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MORE POWER TO THE PEOPLE: ELECTRICITY ADOPTION, TECHNOLOGICAL CHANGE AND SOCIAL CONFLICT

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Abstract

There is a wide-spread concern that technical change may spur social conflicts, especially if workers are replaced with machines. To empirically analyze whether job destruction drives protests, we study a historical example of a revolutionary new technology: the adoption of electricity. Focusing on the gradual roll-out of the Swedish electricity grid between 1900 and 1920 enables us to analyze 2,487 Swedish parishes in a difference-in-differences framework. Proximity to large-scale water-powered electricity plants is used to instrument for electricity adoption. Our results confirm that the labor saving nature of electricity was followed by an increase of local conflicts in the form of strikes. But displaced workers were not likely to initiate conflicts. Instead, strikes were most common in sectors with employment growth. Similarly, we find that the strikes were of an offensive rather than a defensive nature. Thus, electrification did not result in rebellions driven by technological anxiety. It rather provided workers with a stronger bargaining position from which they could voice their claims through strikes.

JEL Classification: N14, N34, N74, O14

Keywords: Technological change, electrification, labor demand, Labor conflicts, strikes, infrastructure investments

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More Power to the People: Electricity Adoption, Technological Change and Social Conflict

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Abstract

There is a wide-spread concern that technical change may spur social conflicts, especially if workers are replaced with machines. To empirically analyze whether job destruction drives protests, we study a historical example of a revolutionary new technology: the adoption of electricity. Focusing on the gradual roll-out of the Swedish electricity grid between 1900 and 1920 enables us to analyze 2,487 Swedish parishes in a difference-in-differences framework. Proximity to large-scale water-powered electricity plants is used to instrument for electricity adoption. Our results confirm that the labor saving nature of electricity was followed by an increase of local conflicts in the form of strikes. But displaced workers were not likely to initiate conflicts. Instead, strikes were most common in sectors with employment growth. Similarly, we find that the strikes were of an offensive rather than a defensive nature. Thus, electrification did not result in rebellions driven by technological anxiety. It rather provided workers with a stronger bargaining position from which they could voice their claims through strikes.

Key words: technological change; electrification; labor demand; labor conflicts; strikes; infrastructure investments

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1 Introduction

The current debate on technological change and the labor market is ridden by anxiety. Empirical evidence suggest a "hollowing out" of the skill distribution; that middle-class or medium-skilled workers have been the most vulnerable to job loss during the last decades (Goos and Manning, 2007; David et al., 2006). A recent study warns that 48 percent of the American workforce could be replaced by computers within a few decades or so (Frey and Osborne, 2017). Some scholars have suggested that "technological anxiety" is channeled through the political system and manifested in increasing support for right-wing populism (Dal Bo et al., 2017; Frey et al., 2017).

Given the potentially large societal impact inherent in the introduction of new technology, we may expect potential losers to try to use non-market means to hinder the adoption of technology (Mokyr, 1992; Mokyr et al., 2015). These non-market means have taken different expressions. The most well-known historical examples are probably the Luddite uprising and the Captain Swing Riots in the wake of the First Industrial Revolution. It is easy to be caught by the dramatic and colorful stories of machine breaking. The question is, however, how representative anti-machine protests have been in the overall spectrum of the responses of workers to technological change. The Second Industrial Revolution was not associated with machine breaking. Frey (2019) suggest that the main reason for the absence of such conflicts was the increasing supply of good jobs that were relatively easy to learn. However, workers may not only use non-market means to save their jobs, they may also use similar means to take advantage of technological change to improve their jobs and wages. These "offensive" protests are easily disregarded, since they are rarely explicitly linked to machines.

This study analyzes the relation between technological change and social protests in 2,487 parishes in early 20$^{\text{th}}$ century Sweden. More precisely, we study the adoption of electricity and how it influenced labor conflicts in the form of strikes. Electricity was one of the cornerstones of the Second Industrial Revolution and enabled the mechanization of production and new ways of organizing it. Chronologically, Swedish electrification was early and influential and coincided with a documented increase in labor conflicts. Yet, these developments are rarely connected in the literature. Our analysis proceeds in two steps. Firstly, we establish the causal impact of electricity adoption on labor demand and strikes in local labor markets. Secondly, we dig into the mechanisms by providing evidence of changes in labor demand at different skill levels and different sectors. The frequency of strikes at the parish level has been drawn from a recently geo-coded and digitized dataset on work stoppages in Sweden and allows a separation between strikes based on offensive claims and those based on defensive claims.[1] We establish access to the electricity grid by digitizing contemporary survey

[1]See Enflo and Karlsson (2019) and Molinder et al. (2018). The dataset is stored at the Swedish National Data Service

maps. To control for the potential endogeneity of electricity adoption with respect to conflicts and labor demand, we use distance to state-run power plants as instrument for electricity access. Information on the occupational structure of each parish is based on full-count census data from the North Atlantic Population Project (NAPP).

Our results speaks broadly to three large debates in the field of economic history. Firstly, we add to the debate about technological change and social unrest. In the Luddite uprisings, the protests took a radical turn when textile workers physically destroyed the machines they feared would replace their labor. Similarly, agricultural workers demolished threshing machines during the Captain Swing riots in the 1830s. Whether new technology really was the root of the uprisings has been questioned. Mokyr et al. (2015), for example, have suggested that the Luddite and Swing Riots in fact may have been driven by a "multitude of causes" not necessarily caused by technological change. Potentially bi-directional causation between technology and protests and limitations in the available data pose severe challenges to an empirical identification. We follow Caprettini and Voth (2017) in using instrumental variable techniques to establish a causal connection between new technology and local protests. Our results indicate that, in contrast to Frey's (2019) account, electrification increased conflicts, but these conflicts were rather "offensive" (higher wage demands, etc.) than "defensive" ones (demonstrations against job losses, wage decreases, etc.). Offensive strikes were particularly frequent in manufacturing, where the demand for labor was increasing. Thus, we argue that electrification did not result in rebellions driven by "technological anxiety." The strikes were instead driven by workers taking advantage of their improved bargaining position.

Secondly, we contribute to the literature on technological change and the skill-composition of jobs in various historical epochs. Echoing modern studies on the effects of computerization (Frey and Osborne, 2017) and the Braverman (1974) thesis of the "degradation" of labor, we find that technological change influenced labor demand differently across the occupational structure. However, when it comes to electricity's impact on the skill distribution, the previous literature has not reached a consensus. Whereas Goldin and Katz (1998) argue that the Second Industrial Revolution was associated with an increased demand for skilled labor,[2] Gray (2013) and Leknes and Modalsli (2018) find that the skill structure was "hollowed out," since the demand for white-collar and unskilled jobs increased while the demand for semi-skilled work decreased. Or results show that the decrease in the demand for labor was particularly pronounced for low skilled workers, whereas electrification led to an increased demand for medium skilled workers, suggesting a "hollowing in," rather than a "hollowing out," of the distribution of skills.

(https://snd.gu.se/en/catalogue/study/snd1088), from which it can be obtained upon request.

[2]Prado and Theodoridis (2017) present results in the same direction for Sweden, but of smaller magnitude.

Finally, we speak to the debate about the effects of historical infrastructure investments on local growth. Previous results on the impact of electricity have been mixed, and mainly underline the importance of understanding to what extent electricity was able to coordinate the economic activity to particular locations. Economies of agglomeration appear large in early-developing regions and areas where electricity investments were accompanied by complementary infrastructure investments, thus signalling general faith in the region, which helped to coordinate expectations (Kline and Moretti, 2013; Leknes and Modalsli, 2018). In rural settings and where electricity investments mainly occurred along a gradually expanding network, the impact of the new technology mainly served to reduce the costs of machinery. In such a setting, electricity influenced sectoral specialization and structural change and had less of an impact on agglomeration or total labor demand. This seems to be the result of the gradual roll-out of the US electricity grid from the 1930s and onwards. Lewis and Severnini (2017) have for example estimated an expansion of the agricultural sector in remote rural areas following the expansion of the electricity network. That study only finds persistent population agglomeration effects in the counties that were the very first to electrify. Kitchens and Fishback (2015) look more deeply at the Rural Electrification Administration (REA) low-interest loans in the 1930s and establish productivity effects in agriculture, leading to a small reduction of labor input. Similarly, they do not find any net effect on the size and number of farms or on changes in the population. Our results side with these latter studies in that we do not estimate any net effect on aggregate labor demand. However, looking at sectors, we find that electricity drove structural change away from agriculture, into manufacturing and other non-agricultural sectors. Thus, employment growth in new industries were offset by a large decrease in the demand for low skilled workers in agriculture.

