consistent patterns about the link between sector-level energy intensity, county-level access to hydropower, and electrification.

of establishments is the criteria that the Census of Manufactures used to determine whether a cell would or would not be included in the report. Thus, by weighting by the number of establishments, we also give more weight to observations that are more continuously in our sample, ensuring that our fixed effects strategy is well identified.

Weighting by the number of establishments is only valid if our interaction does not influence the number of establishments present in the sample. To check for this, we run as an outcome variable three different measures of "size" of a cell against our interaction on a sample that includes every single industry ever present in our sample for every single county ever included in our sample. We continue to include county and industry fixed effects. The results of these regressions are presented in Appendix Table A.6. The first column shows the impact of our interaction on the cell being in the sample in that year. The second column uses as an outcome variable the number of establishments imputing as "0" as cell that is not in our sample while the third does the same thing with the number of workers in that cell.

Overall, the results suggest that industries that were more energy-intensive and that were close to a power plant were not more likely to be in the sample, nor more likely to have more establishments or more workers. In 1900 and 1920, we actually find a significant impact of the interaction on the likelihood of being in the sample but the impact is negative suggesting that those cells were less likely to be in the sample. We find an initially significant and positive relationship between our variable of interest and the number of workers (including 0s for missing cells) but the significance disappears. Similarly, we find no significant correlation between our interaction and the number of establishments in any years. This suggests that we can use the number of establishments as a weighting variable since our treatment of interest does not seem to be correlated with it. Furthermore, and consistent with our argument, we find that the results are qualitatively similar, but noisier, when we omit our weights.[10]

4 Impacts on Productivity

4.1 Productivity growth

Having shown that the combination of energy-intensity and proximity to power plants generated considerable variation in electricity intensity, we now turn to exploring the impact of electricity on productivity. While we do not have data on electricity use at the county-sector level except for 1920, we can use overall energy intensity by sector before electrification, interacted with proximity to hydropower, to assess the impacts of this major source of electric power on productivity.

Figure 3 shows the results from estimating equation (1) for labor productivity. The top panel

[10] Results are available upon request.

controls for the 1890 values of the dependent variable, while the bottom one does not. The first figure thus shows how the interaction between poximity to hydropower and energy-intensity impacted productivity growth at the industry-county level over the period. The fact that we do not observe a difference between industry-county cells that would benefit from electricity in 1880 (visible in the lower panel of Figure 3) is consistent with assumptions needed to support the validity of our empirical strategy. The figure shows that a significant differential in productivity trajectories emerges as early as 1900. Similar to the patterns documented for electricity adoption, the estimated coefficients increase until 1920 and remain fairly stable thereafter.

To get a sense of the magnitudes, having one power plant within 70 km increases the labor productivity of an industry that was at the 75th percentile of energy needs by 4 percent compared to one at the 25th percentile as early as 1900. The magnitude increases to around 11 percent by 1920 and remains at that level until 1940.[11] Combined with the results presented in Table 3, the results for 1920 imply that having one more percent in electric horsepower per value-added leads to 1.5 percent higher labor productivity. In the bottom panel, we show the same estimations but without controlling for labor productivity in 1890 and find a similar pattern with slightly larger magnitudes. This suggests that the growth may have been larger in part because there industries in these counties may have had lower than average productivity in 1890. Nevertheless, in either version, our results suggest immediate, large, and significant impacts on labor productivity.

The next table explores the robustness of these results. Columns 1-2 of Table 4 show results restricting the sample to industry-county cells that were present in all of the 5 periods included in the analysis, to make sure that the time patterns of productivity impacts documented before are not affected by changes in the sample (which for some years is less than half the size than for other others). The results for the balanced panel confirm the previous time patterns, showing significant, sizable, and early productivity growth like in Figure A.3. The rest of Table 4 checks whether our results are robust to different measures of proximity to hydropower. Columns 3-4 use the inverse distance to the closest power plant in 1912. The results again indicate that, as early as 1900, productivity growth was larger in county-industries cells that were able to electrify more intensively. Estimated productivity gains by 1920 are strong and robust. Furthermore, we repeat our main analysis for 1920 but changing the specification of proximity to a series of indicators for 10km intervals. Appendix Figure A.4 shows the coefficients on the interaction of each proximity indicator variable and initial energy intensity. Our results show the same type of discontinuity around 70km, suggesting that productivity gains disappear precisely at the distance at which firms stopped benefiting from low price of electricity through hydropwer. Finally, the last two columns of Table 4 use a different proxy for closeness to a hydropower: whether the county had a power plant in 1900. In these columns, we see much noisier results but still find productivity gains by

[11] These results assume that the errors of each equation in every year are independent. Allowing correlations by county or by industry does not change the results, as shown in Appendix Table A.7.

1920. In sum, our robustness analysis confirms that firms that became more electricity-intensive earlier observed rapid productivity gains.

Our baseline measures of productivity are based on valued added as these are uniformly constructed for the period and avoid problems related to changing costs of materials. A possible concern is that since part of the materials include energy costs, observed productivity gains could be simply a reflection of lower energy costs. This is not obvious since a reduction in the per-unit cost of energy does not imply that total energy costs would decrease if energy intensity increases, something that we explore in the next section. We show, in Appendix Table A.8, that our conclusions about productivity are unchanged if we instead use total output value or value added without energy costs, something we can only compute for some years.

While our empirical strategy combining county and industry variation has multiple advantages, it does not take into account interactions across industries within a geographical area, which could be problematic if spillovers are strong and differ systematically by industry. In particular, if electricity led to agglomeration benefits that were particularly strong for industries with high initial energy intensity, our estimates would be biased. To address this possibility, we include as an additional regressor in our main specification an interaction between a dummy for a county having more than 20,000 manufacturing workers or having grown their total manufacturing labor force by more than 30 percent since 1890 and our measure of energy intensity. The results, presented in Appendix Table A.9, show that including these additional controls do not change our results in terms of timing, magnitude or significance.

Finally, we explore the reasons behind this increased labor productivity in Appendix Figures A.3, by looking at output and employment separately. The first figure shows that the increased productivity resulted from faster increases in output than in employment. The coefficients for output are significant and positive for all years and suggest sizable increases in output when a cell is close to a hydropower plant and was intensive in energy before the arrival of electricity. For employment, we observe the coefficients being smaller and less often statistically significant. This would suggest that electricity may have initially replaced some workers with more or better machines. Excluding controls for 1890 outcomes shows smaller increases in output and much less significant increases in employment, as can be seen in panel (b).

Long lags or speedy adaptation? Why do we find rapid productivity gains from electrification, while the previous literature (e.g., David, 1991) highlights long time lags? The answer is that previous studies mostly consider industry level patterns. In Appendix Table A.10, we contrast our previous results from a "double difference" approach with those we obtain from cross-industry comparisons for the whole sample. We report the estimated impact on productivity from comparing industries that had high and low energy demands in 1890. These cross-industry comparisons suggest insignificant impacts of electrification on labor productivity, which is much more aligned with the previous literature than with the results from our proposed cross-industry cross-county comparison. The benefits of the new technology in Appendix Table A.10 are only visible in 1930, which is 20 to 30 years later than our cross-industry cross-county analysis would suggest. This is consistent with the previous literature, and suggests that not all firms in energy-intensive industries experienced rapid productivity benefits from electrification; only firms with access to hydropower had gains early on.

The observed patters suggest that the main barrier to the adoption of technology was its high price or inexistent supply in some regions, not the need to reorganize the production process as previously argued. To substantiate this claim, we classified all manufacturing patents from 1870 to 1940 as "electric" if they included "electr" somewhere in their text (similar to the measurement strategy used by Petralia, 2021, whose results are consistent with ours). We find that by 1895—the time at which the AC/DC battle was settled in factor of AC current, facilitating further advances—already 10 percent of patents were electrical. This early dynamism suggests that some innovations complementary to electricity adoption were already available by 1900, the period for which we find the earliest positive impacts on productivity. What lagged behind was the capacity to transmit it over long distances, which implied that geographical advantages would remain at play until the 1950s.

Many examples further support the idea that early adaptation to industrial electrification was feasible under the right conditions. The rapid switch to the unit drive in much of the printing industry—whose power use was mostly electric already by 1900 (Goldfarb, 2005, Table 1)—may have been kicked off by the Government Printing Office's successful switch to electric power in 1895 (Du Boff, 1967). New electrical machinery in glass-making aimed to take over the work of craftsmen was also rolled out as early as the 1890s (Nye, 1990, p. 14). For instance, a patent for a flat-glass making machine that claimed to "dispense with a number of skilled workmen" was filed in April 1899 (US patent 696,007). Stressing the importance of geographic advantage, even in textile production, an industry that was initially very slow to adopt electricity, a plant in Columbia, SC that adopted hydroelectric power early for idiosyncratic reasons (the river bank was too steep to feasibly use the river's mechanical power) successfully relied on electrical motors beginning in 1894 (Du Boff, 1967, p. 512).[12] Importantly, adoption in this case required overcoming a "co-invention" barrier (an often-mentioned reason for slow impacts of general-purpose technologies): the plant's alternating current motors—specifically designed for it—were reportedly at least six times more powerful than anything previously built by General Electric (Hammond and Pound, 1941, p. 211).

[12] For a summary of the plant's history, see also Hammond and Pound (1941, pp. 210-212), Passer (1953, pp. 303-305) and https://www.scencyclopedia.org/sce/entries/columbia-mills, accessed on November 1st, 2021. This and similar examples of early success publicized in trade journals—including another hydroelectric powered textile plant opening down the road a year later (Passer, 1953, p. 305)—may have jumpstarted the sector's electrification, which took off in subsequent decades (Goldfarb, 2005, Table 1).

4.2 Sources of productivity growth

Our findings indicate that high-energy sectors who were close to an early hydropower station experienced immediate and sizable productivity gains compared to less-energy intensive sectors and those further away from cheap electricity sources. What were the sources of these labor productivity gains?

This section argues that productivity gains were not only caused by the direct impact of having access to a cheaper source of energy, but rather also involved changes in production organization, including capital deepening, deskilling, and increased occupational diversity. Employing a cheaper source of energy to power existing machines could lead to higher productivity, even if firms do not change their way of producing their goods nor the organization of their floor plan. However, we find that electrification did lead to significant organizational changes. In particular, we examine the effects of electrification (again, leveraging the interaction between sector-level energy intensity and country-level access to hydropower) on capital per worker, the labor share, the skill mix employed in production, and the number of distinct occupations.

Table 5 displays the estimated effects on capital per worker and the labor share. The first two columns show that energy intensive sectors in locations with access to hydropower increased their capital per worker, consistent with the presence of complementarities between electricity and capital (as suggested by Goldin and Katz, 1998, 2009). Columns 3-4 report negative estimated impacts on the labor share, though only statistically significant for 1920. This negative effect may have been a byproduct of increased capital intensity, and may have also partly reflected the changes in the skill mix of workers that we document below. While the negative effects of electrification on the labor share that we find echoes results from studies on recent technological changes, an interesting contrast is that the early 20th century was, overall, marked by an increasing labor share.

We then examine the distribution of workers by skill level, as a key dimension of the organization of production. We rely on micro-level data from the Census of Population and consider three broad occupational groups, following the classification proposed by Katz and Margo (2014): high-, medium-, and low-skill. Since we have no data for 1890, our outcome is now in levels instead of changes as in the productivity regressions. The results, displayed in the first three panels of Figure 4, indicate that electricity adoption induced a reduction of middle-skill jobs in favor of low-skill employment.[13] While Lafortune et al. (2019) find no indication that the changing relationship between capital and skill was masking polarization, there is a stronger pattern in the case of electricity. This suggests that electricity increased productivity not simply by providing cheaper energy but also by changing how (specifically, by which types of workers) goods were produced.

[13] We conduct a similar exercise dividing workers into "blue-collar" and "white-collar" as defined in the Census of Manufacturing. The estimated effects with this classification do not show a clear pattern, consistent our finding that electricity had non-monotonic effects on demands for skill.

To better understand the reasons behind the observed patterns, we break down occupational groups into finer sub-groups. For low-skill occupations, we consider four groups: transportation workers, service workers, apprentices, and production workers.[14] For medium-skill workers, we use the IPUMS 1950 occupation (OCC1950) division between clerks and salesmen, and divide the remaining occupations into craftsmen and machine operators. For high-skill workers, we consider the OCC1950 classification, with professionals, technical and kindred workers in one category, and managers in another.

Figure 5 presents the results. The increase in the fraction of employees concentrated in low-skill occupations is entirely due to a large increase in production workers, consistent with the notion that electricity increased the weight of production line tasks performed by low-skill workers. The share of apprentices fell significantly by 1940, although in terms of magnitude this is irrelevant for low skill workers overall. When looking at medium-skill workers, we find that the share of craftsmen within manufacturing employment was substantially lower in sector-countries affected by electrification in all years, though not significantly after 1920. Clerical workers had lower employment shares in those cells in 1940. We also see a significantly lower relative size of the sales workforce in manufacturing in 1930 and 1940. Finally, employment of machine operators initially increases (although not significantly) with the arrival of electricity, but the coefficients subsequently fall to zero. The reason behind this shift may be found in the last panel of Figure 5, which shows that the null impact on high-skill workers hides a positive impact on professional and technical workers after 1930. Thus, while medium-skill workers may have initially been well suited to work with electric machinery, by 1930 firms may have started to require more skilled workers, such as engineers.[15]

Finally, we examine the impacts on the complexity of production organization, as proxied by occupational diversity. In particular, we consider how the number of distinct occupations in each sector-county was affected by the electrification. The results, displayed in the last panel of Figure 4, show a positive and sizable association from 1910 onward. This increase in the number of occupations was not mechanically driven by electricity-related occupations, e.g. electricians. We do not find significant effects for a Herfindahl index of occupations, suggesting the positive effects on diversity were mainly driven by occupations with small shares of total employment.. The positive effects of electrification on occupational variety are the possibility that new technologies create tasks (see Acemoglu and Restrepo, 2019), and may have played a role as a source of productivity growth—in line with Adam Smith's classic discussion of the division of labor and Jane (1969)'s

[14] The latter includes operative and kindred workers not elsewhere classified and laborers not elsewhere classified, the two largest occupational groups in our sample, preventing us from obtaining a better picture of that sub-group.

[15] We also considered the shares of literate workers, some proxies for tasks and female workers as outcomes, and found no significant effects. The non-result for female employment differs from the findings of Vidart (2023), a contrast that may be due to our focus on manufacturing employment, or to our identification strategy based on hydropower, which had declining relevance over time, while the increases in female employment found by Vidart (2023) played out gradually through generational change, as young women acquired skills to take on new opportunities.

thesis on the dynamic effects of economic diversity. .

Overall, our results suggest that the productivity effect documented above could be due to cheaper energy, there is suggestive evidence that it also may have operated through a more radical transformation of the production function. This was visible also as early as 1900 suggesting that such adjustments could be made when access to cheaper electricity diminished the cost of their adoption.

4.3 Heterogeneous impacts by market structure

The previous results indicate that electricity increased labor productivity rapidly and substantially, with significant impacts on the organization of production. These productivity gains reflected rates of expansion for output above those for employment. In this section, we examine the role of market structure (proxied in different ways) in shaping how much technological progress translated into employment growth.

In markets with large firms, where product demand is relatively inelastic (as implied by Marshall's second law of demand), responses to reductions in energy costs are likely to involve relatively large increases in markups, rather than in output quantities. Employment is bound to have smaller increases or even decrease. In Appendix B, we formalize this argument in a simple model similar to Autor et al. (2020)'s. This section empirically explores whether the impact of electricity adoption depended on the elasticity of product demand.

First, we focus on local market structure as a determinant of demand elasticity and use average firm size as a proxy. Ideally, we would proxy market structure by computing markups, but we do not have data on output quantities, only on output value. We also do not have detailed data on the size distribution of firms at the sector-county level, so we have to rely on average value-added per firm or average number of workers per firm.[16] We thus classify each industry-county cell as competitive (non-competitive) if the average firm size is below (above) the median in 1890.[17]

Table 6 shows the impacts of access to cheaper electricity on productivity, output, and employment depending on whether the average firm size (as measured by output per firm) in a sector-county was above below the median. All regressions here include a control for the 1890 value of the outcome variable. We observe contrasting patterns: for sector-counties with large firms in 1890, we find large and immediate increases in labor productivity, more muted changes in output, and

[16] While our data does not allow us to quantitatively support the idea that firm size is associated with markups,this is borne out using Atack et al. (2008)'s state level sample (which reports both output quantities and values, allowing us to compute markups for each firm). Results are available on request. While this state-industry level data does not provide enough variation to conduct our analysis, these results suggest that average firm size can be a reasonable way to capture demand elasticity.

[17] About a third of the sector-county cells in our subsequent years did not exist in 1890 and thus are dropped from the rest of the analysis.

smaller increases in employment. On the other hand, for sector-counties with small firms, we find no significant changes in labor productivity until 1940, with large increases in output and employment. This supports the hypothesis that the impact of a new technology depends on the elasticity of demand curve faced by firms.[18]

A possible concern about our measure of market structure is that it may actually reflect returns to scale. However, Lafortune et al. (2020) show that returns to scale in less competitive sector-cities cells are slightly lower, not higher, than in more competitive ones. This is in line with the argument made by historians that "bigness" at the turn of the twentieth century was driven by collusive practices more than by technological advantage (for a discussion of competitive behavior and anti-trust responses over this period, see Lamoreaux, 2019).

Another concern would be that cells with above median size have large firms because of supply-side factors and not because of the demand they can access. To address this issue, we try to construct a measure of technological capacity to expand. To do so, we employ the Hoover index (see Kim, 1995) calculated with 1880 data at the two-digit industry level. Industries that have high Hoover index are those that are more regionally concentrated, indicating that what they can produce is relatively easy to transport to other locations. Kim (1995) shows that industries with larger Hoover index are more likely to have large firms, confirming our hypothesis. We then combine this with a measure of transport costs to obtain a measure of how easily can the products of a given industry in a given county be transported to other markets. Specifically, we divide the Hoover index by county-level market access data from Donaldson and Hornbeck (2016), calculated as the inverse of the cost of reaching every person in the US from a given county. We posit that firms that produce goods that can be shipped cheaply and can reach a large fraction of the U.S. population at low costs have the capacity to be bigger than others, implying more potential market power. We then split the sample into sector-counties above and below the median value of this measure of market access. The results, reported in Appendix Table A.15, are in line with our previous findings, showing that industry-county cells expected to face inelastic demand curves (here, based on the combination of industry and market access) experienced larger increases in labor and output than those that were not.[19]

Having documented heterogeneous impacts on output and employment, we examine whether the changes in the organization of production documented earlier were also influenced by market structure. Table 7 presents these results contrasting industry-county cells with large and small average firm size in 1890. We find that only the former display a consistent decline in mid-skill

[18] Appendix Table A.12 shows that the results are similar if we do not control for the 1890 value of the outcomes variable. We also show, in Appendix Table A.13, that results are also very similar when we conduct this analysis defining firm size in terms of employees per firm instead of output per firm.

