Like moths to a flame: technological change and its effects on the labour market in Sweden in the 20th century.

Project Plan

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Project on a page:

- **Research question: how did the rapid spread of new technologies in Sweden alter the dynamics in the labour market in the 20th century?**
- There is currently a great deal of debate about the role of cutting-edge technologies that are increasingly capable of automating work previously done by humans, including Artificial Intelligence (AI) and Machine Learning (ML). Amongst economists, there is concern about a 'hollowing-out' effect in the labour market whereby few jobs are created to program and maintain the automated systems (highly skilled, highly paid workers) and relatively many jobs for human workers will become contingent, insecure, 'gig-work' – jobs for which it is not difficult to train a replacement.
- In contrast, previous research on the expansion of electricity in Sweden has found a strengthened bargaining position for workers, whose productivity increased as a result of the new technology.
- The purpose of this project is to better understand how the dynamics in the Swedish labour market changed during the 20th century (which coincided with a rapid expansion of the electricity grid), focussing on sectoral employment, its effect on economies of agglomeration, and its effect on patterns of migration within Sweden
- I will employ newly digitized data on agricultural output and inputs, trade, and electrification in rural areas of Sweden.
- My dissertation will contain four articles, tied together in that they assess different effects of technological change in the labour market.
- Supervisors: Kerstin Enflo (primary), Jakob Molinder.

Introduction

"Our fascination with our own day and age, and our preoccupation with both the promise and peril of new technology, often leads us to think that we are experiencing something entirely new. Seen through the lens of the long record of human history, however, this seems unlikely to be true" (Frey, 2019, p. xii).

Artificial intelligence, big data and machine learning are buzzwords that dominate the academic literature that assess the future of the labour market, as shown in Figure 1. There is increasing concern about a bifurcation of the labour market, whereby a hollowing-out effect results in few high paying jobs and many low-paying, insecure, 'gig-work' jobs The rise of robotics and artificial intelligence is making it possible to automate an increasingly large number of tasks. This is having a profound impact on the labour market, as jobs that can be automated are increasingly being replaced by machines. In the past, technological change has typically resulted in the creation of new and better-paying jobs. However, this time may be different. The pace of change is accelerating, and the types of jobs being created are often very different from those that are being destroyed. This is leading to rising levels of unemployment and underemployment, as well as increased inequality (Furman and Seamans, 2019).

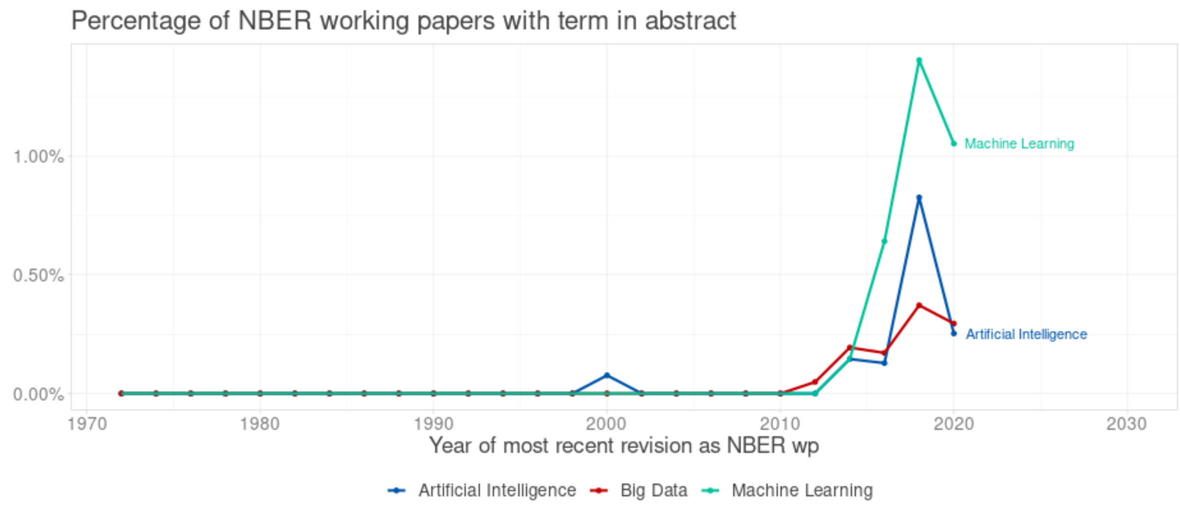

Figure 1: Growth in economic literature on AI, ML and Big Data

Source: (Author's own figure, 2021)