The rest of this paper is organized as follows. Section 2 lays out the conceptual framework, explaining how we think about electricity adoption as an exogenous impulse to local technological change, its impact on labor demand, and subsequent protests in the form of strikes. Section 3 explains the empirical strategy and data, while Section 4 presents the results. Section 5 concludes the paper.

2 Conceptual Framework and Historical Background

2.1 Electrification as a driver of local technical change

The notion of "electrification" involves two separate developments: (i) the increased use of electricity for lighting purposes; and (ii) the use of electricity to power machines (Sahlholm, 1984). With regard to lighting, Sweden was largely electrified already by the turn of the century (1900) (Hjulström, 1940). Most factories had installed some electrical power source that could generate enough electricity to light its interior using light bulbs. However, this study is primarily interested in the use of electricity for heating and motive purposes. In this regard, electrification began slowly in the late nineteenth century and accelerated in the first decades of the twentieth century, when different parts of the country became connected to the power grid.

Lacking domestic coal deposits, electricity played a key role in Sweden's transition from a predominantly agrarian economy to a leading industrial nation (Enflo et al., 2008). Sweden's industrial expansion had started in raw-material processing, such as iron and wood, but shifted to higher value-added activities, such as pulp and paper and engineering around the turn of the 20$^{\text{th}}$ century. The rapidly expanding engineering industry was spurred by homegrown innovations using electricity, such as the milk separator invented by Gustaf De Laval and technologies for telephone lines introduced by LM Ericsson. But Swedish engineers also played a role in the evolution of the system itself. The three-phase machines for the long-distance transfer of electricity was pioneered by ASEA, a company that was central in the expansion of the Swedish electricity grid. The technology was used by private entrepreneurs to build lines for the transmission of energy from the source of power generation, such as a waterfall, to the place where the energy was used to power machines. Some of the first users were mines and other capital-intensive firms that could afford to make the large investments necessary. Companies would often come together and pay for the construction of the power plant and the lines (Hjulström, 1940).

Access to the electricity grid provided a reliable and powerful source of electrical power. Before the grid, many industries could potentially connect to a local water-power source to generate electricity. Yet, there is wide-spread evidence that local water power sources were unreliable and often seasonal. The lack of water-power was especially prevalent in many local waterfalls during the summer months. Surveys that were carried out among firms in the beginning of the 20$^{\text{th}}$ century reveal the problems. Unstable or lacking energy supplies were stated as one main reason why firms could not expand production or modernize their machine park (Hjulström, 1940, 266).

Having access to the electricity grid was important for industry and agriculture alike. This is manifest in that firms and farms closer to the power grid were more electrified than those further away. ASEA (1912) details the farms which had installed electrical equipment for running the farm. The lists clearly indicate that estates located near the Olidan power plant made heavier use of electrical equipment. Morell (2001) report that the construction of the Älkarleby plant explains why farms were electrified to a greater extent in the Uppland region, where the plant was located.

Once connected to the grid, investments in electric motors were relatively affordable. The cost of a motor with three horsepower would amount to some 420 SEK, a little less than the yearly wage for an industrial worker during the early 20$^{\text{th}}$ century.[3] Such a motor could perform the most common tasks around farms and in rural industry. They were often installed in wheeled containers, which made them portable and suitable for multiple purposes (ASEA, 1912, p. 14–27).

2.2 The role of the state in the expansion of the power grid

From the beginning of the twentieth century, the state began to take on a more significant role in the expansion of electricity. With the three-phase system, it became feasible to take advantage of the large Swedish rivers that ran from the mountains in the north down to the eastern coast and the lakes in the south. A public company, The Royal Waterfall Board (*Kungliga Vattenfallsstyrelsen*), was set up with the purpose of exploiting these natural resources. They came to play a key role in the expansion of the national system that developed from this time onward.

Figure 1 depicts the electricity grid in the years 1906, 1911 and 1916 based on digitized survey maps provided by the Swedish National Archive, *Riksarkivet*. The rapid expansion of the network is striking: in 1906, less than 5 percent of parishes were traversed by the grid; by 1916, the number had increased to more than 40 percent. Through the construction of three plants for hydropower generation, the state had accelerated the expansion of the use and generation of electricity and determined much of its shape.

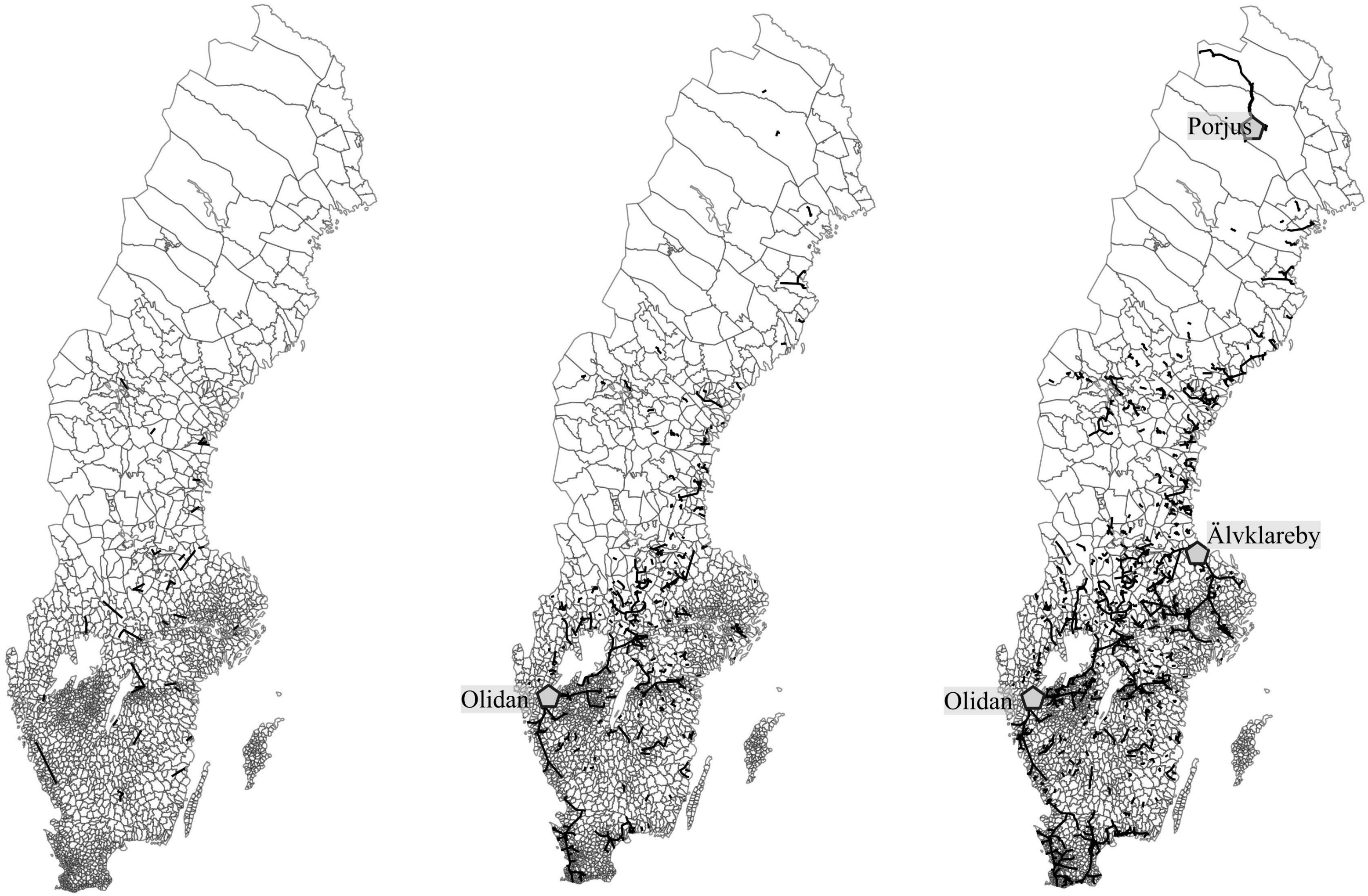
Figure 1 shows the location of the three state-run hydropower plants that were constructed during this period. Olidan was the first to be built. It began generating power for users throughout western Sweden in 1908. By then, the grid had expanded significantly relative to the situation in 1906, and the area around the Olidan power plant was one of the areas with a significant increase in access. By 1916, the state had built two additional plants: Älvkarleby in the east and Porjus in the north, shaping the continued expansion of the grid throughout the country.