[19] Similar results are obtained if we split the sample grouping together all industry-county cells where either the Hoover index is above the median *or* the transportation costs are below the median (see Appendix Table A.16).

jobs. These are exactly the cells where overall employment growth was null or negative. On the other hand, in cells with smaller average firms, we observe limited impact on the skill mix (with some reallocation toward low-skill jobs in sector-countries with small firms by 1900). Thus, it was when electricity had no positive impact on employment that mid-skill workers decreased their relative share of employment.

Finally, we explore whether market concentration, which as we show here influenced the impacts of electrification, was itself deepened in the process. In Appendix Table A.17, we consider the change in log number of firms in a sector-county as an outcome, splitting the sample into sector-counties with large firm size before the arrival of electricity and those with small average firm size. We find that in sector-counties with large firms in 1890, the number of firms went down, while the opposite happened in sector-counties with initially small firms. Thus, electricity appears to have deepened the gap between sector-counties with high and low levels of market concentration.

5 Conclusion

This paper uses a new approach to study the impact of electricity on productivity, exploiting cross-industry cross-county variation in how accessible and beneficial the arrival of electricity were for manufacturing activities. Using this approach, we find that electricity increased labor productivity of manufacturing firms in a sizable and rapid manner. The previous literature, in contrast, found that productivity gains significantly lagged the spread of electricity, a result that also appears in our data using a simpler cross-industry approach. Thus, the emerging picture is that productivity gains were immediate but *localized* to areas with access to cheap hydropower.

While some of these fast productivity gains were likely due to cheaper electricity, we also find evidence that electrification led to changes in the organization of production. These results suggest a reconsideration of the typical narrative that general purpose technologies need time to be transformative because of required complementary innovations and difficulties in adoption. Our results refocus the reasons for delayed impact toward the costs of accessing the new technology. An interesting implication is that future technological changes that imply a geographical advantage (e.g., new sources of energy that depend on climatic conditions) may also display this type of pattern.

Our findings also highlight the important role of initial market conditions in shaping the impact of a new technology. Consumers and workers appear to benefit from cheap electricity when this occurs in a market where firms face high elasticity of demand. On the other hand, larger firms responded to cheap electricity with faster increases in labor productivity but more limited expansion in output and employment, that is, consistent with increasing markups. This result is a relevant lesson for industrial revolutions of the past, present, and future—"bigness" should be a concern for public policy in the context of technological changes that may displace workers.

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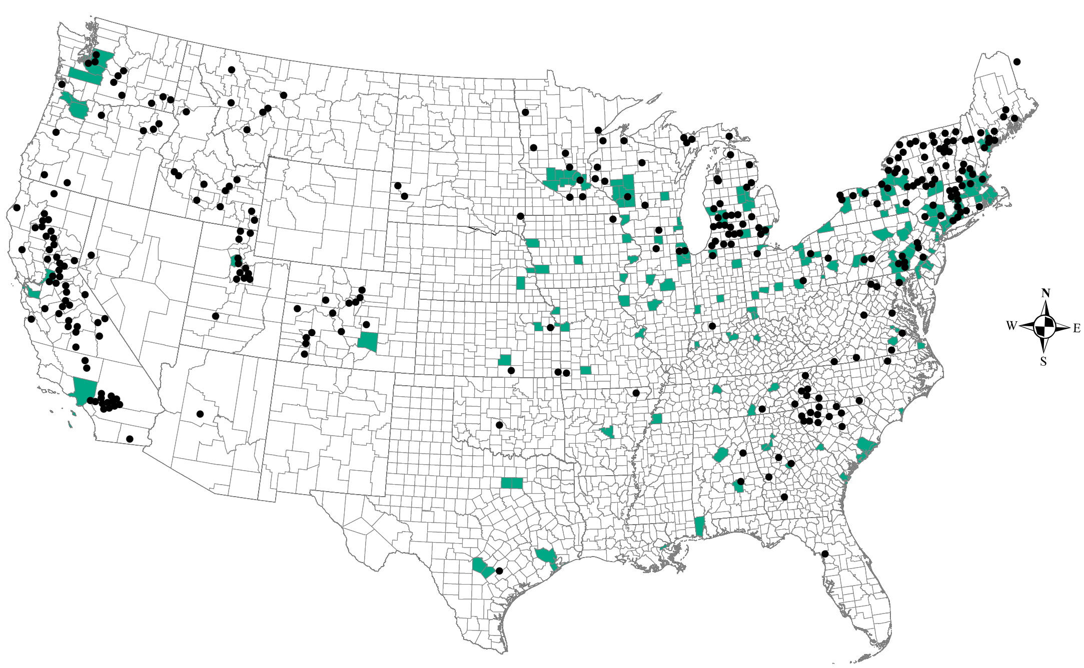
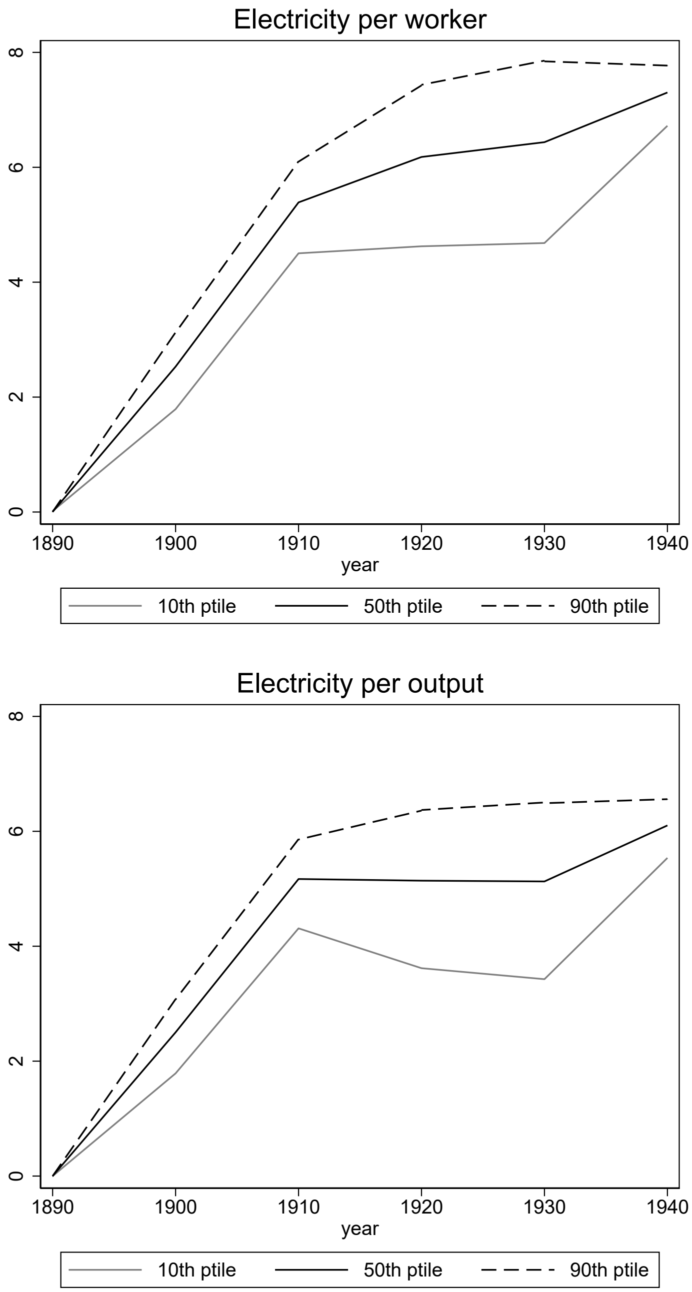
Figures and Tables

Figure 1: Location of hydropower plants with 1,000 or more horsepower in 1912 and counties included in our sample (1920 county boundaries shown)



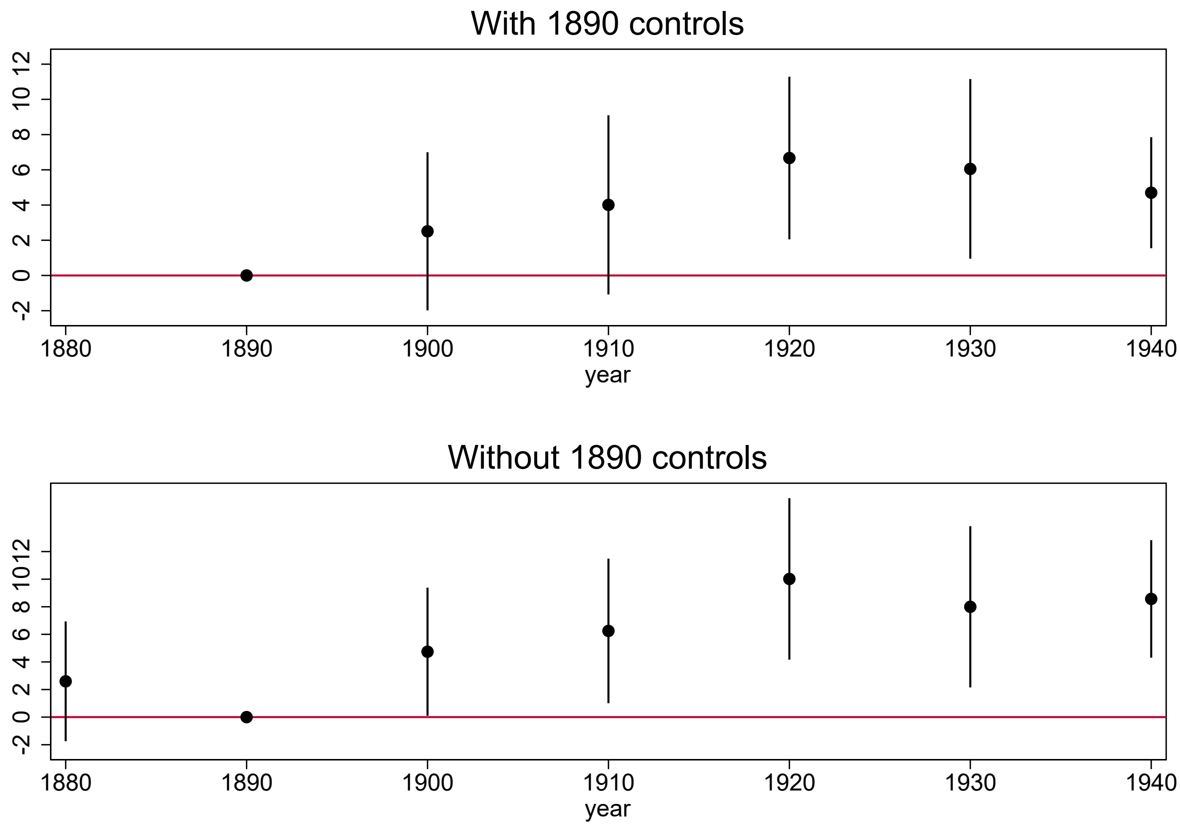
Notes: This figure presents the counties that are included in our sample (in green). It also identifies the location (in black dots) of hydropower plants with 1,000 or more horsepower in 1912. The 1920 county boundaries are shown. The location of the hydropower plants were obtained from the Census Bureau Report on "Central Electric Light and Power Statios and Street and Electric Railways with Summary of the Electrical Industries", 1912.

Figure 2: Difference in predicted electricity adoption depending on initial energy-intensity



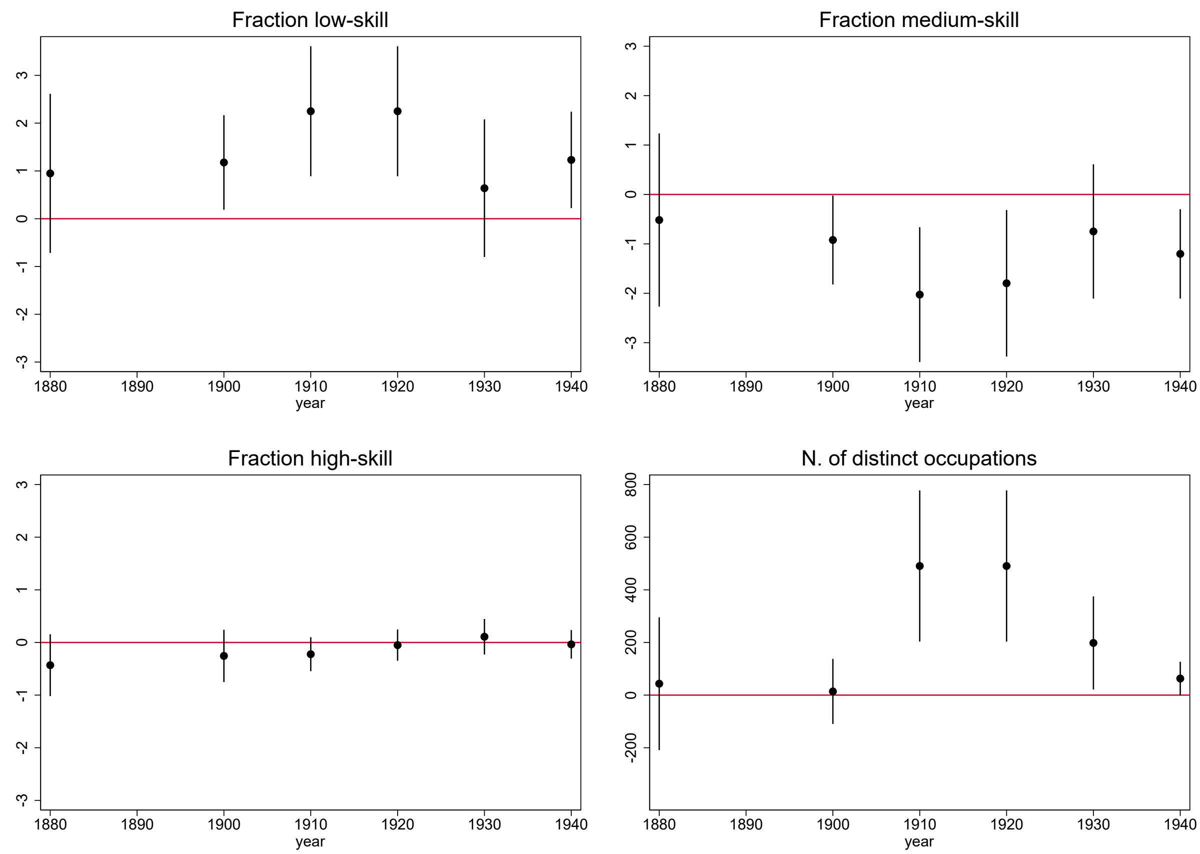
Notes: This figure presents the predicted electricity adoption (as measured by log electricity per worker in the first panel, log electricity per unit of output in the middle one and the percent of horsepower that has been electrified in the bottom) for an industry at the 10th, 50th, and 90th percentile in terms of 1890 horsepower per unit of output. These figures are obtained by multiplying the 1890 horsepower per unit of output of the 10th, 50th and 90th percentile by the coefficients presented in the even columns of Table A.4 for each year.

Figure 3: Impact of electricity on productivity



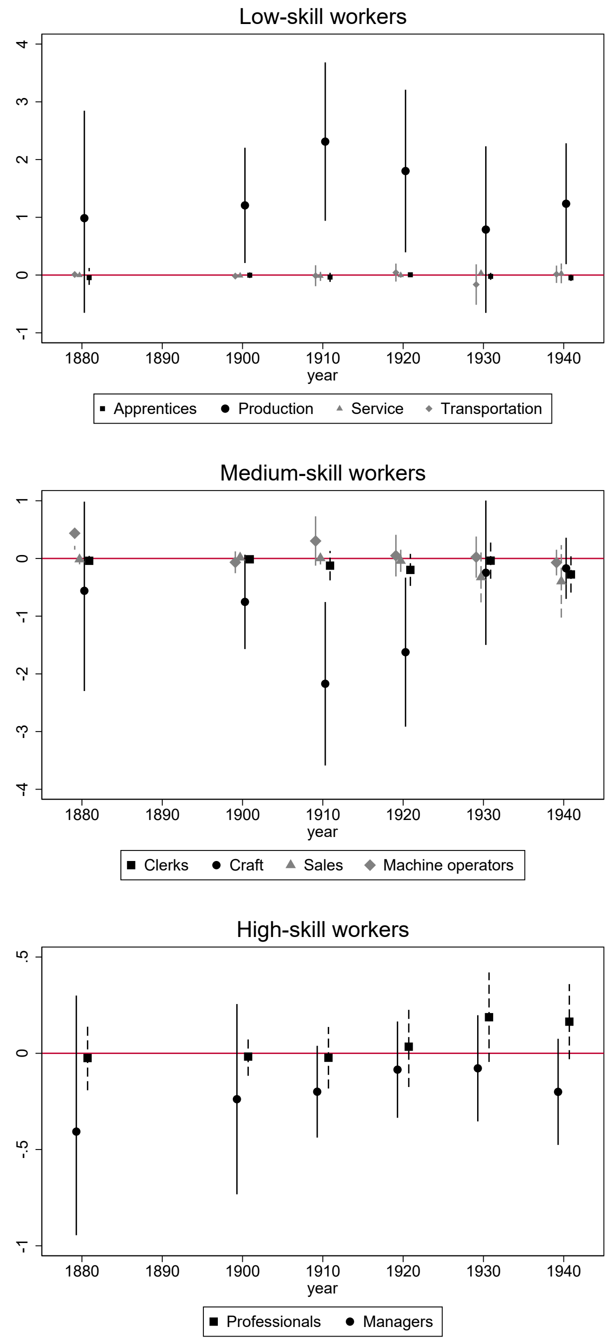
Notes: This figure presents the coefficients of regression equation (1) where the outcome variable is the change in productiçity (log of output per worker) since 1890 and the main variable of interest is the interaction between the 1890 HP per unit of output of the industry and a dummy if the centroid of the county is within 70km of a power plant in 1912 divided by 100. 95% confidence intervals are included. The first panel represents coefficients where the regression includes controls for the 1890 productivity levels while the second omits that control. 1890 is omitted since it is the reference year. Actual coefficients and their standard errors are presented in Columns (1) and (2) of Table A.7.