The potential of artificial intelligence (AI) to transform the economy and labour market is widely recognized. Carl Benedikt Frey (2019) estimated that 47 per cent of US employment is at risk of computerisation within the 'next decade or two'. As Frey notes: 'factory electrification allowed workers to produce more and thus earn more. Instead of raging against the machine, workers and trade unions battled to maximise their gains from progress' (190). The explanation for this reversal of fortunes rests on the adoption and proliferation of so-called labour-enabling technologies amid a general period of 'welfare capitalism' that has seen the rise of Amazon, Facebook and Google and the decline of the already marginalised working class (Kroll et al., 2018; Susskind and Susskind, 2015). When the US economy entered into a recession in 2008, many companies started to look for ways to minimise labour costs and maximise profits. In their search for cheaper alternatives to human workers, companies discovered that the deployment of robots and machine learning could be used to achieve their goals. These technologies have been deployed to automate the routine tasks of human workers, such as factory assembly lines and logistics, as well as to replace human workers with robots in retail and service industries. With the adoption of these technologies, companies are now able to minimise labour costs, maximise profits and outcompete their rivals. In addition to the deployment of robots and machine learning, the other major factor that has contributed to the decline of the working class is the proliferation of gig economy jobs. Gig economy jobs are those that are typically short-term, low-paid and provide little in the way of job security or benefits. They are often referred to as 'precarious work', 'contingent work', or 'zero-hours work'. Gig economy jobs have been made possible by the proliferation of digital platforms such as Uber, Airbnb and Deliveroo, which connect workers with employers. The rise of the gig economy has been accompanied by the decline of the traditional employment contract. In the past, most workers were employed under an employment contract, which provided them with job security and a range of benefits, such as sick pay and holiday pay. However, in the gig economy, workers are typically employed on a 'zero-hours contract', which means that they are not guaranteed any work and are only paid for the hours that they actually work. This type of contract provides employers with a great deal of flexibility, but it leaves workers vulnerable to exploitation and insecurity. The decline of the working class is a global phenomenon. In the UK, for example, the proportion of people in work has fallen from 71 per cent in 1971 to 64 per cent in 2017 (Office for National Statistics, 2018). In the US, the proportion of people in work has fallen from 67 per cent in 2000 to 63 per cent in 2016 (Bureau of Labor Statistics, 2017). In Germany, the proportion of people in work has fallen from 74 per cent in 1991 to 67 per cent in 2017 (Destatis, 2018).

Several highly publicized studies have found that AI could have a significant positive impact on growth despite determinantal effects on the labour market, with one study estimating that AI could boost global economic growth by up to 1.7% per year between 2020 and 2030 (Aghion et al., 2019). Big data is another area that is having a major impact on the labour market. The rise of big data has led to a new breed of jobs that require workers to have skills in data analysis and interpretation. Machine learning is a subfield of AI that is particularly relevant to the labour market. Machine learning algorithms are being used to automate tasks that have traditionally been carried out by human workers, such as data entry and analysis.

It is also creating significant challenges for policymakers, who are struggling to find ways to address the problem. The situation is likely to get worse before it gets better. As technology continues to advance, an ever-larger number of jobs will be at risk of being automated. This could have a devastating impact on the economy and society, unless we find a way to address the problem.

Some proposed solutions include:

- Providing a basic income for all citizens, which would ensure that everyone has a minimum level of income and would help to offset the loss of jobs due to automation.
- Introducing a shorter work week, which would reduce the number of hours worked and would make it easier for people to find employment.

- Investing in education and training, which would help people to acquire the skills needed to find employment in the new economy.
- Encouraging entrepreneurship, which would create new jobs and help to offset the loss of jobs due to automation.
- Developing policies to help people adjust to the new economy, which would help to mitigate the negative impact of automation on the labour market.