The selection of the locations for the state-run hydroplants was guided by the availability of large waterfalls and their strategic location in a network intended to cover the entire country. For example the location of Porjus was selected based on its high potential for future capacity expansion (Hjulström, 1940, p. 168). Älvkarleby was chosen based on the availability of water power, but also with the explicit idea that the location was strategic for a future connection to the existing power plant in Olidan. By connecting these

[3] This calculation is based on the 140 SEK per horsepower around 1906–07 cited in Ljungberg (1990). The average yearly cost of an unskilled agricultural worker was about 600 SEK, according to data for 1907 presented in the Historiska lönedatabasen (HILD) at Göteborgs universitet.

two power stations, the industrial regions of Bergslagen (historically endowed with iron ore and specializing in industrial production, but with a lack of larger water-power resources) could be provided with a stable supply of energy (Hjulström, 1940, 170). Thus, although the needs of industry were a strong determinant in the development of the power grid, the immediate surroundings of the large state-run hydropower plants were not particularly industrial prior to the construction of those plants.

Figure 1: Rollout of the Swedish Electricity Grid, 1906–1916.



(a) 1906 **(b)** 1911 **(c)** 1916

2.3 Potential impact of electricity

2.3.1 Agriculture

The historical record indicates that the first farms to electrify were the greater estates that employed a large number of agricultural laborers. There were many operations on a farm that could be mechanized using electricity. If the farm moved from manual labor to machines in the process of threshing, cleaning, and crushing, the change was radical. But even in cases when many operations had already been mechanized through the use of steam and hand power, electric motors could save on labor (Morell, 2001). Traditionally, threshing—the first stage of the harvest after reaping—had been done manually. The person performing the task used a flail, consisting of two sticks connected by a chain, to hit a pile of grain, leading the wheat to be released from the husks. This process could be mechanized using a threshing machine that would beat the plants to make the seeds fall out. This machine could be run either by a horse or by a steam motor. Using an electric motor, however, there was no longer the need for someone to tend to the horse and it was not necessary to carry water and fuel to the machine. After threshing, the grain and the chaff have to be separated. This was originally done by hand, through winnowing, a process which uses the fact that the chaff is lighter than the grain and blows away when thrown in the air, while the grain returns to the basket. This was likewise a very labor-intensive task that could be mechanized by a cleaning machine. The machine was fed in the front by one person and another person was needed to crank. When an electric motor was installed to run the machine, the worker doing this task could be spared. The final stage is the crushing and grinding, when the grain is turned into flour. This process was originally done by hand by crushing the grain against a rock. Most often, watermills or windmills were used, and farmers could bring the grain that they intended to sell on the market to the local miller. However, there were also uses for crushing and grinding on the farm, for example, to produce feed for the animals. These machines were often driven by hand, and so an electric motor could replace the labor needed to perform this task. There were numerous other uses for electric motors on the farm as well. Pumps and dairy machines could be used in a more flexible way. Many of the machines used on the farm for carpentering and blacksmithing could be run with an electrical engine, reducing the need for assistants in these activities. Cutting of wood for fuel and heat could also be mechanized, and elevators could be installed and used for lifting. Electric heating also reduced the need to chop and transport of firewood.

As most uses for electric motors on the farm appear to have saved on unskilled labor, the effect of labor-saving mechanization likely had different implications for large farms, where most of the work was performed by hired laborers, than in the situation on yeoman-farms, where the family of the owner made up the majority of the labor force. This was expressed in a Swedish public investigation on the subject in 1924, which stated, regarding the economic benefits of electrification, that:

"This value is mainly dependent on whether electrification allows for a reduction of the labor needed on the farm. [...] [O]nly when the labor released can be used for other productive activities or allow for a reduction in the workforce, will there be a reduction in costs. The possibilities for this are greater on larger farms than small. For smallholders, where the owner and his family alone are performing the work, even the theoretical possibility of reducing the labor force becomes ineffective (SOU 1924:52)"

Kitchens and Fishback (2015)'s study of the Rural Electrification Administration, which focused mainly on smaller farm households in the United States during the 1930s, underlines the positive impact on farm productivity, while downplaying the effects on labor demand. They find that output and crop productivity both rose with access to electricity, while there was no statistically significant impact on the use of hired laborers or family workers. In contrast to the REA, large estates appear to have been the forerunners in electrification in Sweden in the early twentieth century. For this reason, we believe that the effect on employment was greater for unskilled agricultural laborers than for the yeoman-farms.

2.3.2 Manufacturing

In manufacturing, electrification was less obviously associated with skill-biased technological change or a general reduction in the demand for labor. Instead, electricity stimulated mechanization and may have given rise to new products, fields, and occupations, as well as influencing the pattern of the location of enterprises, thus freeing enterprises from their previous geographical constraints. In the late 1930s, a government inquiry (Rationaliseringsutredningen, 1939) established that "The firms have become less dependent on proximity to previously used energy sources [and that] small-scale industry has been able to emerge in locations which previously had lacked the opportunities for manufacturing activities."

Mechanical engineering, a sector of growing importance and the most well-researched one in the manufacturing sector, was among the early adopters of electricity (Norgren, 1992). Here, electrification meant a gradual replacement of previous systems of transmittin the power to each unit. Ultimately, each machine was either connected to or integrated with an electric motor. In some firms, such as Munktells in Eskilstuna, this transition was basically completed already in the late 1910s (Magnusson, 1987). In many cases, however, the move to unit drive was preceeded by group drive arrangements, where a group of machines were connected to an electric motor.

At Munktells, electrical lathes could be run at twice the speed of the old semi-manual lathes (Magnusson, 1987). Electricity not only helped to mechanize the actual production, but also the transport within the factory, using cranes and traverses. The decreased reliance on a single power source meant that the physical layout of the shopfloor could be more flexible. Machines no longer had to be placed along central shafts. Shopfloors became less crowded and lighter, as machines were removed from windows. Moreover, the relative demand for different kinds of occupations changed. Referring to Swedish mechancial engineering more generally, Olsson (1979) observes that the share of non-skilled workers increased, which was also the case at Munktells.[4] Looking at particular occupational groups, the so-called machine workers (*maskinarbetare*) increased in relative numbers, along with manual laborers (*grovarbetare*),[5] whereas the share of craft workers, such as tool and die makers and sheet metal workers, decreased. If we focus on blue collar workers, the electrification period at Munktells saw a tendency to de-skill. Taking into account white collar workers, which doubled its share of total employment, however, the same tendency can be described as "hollowing out."

2.4 The organization on the labor market

With industrialization there occurred a shift of labor out of agriculture and into industry and services. Swedish urbanization started to gain ground in the 19$^{\text{th}}$ century, but from very low levels by international standards. Many of the industries that led in the first phase of industrialization were tied to natural resources. In 1900, 60 percent of all industrial workers were found in the countryside (Berger et al., 2012). With the growth of the industrial working class there came increasing attempts to organize collective action from the side of workers. Unionization had started in the 1870s and the first national organizations were formed in the 1890s. Around that time, union density was still below 2 percent, but would grow to about 17 percent by the early twentieth century. There were also considerable differences between industries and occupations. For example, about 50 percent of the skilled workers in large mechanical-engineering factories were unionized. Similar levels would not be reached among agricultural workers for several decades.

During the early 20$^{\text{th}}$ century, union activity was still in its infancy and most labor organizations were local in nature. Union recognition was won around the the first years of the century. Yet, the period is characterized by labor conflicts that were large, frequent, and long. Sweden stands out as one of the

[4] Magnusson (1987) points out that this was not just simply a reflection of a reduced demand for skilled labor, but also a consequence of the company's expansion in a period when there was a shortage of labor. Skill levels were partly determined by age and length of employment. An influx of young workers would by definition increase the share of non-skilled workers.

[5] This may seem counterintuitive, as transport was mechanized. Magnusson (1987) argues that the increased share of laborers was due to an overall expansion of production, which brought along "more material to handle, more spaces to clean, more products to wrap and unpack."

most strike-prone countries in the industrial world Shorter et al. (1974). Table 1 summarizes all strikes, categorized by cause, during our analysis period. As shown in the table, a majority of strikes concerned offensive claims, such as wage increases. Defensive claims (against wage decreases or layoffs) were much less common. A struggle for union recognition can only be discerned in a small minority of cases, whereas "other causes" (collective agreements, hours, personal issues, as well as those with multiple causes and other causes) constituted a significant portion during certain years.