Figure 4: Impact of electricity on labor market outcomes



Notes: This figure presents the coefficients of regression equation (1) *where the outcomes are the fraction of low-skill, medium-skill and high-skill workers for the first three panels and the number of distinct occupations in the bottom one. The main variable of interest is the interaction between the 1890 HP per unit of output of the industry and a dummy if the centroid of the county is within 70km of a power power plant in 1912 divided by 100. 95% confidence intervals are included. we have no data for 1890 which is why no estimate is presented for that year.*

Figure 5: Impact of electricity on occupational shares, by sub-groups



Notes: This figure presents the coefficients of regression equation (1) where the outcomes are the fraction of each type of occupations. The main variable of interest is the interaction between the 1890 HP per unit of output of the industry and a dummy if the centroid of the county is within 70km of a power power plant in 1912 divided by 100. 95% confidence intervals are included.

Table 1: Predicting Electricity Use in 1920

	Electricity per Worker (1)	Electricity per Unit of Output (2)
	Panel A: Using HP/Y as measure of energy intensity	
ln HP/Y1890	0.631***	0.668***
	(0.232)	(0.255)
r2	0.144	0.160
N	2,633	2,637
	Panel B: Using HP/N as measure of energy intensity	
ln HP/N1890	0.537	0.582*
	(0.340)	(0.344)
r2	0.114	0.130
N	2,633	2,637

Each observation corresponds to an industry-county cell in 1920. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log electricity per worker and log electricity per unit of output on industry-level log horsepower per unit of output in 1890 in Panel A and log horsepower per worker in 1890 in Panel B. Weights are the number of establishments in a cell. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2: Correlations between 1947 manufacturing electricity prices and hydroelectric plants

	Levels			Logarithms		
Plant within 70km	-0.010***			-0.567***		
	(0.003)			(0.159)		
Inverse distance		-0.038*			-2.103*	
		(0.020)			(1.158)	
Plant in 1900			-0.008**			-0.535**
			(0.004)			(0.237)
r2	0.212	0.160	0.066	0.160	0.126	0.085
N	2,433	2,433	2,433	2,421	2,421	2,421

Each observation corresponds to an industry-county cell. Clustered standard errors by county are presented between parentheses. Coefficients presented are those from a regression of electric prices in level (columns (1)-(3)) and in log (columns (4)-(6)) on each measure of proximity to an electric power plant. Weights are the number of establishments in a cell. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Relationship between access and need for electricity and use of electricity

	Electricity per Worker (1)	Electricity per Unit of Output (2)
	1912 power plants within 70km	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	14.549***	8.591
	(4.983)	(5.461)
r2	0.862	0.868
N	2,581	2,583
	Distance to 1912 power plants	
$\frac{\text{ln HP/Y1890} \times \text{inv. distance}}{100}$	68.643*	49.255
	(38.278)	(36.464)
r2	0.859	0.867
N	2,581	2,583
	Had a power plant in 1900	
$\frac{\text{ln HP/Y1890} \times \text{ had early plant}}{100}$	17.090***	9.691*
	(4.434)	(5.125)
r2	0.858	0.866
N	2,581	2,583

Each observation corresponds to an industry-county cell in 1920. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log electricity per worker and log electricity per unit of output on industry-level log horsepower per worker in 1890 interacted with proximity to an hydrolectric power in each panel divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Robustness checks for impact on productivity

	Balanced panel		Using inv. distance		Using plants in 1900	
	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\ln HP/Y1890 \times \text{proximity}}{100}$	7.568***	4.215*	18.118	6.415	0.164	-0.493
	(2.399)	(2.181)	(15.716)	(12.416)	(2.353)	(1.966)
r2	0.603	0.715	0.299	0.448	0.297	0.448
N	449	449	4,263	4,263	4,263	4,263
			1910			
$\frac{\ln HP/Y1890 \times \text{proximity}}{100}$	5.359	1.574	28.814*	5.941	4.533	2.652
	(3.264)	(3.253)	(16.069)	(14.225)	(3.002)	(2.761)
r2	0.342	0.407	0.230	0.318	0.230	0.319
N	449	449	1,599	1,599	1,599	1,599
			1920			
$\frac{\ln HP/Y1890 \times \text{proximity}}{100}$	14.013***	10.858***	46.225**	26.718*	6.626*	6.399***
	(4.229)	(3.331)	(19.566)	(14.585)	(2.412)	(1.824)
r2	0.767	0.867	0.600	0.768	0.593	0.768
N	449	449	2,633	2,633	2,633	2,633
			1930			
$\frac{\ln HP/Y1890 \times \text{proximity}}{100}$	10.603**	8.487**	26.083	16.269	6.192**	5.071*
	(4.674)	(3.998)	(16.178)	(12.437)	(3.143)	(2.644)
r2	0.662	0.785	0.581	0.754	0.583	0.756
N	449	449	1,178	1,178	1,178	1,178
			1940			
$\frac{\ln HP/Y1890 \times \text{proximity}}{100}$	11.834***	7.220***	46.213***	24.815**	6.732***	4.550***
	(2.972)	(2.430)	(12.418)	(10.181)	(2.437)	(1.723)
r2	0.624	0.821	0.509	0.751	0.506	0.752
N	449	449	1,599	1,599	1,599	1,599
1890 Control	No	Yes	No	Yes	No	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 in the first two columns, with the inverse distance between the centroid and the closest hydroelectric power plant in 1912 in columns (3) and (4) and with a dummy for having a hydroelectric plant in one's county in 1900 in the last two columns. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. The first two columns include only industry-county cells that are in every single year of our panel data. Even columns include values of the dependent variable in 1890 as control. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Impacts on capital intensity and labor share

	Δ Ln capital per worker		Labor share	
	(1)	(2)	(3)	(4)
		1900		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	4.475	3.114	-3.549	-4.566
	(3.307)	(2.282)	(3.576)	(3.499)
		1910		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	6.848*	5.089*	-8.399*	-10.576**
	(3.994)	(2.696)	(4.963)	(4.961)
		1920		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	8.567*	6.783***	-3.178	-4.327
	(4.892)	(2.408)	(6.047)	(6.278)
		1930		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$			-2.418	-6.356
			(7.000)	(7.555)
1890 Control	No	Yes	No	Yes

Each observation corresponds to an industry-county cell in a given year. Standard errors are presented between parentheses. Coefficients presented are those from a regression of log capital per worker (measured as the ratio of the wage bill to the value-added) (columns (1) and (2)) and log of wage bill per value-added (columns (3) and (4)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Even columns include values of the dependent variable in 1890 as control. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Heterogeneity by initial firm size-productivity, output, and hiring

	Δ ln Y/N		Δ ln Y		Δ ln N	
Average firm size	Large	Small	Large	Small	Large	Small
(output per establishment)	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\text{ln HP/Y1890} \times \text{plant within 70km}}{100}$	4.690*	-1.812	1.248	15.666***	-5.582**	18.429***
	(2.415)	(2.093)	(3.431)	(4.978)	(2.642)	(5.825)
F-test of equality	4.14**		5.67**		14.02***	
N	1,725	1,597	1,725	1,597	1,725	1,597
			1910			
$\frac{\text{ln HP/Y1890} \times \text{plant within 70km}}{100}$	1.081	2.867	11.880**	11.394	8.161*	7.389
	(2.249)	(5.900)	(4.652)	(11.447)	(4.825)	(11.433)
F-test of equality	0.09		0.00		0.00	
N	892	461	892	461	898	464
			1920			
$\frac{\text{ln HP/Y1890} \times \text{plant within 70km}}{100}$	8.325***	0.169	12.839*	22.870*	0.226	25.152**
	(2.571)	(2.656)	(7.457)	(13.062)	(6.461)	(12.539)
F-test of equality	4.91**		0.46		3.21*	
N	1,188	741	1,188	741	1,188	741
			1930			
$\frac{\text{ln HP/Y1890} \times \text{plant within 70km}}{100}$	9.205***	7.681**	14.768**	45.760***	3.111	38.639**
	(2.588)	(3.492)	(6.732)	(15.710)	(6.863)	(15.014)
F-test of equality	0.13		3.41*		4.79**	
N	533	310	533	310	533	310
			1940			
$\frac{\text{ln HP/Y1890} \times \text{plant within 70km}}{100}$	5.329***	6.130*	20.033	43.796***	12.396	38.584***
	(2.043)	(3.385)	(13.317)	(13.240)	(13.394)	(11.858)
F-test of equality	0.04		1.63		2.17	
N	730	382	730	382	730	382
1890 "Y" Control	Yes	Yes	Yes	Yes	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in all regressions In odd columns, industry-county cells that had in 1890 above median output per establishment are included while those below the median are included in even columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

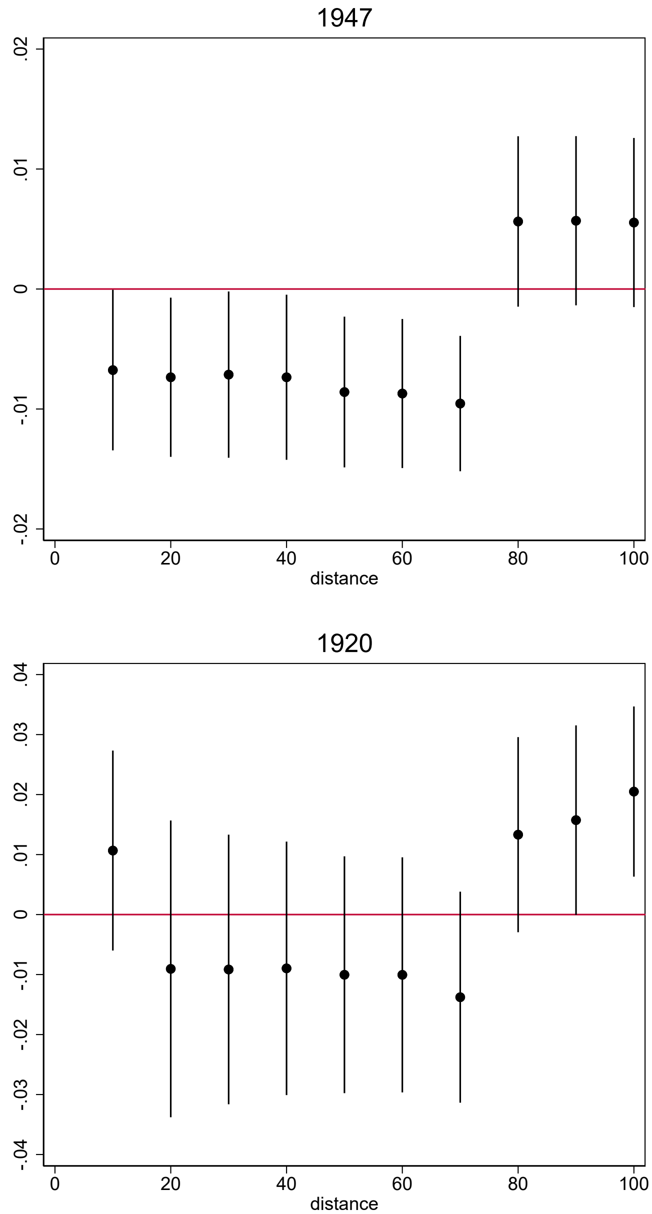
Table 7: Heterogeneous impacts on labor markets

Average firm size (output per establishment)	Fraction of high-skilled Large (1)	Fraction of high-skilled Small (2)	Fraction of medium-skilled Large (3)	Fraction of medium-skilled Small (4)	Fraction of low-skilled Large (5)	Fraction of low-skilled Small (6)	Number of dist. occ. Large (7)	Number of dist. occ. Small (8)
1900								
$\frac{\ln HP/Y1890\times \text{ plant within 70km}}{100}$	-0.035	-0.813*	-0.818	-1.512*	0.853	2.324**	37.674	17.669
	(0.350)	(0.480)	(0.646)	(0.823)	(0.569)	(0.991)	(56.651)	(35.280)
F-test of equality	1.72		0.44		1.66		0.09	
1910								
$\frac{\ln HP/Y1890\times \text{ plant within 70km}}{100}$	-0.071	-0.416	-2.735***	0.324	2.806***	0.092	444.160***	340.844*
	(0.210)	(0.432)	(0.953)	(1.538)	(0.931)	(1.619)	(153.032)	(194.198)
F-test of equality	0.52		2.86*		2.11		0.17	
1920								
$\frac{\ln HP/Y1890\times \text{ plant within 70km}}{100}$	-0.000	0.012	-3.033***	1.453	3.033***	-1.464	151.677***	67.554
	(0.186)	(0.321)	(0.962)	(1.073)	(0.907)	(1.164)	(51.852)	(42.500)
F-test of equality	0.00		9.69***		9.29***		1.57	
1930								
$\frac{\ln HP/Y1890\times \text{ plant within 70km}}{100}$	0.146	-0.358	-2.279***	-0.904	2.133**	1.263	437.796***	265.389**
	(0.243)	(0.399)	(0.814)	(1.322)	(0.872)	(1.438)	(107.841)	(118.010)
F-test of equality	1.16		0.78		0.27		1.16	
1940								
$\frac{\ln HP/Y1890\times \text{ plant within 70km}}{100}$	-0.009	-0.164	-1.651***	-0.572	1.651***	0.719	105.617**	79.591
	(0.181)	(0.254)	(0.558)	(0.901)	(0.599)	(1.002)	(50.212)	(76.546)
F-test of equality	0.25		0.31		0.64		0.08	

1.2Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of fraction of workers in high-level occupations (columns (1) and (5)), medium level occupations (columns (2) and (6)) and low level occupations (columns (3) and (7)) and the number of distinct occupations (columns (4) and (8)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of a hydroelectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. In the first four columns, industry-county cells that had in 1890 above output per establishment are included, while those below the median are included in the next four columns.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

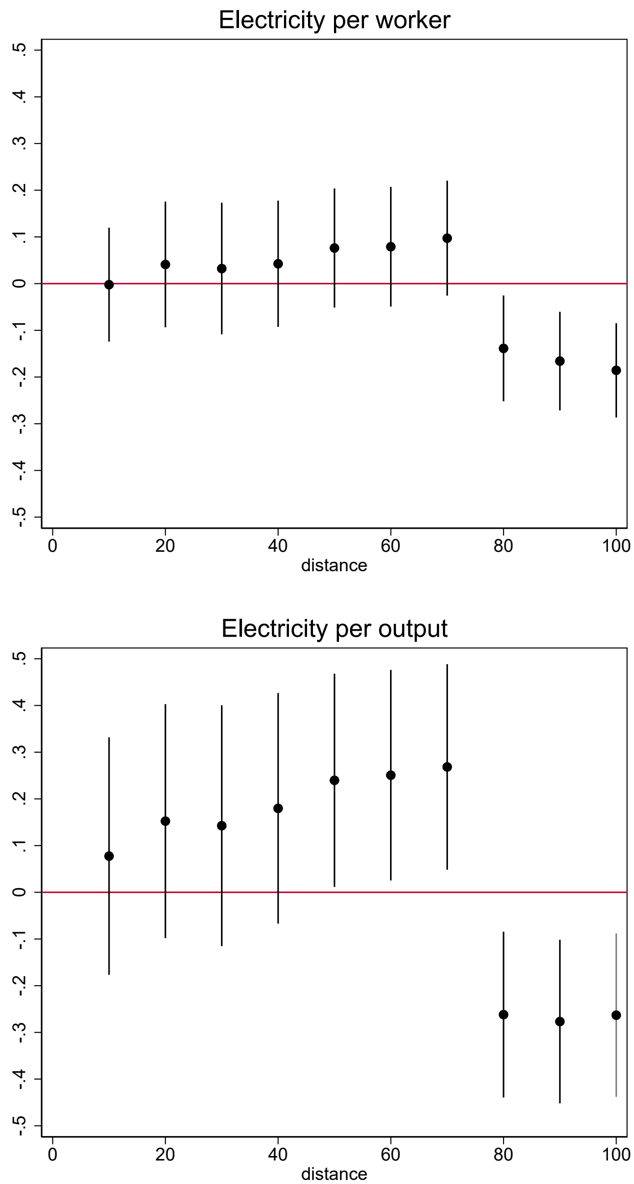
A Additional Figures and Tables

Figure A.1: Impact of closeness to hydropower plants on energy prices, by distance



Notes: This figure presents the coefficients of a regression of electricity prices on a dummy for being within less than a certain distance from a 1912 hydropower power plant. Each coefficient represents a different regression. Regression is weighted by the number of establishments and is run by industry-county cells but clustering by county. 95% confidence intervals are presented. The top panel uses 1947 manufacturing prices and the second one uses 1920 residential rates.

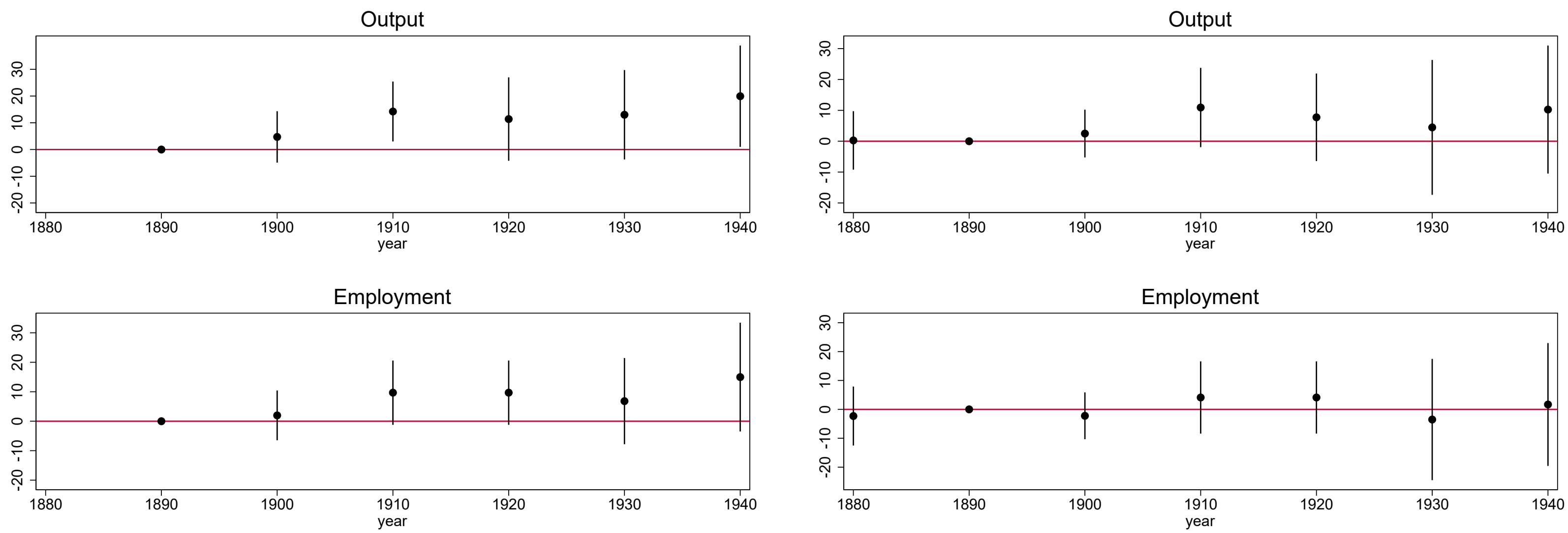
Figure A.2: Impact of closeness to hydropower plants on energy use, by distance



Notes: This figure presents the coefficients of a regression of electricity usage in 1920 on a dummy for the centroid of the county being within less than a certain distance from a 1912 hydropower power plant interacted with the horsepower per unit of output of the industry in 1890, including industry and county fixed effect. Each coefficient represents a different regression. Regression is weighted by the number of establishments and standard errors are robust to heteroscedasticity. 95% confidence intervals are presented. The top panel uses electricity per worker and the second, electricity per unit of output.