In order to better understand the implications of these coming changes to the labour market in light of artificial intelligence and the potential 'hollowing-out' of the labour market, it is worth looking back in history for some examples of general-purpose technologies (GPTs) that had a large impact on labour markets and tracing their histories. In this way, we can be better informed on how to deal with future threats to our economy.

The first industrial revolution

The first industrial revolution, about which a great deal has been written on the role of steam power, shows us that the new technology itself did not bring the high unemployment, but the new technology in combination with other factors. For example, the introduction of the spinning jenny (the first of the spinning machines) in England in the late 18th century led to the creation of an industry based on the production of cheap cloth. This led to a decrease in the demand for weavers and spinners. The combination of this technology, along with the enclosure of agricultural land and the development of a new transportation network, led to an increase in rural-to-urban migration. This migration created a surplus of labour in urban areas, which put downward pressure on wages, which in turn meant that workers had less money to spend on goods, which in turn led to increased unemployment.

Further, the first industrial revolution showed us that it is important to look not only at the direct impact of the technology on jobs, but also at the indirect impact. For example, the introduction of the steam engine led to the development of new industries, such as the coal and iron industries, which created new jobs. It also led to the development of the railway, which created even more jobs. So, while the steam engine may have had a direct impact on the employment of weavers and spinners, it also had an indirect impact on the employment of workers in other industries.

Yet, previous studies on general purpose technologies that have rapidly transformed the labour market do not find a consistent effect in magnitude or even in sign in terms of labour earnings. Nicholas Crafts has studied the first industrial revolution, and concludes that steam did not spur productivity growth in as much as the industrial revolution spurred urbanization, which benefitted future growth patters (Crafts, 2009).

Crafts and Mills (2004) find that primarily because steam's contribution to industrial output and labour productivity growth was stronger after 1870 than before and that the non-steam-intensive sectors exhibited an inverted U-shape in trend output growth through the 19th century, experiencing a marked slowdown between 1830 and the 1870s.

However, Voth (2000) argues that Total Factor Productivity growth (TFP) was not just driven by the steam engine and that the timing of the industrial revolution (IR) was dictated by the spread of 'good governance', as well as the diffusion of technology across industries. He argues that the spread of technology was not a necessary or sufficient condition for the industrial revolution, as the late spread of technology to the US and Japan, for example, did not lead to an IR in those countries. He argues that the late industrialisation of the US was in part due to its founding fathers' insistence on a high degree of political decentralisation, which led to the development of small, efficient, and well-regulated local markets. In contrast, the spread of technology played a limited role in the industrialization of Japan, where the Meiji state, by centralizing power and by imposing a single set of legal rules, created the environment that was necessary for technological change to take off. Voth (2000) concludes that the technology of the industrial revolution was not the only technological change that mattered to economic growth; technology spread had been going on for a long time before the industrial revolution. The technology of the industrial revolution was only one of many important technological changes that occurred during the period of industrialization.

Crafts and Mills (2004) examine the contribution of technological change to industrial output growth for the United Kingdom, France, and the United States and conclude that this is an area where the two countries differed substantially. The United Kingdom and the United States, being more technologically advanced than France, experienced much higher rates of industrial output growth during the industrialization process. The consequences for the labour market depended on these initial conditions and so a certain, on-size fits all policy solution would not have been applicable to smooth out the transitions that took place in the various labour markets.

The second industrial revolution

The second industrial revolution, which is associated with the introduction of electricity, also provides some useful lessons. The electrification of factories led to the development of new production processes, such as mass production, which led to the creation of new jobs. However, it also led to the displacement of workers in other industries, such as the textile industry, which saw a decline in employment as a result of the introduction of electric looms. So, while the second industrial revolution led to the creation of some new jobs, it also led to the displacement of workers in other industries. This has been studied by David Autor, in his paper "The Impact of the Second Industrial Revolution on European Society." The paper looks at how the second industrial revolution led to the displacement of workers in some industries and the creation of new jobs in others.

The literature also looks at how the second industrial revolution led to the development of new technologies, such as the telephone and the automobile, which led to the creation of new jobs. So, while the second industrial revolution led to the displacement of workers in some industries, it also led to the creation of new jobs in others.