Table 1: Number of Strikes and Strikes by Cause

		Cause: % of total			
Year	(1) Total	(2) Offensive	(3) Defensive	(4) Union Recognition	(5) Other
1907	312	37	11	3	50
1908	302	42	14	3	41
1909	138	46	20	1	36
1910	76	41	16	0	45
1911	98	47	22	1	31
1912	116	47	15	1	38
1913	119	55	10	1	36
1914	115	55	17	0	30
1915	80	49	11	0	40
1916	227	69	5	0	27
1917	475	66	9	1	26
1918	708	67	6	0	29
1919	440	63	6	0	31
1920	486	66	11	1	23

Note: An offensive strike is defined as one over wage increases; defensive strikes are all conflicts caused by wage decreases or layoffs. "Other" include strikes over collective agreements, hours, personal issues, as well as those with multiple and other causes. Source: Enflo and Karlsson (2019)

3 Empirical Strategy and Data

We construct a panel dataset based on 2,487 parishes from three benchmark years. A map of historical administrative borders provided by the National Archive *Riksarkivet* was used to construct parish-level data at unchanging historical borders. To measure electricity adoption, strikes, and employment structure, we combined data from three sources.

For electricity adoption, digitized survey maps of the Swedish electricity grid in 1906, 1911 and 1916, give us a spatially coded dataset on the geographical location of all power lines in existence. This information allows us to construct a dummy indicator that takes the value of 1 if the parish is traversed by a line and 0 otherwise.

Data on industrial conflicts comes from Enflo and Karlsson (2019) and includes information on the place of the conflict, the cause of the dispute, as well as the industry that the striking workers belonged to. We assign geographical coordinates to every location where there was a strike and then construct three indicators of strike activity. The first measure counts the total number of strikes, the second and third tally the number of offensive and defensive strikes, respectively. Following Table 1, we define offensive strikes as those concerning demands for wage increases. Defensive strikes are those that were induced either by layoffs or attempts to avoid wage cuts. All strike data was coded by sectors of economic activity.

For temporal coherence with the survey maps, we aggregate the strike data to cover the five years following the year covered by the map (i.e., 1907–1910, 1912–1915 and 1917–20).[6]

We collect data on the occupational structure of each parish by aggregating census information on the number of persons involved in different activities. The digitized census from NAPP was used for this. Unfortunately, this data is only available for 1900 and 1910, so the scope of the analysis concerning the employment structure is limited to those years. The occupations recorded in the census are assigned to different categories of skill, using the HISCLASS class scheme. This is a system that divides historical occupations into 12 categories, ranging from elite to unskilled farm workers. To make the interpretation of our results easier, we use an abbreviated version of HISCLASS, with only seven groups. These are: "1. Elite," "2. White collar," "3. Foremen," "4. Medium skilled," "5. Farmers," "6. Low skilled," and "7. Unskilled". The HISCLASS scheme and our aggregate categories are described in more detail in Appendix D.

Finally, we assign the occupations to the main economic sectors. There is sufficient detail in the source data to allow us to code the occupations into three broad sectors: agriculture, industry and "other." In manufacturing and "other," we are able to identify the three occupational groups of unskilled, low skilled and medium skilled workers. In agriculture, we can code unskilled and low skilled workers, but there are no occupations designated as medium skilled. It is also not possible to code any of the three most highly skilled groups, viz., elite, white collar workers, and foremen, to specific economic sectors, since the occupational titles do not provide sufficient detail. It should be noted, however, that the shares of these groups in overall employment was very low in early twentieth century Sweden.

Agriculture remained the largest sector in the Swedish economy until the 1930s, and we find jobs such as farm workers, farmhands, and assistants in dairy production in the unskilled category, while dairymen, dairymaids and charcoal burners belong to the low-skilled group. In manufacturing, we find job categories

[6] We tried different specifications with regards to aggregating the data, for example covering census years instead. However, the results are not sensitive to alternative forms of aggregation.

such as machine workers and manual laborers among the unskilled, and founders, metal workers, and weavers among the low skilled. Finally, jobs that could not be assigned to either agriculture or manufacturing were assigned to "other." Here we find many jobs in the service sector, such as stokers, telephone workers, and electricity workers among the medium skilled, and coalers and drivers among the low skilled.

Based on Section 2.3, we expect electrification to reduce the demand for jobs at the lower range of the skill distribution in agriculture, but potentially increase it in manufacturing. Decreasing demand for agricultural workers is in line with large estates replacing many jobs with machines. The increased demand for low skilled labor in manufacturing is in line with the new forms of organization as a consequence of the installation of electricity and unit drive in machines. It is harder to articulate expectations for the changing demand for workers in the "other" category. The demand for jobs such as electricity workers should naturally be expected to increase, while other jobs could be more responsive to the structural change away from agriculture in general. The sizes of the effects is an empirical question.

3.1 Regression Framework

Our regression specification takes the form

$$y_{i,t} = \alpha + \beta \, electricity_{i,t} + \mu_i + \lambda_t + \epsilon_{i,t}, \tag{1}$$

where $y_{i,t}$ is the logarithm of the outcome variable + 1 (number of strikes or employment in total and by sector) i in year t. If parish i in year t is connected to the grid, the dummy variable $electricity_{i,t}$ takes the value 1, and 0 otherwise. Parish-fixed effects μ_i ensure that variation in the model is restricted to parishes that actually experienced a change in access to the grid, while holding all other non-varying parish-specific effects constant, and a full set of time dummies, λ_t, control for common time trends. The panel data structure with time- and parish-fixed effects allows a difference-in-difference design and interpretation of the estimates. We cluster standard errors at the parish level throughout.

To address the potential endogeneity of electricity adoption, we follow the approach of Lewis and Severnini (2017) in using the proximity to major power plants as a source of exogenous variation in access to electricity. The idea behind this measure is that districts that happened to be close to a power plant were in all other respects similar to areas that were located further away. After construction, however, the cost of gaining connectivity differed significantly between areas, since the price of access was fundamentally dictated by the distance to the power-generating source. This method is similar to the approach taken by Kitchens and Fishback (2015), who argue that the potential costs of distributing electricity are strongly correlated with the distance to the existing electricity grid. In our analysis, we use the distance to the three major plants for hydropower generation constructed by the state during the period. The idea of this instrument is illustrated in Figure A1 in the Appendix, which shows binned scatter-plots illustrating the relationship between distance to the plant and access to electricity before and after its construction, for each of the three state-owned hydroplants. The figure records the absence of a link between distance to the site and access to the electricity grid before the inauguration of the plants. Once a plant was constructed, however, the parishes located in its proximity were significantly more likely to have access. We instrument for access to electricity using the distance to each of the state-run power plants in the first year in the dataset after the plant was inaugurated.

4 Results

4.1 Main Results

Our main results, organized into four outcome variables, are presented in Table A2. Column 1 reports the effects of electricity on total labor demand as signified by the change in the size of the labor force. Columns 2–4 of the table report outcomes with respect to total strikes, and divided between offensive strikes and defensive strikes, respectively.

The first part of the table compares the naïve OLS estimates (top) to the more meaningful IV results (below). The following part of the table gives the first stage estimates and shows that there is a statistically highly significant correlation between the distance to the state-run plants and access to the electricity grid. For the results on labor demand, we are limited to the sample 1900–1910, meaning that the IV estimates only include the distance to the power plants that existed in 1910 (Olidan). For strikes, we are able to use the period until 1920 and include distance to the power plants Porjus and Älvkarleby, which were built later.

As expected, the OLS and IV estimates differ. The OLS estimates in column 1 show the positive bias in terms of labor demand on electricity adoption. Unsurprisingly, fast growing parishes were more likely to adopt electricity, resulting in a correlation of 6.43 log points (the equivalent of about a 7 percent higher labor demand in electricity-adopting parishes 1910 compared to 1900). However, instrumenting for this potential endogeneity, the IV suggests a negative, but statistically insignificant, causal shock from electrification. Thus, our estimates imply that the net causal effect of electricity on demand for labor seems to have been statistically indistinguishable from zero. This result is in line with the previously-mentioned studies showing no short run impact on labor demand in electrifying rural areas (Kitchens and Fishback, 2015; Severnini, 2013).