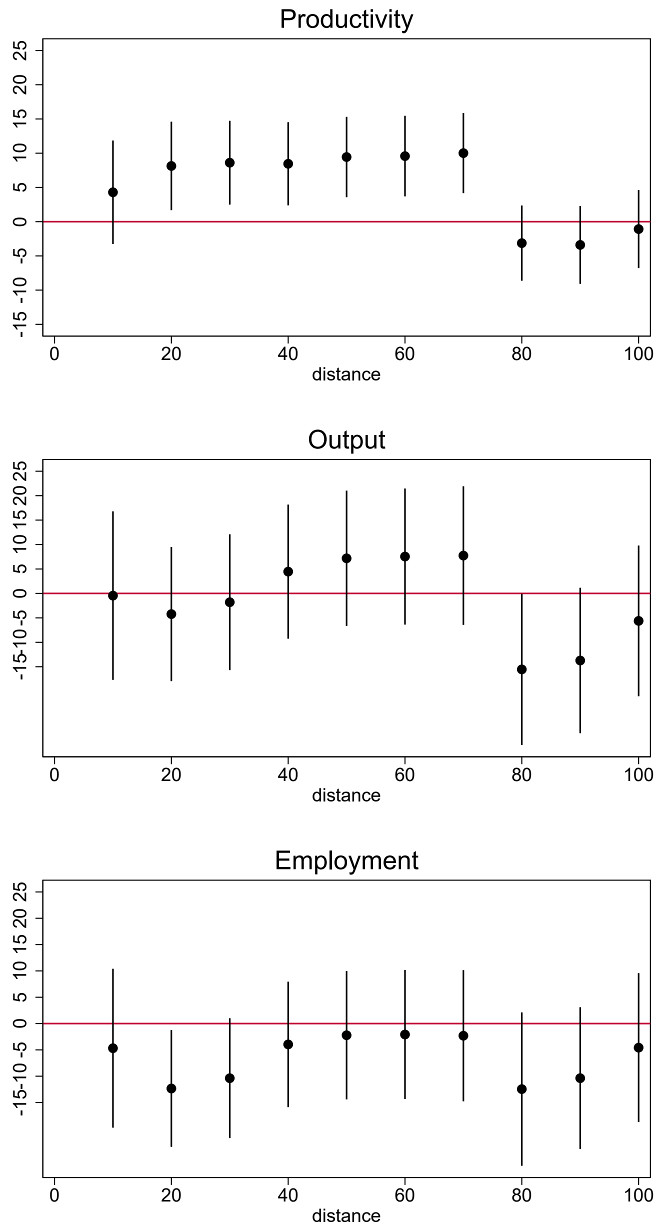
Figure A.3: Impact of electricity on employment and output

(a) With 1890 controls (b) Without 1890 controls



Notes: This figure presents the coefficients of regression equation (1) where the outcome variable is the change in log output since 1890 and the change in log workers since 1890 and the main variable of interest is the interaction between the 1890 HP per unit of output of the industry and a dummy if the centroid of the county is within 70km of a power plant in 1912 divided by 100. The regression includes the 1890 value of output or number of workers as an additional control, respectively, in panel (a). 95% confidence intervals are included. 1890 is omitted since it is the reference year.

Figure A.4: Impact of closeness to hydropower plants on productivity, output and employment, by distance, 1920



Notes: This figure presents the coefficients of regression equation 1 where the outcome variable is the log change since 1890 of each outcome and the main variable of interest is the interaction between the 1890 HP per unit of output of the industry and a dummy if the centroid of the county is within each distance of a power power plant in 1912 divided by 100. Each coefficient represents a different regression. 95% confidence intervals are included. The outcome is productivity in the top panel, output in the middle one and the number of workers in the bottom one.

Table A.1: Summary statistics, county-industry database

Variable	N	Mean	St. Dev.
Log Electricity per worker	2,828	0.014	1.114
Log Electricity per unit of output	2,830	-7.928	1.045
Log (% elec. HP)	2,830	-0.320	0.575
Was in sample	169,830	0.098	0.297
Number of establishments	169,830	3.938	78.671
Number of establishments (if cell exists)	16,600	40.293	248.711
Number of workers	169,830	88.5	1556.45
Number of workers (if cell exists)	16,600	905.802	4903.617
Δ ln Y/N	11,696	0.435	0.611
Δ ln Y	11,708	1.828	2.442
Δ ln N	11,719	1.396	2.460
Δ ln HP/N	5,610	1.926	2.529
Δ ln K/N	8,827	0.710	0.916

Table A.2: Large sectors in top, bottom 5% of HP/Y, 1890

Most Horsepower Intensive		Least Horsepower Intensive	
(4)	Flour	(63)	Turpentine and Rosin
(52)	Paper Goods	(153)	Hairwork
(96)	Iron and Steel	(89)	China firing and decorating
(124)	Electrical Machinery	(146)	Artificial feathers/flowers
(16)	Ice	(33)	Fur Goods
(100)	Nail and spikes	(74)	Fireworks
(38)	Lumber and timber products	(30)	Clothing
(99)	Wire	(36)	Awnings, Tents & Sails

See Appendix Table C.18 for detailed sector descriptions, using reference number.

Table A.3: Predicting Electricity Use in 1920

	Electricity per Worker (1)	Electricity per Unit of Output (2)
	Panel A: Early Adopters	
ln EHP1890/HP1890	-0.873***	-0.873***
	(0.136)	(0.149)
r2	0.289	0.294
N	2,633	2,637
	Panel B: Capital Intensive Industries	
ln K/N1890	-0.703**	-0.741**
	(0.289)	(0.362)
r2	0.114	0.128
N	2,633	2,637
ln K/Y1890	1.850***	1.877***
	(0.575)	(0.626)
r2	0.125	0.137
N	2,633	2,637
	Panel C: Human Capital Measures	
Average literacy	-27.530***	-24.625***
	(4.473)	(4.773)
r2	0.177	0.171
N	2,633	2,637
White-Collars/Blue-Collars	-1.287***	-1.348***
	(0.171)	(0.194)
r2	0.176	0.193
N	2,633	2,637
	Panel D: Complexity Measures	
Distinct Occ.	-0.057***	-0.058***
	(0.007)	(0.007)
r2	0.218	0.226
N	2,633	2,637
HHI Occ. 1900	0.618	0.008
	(0.915)	(0.952)
r2	0.097	0.109
N	2,633	2,637
1890 Control	No	No

Each observation corresponds to an industry-county cell in 1920. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log electricity per worker (columns (1) and (2)), log electricity per unit of output (columns (3) and (4)) and percent of horsepower electrified (columns (5) and (6)) on industry-level characteristics in each panel. Weights are the number of establishments in a cell. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.4: Predicting Electricity Use, with Energy Intensive Industries in 1890

	Δ Electricity per Worker		Δ Electricity per Unit of Output	
	(1)	(2)	(3)	(4)
			1900	
ln HP/Y1890	0.480***	0.443***	0.463***	0.418***
	(0.117)	(0.153)	(0.117)	(0.140)
r2	0.040	0.414	0.037	0.417
N	156	156	156	156
			1910	
ln HP/Y1890	0.574***	0.537***	0.557***	0.512***
	(0.121)	(0.143)	(0.119)	(0.128)
r2	0.086	0.847	0.080	0.875
N	156	156	156	156
			1920	
ln HP/Y1890	1.008***	0.971***	0.988***	0.942***
	(0.146)	(0.143)	(0.149)	(0.142)
r2	0.150	0.686	0.143	0.682
N	156	156	156	156
			1930	
ln HP/Y1890	1.138***	1.101***	1.103***	1.058***
	(0.194)	(0.189)	(0.195)	(0.179)
r2	0.143	0.473	0.138	0.486
N	156	156	156	156
			1940	
ln HP/Y1890	0.376*	0.339***	0.366*	0.321***
	(0.213)	(0.123)	(0.190)	(0.115)
r2	0.023	0.655	0.023	0.671
N	156	156	156	156
1890 Control	No	Yes	No	Yes

Each observation corresponds to an industry cell in a given year for each panel. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log electricity per worker (column (1)) and log electricity per unit of output (columns (2)). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: Correlations between 1920 residential electricity prices and hydroelectric plants

	Levels			Logarithms		
Plant within 70km	-6.889			-0.191		
	(4.434)			(0.117)		
Inverse distance		9.802			0.247	
		(25.765)			(0.680)	
Plant in 1900			-13.954***			-0.407**
			(4.537)			(0.170)
r2	0.043	0.005	0.104	0.038	0.004	0.118
N	2,637	2,637	2,637	2,637	2,637	2,637

Each observation corresponds to an industry-county cell. Clustered standard errors by county are presented between parentheses. Coefficients presented are those from a regression of electric prices in level (columns (1)-(3)) and in log (columns (4)-(6)) on each measure of proximity to an electric power plant. Weights are the number of establishments in a cell. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Impact on sample selection, number of establishments, and employment

	Was in sample	Number of establishments	Number of workers
	(1)	(2)	(3)
		1900	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.698***	22.531	1656.782**
	(0.216)	(69.365)	(730.101)
r2	0.565	0.147	0.132
N	28,182	28,182	28,182
		1910	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.136	35.535	1693.347*
	(0.146)	(35.997)	(976.980)
r2	0.343	0.117	0.094
N	28,182	28,182	28,182
		1920	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.355*	48.546	2159.891
	(0.187)	(88.484)	(2040.420)
r2	0.400	0.063	0.068
N	28,182	28,182	28,182
		1930	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.248*	36.228	739.576
	(0.129)	(34.695)	(650.246)
r2	0.290	0.083	0.070
N	28,182	28,182	28,182
		1940	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.272*	31.584	832.007
	(0.144)	(29.547)	(599.209)
r2	0.320	0.082	0.064
N	28,182	28,182	28,182

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of dummy for whether was in the sample (column (1)), number of establishments (columns (2)) and number of workers (columns (3)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Fixed effects for county and industry are included. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: Impact on productivity, different clustering

	From Figure 3		Cluster by county		Cluster by industry	
	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\text{ln HP/Y1890} \times \text{ proximity}}{100}$	4.742*	2.509	4.742**	2.509*	4.742**	2.509*
	(2.367)	(2.290)	(1.986)	(1.513)	(2.318)	(1.469)
r2	0.303	0.450	0.303	0.450	0.303	0.450
N	4,263	4,263	4,263	4,263	4,263	4,263
			1910			
$\frac{\text{ln HP/Y1890} \times \text{ proximity}}{100}$	6.249**	4.010	6.249**	4.010	6.249**	4.010*
	(2.670)	(2.593)	(2.448)	(2.707)	(2.747)	(2.120)
r2	0.233	0.321	0.233	0.321	0.233	0.321
N	1,599	1,599	1,599	1,599	1,599	1,599
			1920			
$\frac{\text{ln HP/Y1890} \times \text{ proximity}}{100}$	10.017***	6.669***	10.017***	6.669**	10.017**	6.669*
	(2.985)	(2.355)	(3.246)	(3.146)	(4.231)	(3.441)
r2	0.611	0.774	0.611	0.774	0.611	0.774
N	2,633	2,633	2,633	2,633	2,633	2,633
			1930			
$\frac{\text{ln HP/Y1890} \times \text{ proximity}}{100}$	7.997***	6.052**	7.997***	6.052**	7.997	6.052
	(2.978)	(2.599)	(1.882)	(2.380)	(5.340)	(4.851)
r2	0.587	0.759	0.587	0.758	0.587	0.758
N	1,178	1,178	1,178	1,178	1,178	1,178
			1940			
$\frac{\text{ln HP/Y1890} \times \text{ proximity}}{100}$	8.568***	4.700***	8.568***	4.700**	8.568***	4.700**
	(2.171)	(1.607)	(1.506)	(1.852)	(2.932)	(1.857)
r2	0.513	0.753	0.513	0.753	0.513	0.753
N	1,599	1,599	1,599	1,599	1,599	1,599
1890 Control	No	Yes	No	Yes	No	Yes

Each observation corresponds to an industry-county cell in a given year. Standard errors are presented between parentheses, robust in columns (1) and (2), clustered by county in columns (3) and (4) and by industry in columns (5) and (6). Coefficients presented are those from a regression of log output per worker on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Even columns include values of the dependent variable in 1890 as control. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: Robustness checks for impacts on productivity and output, using alternative output measures

	Value of output		VA, excl. energy costs	
	ΔlnY	$\Delta lnY/N$	ΔlnY	$\Delta lnY/N$
	(1)	(2)	(3)	(4)
		1900		
$\frac{\text{ln HP/Y1890} \times \text{proximity}}{100}$	6.701*	6.295*	4.886	4.480*
	(3.785)	(3.237)	(3.477)	(2.622)
r2	0.449	0.397	0.4530	0.338
N	3,322	3,322	3,322	3,322
		1910		
$\frac{\text{ln HP/Y1890} \times \text{proximity}}{100}$	11.182**	8.842***	8.444*	6.395***
	(5.274)	(2.620)	(5.089)	(1.939)
r2	0.461	0.357	0.451	0.269
N	1,361	1,361	1,348	1,348
		1920		
$\frac{\text{ln HP/Y1890} \times \text{proximity}}{100}$	9.627	13.439***	7.135	10.945***
	(7.255)	(4.342)	(6.821)	(3.187)
r2	0.661	0.609	0.667	0.642
N	1,931	1,929	1,931	1,929
		1930		
$\frac{\text{ln HP/Y1890} \times \text{proximity}}{100}$	9.284	12.232***	7.143	10.109***
	(7.568)	(4.437)	(7.011)	(3.560)
r2	0.726	0.645	0.721	0.614
N	843	843	842	842
		1940		
$\frac{\text{ln HP/Y1890} \times \text{proximity}}{100}$	14.947	11.384***		
	(10.830)	(4.018)		
r2	0.711	0.579		
N	1,112	1,112		
1890 Control	No	No	No	No

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output (in columns (1) and (3)) and log output per worker (in columns (2) and (4)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant divided by 100. Weights are the number of establishments in a cell. Output is measured as Total value of products in columns (1) and (2) and as Value-added without energy costs in columns (3) and (4). The last outcome is not available for 1940. Fixed effects for county and industry are included. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.9: Impact on productivity, robustness checks for agglomeration

	Interaction with large counties		Interaction with high growth counties	
	(1)	(2)	(3)	(4)
		1900		
$\frac{\text{ln HP/Y1890}\times\text{ proximity}}{100}$	4.598**	2.335	5.381**	2.880
	(2.244)	(2.129)	(2.258)	(2.130)
r2	0.305	0.452	0.304	0.450
N	4,263	4,263	4,263	4,263
		1910		
$\frac{\text{ln HP/Y1890}\times\text{ proximity}}{100}$	6.260**	3.856	4.600*	1.996
	(2.706)	(2.631)	(2.647)	(2.621)
r2	0.233	0.321	0.237	0.326
N	1,599	1,599	1,599	1,599
		1920		
$\frac{\text{ln HP/Y1890}\times\text{ proximity}}{100}$	10.025***	6.669***	9.259***	6.695***
	(2.976)	(2.318)	(2.804)	(2.275)
r2	0.611	0.776	0.612	0.774
N	2,633	2,633	2,633	2,633
		1930		
$\frac{\text{ln HP/Y1890}\times\text{ proximity}}{100}$	8.137***	6.064**	8.110**	7.305***
	(2.981)	(2.601)	(3.308)	(2.733)
r2	0.587	0.759	0.587	0.759
N	1,178	1,178	1,178	1,178
		1940		
$\frac{\text{ln HP/Y1890}\times\text{ proximity}}{100}$	8.708***	4.603***	8.481***	4.966***
	(2.199)	(1.597)	(2.267)	(1.646)
r2	0.513	0.753	0.513	0.753
N	1,599	1,599	1,599	1,599
1890 Control	No	Yes	No	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Regressions include as an additional regressor an interaction between industry-level log horsepower per worker in 1890 and with a dummy if the county has more than 20,000 manufacturing workers (in the first two columns) or with a dummy if the county's manufacturing workforce has grown by more than 30 percent since 1890 (last two columns). Even columns include values of the dependent variable in 1890 as control. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.10: Estimated effects on productivity with cross-industry methodology

	National level	
	(1)	(2)
	1900	
ln HP/Y1890	0.017	0.016
	(0.016)	(0.016)
r2	0.010	0.013
N	156	156
	1910	
ln HP/Y1890	0.017	0.017
	(0.018)	(0.018)
r2	0.009	0.026
N	156	156
	1920	
ln HP/Y1890	0.020	0.021
	(0.021)	(0.021)
r2	0.010	0.031
N	156	156
	1930	
ln HP/Y1890	0.035*	0.035*
	(0.022)	(0.022)
r2	0.020	0.020
N	156	156
	1940	
ln HP/Y1890	0.009	0.009
	(0.035)	(0.035)
r2	0.001	0.008
N	156	156
1890 Control	No	Yes

Each observation corresponds to an industry in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of the change in log output per worker on industry-level log horsepower per worker in 1890. Even columns include values of the dependent variable in 1890 as control. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.11: Impacts on labor markets (using Census of population data)

	High (1)	Medium (2)	Low (3)	N. of dist. occ. (4)
			1900	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.255	-0.921**	1.177**	14.044
	(0.253)	(0.459)	(0.505)	(63.078)
			1910	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.223	-2.027***	2.249***	490.554***
	(0.164)	(0.696)	(0.694)	(146.455)
			1920	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.051	-1.797**	1.848***	104.785***
	(0.152)	(0.756)	(0.716)	(37.700)
			1930	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	0.110	-0.748	0.638	198.218**
	(0.172)	(0.693)	(0.734)	(90.126)
			1940	
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.036	-1.203***	1.231**	63.058*
	(0.139)	(0.461)	(0.514)	(32.520)
1890 "Y" Control	No	No	No	No

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of fraction of workers in high-level occupations (first column), medium level occupations (column (2)) and low level occupations (column (3)) and the number of distinct occupations (last column) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.12: Heterogeneity of impacts by market competitiveness (without 1890 controls)