The third industrial revolution

The third industrial revolution, which is associated with the introduction of computers and automation, has also led to the displacement of workers in some industries, such as the manufacturing industry. However, it has also led to the creation of new jobs in other industries, such as the software industry. So, while the third industrial revolution has had some negative impacts on employment, it has also had some positive impacts.

Enrico Moretti (2011) has focussed on the geographic distribution of skilled workers in the knowledge economy as a prime force in determining the path of a local labour market. He finds that knowledge intensive sectors have spillovers into the rest of the economy, with a multiplier such that each knowledge economy job can create up to 2.4 additional jobs in the service and government sectors within that local labour market. Moretti (2011) argues that the development of the knowledge economy is a key driver of economic growth in the twenty-first century.

The knowledge economy is often associated with the clustering of skilled workers into knowledge intensive sectors in cities. This clustering can have a number of benefits, such as economies of scale, increased productivity, and greater innovation (Florida, 2002).

The development of the knowledge economy can also have negative effects, however. The concentration of skilled workers in knowledge intensive sectors can lead to increased inequality and social polarization. It can also lead to increased housing costs and congestion, as more people compete for scarce space in desirable locations.

Martin Feldstein, meanwhile, looks at the effect of the introduction of computers in the United States and concludes that there is no evidence that computerisation led to lower wage growth, and, in fact, it may have even contributed to the stagnation of wages in the 1980s and early 1990s (Feldstein, 1995).

More recently, Acemoglu and Restrepo have studied the effect of industrial robots on employment and conclude that the introduction of industrial robots has been a significant factor behind the decline in employment in the United States, and that this effect is likely to grow (Acemoglu and Restrepo, 2017). This is consistent with the idea that the effect of technological change on employment depends on the type of technology and the context in which it is introduced.

This project's intended location in the literature

This project will focus on the second industrial revolution – using as a case study the effects of expanding electricity supply in Sweden in the first half of the 20th century – on labour markets in a broad sense. It will look first at the effect of electrification on sectoral employment, second at its effect on economies of agglomeration, and third its effect on patterns of migration within Sweden. I expand on each of these in turn.

Electrification can be looked at as a technology change. This means that it has various effects on the labour market, such as changes in the nature of the jobs that are available, changes in the skills that are required for jobs, and changes in the geographical distribution of jobs.

In terms of the first effect, electrification led to the creation of new jobs in the electricity sector, as well as new jobs in industries that used electricity as an input, such as the manufacturing and mining industries. In the case of Sweden, it allowed agricultural output per worker to rise, freeing up labour from the agricultural sector and allowing these individuals to urbanize and specialize in ways that were not possible before.

In terms of the second effect, electrification led to an increase in the demand for skilled workers, as the new jobs that were created required new skills.

In terms of the third effect, electrification led to a change in the geographical distribution of jobs, as the new jobs that were created were not necessarily created in the same places as the old jobs that were destroyed. This led to an increase in migration, as people moved to where the new jobs were.

With regard to economies of agglomeration, these are defined as Agglomeration economies describe the mechanisms by which firms, workers and consumers benefit from the presence of each other (Fujita and Krugman, 2004). The term agglomeration economies refers to the positive externalities generated by agglomeration. These externalities can be generated by the firms of the same sector, by different sectors or by the linkages between firms and workers. The concept of agglomeration economies was first introduced by Edward Ullman (1954)and is also known as Ullman's externalities or, more generally, as agglomeration effects. The concept has been widely studied in economics, urban economics, regional economics, and economic geography.

The positive externalities associated with agglomeration can be divided into three main categories:

1. Location and scale economies: Firms benefit from being close to other firms in the same sector as they can share the same inputs and knowledge. They can also benefit from economies of scale by being able to produce at lower costs.
2. Productivity spillovers: Firms can benefit from the presence of other firms in different sectors as they can share knowledge and best practices. Workers can also benefit from the presence of other workers as they can learn from each other.
3. Social and cultural amenities: Firms and workers can benefit from the presence of social and cultural amenities.

The next section describes each of the four papers that comprise the dissertation.

Paper 1

Agricultural output and employment in electrified parishes in Sweden

Research question:

How did the plausibly exogenous shock of electrification impact agricultural output and agricultural employment in parishes receiving early electrification in Sweden?