In light of the absence of positive effects on labor demand estimated in column 1, it is perhaps not surprising that the number of strikes rose. Column 2 shows the effect on the total number of strikes. Again, the IV estimates suggest a much larger effect (45 log point increase) than the naïve OLS. It is tempting to draw the conclusion that workers used strikes as a way to oppose potential layoffs or wage decreases following the reduction in labor demand. However, our IV estimates for the impact of offensive and defensive strikes tell a different story. While defensive strikes rose by only 14 log points, offensive strikes, that involved demands for wage increases, grew by about 38 log points. The OLS estimates show a similar compositional effect towards offensive strikes, but at much lower levels.

Table 2: Main Results

Dependent Variable:	(1) Log(1+Labor Force)	(2) Log(1+Total Strikes)	(3) Log(1+Offensive Strikes)	(4) Log(1+Defensive Strikes)
OLS				
Electricity (Dummy=1)	7.51**	1.9	3.2**	0.0
	(2.887)	(1.389)	(1.304)	(0.583)
	(1.866)	*(2.370)*	*(1.962)*	*(0.430)*
IV				
Electricity (Dummy=1)	-5.3	45.8***	38.3***	13.9*
	(4.13)	(14.18)	(13.14)	(7.49)
First stage (IV)				
Distance to Olidan (1910)	-.066***	-0.066***	-0.066***	-0.066***
Distance to Olidan (1920)		-0.061***	-0.061***	-0.061***
Distance to Porjus (1920)		-0.104***	-0.104***	-0.104***
Distance to Älvkarleby (1920)		-0.022	-0.022	-0.022
1910 (Dummy=1)	.564***	0.564***	0.564***	0.564***
1920 (Dummy=1)		1.569***	1.569***	1.569***
Mean dependent variable	583	13.02	8.98	2.17
St. dev. dependent variable	104	42.71	34.26	14.36
Parish FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	4946	7461	7461	7461
No. of parishes	2479	2487	2487	2487
Cragg–Donald Wald F-statistic (first stage)	39.07	11.18	11.18	11.18

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Standard errors in italics computed using Conley's method assuming linear decay and cut-off at 100 km.

4.2 Employment Growth by Occupation

To understand the mechanisms behind electrification's impact on strikes, we now turn to discussing its impact on the demand for workers, separated by skill levels and sectors. This allows us to dive deeper into the changes that took place as a parish gained access to electricity. Again, we estimate the instrumented version of the regression explained in 1. This time we replace the previous four outcome variables with the employment in each of the seven HISCLASS-coded occupational groups, and for ease of interpretation we present the results in a figure. Figure 2 displays the resulting coefficients on the impact of instrumented electricity on the different occupations, presented in order of the level of skill needed for the job (the full regression tables can, however, be found in Table A1 in Appendix A).

The pattern in Figure 2 can at best be described as occupational upgrading. Looking at the three highest skilled groups (the elite, white collar workers, and foremen) in the figure, we do not detect any sign of electricity being a skill-biased technology. Medium-skilled workers increased by more than 100 percent, while farmers do not seem to be impacted by electricity. Among the low skilled and the unskilled, the reduction of employment effect is estimated to between 100 and 50 log points.

Our results do not support the notion of electricity as a skill-biased technology (Goldin and Katz, 1998), nor as driving occupational hollowing out (Gray, 2013). Our pattern regarding the impact of electricity can rather be described as "hollowing in," with employment growth by more than 100 log points in medium-skilled occupations. As expected, electricity has no impact on the demand for farmers, quite in line with the notion that self-owning yeomen were unlikely to adjust their family labor force with the advent of mechanical operations on the farm (Olsson, 1979). However, it is possible to reconcile our "hollowing in" with the previous results by remembering that the above-mentioned studies focus on the manufacturing sector only. Looking at the American economy in the same period more broadly, Katz and Margo (2014) found neither deskilling nor hollowing out, emphasizing that it may not be correct to infer economy-wide patterns of occupational change from those occurring in manufacturing alone.

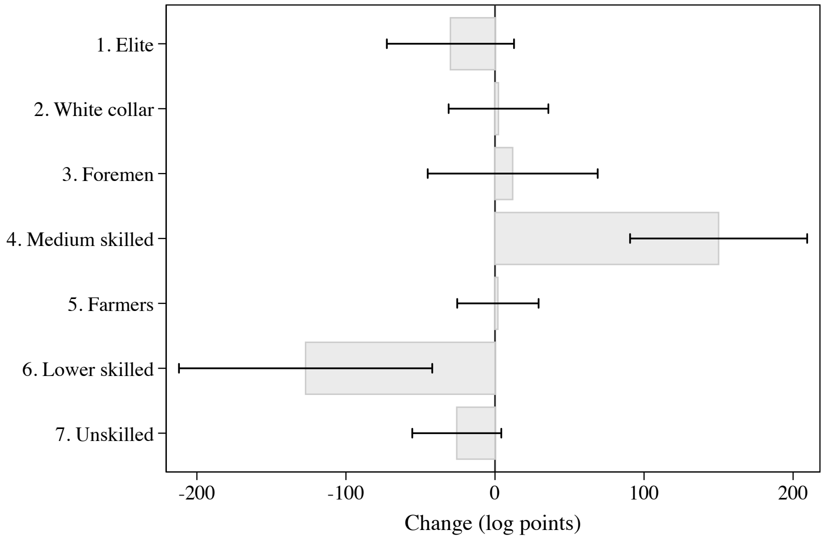
4.3 Employment Growth by Sectors

Following up on the large distributional shifts that we estimate in the medium to lower ranges of the skill distribution, we want to consider if groups were affected differently in different sectors. The results for medium, low, and unskilled workers, separated by whether they belonged to the agricultural, industrial, or other sector, are shown in Figure 3. The corresponding regression table is available in Appendix A, Table A2.

The top part of Figure 3 shows the evolution for low skill groups in agriculture.[7] In line with the observation that electrification in agriculture made it possible to save on unskilled labor in many operations, we find a fall in employment by about 200 log points among low and unskilled workers relative to parishes that did not gain access to electricity. Since agriculture remained the largest sector of the Swedish economy

[7]Note that we are not able to estimate the impact of electrification on the demand for medium skilled workers in agriculture, due to the lack of occupations coded to that group.

Figure 2: Regression Results for Absolute Growth of Occupational Groups



Note: This figure shows coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the growth of employment by skill group. Standard errors clustered at the parish level. The full regression tables can be found in Table A1 in Appendix A

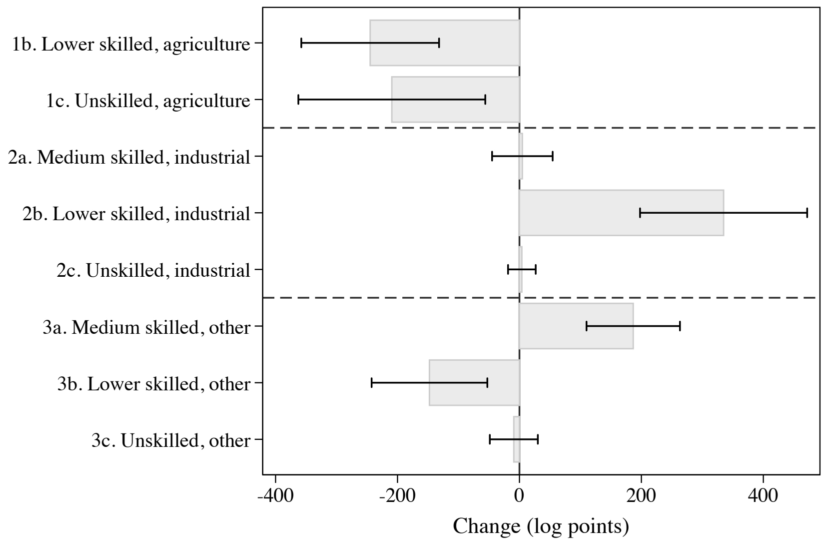
until the 1930s, this is a substantially important change. The results are also interesting in relation to the effect on farmers shown previously in Figure 2, who were not impacted by electricity. This suggests that larger agricultural estates with many workers employed were the ones to adjust their use of labor following electrification, while self-owning farmers were less affected.

For the industrial sector, displayed in the middle part of the figure, we find that employment among the low skilled increased after electrification, while the effects were small and statistically insignificant for the medium skilled and the unskilled. An increase in employment among this group is consistent with increasing productivity from new ways of organizing work and installing, for example, unit drive in machines.

Finally, the lower part of the figure shows the shift in the other sectors. There was a positive change in the number of medium skilled workers. For the group of low skilled workers in the same economic activities, employment fell instead.