	Δ ln Y/N		Δ ln Y		Δ ln N	
Average firm size:	Large	Small	Large	Small	Large	Small
(output per establishment)	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	8.345***	-3.710*	0.127	15.420**	-8.218***	19.130***
	(2.484)	(2.218)	(3.349)	(6.528)	(3.071)	(6.775)
F-test of equality	13.10***		4.34**		13.52***	
N	1,731	1,591	1,731	1,591	1,731	1,591
			1910			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	5.348**	-0.756	10.817**	2.558	5.483	2.737
	(2.586)	(5.565)	(4.961)	(12.022)	(5.163)	(11.625)
F-test of equality	0.99		0.40		0.05	
N	888	465	888	465	894	468
			1920			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	13.872***	-5.250	12.098	10.434	-1.775	15.629
	(2.802)	(3.625)	(7.475)	(14.132)	(6.589)	(12.909)
F-test of equality	17.42***		0.01		1.44	
N	1,170	759	1,170	761	1,170	759
			1930			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	12.916***	5.660	10.275	37.959**	-2.641	32.299**
	(3.111)	(4.408)	(7.031)	(17.027)	(7.273)	(16.182)
F-test of equality	1.81		2.26		3.88**	
N	529	314	529	314	529	314
			1940			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	10.153***	2.251	14.032	36.256***	3.879	34.005***
	(2.752)	(4.687)	(13.693)	(13.341)	(14.147)	(12.516)
F-test of equality	2.11		1.35		2.54	
N	708	404	708	404	708	404
1890 "Y" Control	No	Yes	No	Yes	No	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. In odd columns, industry-county cells that had in 1890 above median output per establishment are included while those below the median are included in even columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.13: Heterogeneity by market competitiveness: productivity, output, and employment (using employees per firm as measure of firm size)

	Δ ln Y/N		Δ ln Y		Δ ln N	
Average firm size	Large	Small	Large	Small	Large	Small
(employees per establishment)	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	4.020*	-1.880	1.826	15.848***	-3.995	18.602***
	(2.276)	(2.135)	(3.263)	(5.513)	(2.649)	(6.375)
F-test of equality	12.17***		16.80**		34.94***	
N	1,726	1,596	1,726	1,596	1,726	1,596
			1910			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	5.214	-0.096	14.446***	4.005	7.180	4.770
	(3.420)	(5.009)	(5.204)	(10.149)	(5.023)	(10.539)
F-test of equality	0.62		1.03		0.06	
N	886	467	886	467	892	470
			1920			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	8.172***	-1.241	11.100	17.016	-1.181	19.928
	(2.592)	(2.458)	(7.207)	(13.264)	(6.223)	(12.708)
F-test of equality	15.03***		0.39		5.57**	
N	1,166	763	1,166	765	1,166	763
			1930			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	9.213***	5.617*	11.937*	41.300**	0.648	36.714**
	(2.867)	(3.283)	(6.782)	(16.756)	(6.720)	(16.137)
F-test of equality	0.56		2.91*		4.58**	
N	526	317	526	317	526	317
			1940			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	5.883***	6.117*	17.693	44.184***	8.806	39.484***
	(2.061)	(3.468)	(13.732)	(13.919)	(13.828)	(12.279)
F-test of equality	0.00		3.02*		4.30**	
N	704	408	704	408	704	408
1890 "Y" Control	Yes	Yes	Yes	Yes	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in all regressions. In odd columns, industry-county cells that had in 1890 above median workers per establishment are included while those below the median are included in even columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.14: Heterogeneity by tradability-productivity, output, and employment

	Δ ln Y/N		Δ ln Y		Δ ln N	
Industry's tradeability index:	High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\ln \text{HP/Y1890} \times \text{ plant within 70km}}{100}$	0.053	3.389	16.549***	1.860	16.889***	-2.506
	(2.507)	(2.627)	(6.412)	(5.549)	(6.047)	(4.686)
N	1,730	2,533	1,736	2,533	1,730	2,533
			1910			
$\frac{\ln \text{HP/Y1890} \times \text{ plant within 70km}}{100}$	5.923	3.334	30.889***	8.958	23.696***	4.776
	(6.046)	(2.070)	(9.439)	(7.019)	(8.271)	(6.763)
N	608	991	608	991	615	1,002
			1920			
$\frac{\ln \text{HP/Y1890} \times \text{ plant within 70km}}{100}$	16.524***	3.485	52.131***	0.363	36.732***	-4.773
	(5.618)	(2.490)	(10.813)	(8.703)	(8.333)	(7.387)
N	1,006	1,627	1,008	1,629	1,006	1,627
			1930			
$\frac{\ln \text{HP/Y1890} \times \text{ plant within 70km}}{100}$	15.318***	2.804	40.441***	3.587	26.590***	0.259
	(3.770)	(10.473)	(9.083)	(3.145)	(10.436)	(8.895)
N	445	733	445	733	445	733
			1940			
$\frac{\ln \text{HP/Y1890} \times \text{ plant within 70km}}{100}$	5.898**	4.225**	58.018***	9.393	52.392***	4.703
	(2.487)	(1.777)	(13.924)	(10.898)	(14.759)	(10.253)
N	555	1,044	555	1,044	555	1,044
1890 "Y" Control	Yes	Yes	Yes	Yes	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in all regressions In odd columns, industries with tradability index above the median are included while the even columns those with index below the median are presented. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.15: Heterogeneity by market competitiveness-productivity, output, and employment (by potential market size)

	Δ ln Y/N		Δ ln Y		Δ ln N	
Potential market size	Large	Small	Large	Small	Large	Small
(Hoover divided by transp. costs)	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.778	4.394	-1.582	14.251***	-0.683	9.252**
	(2.277)	(2.947)	(5.801)	(4.943)	(5.269)	(4.325)
F-test of equality	1.93		4.32**		2.12	
N	2,106	2,157	2,109	2,161	2,106	2,157
			1910			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	4.123	4.898**	4.637	27.052***	0.147	21.355***
	(5.555)	(2.225)	(11.666)	(7.446)	(9.033)	(6.518)
F-test of equality	0.05		4.31**		4.36**	
N	829	770	829	770	838	779
			1920			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	3.426	11.088***	-3.502	35.841***	-7.443	24.071***
	(5.555)	(2.225)	(11.666)	(7.446)	(9.033)	(6.518)
F-test of equality	1.64		8.10***		8.02***	
N	1,263	1,370	1,265	1,372	1,263	1,370
			1930			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-3.911	14.134***	-10.399	32.016***	-7.143	18.074**
	(5.577)	(2.489)	(14.980)	(9.315)	(11.520)	(8.973)
F-test of equality	8.79***		5.76**		2.98*	
N	574	604	574	604	574	604
			1940			
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	0.506	6.981***	-2.754	24.654**	-3.817	17.542*
	(2.091)	(1.886)	(13.296)	(10.540)	(12.903)	(10.532)
F-test of equality	5.29**		2.62		1.65	
N	774	825	774	825	774	825
1890 "Y" Control	Yes	Yes	Yes	Yes	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in all regressions. In odd columns, industry-county cells that had in 1890 above median Hoover index divided by transportation costs are included while those below the median are included in even columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.16: Heterogeneity by market competitiveness-productivity, output, and employment (by alternative potential market size proxy)

	Δ ln Y/N		Δ ln Y		Δ ln N	
Potential market size	Large	Small	Large	Small	Large	Small
(High Hoover or low trans. costs)	(1)	(2)	(3)	(4)	(5)	(6)
			1900			
$\frac{\ln HP/Y1890 \times \text{ plant within 70km}}{100}$	-0.250	5.039	-1.317	19.043***	-1.081	13.486***
	(1.956)	(3.904)	(4.785)	(5.856)	(4.200)	(5.206)
F-test of equality	1.49		7.32***		4.79**	
N	3,092	1,171	3,096	1,174	3,092	1,171
			1910			
$\frac{\ln HP/Y1890 \times \text{ plant within 70km}}{100}$	2.882	5.632**	6.321	29.990***	2.953	23.734***
	(3.588)	(2.547)	(7.037)	(7.853)	(6.728)	(8.143)
F-test of equality	0.39		5.14**		3.96**	
N	1,159	440	1,159	440	1,167	450
			1920			
$\frac{\ln HP/Y1890 \times \text{ plant within 70km}}{100}$	2.960	13.267***	-1.159	40.882***	-4.483	27.013***
	(1.059)	(1.060)	(4.842)	(4.778)	(4.644)	(4.643)
F-test of equality	5.72**		11.84***		9.16***	
N	1,847	786	1,850	787	1,847	786
			1930			
$\frac{\ln HP/Y1890 \times \text{ plant within 70km}}{100}$	-2.756	16.147***	-4.492	31.472***	-2.388	15.851
	(3.393)	(2.886)	(10.925)	(10.681)	(9.226)	(10.145)
F-test of equality	18.15***		5.61**		1.80	
N	828	350	828	350	828	350
			1940			
$\frac{\ln HP/Y1890 \times \text{ plant within 70km}}{100}$	0.186	8.718***	0.803	20.753*	0.224	11.780
	(1.691)	(2.032)	(10.485)	(11.366)	(9.901)	(11.732)
F-test of equality	10.63***		1.69		0.58	
N	1,144	455	1,144	455	1,144	455
1890 "Y" Control	Yes	Yes	Yes	Yes	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log output per worker (columns (1) and (2)), log output (columns (3) and (4)) and log workers (columns (5) and (6)) on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in all regressions. In odd columns, industry-county cells that had in 1890 above median Hoover index or below median trade costs while those that had below median Hoover and above median trade costs are included in even columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.17: Heterogeneous impact on log number of establishments

Average firm size (ouptut per establishment)	Large (1)	Small (2)	Large (3)	Small (4)
		1900		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-9.442***	8.762*	-4.729	6.375
	(3.270)	(5.201)	(3.325)	(4.299)
F-test of equality	8.78***		4.17**	
		1910		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-0.369	0.513	-2.858	2.825
	(4.617)	(9.808)	(5.004)	(9.376)
F-test of equality	0.01		0.29	
		1920		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-7.193	-2.863	-16.067**	-2.819
	(6.795)	(10.413)	(6.653)	(10.396)
F-test of equality	0.12		0.15	
		1930		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	4.945	34.401***	-3.174	34.358***
	(7.564)	(11.035)	(7.573)	(11.180)
F-test of equality	4.85**		7.72***	
		1940		
$\frac{\text{ln HP/Y1890} \times \text{ plant within 70km}}{100}$	-4.819	26.363**	-7.455	28.060**
	(10.721)	(11.797)	(11.281)	(11.777)
F-test of equality	3.83*		4.74**	
1890 "Y" Control	No	No	Yes	Yes

Each observation corresponds to an industry-county cell in a given year. Robust standard errors are presented between parentheses. Coefficients presented are those from a regression of log number of establishments on industry-level log horsepower per worker in 1890 interacted with a dummy indicating whether the centroid of the county was within 70km of an hydrolectric power plant in 1912 divided by 100. Weights are the number of establishments in a cell. Fixed effects for county and industry are included. Values of the dependent variable in 1890 are included in even columns. In the first two columns, industry-county cells that had in 1890 above output per establishment are included while those below the median are included in the next two columns. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B A Simple Model of Electricity's Heterogeneous Effects

We set up a simple model that links labor demand, energy prices, and firm/market characteristics. This model incorporates multiple factors of production into the model of Autor et al. (2020) to show that a decrease in the price of one factor may have differential impact on the demand for the other depending on the structure.

Firms in city c and industry i at time t have a production function given by

$$Y_{cit} = A_{ct} z (\alpha_i E_{cit}^{\rho} + (1-\alpha_i) L_{cit}^{\rho})^{1/\rho}$$

where E is energy and L is labor and ρ represents the substitution parameter between both inputs where $-\infty < \rho < 1$. We assume firms have constant return to scale. As α increases, the industry is more energy intensive. Productivity is allowed to depend on county-level characteristics (A_{ct}) and on firm characteristics (z). The price of energy is r_{ct} and the price of labor is w_{ct}. We will thus follow the literature on skill-biased technological change as modelling electricity as a fall in the price of one of the inputs in the production function.

Define $\Delta_{ict} = (1-\alpha_i)^{\frac{1}{1-\rho}} w_{ct}^{\frac{-\rho}{1-\rho}} + \alpha_i^{\frac{1}{1-\rho}} r_{ct}^{\frac{-\rho}{1-\rho}}$, the CES aggregate of the factor costs. We can show that firms have constant marginal costs equal to $\Delta_{ict}^{\frac{\rho-1}{\rho}} / A_{ct} z$.

We now follow Autor et al. (2020) in defining the market in which firms are operating. We assume an industry with monopolistic competition and firm-level heterogeneity in productivity (z_i), each producing a differentiated variety. Individual demand for a good ω from industry i is of the type

$$q(p_{\omega}) = p_{\omega}^{-\sigma_i} d(p_{\omega})$$

Each firm produces one good/variety ω. The function $d(\cdot)$ is assumed to satisfy additional conditions. In particular, there exists a "choke price" $\bar{p}$ such that $d(p) = 0 \forall p \geq \bar{p}$. Secondly, $d(\cdot)$ must be such that Marshall's Second Law is satisfied which implies that the absolute elasticity of demand must be decreasing in the quantity demanded. This implies specifically that $d(p_{\omega}) > 0$, $d'(p_{\omega}) < 0$, $d \log d(p)/d \log p < \sigma - 1$ and $d^2 \log d(p)/d \log p^2 < 0$.

Firms who want to enter into the market need to pay an entry cost $\kappa > 0$. Once this fixed cost has been paid, firms draw their productivity level z from a known distribution with pdf $\lambda(z)$. The firm will thus maximize its profits by selecting the price that maximizes

$$\left(p_{\omega} - \Delta_{ict}^{\frac{\rho-1}{\rho}} / A_{ct} z \right) q(p_{\omega})$$

This will imply that firms will produce until:

$$q(p_\omega) + \left(p_\omega - \Delta_{ict}^{\frac{\rho-1}{\rho}}/A_{ct} z\right) q'(p_\omega) = 0$$

Defining the markup as

$$m(p_\omega, \sigma_i) = \frac{-\sigma_i + p_\omega d'(p_\omega)/d(p_\omega)}{1 - \sigma_i + p_\omega d'(p_\omega)/d(p_\omega)}$$

we obtain that

$$\log p_\omega = \log m(p_\omega, \sigma_i) + \frac{\rho - 1}{\rho} \log \Delta_{ict} - \log A_{ct} - \log z$$

Autor et al. (2020) shows that prices will be decreasing in marginal costs. We will extend this result to show that prices will fall in response to a fall in the price of electricity.

First, we can show that $\frac{\partial m}{\partial p_\omega} < 0$. Using that

$$\frac{\partial \log p_\omega}{\partial \log r} = \frac{-1}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \frac{1 - \rho}{\rho} \frac{\partial \log \Delta_{ict}}{\partial \log r}$$

$$\frac{\partial \log p_\omega}{\partial \log r} = \frac{1}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \frac{\alpha^{\frac{1}{1-\rho}} r^{\frac{\rho}{1-\rho}}}{\Delta_{ict}} > 0$$

Finally, we can show that

$$\frac{\partial \log q}{\partial \log r} = \frac{\sigma_i - p_\omega d'(p_\omega)/d(p_\omega)}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \frac{1 - \rho}{\rho} \frac{\partial \log \Delta_{ict}}{\partial \log r}$$

$$\frac{\partial \log q}{\partial \log r} = \frac{-\sigma_i + p_\omega d'(p_\omega)/d(p_\omega)}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \frac{\alpha^{\frac{1}{1-\rho}} r^{\frac{\rho}{1-\rho}}}{\Delta_{ict}} < 0$$

A decrease in the price of electricity thus leads higher output, lower prices, and higher markups.

Our focusis on the impact of lower electricity prices on productivity and employment. The (unconditional) labor demand is given by

$$\log L_{ict} = \log q(p_\omega, w_{ct}, r_{ct}) - \log z - \log A - \frac{1}{\rho - 1} \log(\alpha_i) - \frac{1}{\rho - 1} \log w_{ct} - \frac{1}{\rho} \log \Delta_{ict}$$

which implies that

$$\frac{\partial \log L}{\partial \log r} = \left(-\frac{1}{\rho} + \frac{\sigma_i - p_\omega d'(p_\omega)/d(p_\omega)}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \frac{1 - \rho}{\rho}\right) \frac{\partial \log \Delta_{ict}}{\partial \log r}$$

or

$$\frac{\partial \log L}{\partial \log r} = \left(\frac{1}{1-\rho} + \frac{-\sigma_i + p_\omega d'(p_\omega)/d(p_\omega)}{1 - \frac{\partial \log m}{\partial \log p_\omega}} \right) \frac{\alpha^{\frac{1}{1-\rho}} r^{\frac{\rho}{1-\rho}}}{\Delta_{ict}}$$

The impact of a fall in r will thus be undetermined since the substitution effect (the first term) may or may not dominate the scale effect (second term).

Finally, labor productivity will increase in response to a fall in electricity price since combining the above equations give us

$$\frac{\partial \log(Y/L)}{\partial \log r} = \left(\frac{1}{1-\rho} \right) \frac{\alpha^{\frac{1}{1-\rho}} r^{\frac{\rho}{1-\rho}}}{\Delta_{ict}} > 0$$

It is easy to show that all these impacts will be larger for sectors where α_i is larger.

Proposition. The impact of a decrease in electricity price on employment will be more negative the larger the firm's productivity (z).

Proof. Whether a fall in electricity prices will increase or decrease unconditional labor demand depends entirely on whether the substitution effect dominates the scale effect. The first effect is independent on characteristics linked to productivity. Thus, the impact of a fall in electricity prices will depend on the latter variables only in so it affects the scale of production.

We thus need to determine the sign of

$$\frac{\partial^2 \log q}{\partial \log r \partial \log z} = \frac{\partial^2 \log d}{\partial \log p^2} \frac{\partial \log p_w}{\partial \log z} \frac{\partial \log p_w}{\partial \log r} + \left(-\sigma_i + \frac{\partial \log d}{\partial \log p_w} \right) \frac{\partial^2 \log p_w}{\partial \log r \partial \log z}$$

For this, we will need to obtain how the price response to a fall in electricity price depends on z.

We find that

$$\frac{\partial^2 \log p}{\partial \log r \partial \log z} = \frac{\frac{\partial^2 \log m}{\partial \log p^2} \frac{\partial \log p_w}{\partial \log r} \frac{\partial \log p_w}{\partial \log z}}{1 - \frac{\partial logm}{\partial logp}}$$

Combining the two derivatives, we conclude that

$$\frac{\partial^2 \log q}{\partial \log r \partial \log z} > 0$$

as long as $\frac{\partial^3 \log d}{\partial \log p^3}$ is not too negative. In that case, more productive firms will respond less strongly to a fall in electricity in terms of output. This will make their effect on labor demand be more negative.