A wealth of literature has shown that electrification can reduce the amount of human labour needed to produce agricultural products, freeing up farm labour to move into other sectors. Figure 2 shows that in the first half of the 20th century manufacturing as well as building and construction grew dramatically as a share of total employment in Sweden. However, to pin down the causal catalyst in this regard is difficult. It could be that areas which were economically dynamic and would have shifted employees into new sectors were also the ones that adopted electricity first.

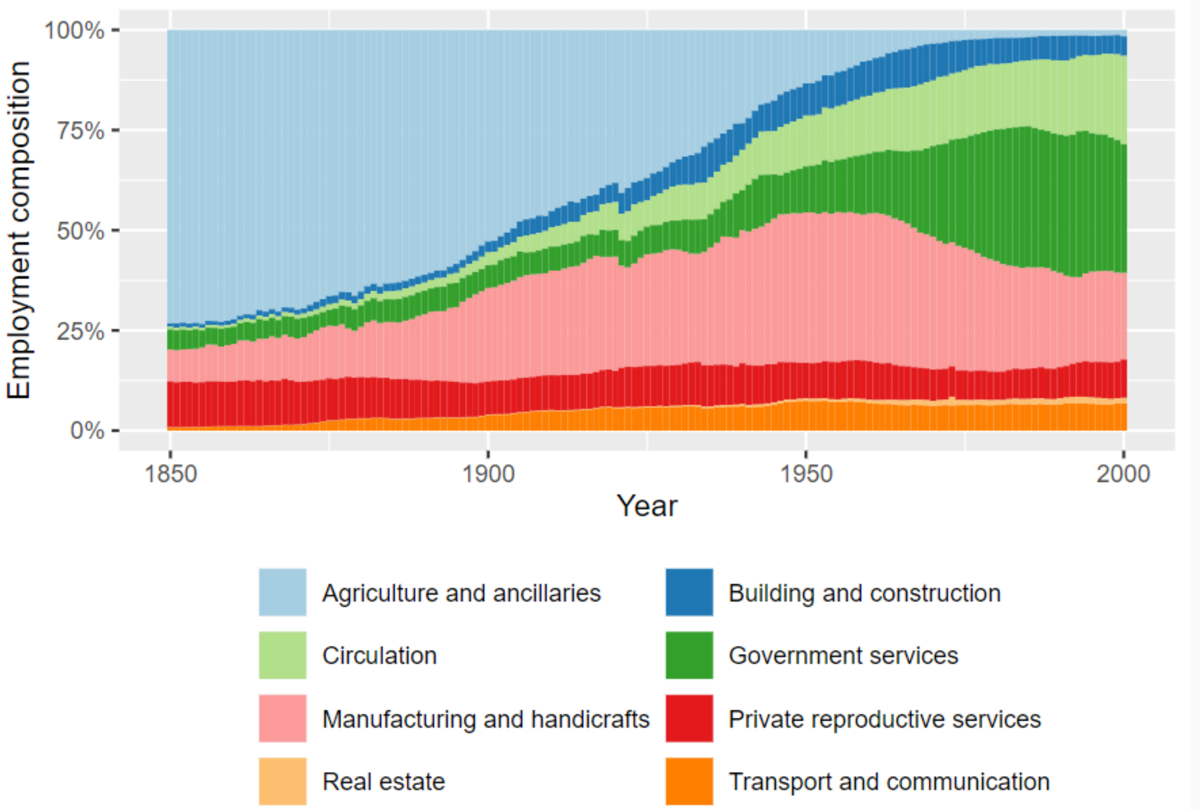

Figure 2: Employment by sector in Sweden: 1850-2000

Source: Source: Edvinsson, R. Number of employees in eight types of activities in Sweden 1850-2000 Via Historia.se

Following Molinder, Karlsson and Enflo (2021), I will exploit an as-good-as random allocation of 192 parishes to the central electricity line between the two largest hydro power stations in Southern and Central Sweden, Olidan and Alvkarleby as a source of causal identification. These parishes had access to an electricity supply that was cheaper and more reliable than similar parishes in the vicinity that had to rely on small scale hydro and heat power from peat or imported coal.