Taken together, our results suggests that electrification drove a relatively substantial shift in terms of occupational upgrading and sectoral specialization. The agricultural sector contracted in terms of unskilled workers, whereas farmers were left unchanged by the new technology, quite in line with the expectations we formed about large-scale farming and electricity. We are, however, able to observe a large relative increase among low skilled industrial workers and the medium skilled in sectors outside agriculture and manufacturing. To what extent new jobs in the expanding industrial and other sectors could be offered to the displaced agricultural workers, or whether they were able to seek employment outside the parish, is a question beyond the scope of this paper. The differing skill levels in the contracting versus the expanding sectors, suggests the existence of either migration or educational upgrading to meet the new requirements.

Figure 3: Regression Results for Absolute Growth of Employment by Occupational Group by Sector



Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the growth of employment for occupational groups by sector. Standard errors clustered at the parish level. The corresponding regression tables are found in Appendix A, Table A2. We do not report sectoral skill categories for the higher skill groups, since they cannot easily be allocated to sectors. It should also be noted that we did not find any results on those in the regression results presented in Figure 2.

4.4 Robustness of Results for Occupational and Sectoral change

One concern with the regressions in Figure 2 is that the coefficients reported are measured as change relative to the initial year. This means that we can only relate the impact of electricity between shocked parishes and others relative to their initial situation. If a certain sector was very small to begin with, the relative differences might look overly large. We might therefore wish to look at the impact of electricity on the composition of skills as shares of the total. These results are reported in Table A4 in Appendix B. The results look very similar to those reported for absolute changes. The medium skilled group increased its share by about 10 percentage points while low skilled workers decreased by about 11 percentage points. With the exception of foremen, which dropped by almost 2 percentage points, the remaining occupational groups did not experience a statistically significant change in their share of employment, just as in the regression estimating absolute changes.

As mentioned previously, Sweden in the early 20$^{\text{th}}$ century was a preponderantly rural and agricultural country. Yet, we might worry that our results are driven by developments taking place mostly in the urban sector. To address this concern, we provide additional results in Table A5, where we estimate the impact on each occupational group when we drop the one-third of parishes with the highest population density in 1900. The results presented in Table A5 are very similar to those for the full sample of parishes. The effect on medium skilled and low skilled workers are both highly statistically significant. Focusing on the rural part of the sample also increases the size of the coefficients. The impact on medium skilled workers is 177.9 percent compared to 150.1 percent in the full sample, while the effect on low skilled workers is larger yet, -361.7 percent compared to -127 in the full sample. The negative impact of electricity adoption on low skilled workers is even stronger in rural areas, where we might expect agriculture to be the dominant sector.

A similar concern might apply to more industrial parishes. While urban areas tended to have a larger industrial base, in the Swedish case there were many parishes in the countryside with significant fractions of employment in manufacturing. In Table A6 we estimate the impact on each occupational group when we drop the one-third of parishes with the highest share of manufacturing in total employment in 1900. When restricting the sample to the least industrialized parishes, we once again find results similar to those in the full set of parishes. The impact on medium skilled workers is slightly smaller: 143.3 percent compared to 150.1 percent in the full sample. The effect on low skilled is slightly larger: -190.7 compared to -127.

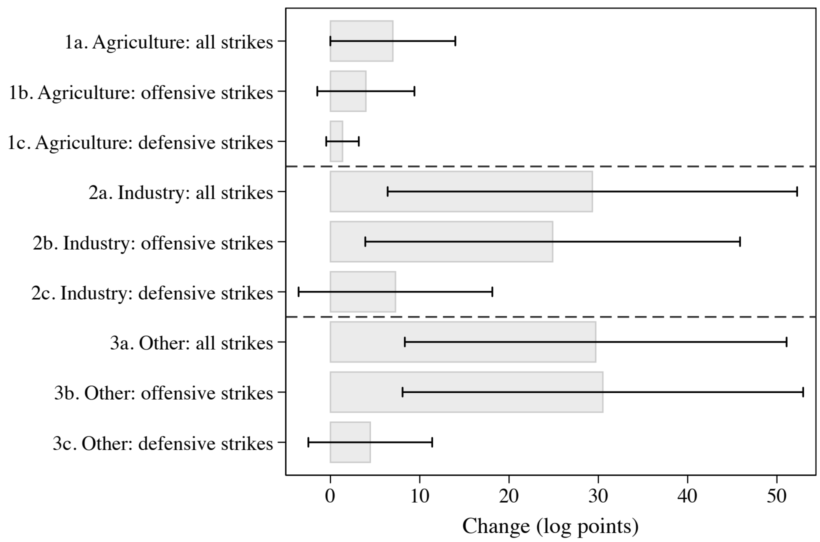
4.5 Strikes by sector

Following the previous literature and the examples from the Swing riots and the Luddites, we expect to see large protests among the groups that were hit hardest by the new technology, i.e., low skilled and unskilled agricultural workers. In Figure 4, we run our regression with number of strikes, divided into offensive and defensive, by the three sectors mentioned before (agriculture, industry, and "other"). As shown in the figure, the increase in the total number of strikes in the agricultural sector is small and just barely statistically significant, while that for in offensive and defensive strikes cannot be distinguished from zero. The displaced agricultural workers do not appear to have met the fear of being replaced by machines by mounting large scale protests.

Instead we see how the total number of strikes increased in manufacturing. The figure reports the coefficients of the instrumented electricity dummy, showing that the largest increase in strikes (about 60 percent) is estimated for industrial occupations. The strikes of offensive nature increased by almost the same magnitude, while the increase in defensive strikes is smaller (some 10 percent) and not statistically significantly different from zero.

Finally, the other sector also displays more strikes. Again, offensive strikes are the source of the increase, whereas the defensive claims are not statistically significant. These results suggest that the expanding sectors outside of manufacturing also saw their labor market position improving and could claim the benefits by asking for more from employers.

Figure 4: Regression Results for Strikes by Sector



Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the increase in the number of strikes. Standard errors are clustered at the parish level. The corresponding regression tables are found in Appendix A, Table A3.

4.6 Robustness of Results for Strikes by Sector

Just as with the results for occupational change, one worry could be that the results for strikes are driven by developments in urban areas. In Table A7 we estimate the effect on strikes in each sector while dropping the one-third of parishes with the highest population density in 1900. The results presented in Table A7 are very similar to those for the full set of parishes. The effect on all strikes and offensive strikes is significant for the manufacturing and "other" sector, and the point estimates are very similar to those in the baseline regression.

In Table A8 in the Appendix, we also test whether excluding the one-third of parishes with the highest share of manufacturing in employment affects the results. Here, the difference is somewhat larger compared to the regression with the full set of parishes. While the effect on all strikes and offensive strikes is statistically significant both in the case of manufacturing and "other," the point estimates are smaller. The effect on all strikes is 15 log points in manufacturing and 12.4 log points in "other," compared to about 30 log points in both cases in the baseline regression. This is an indication that already industrialized areas saw a larger increase in labor militancy with the arrival of electricity.

5 Conclusions

By investigating the relationships between the roll-out of the electricity grid, the demand for labor, and labor conflict in early twentieth century Sweden , this paper contributes to three major debates in the field of economic history, and the social sciences more generally.

The first debate concerns how technological change influences social conflict. We establish a strong and causal increase in strikes following electrification. However, the conflicts caused by electrification were typically not conflicts with the intention of blocking technological development. Conflicts with the openly declared intention to resist mechanization were extremely rare. Electrification was more associated with workers demanding higher wages and better working conditions, rather than workers defending their status quo. This pattern can easily escape observation since workers did not explicitly relate their demands and actions to electrification. Looking at the past two centuries, offensive worker responses to technological change have probably been much more common than protests of the same kind as the early nineteenth-century Luddites and Captain Swing Rioters, although the voices of the latter have made a huge imprint in the popular understanding of history.

Concerning changes in the skill distribution, the second debate, we find that electricity did not drive any net changes in the demand for labor. Instead, it had large impacts on structural change, with unskilled and low skilled workers in agriculture mainly made redundant. We do not find evidence of a "hollowing out" of the skill distribution, echoing the need to look at the entire economy, and not just manufacturing, as pointed out by Katz and Margo (2014).

Regarding the third debate, we do not find evidence of agglomeration effects from electrification. This is in contrast to Leknes and Modalsli (2018); Kline and Moretti (2013). Although we find that electrification did have an impact on structural change towards manufacturing, the net effects on labor demand were cancelled out by decreases in the demand for agricultural labor. We believe this is due to the rural character of the parishes under study. While labor costs decreased, the associated income gains were not large enough to offset the effects by driving increasing demand locally. Therefore, unoccupied unskilled agricultural workers had to seek their fortune elsewhere. Electrification could potentially be a driving factor behind the onset of urbanization. However, the mechanism may have operated by pushing workers out of agriculture rather than pulling them into the city. Instead, parishes that were connected to the grid saw an increasing demand for medium skilled workers, as well as low skilled workers in manufacturing.