Thus, the model suggests that labor demand decreases in response to a fall in electricity prices when the output response is more muted, which is the case for firms with high productivity. This is a direct corollary of Marshall's Second Law. More productive firms produce more for their market, which implies that they face a relatively inelastic demand. In response to a fall in their marginal costs because of electricity prices, they respond with smaller output increases, leading to the substitution effect of r to be larger relative to the substitution effect.

A similar result would be obtained if we modelled the arrival of electricity not simply as cheaper energy but also as a skill-biased technological change that increases the marginal productivity of energy relative to labor. However, modeling electricity as a TFP shock would not produce the same results as it would not lead to a substitution pattern between labor and energy.

Finally, we could model labor in a richer fashion by adding multiple types of skills. What would differ then is that the substitution effect may lead to an increase in the demand for some types of workers and a decrease in the demand for others. Looking at how the labor demand for each type of workers respond to changes in energy demands would be indicative of the type of substitutability or complementarity that one would observe between energy and that type of labor.

C Industry classification

Table C.18: Industries included in each industry group

Industry 1 (Industry 1950: 406)
Slaughtering and meat packing, not including retail butchering; Slaughtering, wholesale, not including meat packing; Sausage; Slaughtering and meat packing, wholesale; Meat packing, wholesale; Sausage, meat puddings, headcheese, etc., and sausage casings, not made in meat-packing establishments; Poultry, killing and dressing, not done in slaughtering and meatpacking establishments; Slaughtering and meat packing; Sausage casings—not made in meat-packing establishments; Sausages, prepared meats, and other meat products—not made in meat-packing establishments; Poultry killing, dressing, and packing, wholesale; Slaughtering and meat-packing, wholesale; Sausage, meat puddings, headcheese, etc, and sausage casings, not made in meat-packing establishments, sausage; Sausage, not made in slaughtering and meat-packing establishments; Sausage, meat puddings, headcheese, etc, and sausage casings, not made in meat-packing establishments, sausage casings; Poultry dressing and packing, wholesale; Custom slaughtering, wholesale
Industry 2 (Industry 1950: 407)
Cheese; Butter; Butter, reworking; Cheese and butter (factory); Condensed and evaporated milk; Butter, cheese, and condensed milk; Cheese, butter, and condensed milk; Cheese and butter, urban dairy product; Condensed milk; Creamery butter
Industry 3 (Industry 1950: 408, 416, 417, 419)
Food preparations, not elsewhere classified, breadstuff preparations, cereals, and breakfast foods. Macaroni, vermicelli and noodles; Confectionery; Bread and other bakery products; Pickled fruits and vegetables and vegetable sauces and seasonings; Bread and other bakery products (except biscuit, crackers, and pretzels); Ice cream; Food preparations, not elsewhere classified, except breadstuff preparations, cereals, and breakfast foods-for animals and fowls; Pickles, preserves, and sauces, pickles and sauces; Food preparations, not elsewhere classified, except macaroni, vermicelli and noodles-for human consumption; Food preparations, not elsewhere classified, except breadstuff preparations, cereals, and breakfast foods; Feeds, prepared, for animals and fowls; Food preparations, not elsewhere classified; Canning and preserving, fruits and vegetables, canned vegetables; Food preparations; Fish, canning and preserving; Food preparations, not elsewhere specified; Canning and preserving, fruits and vegetables; Canning and preserving, fruits and vegetables, canned fruits; Fruits and vegetables, canning and preserving; Food preparations, not elsewhere classified, except macaroni, vermicelli and noodles and peanut butter and sweetening sirups-for human consumption; Coffee and spice, roasting and grinding, coffee; Food preparations, not elsewhere classified, except breadstuff preparations, cereals, and breakfast foods-for human consumption; Confectionery and ice cream; Oysters, canning and preserving; Cereal preparations; Confectionery and ice cream, confectionary; Lard, not made in slaughtering and meat-packing establishments; Coffee and spice, roasting and grinding; Chewing gum; Food preparations, not elsewhere classified, breadstuff preparations, cereals, and breakfast foods; Food preparations, not elsewhere classified, all other food preparations; Canning and preserving: Fruits and vegetables: pickles, jellies, preserves, and sauces; Canned and dried fruits and vegetables (including canned soups)
Industry 4 (Industry 1950: 409)
Flouring and grist mill products; Flour and other grain-mill products; Flour-mill and gristmill products
Industry 5 (Industry 1950: 419)
Rice, cleaning and polishing; Rice cleaning and polishing

Industry 6 (Industry 1950: 417)

Sugar, refining, not including beet sugar; Sugar refining, cane; Sugar and molasses, refining; Cane-sugar refining; Sugar, beet; Beet sugar; Sugar and molasses, beet; Cane sugar-except refineries; Sugar and molasses, not including beet sugar; Sugar, cane; Sugar, cane, not including products of refineries

Industry 7 (Industry 1950: 417)

Chocolate and cocoa products; Chocolate and cocoa products, not including confectionery

Industry 8 (Industry 1950: 418)

Mineral and soda water: except mineral and carbonated waters; Mineral and soda waters; Beverages; Nonalcoholic beverages; Mineral and soda water: mineral and carbonated waters

Industry 9 (Industry 1950: 418)

Alcohol, ethyl, and distilled liquors; Liquors, malt; Liquors, distilled; Liquors, vinous; Wines; Liquors, rectified or blended; Malt liquors

Industry 10 (Industry 1950: 418)

Malt

Industry 11 (Industry 1950: 409)

Baking powders and yeast; Baking and yeast powders; Baking powder, yeast, and other leavening compounds; Baking powders, yeast, and other leavening compounds

Industry 12 (Industry 1950: 419)

Oleomargarine; Oleomargarine and other butter substitutes; Oleomargarine—not made in meatpacking establishments; Oleomargarine, not made in meat-packing establishments

Industry 13 (Industry 1950: 419)

Corn sirup, corn sugar, corn oil, and starch; Glucose; Starch; Glucose and starch

Industry 14 (Industry 1950: 419)

Flavoring extracts; Flavoring extracts and flavoring syrups; Flavoring extracts and flavoring syrups, not elsewhere classified; Cordials and syrups; Cordials and flavoring syrups

Industry 15 (Industry 1950: 419)

Vinegar and cider

Industry 16 (Industry 1950: 419)

Ice, manufactured; Ice, artificial

Industry 17 (Industry 1950: 429)

Tobacco, chewing, smoking, and snuff; Tobacco, cigars, and cigarettes; Tobacco manufactures; Tobacco, chewing and smoking, and snuff; Cigars; Tobacco, cigars and cigarettes; Cigarettes; Cigars and cigarettes; Tobacco (chewing and smoking) and snuff; Tobacco: Chewing and smoking, and snuff

Industry 18 (Industry 1950: 439)

Cotton goods; Cotton thread; Cotton small wares; Cotton, compressing; Cotton, ginning; Cotton yarn; Cotton broad woven goods; Cotton goods, including cotton small wares; Cotton lace; Cotton, cleaning and rehandling; Cotton narrow fabrics; Lace goods

Industry 19 (Industry 1950: 439)

Silk and rayon manufactures; Rayon narrow fabrics; Silk throwing and spinning—contract factories; Rayon throwing and spinning—contract factories; Silk and silk goods, including throwsters; Rayon broad woven goods—regular factories or jobbers engaging contractors; Silk broad woven goods—regular factories or jobbers engaging contractors; Rayon yarn and thread, spun or thrown—regular factories or jobbers engaging contractors; Silk and silk goods; Silk broad woven goods—contract factories; Silk goods; Silk and silk goods, finished products; Silk narrow fabrics; Silk yarn and thread, spun or thrown—regular factories or jobbers engaging contractors; Rayon broad woven goods—contract factories; Silk and silk goods, throwsters and winders

Industry 20 (Industry 1950: 448)

Woolen, worsted, felt goods, and wool hats; Wool scouring; Men's and boys' hats and caps (except felt and straw); Finishing of men's and boys' hats of fur-felt, wool-felt, and straw; Clothing, women's, factory product; Clothing, women's, contract work, except suits, skirts, and cloaks, shirt waists and dresses, except house dresses; Women's, children's and infants' underwear and nightwear of cotton and flannelette woven fabrics; Hat and cap, except felt and straw men's; Millinery and lace goods, except trimmed hats and hat frames; Wool pulling; Fur hats; Clothing, women's, except suits, skirts, and cloaks, shirt waists and dresses, except house dresses, undergarments and petticoats and wrappers and housedresses; Collars and cuffs, paper; Furnishing goods, men's; Woolen and worsted goods; Embroideries; House dresses, uniforms, and aprons—made in inside factories or by jobbers engaging contractors; Clothing, women's, contract work, undergarments and petticoats; Clothing, women's, regular factory products, except suits, skirts, and cloaks and shirt waists and dresses, except house dresses; Embroideries, other than Schiffli-machine products—contract factories; Woolen goods; Men's and boys' underwear—made in contract factories; Hat and cap materials; Millinery and lace goods; Women's and misses' clothing, not elsewhere classified—made in contract factories; Trimmings (not made in textile mills), stamped art goods, and art needlework—contract factories; Coats, suits, and skirts (except fur coats)-made in contract factories; Clothing, women's; Men's neckwear—made in contract factories; Women's and misses' dresses (except house dresses)—made in contract factories; Wool hats; Children's and infants' wear not elsewhere classified-made in contract factories; Clothing, women's, except suits, skirts and cloaks, shirt waists and dresses, except house dresses; House dresses, uniforms, and aprons—made in contract factories; Robes, lounging garments, and dressing gowns; Straw goods, not elsewhere specified

Industry 21 (Industry 1950: 437)

Dyeing and finishing textiles; Dyeing and finishing textiles, exclusive of that done in textile mills; Dyeing and finishing cotton, rayon, silk, and linen textiles; Dyeing and cleaning; Dyestuff and extracts; Dyeing and finishing woolen and worsted

Industry 22 (Industry 1950: 436)

Hosiery and knit goods; Knitted underwear; Knitted outerwear (except knit gloves)—contract factories; Hosiery—seamless; Knitted outerwear (except knit gloves)—regular factories or jobbers engaging contractors; Knit goods; Knitted gloves; Knitted cloth; Hosiery—full-fashioned

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Industry 23 (Industry 1950: 437)

Cloth, sponging and refinishing; Cloth sponging and miscellaneous special finishing; Cloth sponging and refinishing

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Industry 24 (Industry 1950: 438)

Carpets and rugs, other than rag; Carpets, rag; Carpet yarn, woolen and worsted; Carpets, rugs, and mats made from such materials as paper fiber, glass, jute, flax, sisal, cotton, cocoa fiber, and rags; Mats and matting, from cocoa fiber, grass, and coir; Mats and matting, grass and coir; Mats and matting; Carpets and rugs, wool; Carpets and rugs, wool, other than rag; Carpets and rugs, rag

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Industry 25 (Industry 1950: 438)

Oilcloth, enameled; Asphalted-felt-base floor covering; Oilcloth; Artificial leather and oilcloth; Oilcloth, floor; Oilcloth and linoleum, floor; Artificial leather; Oilcloth and linoleum; Linoleum; Linoleum, asphalted-felt-base and other hard-surface floor coverings, not elsewhere classified

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Industry 26 (Industry 1950: 449)

Felt goods; Haircloth; Felt goods, wool, hair, or jute; Felt goods, wool, hair, and jute (except woven felts and hat bodies and hats)

Industry 27 (Industry 1950: 446)

Upholstering materials; Batting, padding, and wadding: upholstery filling; Excelsior; Upholstering materials, not elsewhere specified; Upholstering materials, not elsewhere classified

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Industry 28 (Industry 1950: 446)

Processed waste and recovered wool fibers—contract factories; Waste; Cotton waste; Wool shoddy; Shoddy; Oakum; Processed waste and recovered wool fibers—regular factories or jobbers engaging contractors

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Industry 29 (Industry 1950: 449)

Cordage and twine; Cordage and twine and jute and linen goods; Linen goods; Jute goods; Bags, other than paper; Jute and jute goods; Bags, other than paper, not made in textile mills; Jute goods (except felt); Bags, other than paper, not including bags made in textile mills; Textile bags—not made in textile mills; Thread, linen; Bagging, flax, hemp, and jute

Industry 30 (Industry 1950: 448)

Gloves and mittens; Clothing (except work clothing), men's, youths', and boys', not elsewhere classified; Clothing, men's, contract work, men's and youths' and boys'; Clothing, men's, buttonholes; Dress and semidress gloves and mittens: cloth, cloth and leather combined; Trousers (semidress), wash suits, and washable service apparel; Clothing, men's, factory product, buttonholes; Clothing, men's; Leather gloves and mittens; Clothing, men's, custom work and repairing; Work shirts; Men's and boys' suits, coats, and overcoats (except work clothing)—made in contract factories; Clothing, men's, contract work, boys'; Clothing, men's, regular factory products, men's, youths'; Clothing men's, factory products buttonholes; Collars, men's; Clothing, men's, regular factory products, boys'; Clothing, men's, contract work; Shirts; Men's and boys' shirts (except work shirts), collars, and night-wear made in inside factories or by jobbers engaging contractors; Clothing, men's, including shirts; Clothing, men's, contract work, except men's and youths'; Men's and boys' suits, coats, and overcoats (except work clothing)—made in inside factories or by jobbers engaging contractors; Clothing, men's, regular factory products; Clothing, men's, contract work, men's, youths'; Clothing, men's, regular factory products, except men's, youths' and boys'; Clothing men's, factory products; Gloves and mittens, cloth; Work clothing (except work shirts), sport garments (except leather), and other men's and boys' apparel, not elsewhere classified; Clothing, men's, contract work, men's and youths'; Clothing, men's, factory product; Men's and boys' shirts (except work shirts), collars, and night-wear—made in contract factories; Work gloves and mittens: cloth, cloth and leather combined; Gloves and mittens, leather; Clothing, men's, regular factory products, except men's, youths', and boys'; Clothing, men's, regular factory; Clothing, leather and sheep-lined; Raincoats and other waterproof garments (except oiled cotton)

Industry 31 (Industry 1950: 448)

Corsets; Corsets and allied garments

Industry 32 (Industry 1950: 489)

Saddlery and harness; Pocketbooks, purses, and card cases; Trunks and valises; Women's pocketbooks, handbags, and purses; Leather goods not elsewhere classified; Suitcases, brief cases, bags, trunks, and other luggage; Belts (apparel), regardless of material; Pocketbooks; Leather goods, not elsewhere classified; Trunks, suitcases, and bags; Leather goods; Belting other than leather and rubber, not made in textile mills; Whips; Leather board; Small leather goods; Bellows; Saddlery, harness, and whips; Belting and hose, woven, other than rubber; Leather goods, not elsewhere specified; Leather-boards

Industry 33 (Industry 1950: 449)

Fur goods; Fur coats and other fur garments, accessories, and trimmings

Industry 34 (Industry 1950: 478)

Tires and inner tubes; Suspenders, garters, and other elastic woven goods, made from purchased webbing; Belting and hose, rubber; Rubber goods other than tires, inner tubes, and boots and shoes; Rubber and elastic goods; Suspenders, garters, and elastic woven goods; Rubber tires, tubes, and rubber goods, not elsewhere specified; Rubber products not elsewhere classified; Belting and hose, linen; Rubber goods, not elsewhere specified; Belting and hose, woven and rubber; Reclaimed rubber; Suspenders, garters, and other goods made from purchased elastic material; Belting and hose, other than leather; Rubber tires and inner tubes

Industry 35 (Industry 1950: 449)

House-furnishing goods, not elsewhere specified, mops and dusters; House-furnishing goods, not elsewhere specified; Curtains, draperies, and bedspreads—made in regular factories or by jobbers engaging contractors; Curtains, draperies, and bedspreads—contract factories; House-furnishing goods, not elsewhere classified; Aluminum ware, kitchen, hospital, and household (except electrical appliances); Housefurnishings (except curtains, draperies, and bedspreads); Aluminum products (including rolling and drawing and extruding), not elsewhere classified; Aluminum manufactures; House-furnishing goods, not elsewhere specified, comforts, quilts, feather pillows, and beds; House furnishing goods, not elsewhere specified; House-furnishing goods, not elsewhere specified, except comforts, quilts, feather pillows, and beds and mops and dusters; House-furnishing goods, not elsewhere specified, except mops and dusters

Industry 36 (Industry 1950: 449)

Awnings, tents, and sails; Canvas products (except bags); Awnings, tents, sails, and canvas covers

Industry 37 (Industry 1950: 449)

Regalia, and society badges and emblems; Flags and banners; Regalia and society banners and emblems; Clothing, horse; Nets and seines; Miscellaneous fabricated textile products not elsewhere classified; Nets and selnes; Flags, banners, regalia, society badges, and emblems; Horse blankets, fly nets, and related products; Regalia, badges, and emblems

Industry 38 (Industry 1950: 308)

Charcoal; Lumber and timber products; Boxes, wooden packing; Wooden boxes except cigar boxes; Sawmills, veneer mills, and cooperage-stock mills, including those combined with logging camps and with planing mills; Boxes, wooden, except cigar boxes; Lumber and timber products, not elsewhere classified; Wood distillation; Charcoal, not including production in the lumber and wood distillation industries; Logging camps and logging contractors (not operating sawmills); Boxes, wooden packing, except cigar boxes; Plywood mills; Hardwood distillation and charcoal manufacture; Lumber and other mill products from logs or bolts; Wood distillation, not including turpentine and rosin; Wood distillation and charcoal manufacture

Industry 39 (Industry 1950: 307)

Window shades; Venetian blinds; Planing-mill products (including general millwork), not made in planing mills connected with sawmills; Lumber, planing mill products, including sash, doors, and blinds; Planing mills not operated in conjunction with sawmills; Lumber, planing-mill products, not including planing mills connected with sawmills; Window shades and fixtures; Window and door screens and weather strip; Window and door screens and weather strips

Industry 40 (Industry 1950: 309)

Mattresses and spring beds; Mattresses and spring beds, not elsewhere specified; Mattresses and bed springs, not elsewhere classified; Mattresses and bedsprings

Industry 41 (Industry 1950: 309)

Hammocks; Furniture, including store and office fixtures; Furniture, including cabinetmaking, repairing, and upholstering; Refrigerators; Office furniture; Laboratory, hospital, and other professional furniture; Public-building furniture; Show cases; Upholstered household furniture; Furniture, wood and rattan and willow; Furniture, except wood, other than rattan and willow; Partitions, shelving, cabinet work, and office and store fixtures; Furniture, rattan and willow and metal; Furniture, chairs; Refrigerators, domestic (mechanical and absorption), refrigeration machinery and equipment, and complete air-conditioning units; Household furniture, except upholstered; Furniture, metal furniture and store and office fixtures; Furniture, factory products; Furniture and refrigerators; Refrigerators, mechanical; Furniture, rattan and willow, store and office fixtures; Furniture, cabinet making, repairing and upholstering; Furniture, rattan and willow; Furniture, metal; Furniture; Furniture, wood, other than rattan and willow; Furniture, metal and store fixtures; Furniture, factory product; Refrigerators and refrigerator cabinets, exclusive of mechanical refrigerating equipment; Furniture, store and office fixtures

Industry 42 (Industry 1950: 466, 467)

Chemicals; Perfumery and cosmetics; Druggists' preparations, not including prescriptions; Celluloid and celluloid goods; Drug grinding; Drugs and medicines (including drug grinding); Perfumes, cosmetics, and other toilet preparations; Druggists' preparations; Foundry supplies; Insecticides, fungicides, and related industrial and household chemical compounds; Patent medicines and compounds, patent and proprietary medicines; Patent medicines and compounds; Druggists' preparations; Plastic materials; Coal-tar products; Rayon and allied products; Perfumes, cosmetics, and other toilet preparations; Sulphuric, nitric, and mixed acids; Compressed and liquefied gases—not made in petroleum refineries or in natural-gasoline plants; Patent medicines and compounds and druggists' preparations; Compressed and liquefied gases; Patent medicines and compounds , patent and proprietary compounds, not elsewhere specified; Foundry supplies; Chemicals, not elsewhere classified; Chemicals not elsewhere classified; Patent or proprietary medicines and compounds; Patent medicines and compounds, except patent and proprietary medicines; Coal-tar products, crude and intermediate

Industry 43 (Industry 1950: 308)

Baskets, and rattan and willow ware; Baskets and rattan and willow ware, not including furniture; Baskets and rattan and willow ware; Whalebone and rattan; Baskets for fruits and vegetables; Rattan and willow ware (except furniture) and baskets other than vegetable and fruit baskets

Industry 44 (Industry 1950: 308)

Boxes, cigar; Boxes, cigar, wooden; Cigar boxes: wooden, part wooden

Industry 45 (Industry 1950: 308)

Rules, ivory and wood; Wood products not elsewhere classified; Woodenware, not elsewhere specified; Wood turned and shaped and other wooden goods, not elsewhere classified; Cooperage; Wood, turned and carved; Kindling wood; Cooperage and wooden goods, not elsewhere specified; Cooperage, except hogsheads and barrels; Wooden goods, not elsewhere specified; Wood work - Miscellaneous; Cooperage, hogsheads and barrels

Industry 46 (Industry 1950: 308)

Caskets, coffins, burial cases, and other morticians' goods; Coffins, burial cases, and undertakers' goods

Industry 47 (Industry 1950: 308)

Cork products; Cork, cutting

Industry 48 (Industry 1950: 308)

Matches

Industry 49 (Industry 1950: 308)

Wood preserving; Wood, preserving

Industry 50 (Industry 1950: 308)

Lasts; Lasts and related products

Industry 51 (Industry 1950: 309)

Looking-glass and picture frames; Mirror and picture frames; Mirror frames and picture frames

Industry 52 (Industry 1950: 456)

Pulp, from fiber other than wood; Paper; Paper and wood pulp; Pulp goods; Pulp mills; Pulp, wood; Pulp goods (pressed, molded); Wood pulp; Fabricated plastic products, not elsewhere classified; Paper and paperboard mills; Pulp (wood and other fiber)

Industry 53 (Industry 1950: 458)

Converted paper products not elsewhere classified; Die-cut paper and paperboard, and converted cardboard; Envelopes; Stationery goods, not elsewhere specified; Cardboard, not made in paper mills; Cardboard; Card cutting and designing; Paper goods, not elsewhere classified; Stationery goods, not elsewhere classified; Paper goods, not elsewhere specified; Coated and glazed paper; Pencil cases; Greeting cards (except hand-painted); Card board

Industry 54 (Industry 1950: 458)

Bags, paper; Bags, paper, exclusive of those made in paper mills; Paper bags, except those made in paper mills

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Industry 55 (Industry 1950: 457)

Boxes, fancy and paper; Boxes paper, not elsewhere classified, shipping containers; Boxes, paper, not elsewhere classified; Boxes, paper and other, not elsewhere specified; Paperboard containers and boxes not elsewhere classified; Boxes paper, not elsewhere classified, cartons; Boxes paper, not elsewhere classified, set-up paper boxes; Fiber cans, tubes, and similar products; Boxes paper, not elsewhere classified, all others

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Industry 56 (Industry 1950: 458)

Paper hangings; Wall paper; Wallpaper; Wall paper, not made in paper mills

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Industry 57 (Industry 1950: 459)

Printing and publishing, newspapers and periodicals; Engraving and diesinking; Printing and publishing, music; Printing and publishing, newspaper and periodical; Bookbinding and blank book making; Printing, tip; Printing and publishing; Printing and publishing, book and job, job printing and book publishing and printing; Type founding; Labels and tags; Printing and publishing, book and job; Engraving on metal (except for printing purposes); Lithographing and engraving; Engraving, steel, including plate printing; Type founding and printing materials; Printing and publishing, newspaper and periodical, printing, publishing, and job printing; Machine and hand typesetting (including advertisement typesetting); Engravers' materials; Paper patterns; Engraving, wood; Printing and publishing, book and job, book publishing and printing, linotype work and typesetting; Engravers materials; Periodicals: publishing without printing; Bookbinding and blank-book making; Printing and publishing, book and job , book publishing and printing; Printing materials; Printing and publishing, book and job, job printing; Newspapers: publishing without printing; Printing and publishing, book and job ; Engraving (steel, copperplate, and wood); plate printing; Printing and publishing, book and job, except job printing; Printing-trades machinery and equipment; Books: publishing without printing; Periodicals: publishing and printing; Printing and publishing, music ; Printing and publishing, book and job, book publishing without printing and linotype work and typesetting; Printing materials, not including type or ink; Lithographing and photo-lithographing (including preparation of stones or plates and dry transfers); Books: printing without publishing; General commercial (job) printing; Lithographing; Newspapers: publishing and printing; Printing and publishing, book and job, book publishing and printing, linotype work and typesetting; Bookbinding and related industries; Books: publishing and printing; Engraving (other than steel, copperplate)

Industry 58 (Industry 1950: 459)

Photolithographing and photoengraving; Photo-engraving, not done in printing establishments; Photo-engraving; Photoengraving, not done in printing establishments (including preparation of plates); Gravure, rotogravure, and rotary photogravure (including preparation of plates); Photolithographing and engraving

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Industry 59 (Industry 1950: 459)

Stereotyping and electrotyping; Stereotyping and electrotyping, not done in printing establishments; Electrotyping and stereotyping, not done in printing establishments

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Industry 60 (Industry 1950:459)

Paint and varnish; Varnishes; Paints and varnishes; Colors and pigments; Paints; Varnish; Dyestuffs and extracts; Paints, varnishes, and lacquers; Tanning materials, natural dyestuffs, mordants and assistants, and sizes; Tanning materials, natural dyestuffs, mordants, assistants, and sizes; Dyestuffs and extracts—natural

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Industry 61 (Industry 1950: 469)

Oil, not elsewhere specified; Fish and other marine oils, cake, and meal; Oil, lubricating; Essential oils; Oil, essential; Oil, cake, and meal, linseed; Oil, cottonseed and cake; Oil and cake, cottonseed; Oil, resin; Oil, linseed; Oil, not elsewhere specified, composite; Linseed oil, cake, and meal; Oil, castor; Oil, lard; Oils, not elsewhere classified; Oil, not elsewhere specified, vegetable, animal, and mineral oils; Oil, cake, and meal, cottonseed; Lard, refined; Oils, essential; Soybean oil, cake, and meal; Oil, vegetable, essential; Oil, not elsewhere specified, vegetable; Oil, cottonseed, cake; Cottonseed oil, cake, meal, and linters; Oil, not elsewhere specified, except vegetable and composite; Oil, illuminating, not including petroleum refining; Oil, not elsewhere specified, composite oils; Vegetable and animal oils, not elsewhere classified

Industry 62 (Industry 1950: 469)

Soap and candles; Soap; Candles; Soap and glycerin

Industry 63 (Industry 1950: 477)

Turpentine and rosin; Wood naval stores; Tar and turpentine; Gum naval stores (processing but not gathering or warehousing)

Industry 64 (Industry 1950: 469)

Fertilizers

Industry 65 (Industry 1950: 469)

Explosives; Gunpowder; High explosives

Industry 66 (Industry 1950: 469)

Salt

Industry 67 (Industry 1950: 469)

Bone black, carbon black, and lampblack; Bone, ivory, and lamp black; Bone, carbon, and lamp black; Bone black, carbon black, and lamp black

Industry 68 (Industry 1950: 469)

Ink, printing; Ink, printing; Ink, writing; Printing ink; Ink, writing; Ink; Writing ink

Industry 69 (Industry 1950: 469)

Firearms; Firearms and ammunition; Ammunition and related products; Ammunition

Industry 70 (Industry 1950: 469)

Cleaning and polishing preparations, blackings, and dressings; Cleansing and polishing preparations; Blacking, stains, and dressings; Blacking; Cleansing and polishing preparations, except metal polish and cleansing preparations; Blacking and cleansing and polishing preparations; Cleaning and polishing preparations; Cleansing and polishing preparations, except metal polish; Cleansing and polishing preparations, metal polish; Cleansing and polishing preparations, cleansing preparations; Cleansing and polishing preparations, polishing preparations

Industry 71 (Industry 1950: 469)

Glue, not elsewhere specified; Glue and gelatin; Glue

Industry 72 (Industry 1950: 477)

Grease and tallow (except lubricating greases); Grease and tallow; Grease and tallow, not including lubricating greases

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Industry 73 (Industry 1950: 476)

Petroleum, refining; Gas, illuminating and heating; Axle grease; Lubricating greases; Lubricating oils and greases—not made in petroleum refineries; Petroleum refining; Lubricating oils and greases, not made in petroleum refineries; Gas, manufactured, illuminating and heating

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Industry 74 (Industry 1950: 469)

Fireworks; Fire-works

Industry 75 (Industry 1950: 469)

Bluing

Industry 76 (Industry 1950: 469)

Mucilage, paste, and other adhesives, except glue and rubber cement; Mucilage and paste; Mucilage, paste and other adhesives, not elsewhere specified

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Industry 77 (Industry 1950: 477)

Coke; Coke, not including gas-house coke; Beehive coke; Oven coke and coke-oven byproducts

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Industry 78 (Industry 1950: 318)

Paving materials; Paving and paving materials; Paving materials: Asphalt, tar, crushed slag, and mixtures; Paying blocks and paying mixtures: asphalt, creosoted wood, and composition

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Industry 79 (Industry 1950: 318)

Roofing materials; Roofing and roofing materials; Roofing, built-up and roll; asphalt shingles; roof coating (except paint); Roofing, built-up and roll; asphalt shingles; roof coatings other than paint

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Industry 80 (Industry 1950: 477)

Fuel, artificial; Fuel Briquettes and boulets; Fuel briquets; Fuel, manufactured

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Industry 81 (Industry 1950: 478)

Rubber boots and shoes (including rubber-soled footwear with fabric uppers); Boots and shoes, rubber

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Industry 82 (Industry 1950: 487)

Leather, tanned, curried, and finished; Leather: tanned, curried, and finished-regular factories or jobbers engaging contractors; Leather: Tanned, curried, and finished; Leather: tanned, curried, and finished—contract factories; Leather, patent and enameled; Leather, morocco; Leather, dressed skins; Leather, tanned and curried

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Industry 83 (Industry 1950: 489)

Belting, leather; Belting and hose, leather; Industrial leather belting and packing leather; Packing hose

Industry 84 (Industry 1950: 488)

Boots and shoes, other than rubber; Boot and shoe cut stock; Boots and shoes; Boots and shoes, factory product; Boot and shoe cut stock, not made in boot and shoe factories; Boot and shoe findings; Boots and shoes, custom work and repairing; Boot and shoe findings, exclusive of those produced in boot and shoe factories; Boot and shoe uppers; Boot and shoe cut stock, exclusive of that produced in boot and shoe factories; Boots and shoes, not including rubber boots and shoes; Boots and shoes, including cut stock and findings; Boots and shoes, other than rubber, stitching and crimping; Boots and shoes, other than rubber, regular factory products; Boots and shoes, stitching and crimping; Boots and shoes, regular factory products; Boots and shoes, other than rubber, except regular factory products; Boot and shoe findings, not made in boot and shoe factories; ; Boots and shoes, other than rubber, contract work; Footwear (except rubber); Boot and shoe cut stock and findings; Boots and shoes, contract work

Industry 85 (Industry 1950: 316)

Glass; Tableware, pressed or blown glass, and glassware not elsewhere classified; Glass containers; Flat glass

Industry 86 (Industry 1950: 316)

Glass, cutting, staining, and ornamenting; Mirrors; Mirrors, framed and unframed, not elsewhere specified; Mirrors, framed and unframed; Glass products (except mirrors) made from purchased glass; Mirrors and other glass products made of purchased glass; Glass, cutting, staining, and ornamenting, decalcomania work on glass; Glass, cutting, staining, and ornamenting, except decalcomania work on glass

Industry 87 (Industry 1950: 317)

Lime and cement; Cement; Lime

Industry 88 (Industry 1950: 318, 319)

Pottery, including porcelain ware; Pottery, terra-cotta and fire-clay products; Masonry, brick and stone; Pottery, terra cotta, and fire-clay products; Porcelain electrical supplies; Brick and tile, terra-cotta, and fire-clay products, except building bricks and terra-cotta products; Artificial stone; Brick and tile, terra-cotta, and fireclay products; Whiteware; Concrete products; Brick and tile, terra-cotta, and fire-clay products, building brick; Brick and tile; Clay products (other than pottery) and nonclay refractories; Brick and tile, terra-cotta, and fire-clay products, stove lining and terra-cotta products; Artificial stone products; Crucibles; Clay refractories, including refractory cement (clay); Roofing tile; Concrete products; Brick and hollow structural tile; Clay and pottery products; Terra cotta; Clay products (except pottery) not elsewhere classified; Sand-lime brick, block and tile; Nonclay refractories; Pottery products not elsewhere classified; Brick and tile, terra-cotta, and fire-clay products, fire brick; Floor and wall tile (except quarry tile); Vitreous-china plumbing fixtures; Pottery; Sand-lime brick; Sewer pipe and kindred products; Hotel china; Brick and tile, terra-cotta, and fire-clay products, terra-cotta products

Industry 89 (Industry 1950: 319)

China firing and decorating, not done in potteries; China decorating; China decorating, not including that done in potteries; China firing and decorating (for the trade)

Industry 90 (Industry 1950: 317)

Plastering and stuccowork; Wall plaster and composition flooring; Wallboard and wall plaster (except gypsum), building insulation (except mineral wool), and floor composition; Wall plaster, wall board, insulating board, and floor composition; Mineral wool; Statuary and art goods (except stone and concrete)—factory production; Wall plaster; Gypsum products; Statuary and art goods, factory product; Statuary and art goods

Industry 91 (Industry 1950: 326)

Monuments and tombstones; Mantels, slate, marble, and marbleized; Monuments, tombstones, cut-stone, and stone products not elsewhere classified; Marble and stone work; Marble and stone work, monuments and tombstones; Marble, granite, slate, and other stone products, other marble and stone work, except slated; Marble, granite, slate, and other stone products; Marble and stone work, except monuments and tombstones

Industry 92 (Industry 1950: 326)

Emery and other abrasive wheels; Emery wheels and other abrasive and polishing appliances; Emery wheels; Sand and emery paper and cloth; Abrasive wheels, stones, paper, cloth, and related products; Hones, whetstones, and similar products; Sand paper, emery paper, and other abrasive paper and cloth

Industry 93 (Industry 1950: 326)

Asbestos products (except steam packing and pipe and boiler covering); Asbestos products, not including steam packing; Steam packing; Steam and other packing, pipe and boiler covering, and gaskets, not elsewhere classified; Steam and other packing; pipe and boiler covering; Asbestos products, other than steam packing or pipe and boiler covering

Industry 94 (Industry 1950: 326)

Graphite, ground and refined; Graphite and graphite refining; Natural graphite, ground and refined; Graphite ground and refined

Industry 95 (Industry 1950: 326)

Minerals and earths, ground or otherwise treated; Kaolin and ground earths; Kaolin and other earth grinding

Industry 96 (Industry 1950: 326)

Iron and steel, steel works and rolling mills; Iron and steel: Steel works and rolling mills; Iron and steel; Iron and steel, blast furnaces; Steel castings; Blast-furnace products; Tin and terne plate; Iron and steel: Blast furnaces; Steel works and rolling mills; Iron and steel, tempering and welding; Ferroalloys; Tin plate and terneplate

Industry 97 (Industry 1950: 346)

Gas machines and gas and water meters, gas meters and water meters; Ironwork, architectural and ornamental; Gas machines and meters; Plumbers' supplies; Construction and similar machinery (except mining and oil-field machinery and tools); Hardware, except locks and builder's hardware; Vault lights and ventilators; Foundry and machine-shop products, machine shop and foundry combined; Steam engines, turbines, and water wheels; Signs and advertising novelties, signs, electric and others; Signs, advertising displays, and advertising novelties; Foundry and machine shop products; Foundry and machine-shop products, boiler shops; Hardware, locks; Bridges; Lightning rods; Steam fittings, regardless of material; Pumps, not including steam pumps; Steam fittings and heating apparatus; Foundry and machine-shop products, except machine shops; Steel barrels, kegs, and drums; Registers, car fare; Hardware; Locomotives, not made by railroad companies; Enameled-iron sanitary ware and other plumbers' supplies (not including pipe and vitreous and semivitreous china sanitary ware); Signs and advertising novelties; Mining machinery and equipment; Foundry and machine-shop products, except foundries; Vending, amusement, and other coin-operated machines; Hardware, saddlery; Oil-field machinery and tools; Mechanical power-transmission equipment; Plumbers supplies; Hardware not elsewhere classified; Pumps (hand and power) and pumping equipment; Locomotives, not made in railroad repair shops; Steel barrels, drums and tanks, portable; Engines, steam, gas, and water; Gray-iron and semisteel castings; Blowers; exhaust and ventilating fans; Foundry and machine-shop products, not elsewhere classified; Hardware, vehicle hardware; Cast-iron pipe; Steam fittings and steam and hot-water heating apparatus; Textile machinery and parts; Signs and advertising novelties, electric and other signs; Iron and steel, processed; Steam fittings and steam and hot-water heating apparatus, radiators and cast-iron heating boilers