Our findings concerning technological change and conflicts point to a couple of issues worth further research. Currently, we see strikes rising in sectors where workers inhabit a strategic position with respect to the value-creation chain, for example in the transport sector. Our paper shows that strike patterns can be influenced by technological change by affecting workers' relative bargaining position. Future research should pay closer attention to the role of unions as strategic interactors in the response to technological change. Labor mobility is a related question that needs further scrutiny to fully understand union politics and the bargaining power of workers. To what extent could, and did, workers move between regions, sectors, industries, and occupations, and how did mobility influence the bargaining power of the workers? Finally, we suggest that future accounts of the Second Industrial Revolution pay closer attention to the developments in agriculture. The role of electricity as a pull factor driving urbanization should also be supplemented with an understanding of how it also pushed workers out of the countryside by driving the mechanization of many agricultural jobs.

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Appendix A Regression Tables (Main results)

Table A1: Regression Results for Absolute Growth of Occupational Groups

	(1) Elite	(2) White collar	(3) Foremen	(4) Med. skilled	(5) Farmers	(6) Low skilled	(7) Unskilled
Electricity (Dummy=1)	-29.8	2.5	12.0	150.1***	1.9	-127.0***	-25.6*
	(21.768)	(17.072)	(29.108)	(30.334)	(13.936)	(43.353)	(15.234)
Mean	152.5	312.1	201.8	332.7	460.2	352.6	505.1
(SD)	107.5	118.5	122.8	119.5	92.90	138.4	94.08
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4946	4946	4946	4946	4946	4946	4946
No. of parishes	2479	2479	2479	2479	2479	2479	2479
Cragg–Donald Wald F-statistic (first stage)	39.07	39.07	39.07	39.07	39.07	39.07	39.07

Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the growth of employment by skill group. The coefficients are displayed graphically in Figure 2. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: Regression Results for Absolute Growth of Employment for Occupational Groups by Sector

	Industry			Agriculture	
	(1) Med. skill	(2) Low skill	(3) Unskilled	(4) Low skill	(5) Unskilled
Electricity (Dummy=1)	4.9	335.0***	4.1	-244.7***	-209.2***
	(25.346)	(69.976)	(11.590)	(57.647)	(78.223)
Mean	257.1	131.6	4.95	129.9	217.4
(SD)	118	139.8	28.33	130.7	163.6
Parish FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	4974	4974	4974	4974	4974
No. of parishes	2487	2487	2487	2487	2487
Cragg–Donald Wald F-statistic (first stage)	39.07	39.07	39.07	39.07	39.07

Note: The coefficients are displayed graphically in Figure 3. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A3: Regression Results for Strikes by Sector

	Agriculture			Manufacturing			Other		
	(1) All strikes	(2) Off. strikes	(3) Def. strikes	(4) All strikes	(5) Off. strikes	(6) Def. strikes	(7) All strikes	(8) Off. strikes	(9) Def. strikes
Electricity (Dummy=1)	7.0*	4.0	1.4	29.3**	24.9**	7.3	29.7***	30.5***	4.5
	(3.570)	(2.774)	(0.930)	(11.698)	(10.706)	(5.534)	(10.906)	(11.444)	(3.538)
Mean	1	0.60	0.09	9.8	6.81	1.99	4.66	3.53	0.50
(SD)	9.307	7.157	2.536	35.7	28.85	13.66	24.57	20.19	6.474
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cragg–Donald Wald F-statistic (first stage)	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2
Observations	7461	7461	7461	7461	7461	7461	7461	7461	7461
No. of parishes	2487	2487	2487	2487	2487	2487	2487	2487	2487

Note: The coefficients are displayed graphically in Figure 4. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix B Regression Tables (Robustness)

Table A4: Regression Results for Change in Occupational Groups' Shares

	(1) Elite	(2) White collar	(3) Foremen	(4) Med. skilled	(5) Farmers	(6) Low skilled	(7) Unskilled
Electricity (Dummy=1)	-0.5	-0.8	-1.7***	9.7***	4.2	-10.9***	-0.0
	(0.292)	(1.054)	(0.661)	(1.965)	(3.639)	(4.000)	(3.980)
Mean	1.07	5.60	1.52	7.49	31.35	9.24	43.71
(SD)	(1.00)	(3.69)	(1.40)	(4.44)	(14.56)	(8.01)	(10.71)
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4946	4946	4946	4946	4946	4946	4946
No. of parishes	2479	2479	2479	2479	2479	2479	2479
Cragg–Donald Wald F-statistic (first stage)	39.07	39.07	39.07	39.07	39.07	39.07	39.07

Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the change in occupational group shares. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A5: Regression Results for Absolute Growth of Occupational Groups, Excluding the Most Highly Urbanized Parishes

	(1) Elite	(2) White collar	(3) Foremen	(4) Med. skilled	(5) Farmers	(6) Low skilled	(7) Unskilled
Electricity (Dummy=1)	-74.6*	-47.3	-8.5	177.9***	-30.2	-361.7***	-52.0*
	(43.979)	(31.890)	(52.790)	(58.357)	(20.517)	(122.673)	(30.487)
Mean	136.6	294.9	183	311.8	476.1	334.6	496.3
(SD)	84.26	98.48	109.9	104	86.84	126.5	88.21
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3302	3302	3302	3302	3302	3302	3302
No. of parishes	1656	1656	1656	1656	1656	1656	1656
Cragg–Donald Wald F-statistic (first stage)	14.65	14.65	14.65	14.65	14.65	14.65	14.65

Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the growth of employment by skill group. The regression excludes the one-third of parishes with the highest population density. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A6: Regression Results for Absolute Growth of Occupational Groups, Excluding the Most Highly Industrialized Parishes

	(1) Elite	(2) White collar	(3) Foremen	(4) Med. skilled	(5) Farmers	(6) Low skilled	(7) Unskilled
Electricity (Dummy=1)	-50.0*	-30.1	-28.3	143.3***	-23.6*	-190.7***	-39.5**
	(26.757)	(21.257)	(37.083)	(32.699)	(13.637)	(60.062)	(18.229)
Mean	123.7	280.2	166.8	295	469.2	3136	484.8
(SD)	79.56	93.7	104.5	97.76	88.39	117.5	84.54
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3292	3292	3292	3292	3292	3292	3292
No. of parishes	1646	1646	1646	1646	1646	1646	1646
Cragg–Donald Wald F-statistic (first stage)	36.04	36.04	36.04	36.04	36.04	36.04	36.04

Note: Coefficients and 95% confidence intervals for the impact of a parish gaining access to electricity on the growth of employment by skill group. The regression excludes the one-third of parishes with the highest share of industry in employment. Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A7: Regression Results for Strikes by Sector, Excluding the Most Highly Urbanized Parishes

	Agriculture			Manufacturing			Other		
	(1) All strikes	(2) Off. strikes	(3) Def. strikes	(4) All strikes	(5) Off. strikes	(6) Def. strikes	(7) All strikes	(8) Off. strikes	(9) Def. strikes
Electricity (Dummy=1)	4.7	4.8	0.7	35.5***	32.5***	12.5***	16.0**	14.5**	4.2
	(3.485)	(3.054)	(0.881)	(10.996)	(10.123)	(4.308)	(7.532)	(6.925)	(3.626)
Mean	0.77	0.57	0.06	6.34	4.22	1.11	2.34	1.92	0.18
(SD)	7.76	6.74	1.96	25.08	19.81	9.17	14.41	12.91	3.53
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cragg–Donald Wald F-statistic (first stage)	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4
Observations	4992	4992	4992	4992	4992	4992	4992	4992	4992
No. of parishes	1664	1664	1664	1664	1664	1664	1664	1664	1664

Note: Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A8: Regression Results for Strikes by Sector, Excluding the Most Highly Industrialized Parishes