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Industry 98 (Industry 1950: 338)

Gold and silver, reducing and refining, not from the ore; Tinsmithing, coppersmithing, and sheet-iron working; Smelting and refining, not from the ore; Smelting and refining, lead; Secondary smelting and refining of nonferrous metals, not elsewhere classified; Sheet-metal work not specifically classified; Copper, tin, and sheet-iron products; Tinware, not elsewhere specified; Zinc, smelting and refining; Gold, silver, and platinum, reducing and refining, not from the ore; Smelting and refining, metals other than gold, silver, or platinum, not from the ore; Smelting and refining, copper; Lead, smelting and refining; Smelting and refining, zinc; Cooper, tin, and sheet-iron work; Primary smelting and refining of nonferrous metals; Silversmithing; Copper, smelting and refining; Smelting and refining; Secondary smelting and refining, gold, silver, and platinum; Tin cans and other tinware not elsewhere classified; Zinc; Tin cans and other tinware, not elsewhere classified; Copper, tin, and sheet-iron work, including galvanized iron work, not elsewhere classified

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Industry 99 (Industry 1950: 337)

Wire; Wire, drawn from purchased bars or rods; Wire drawn from purchased rods

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Industry 100 (Industry 1950: 337)

Iron and steel, nails and spikes, cut and wrought, including wire nails; Nails, spikes, etc. not made in wire mills or in plants operated in connection with rolling mills; Iron and steel, nails and spikes, cut and wrought, including wire nails, not made in steel works or rolling mills; Nails, spikes, etc., not made in wire mills or in plants operated in connection with rolling mills; Iron, steel, nails, spikes, cut and wrought, including wire nails, not made in steel works or rolling mills

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Industry 101 (Industry 1950: 337)

Wirework, including wire rope and cable; Wirework, not elsewhere specified; Wirework not elsewhere classified; Wirework, not elsewhere classified

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Industry 102 (Industry 1950: 337)

Cutlery (except aluminum, silver, and plated cutlery) and edge tools; Machine-tool and other metalworking-machinery accessories, metal cutting and shaping tools, and machinists' precision tools; Metal working machinery and equipment, not elsewhere classified; Tools, not elsewhere specified; Cutlery and edge tools; Machine tools; Tools, not elsewhere specified, except machinists'; Tools (except edge tools, machine tools, files, and saws); Cutlery and tools, not elsewhere specified; Cutlery and edge tools, except razors; Cutlery (not including silver and plated cutlery) and edge tools; Cutlery and edge tools, razors; Tools, not elsewhere specified, machinists'; Tools, not including edge tools, machine tools, files, or saws; Machine-tool accessories and small metal-working tools, not elsewhere classified; Tools, not elsewhere specified, shovels, spades, scoops, hoes, and carpenters' tools, not elsewhere classified

Industry 103 (Industry 1950: 346)

Files

Industry 104 (Industry 1950: 346)

Saws

Industry 105 (Industry 1950: 346)

Stoves, ranges, water heaters, and hot-air furnaces (except electric); Gas and oil stoves; Gas stoves; Heating and cooking apparatus, except electric, not elsewhere classified; Stoves, gas and oil; Stoves and hot-air furnaces; Stoves and furnaces, including gas and oil stoves; Stoves and hot air furnaces, stoves and ranges; Oil burners, domestic and industrial; Stoves and ranges (other than electric) and warm-air furnaces; Stoves and hot air furnaces, hot-air furnaces

Industry 106 (Industry 1950: 346)

Japanning; Enameling; Stamped ware; Enameling, japanning, and lacquering; Stamped and pressed metal products (except automobile stampings); Automobile stampings; Enameling and enameled goods; Enameling and japanning; Stamped and enameled ware, not elsewhere specified; Vitreous enameled products, including kitchen, household, and hospital utensils; Stamped ware, enameled ware, and metal stamping, enameling, japanning, and lacquering; Enameled goods

Industry 107 (Industry 1950: 346)

Galvanizing; Galvanizing and other coating processes; Galvanizing and other coating—carried on in plants not operated in connection with rolling mills; Galvanizing and other coating not done in plants operated in connection with rolling mills

Industry 108 (Industry 1950: 346)

Iron and steel, doors and shutters; Doors, shutters, and window sash and frames, metal; Doors, window sash, frames, molding, and trim (made of metal)

Industry 109 (Industry 1950: 346)

Bolts, nuts, washers, and rivets, not made in plants operated in connection with rolling mills; Iron and steel, bolts, nuts, washers, and rivets; Bolts, nuts, washers, and rivets made in plants not operated in connection with rolling mills; Iron and steel, bolts, nuts, washers, and rivets, not made in rolling mills; Iron and steel, bolts, nuts, washers, and rivets, not made in steel works or rolling mills

Industry 110 (Industry 1950: 346)

Iron and steel, forgings; Horseshoes, not made in steel works or rolling mills; Forgings, iron and steel—made in plants not operated in connection with rolling mills; Iron and steel forgings; Iron and steel forgings, not made in steel works or rolling mills; Forgings, iron and steel, not made in plants operated in connection with rolling mills; Horseshoes, factory product; Horse-shoes

Industry 111 (Industry 1950: 346)

Iron and steel, wrought pipe; Wrought pipe, welded and heavy riveted, not made in plants operated in connection with rolling mills; Iron and steel, pipe, wrought; Iron and steel pipe, wrought; Wrought pipes, welded and heavy riveted—made in plants not operated in connection with rolling mills

Industry 112 (Industry 1950: 346)

Springs, steel, except wire, not made in plants operated in connection with rolling mills; Springs, steel, car and carriage, not made in steel works or rolling mills; Springs, steel (except wire)—made in plants not operated in connection with rolling mills; Springs, steel, car and carriage

Industry 113 (Industry 1950: 346)

Screws; Screws, machine; Screw-machine products and wood screws; Screws, wood

Industry 114 (Industry 1950: 346)

Safes and vaults

Industry 115 (Industry 1950: 347)

Bronze castings; Nonferrous-metal products not elsewhere classified; Lead, bar, pipe, and sheet; Brass castings and brass finishing; Alloying; and rolling and drawing of nonferrous metals, except aluminum; Bells; Brass, bronze, and copper products; Lead, bar, pipe and sheet; Brass and bronze products; Brass; Babbitt metal and solder; Brass castings; Nonferrous-metal foundries (except aluminum); Brass and copper, rolled; Brassware; Brass, bronze and copper products, brass and bronze products; Brass, bronze and copper products, copper and all other products; Nonferrous-metal alloys and products, not including aluminum products

Industry 116 (Industry 1950: 388)

Watch and clock materials, except watchcases; Watches and watch movements; Clocks; Watch and clock materials; Clocks and watches, including cases and materials; Watch and clock materials and parts, except watchcases; Watches; Watchcases; Watch cases; Clocks, watches, and materials and parts (except watchcases); Clocks, clock movements, time-recording devices, and time stamps

Industry 117 (Industry 1950: 399)

Costume jewelry and costume novelties (jewelry other than fine jewelry); Jewelry; Jewelers' findings and materials; Jewelry (precious metals)

Industry 118 (Industry 1950: 399)

Lapidary work

Industry 119 (Industry 1950: 346)

Silverware and plated ware; Silverware; Plated and britannia ware; Silversmithing and silverware; Plated ware

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Industry 120 (Industry 1950: 346)

Electroplating, plating, and polishing; Electroplating

Industry 121 (Industry 1950: 358)

Calcium lights; Lamps and reflectors; Gas and lamp fixtures; Gas and electric fixtures, lamps and reflectors; Gas and electric fixtures; lamps, lanterns, and reflectors; Gas and electric fixtures; Gas and electric fixtures, electric fixtures; Gas and electric fixtures, except electric fixtures; Lighting fixtures; Lamps and reflectors, all other lamps; Lamps and reflectors, reflectors; Lamps and reflectors, automobile lamps

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Industry 122 (Industry 1950: 347)

Tin and other foils, not elsewhere specified; Collapsible tubes; tinfoil; Tin and other foils (except gold and silver foil); Tin foil; Tin and other foils, not including gold foil; Tinfoil

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Industry 123 (Industry 1950: 347)

Gold and silver, leaf and foil; Gold leaf and foil; Gold and silver leaf and foil

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Industry 124 (Industry 1950: 367)

Electrical machinery, apparatus, and supplies; Phonographs and graphophones; Electric light and power; Insulated wire and cable; Generating, distribution, and industrial apparatus, and apparatus for incorporation in manufactured products, not elsewhere classified; Electric lamps; Batteries, storage and primary (dry and wet); Electrical apparatus and supplies; Electrical measuring instruments; Electrical products not elsewhere classified; Automotive electrical equipment; Electrical appliances; Wiring devices and supplies; X-ray and therapeutic apparatus and electronic tubes; Radios, radio tubes, and phonographs; Communication equipment; Phonographs; Beauty-shop and barber-shop equipment; Carbon products for the electrical industry, and manufactures of carbon or artificial graphite

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Industry 125 (Industry 1950: 357)

Agricultural implements; Agricultural machinery (except tractors); Windmills; Windmills and windmill towers; Tractors

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Industry 126 (Industry 1950: 357)

Typewriters and supplies; Typewriters and supplies, carbon paper; Office and store machines, not elsewhere classified; Typewriters and supplies, typewriters and parts; Carbon paper and inked ribbons; Typewriters and supplies, except typewriters and parts and carbon paper; Typewriters and parts

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Industry 127 (Industry 1950: 357)

Scales and balances

Industry 128 (Industry 1950: 358)

Washing machines and clothes wringers; Washing machines, clothes wringers; Washing machines, wringers, driers, and ironing machines, for household use; Laundry equipment, domestic

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Industry 129 (Industry 1950: 358)

Sewing machines and attachments; Sewing machines, domestic and industrial; Sewing machines, cases, and attachments; Sewing-machine cases

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Industry 130 (Industry 1950: 376)

Carriage and wagon materials; Carriages and wagons, including repairs; Wheelbarrows; Automobiles, including bodies and parts; Carriages, wagons, sleighs, and sleds; Carriages and wagons; Automobile bodies and parts; Motor vehicles, not including motorcycles; Motor-vehicle bodies and motor-vehicle parts; Carriages and wagons,including repairs, repair work only; Carriages and wagons,including repairs, cars and wagons; Carriage, wagon, sleigh, and sled materials; Automobiles; Carriages and wagons and materials; Automobile trailers (for attachment to passenger cars); Motor vehicles, motor-vehicle bodies, parts and accessories; Transportation equipment not elsewhere classified

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Industry 131 (Industry 1950: 379)

Cars and general shop construction and repairs by steam-railroad companies; Car and general construction and repairs, steam-railroad repair shops; Cars, street-railroad, not including operations of railroad companies; Cars, electric-railroad, not including operations of railroad companies; Cars, railroad and street, and repairs, not including establishments operated by steam railroad companies; Cars and general shop construction and repairs by steam railroad companies; Cars, electric and steam railroad, not built in railroad repair shops; Cars and general shop construction and repairs by street railroad companies; Cars and general shop construction and repairs by street-railroad companies; Cars, street railroad, not including operations of railroad companies; Car and general construction and repairs, electric-railroad repair shops; Cars, steam-railroad, not including operations of railroad companies; Cars, steam railroad, not including operations of railroad companies; Cars and car equipments-railroad, street, and rapid-transit; Cars and general shop construction and repairs by electric-railroad companies

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Industry 132 (Industry 1950: 377)

Bicycles and tricycles; Aeroplanes, seaplanes, and airships, and parts; Bicycles, motorcycles, and parts; Motorcycles, bicycles and parts; Aircraft and parts, including aircraft engines; Motorcycles, bicycles, and parts; Aircraft and parts

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Industry 133 (Industry 1950: 378)

Shipbuilding, including boat building; Shipbuilding; Shipbuilding, wooden, including boat building, yards where work on new vessels was done; Shipbuilding, wooden, including boat building, yards engaged entirely on repair work; Shipbuilding, wooden, including boat building, boats under 5 tons; Boat building and boat repairing; Shipbuilding, iron and steel; Shipbuilding, steel, repair work only, small boats, and masts, spars, oars, and rigging; Shipbuilding, steel, new vessels; Shipbuilding, steel, new vessels, small boats, and masts, spars, oars, and rigging; Shipbuilding, steel; Ship and boat building, steel and wooden, including repair work; Shipbuilding and ship repairing; Ship and boat building, wooden; Shipbuilding, steel, repair work only; Shipbuilding, wooden, including boat building; Shipbuilding, wooden, including boat building, masts, spars, oars, and the rigging of vessels

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Industry 134 (Industry 1950: 386)

Instruments, professional and scientific; Surgical appliances; Artificial limbs; Surgical and medical instruments; Surgical supplies and equipment not elsewhere classified; orthopedic appliances; Instruments, professional and scientific, medical and surgical; Surgical and orthopedic appliances, including artificial limbs; Surgical appliances and artificial limbs; Instruments, professional and scientific, except medical and surgical; Professional and scientific instruments (except surgical and dental)

Industry 135 (Industry 1950: 387)

Photographic materials, motion-picture films not exposed, and motion-picture projection films; Photographic apparatus, except cameras and motion-picture machines; Photographic apparatus and materials; Photographic materials; Photographic apparatus; Photographic apparatus and materials and projection equipment (except lenses); Photographic apparatus, cameras and motion-picture machines; Photographic materials, except motion-picture films; Photographic materials, motion-picture films; Photographic materials, except motion-picture films not exposed, and motion-picture projection films

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Industry 136 (Industry 1950: 386)

Optical goods; Optical instruments and lenses; Ophthalmic goods: lenses and fittings

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Industry 137 (Industry 1950: 386)

Dentists' materials; Dental goods; Dental equipment and supplies; Dental goods and equipment

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Industry 138 (Industry 1950: 399)

Musical instruments, piano and organ materials; Musical instruments, organs and materials; Muscial instruments: Organs; Musical instruments: Pianos; Musical instruments and parts and materials, not elsewhere classified; Musical instruments and materials, not specified; Musical instruments, pianos; Musical instruments, pianos and organs and materials; Musical instruments, parts, and materials not elsewhere classified; Musical instruments, pianos and materials; Pianos; Organs; Musical instruments, organs; Musical instrument parts and materials: Piano and organ; Piano and organ parts and materials

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Industry 139 (Industry 1950: 399)

Toys and games; Games and toys (except dolls and children's vehicles); Dolls (except rubber); Toys (not including children's wheel goods or sleds), games, and playground equipment

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Industry 140 (Industry 1950: 399)

Carriages and sleds, children's; Children's vehicles

Industry 141 (Industry 1950: 399)

Sporting and athletic goods; Sporting goods; Sporting and athletic good not elsewhere classified; Sporting and athletic goods, not including firearms or ammunition; Billiard tables and materials; Billiard tables, bowling alleys, and accessories; Billiard and pool tables, bowling alleys, and accessories

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Industry 142 (Industry 1950: 399)

Pens, steel; Pens, gold; Pencils (except mechanical) and crayons; Pens, fountain and stylographic; Pens, fountain, stylographic and gold; Artists' materials; Pencils, lead; Pens, fountain and stylographic; pen points, gold, steel, and brass; Pens, mechanical pencils, and pen points; Pencils, lead (including mechanical)

Industry 143 (Industry 1950: 399)

Stencils and brands; Hand stamps, stencils and brands; Hand stamps; Hand stamps, stencils, and brands; Hand stamps and stencils and brands

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Industry 144 (Industry 1950: 399)

Buttons

Industry 145 (Industry 1950: 399)

Jewelry and instrument cases; Jewelry cases and instrument cases

Industry 146 (Industry 1950: 399)

Feathers and plumes; Artificial feathers and flowers; Artificial flowers; Feathers, plumes, and manufactures thereof; Feathers, plumes, and artificial flowers; Artificial and preserved flowers and plants; Artificial flowers, feathers and plumes

Industry 147 (Industry 1950: 399)

Brooms and brushes; Brooms; Brushes; Brooms, from broom corn; Brushes, other than rubber; Brushes, except toilet; Brushes, toilet; Brooms, except from broom corn; Brushes, other than toilet

Industry 148 (Industry 1950: 399)

Furs, dressed; Furs, dressed and dyed

Industry 149 (Industry 1950: 399)

Umbrellas and canes; Umbrellas, parasols, and canes

Industry 150 (Industry 1950: 399)

Pipes (tobacco); Pipes, tobacco; Tobacco pipes and cigarette holders

Industry 151 (Industry 1950: 399)

Soda water apparatus; Soda fountains, beer dispensing equipment, and related products; Soda-water apparatus

Industry 152 (Industry 1950: 399)

Models and patterns; Models and patterns (except paper patterns); Models and patterns, not including paper patterns

Industry 153 (Industry 1950: 399)

Hair work; Hairwork

Industry 154 (Industry 1950: 399)

Needles, pins, hooks and eyes, and snap fasteners; Needles and pins; Hooks and eyes; Needles, pins, hooks and eyes, and slide and snap fasteners; Needles, pins, hooks and eyes; Needles, pins, and hooks and eyes

Industry 155 (Industry 1950: 399)

Fire extinguishers, chemical

Industry 156 (Industry 1950: 399)

Ivory and bone work; Combs; Fancy and miscellaneous articles, not elsewhere classified, paper and wood novelties; Fancy articles, not elsewhere specified; Fancy and miscellaneous articles, not elsewhere classified; Theatrical scenery and stage equipment; Ivory, shell, and bone work, not including combs and hairpins; Fancy articles, not else where specified; Ivory, shell, and bone work, not including buttons, combs, or hairpins; Miscellaneous fabricated products not elsewhere classified; Fancy and miscellaneous articles, not elsewhere classified, except beadwork, celluloid and metal novelties; Fancy and miscellaneous articles, not elsewhere classified, metal novelties; Fancy and miscellaneous articles, not elsewhere classified, except metal and paper novelties; Theatrical scenery; Combs and hairpins, not made from metal or rubber; Fancy and miscellaneous articles, not elsewhere classified, except beadwork, celluloid, metal and paper novelties; Fancy and miscellaneous articles, not elsewhere classified, metal and wood novelties; Fancy and miscellaneous articles, not elsewhere classified, beadwork and celluloid novelties; Fancy and miscellaneous articles, not elsewhere classified, paper novelties; Fancy and miscellaneous articles, not elsewhere classified, metal and paper novelties; Fancy and miscellaneous articles, not elsewhere classified, wood novelties; Fancy and miscellaneous articles, not elsewhere classified, except paper and wood novelties; Fancy and miscellaneous articles, not elsewhere classified, except metal and wood novelties; Combs and hairpins, except those made from metal or rubber; Lamp shades