	Agriculture			Manufacturing			Other		
	(1) All strikes	(2) Off. strikes	(3) Def. strikes	(4) All strikes	(5) Off. strikes	(6) Def. strikes	(7) All strikes	(8) Off. strikes	(9) Def. strikes
Electricity (Dummy=1)	1.1	0.9	0.4	15.0*	14.3**	6.2**	12.4**	11.2**	-0.1
	(2.807)	(2.429)	(0.375)	(7.792)	(7.061)	(3.036)	(6.011)	(5.570)	(1.808)
Mean	0.6	0.4	0.04	4.12	2.76	0.57	1.69	1.28	0.14
(SD)	6.74	5.5	1.7	19.47	15.53	6.41	12.12	10.6	3.1
Parish FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cragg–Donald Wald F-statistic (first stage)	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4
Observations	4992	4992	4992	4992	4992	4992	4992	4992	4992
No. of parishes	1664	1664	1664	1664	1664	1664	1664	1664	1664

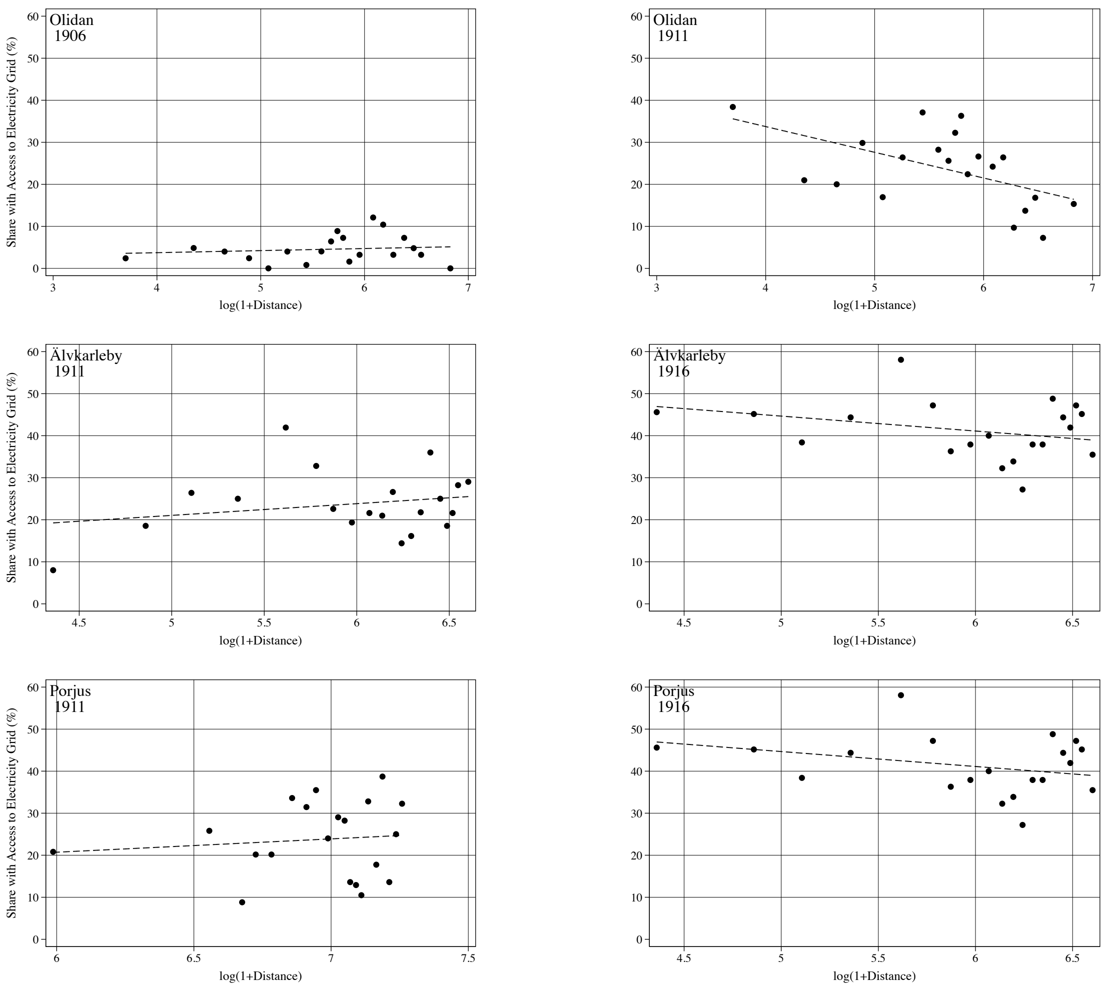
Note: Statistical significance based on standard errors clustered at the parish level is denoted by: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix C Instrument

In this appendix, we explain the reasoning behind the instrument we use to generate exogenous variation in access to the electricity grid. The basic idea is that prior to the construction of the three state-owned plants for hydropower generation, parishes located in their proximity did not differ in any in meaningful way from those that by chance happened to be located further away. Once they were built, however, the cost of gaining access to the electricity grid was much lower for those parishes located in the vicinity of a plant.

Figure A1 illustrates the basic motivation behind the instrument. It uses binned scatter-plots to show the relationship between the distance to each of the three state-owned hydroplants and whether the parish was connected to the grid, before and after the construction of the plant. For the distance to the state plants to be a valid instrument, there should not be any association between access and distance prior to when the plants came online. After construction, however, we expect an increase in the share that gained access as a result. Figure A1 shows that this is indeed what happened.

Figure A1: Illustration of First Stage



Note: Binned scatter-plots of the relationship between the distance from each of the state-run plants for hydropower generation and access to the electricity grid for parishes in the closest observation-years before and after the inauguration of the plant.

Appendix D Occupational Classification

We use an abbreviated version of the HISCLASS scheme to denote the level of skills embedded in different occupations. The HICLASS scheme, introduced in van Leeuwen and Maas (2011), builds on the Historical International Standard of Classification of Occupations (HISCO), where historical occupations are coded into six-digit codes indicating one of 1,600 possible unit groups (van Leeuwen et al., 2002). Examples of six-digit codes include 02220 "Building Construction Engineer" and 61110 "General Farmer." HISCO also allows the coding of three additional variables: Status, Relation, and Product. The most relevant for social class analysis is the Status variable, which provides details on ownership, stages in an artisan's career, and whether someone is a principal or subordinate, information which is sometimes indicated in the original occupational strings but does appear in the occupational code itself. HISCLASS uses the HISCO codes together with the Status variable to sort each occupational unit group into one of twelve social classes. The twelve groups are shown in Table A9.

The HISCLASS scheme is based on three levels of differentiation: between manual and non-manual work, between levels of skill, and whether the occupation involves a supervisory role. Groups one through five are all non-manual. Within this set of non-manual classes, members of the first group, "Higher managers," have a higher level of skill than, for example, those of the fifth group, "Lower clerical and sales personnel." Those in the first group, "Higher managers," have, in turn, a higher status than the second group of "Higher professional," since even though they are both considered highly skilled, the position of the former also involves a supervisory role. As a corollary, among manual workers, "foremen" are given a higher social status than medium, lower and unskilled manual workers, since they also have a supervisory role. While the HISCLASS scale running from one to twelve is nominal, it can be read as a ranking where "Higher managers" have the highest social status and "Unskilled workers" the lowest. An exception to this rule is "Farmers and fishermen," which constitute their own social class. The occupations included in this group involve persons holding a wide range of skills and degrees of supervision. The scheme also divides low skilled and unskilled workers between the primary sector and the rest of the economy. This means that a move in the ranking from group nine, "Low-skilled workers," to group ten, "Low-skilled farm workers," does not mean a drop in social status, but rather a change of sector.

For our empirical analysis, we use an abbreviated version of the system, where we aggregate categories to arrive at seven groups. This classification is also displayed in Table A9. Since we are mainly interested in the skill dimension of social class, we have aggregated groups one and two into the elite, and three, four, and five into white-collar workers. These middle class groups were very small in Sweden at the beginning of the

Table A9: Occupational Classification Schemes: HISCLASS and our abbreviated categorization

HISCLASS		**Abbreviated**	
Number	*Title*	*Number*	*Title*
1	Higher managers	1	Elite
2	Higher professionals		
3	Lower managers	2	White-collar
4	Lower professionals, clerical and sales personnel		
5	Lower clerical and sales personnel		
6	Foremen	3	Foremen
7	Medium-skilled workers	4	Medium-skilled workers
8	Farmers and fishermen	5	Farmers and fishermen
9	Low-skilled workers	6	Low-skilled workers
10	Low-skilled farm workers		
11	Unskilled workers	7	Unskilled workers
12	Unskilled farm workers		

twentieth century, so the number of people coded into any of these two groups is very small even after this aggregation. Because of the focus on skills, we also aggregate into one the two groups of low-skilled workers, who were in the original scheme split between the primary sector and the other sectors, and we do the same for unskilled workers.