The main source of identification is that the electricity rollout to the included parishes was not motivated by the local characteristics of the parish but rather a political decision to extend the grid between the two large hydro power plants. The 192 parishes included in the sample had identical (or very similar) characteristics regarding population size, industry, and other factors that can be expected to affect economic outcomes, prior to electrification. Their trends in agricultural output will be assessed once this data is digitized.

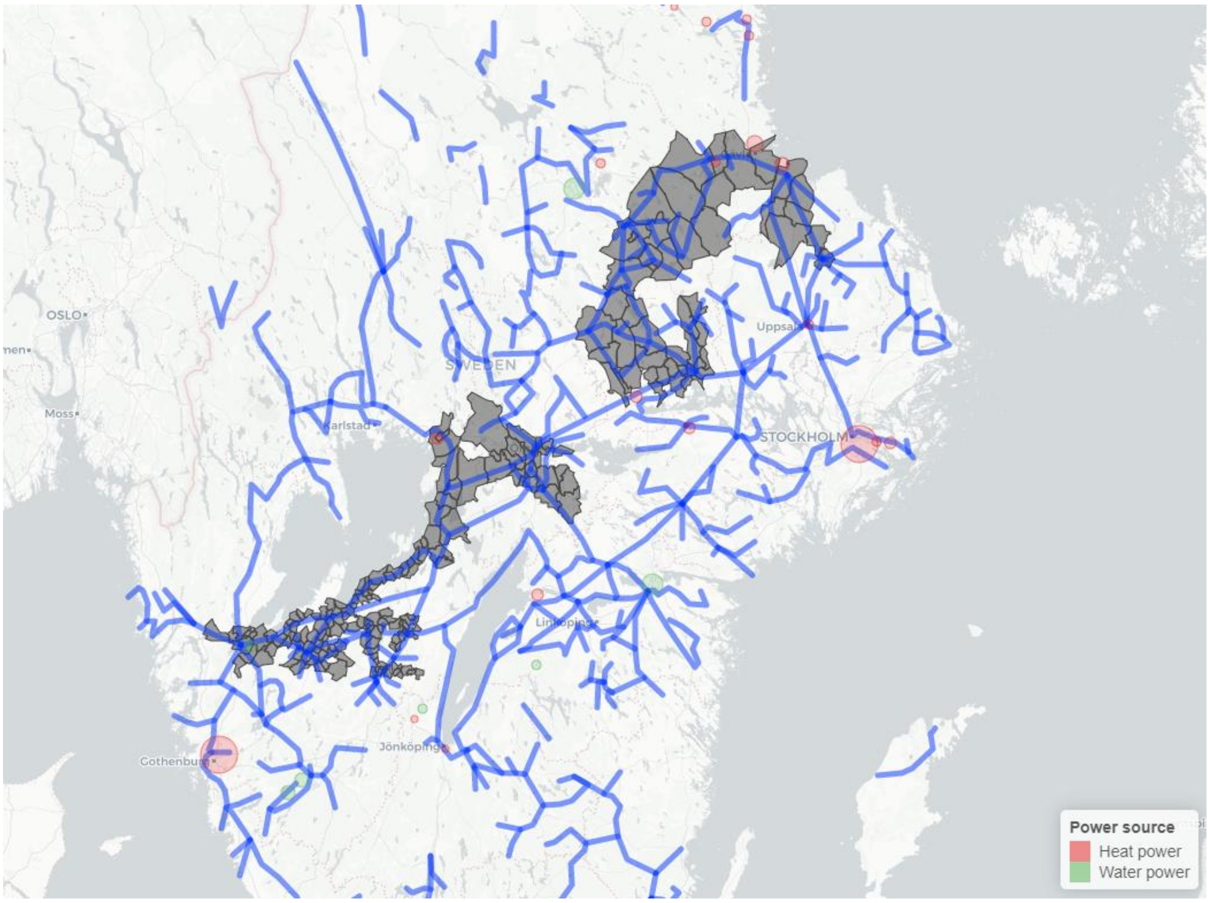

Figure 3: Map of 1926 electricity grid and 192 shocked parishes

Source: (Minnesota Population Center, 2020), (Hjulström et al, 1942)

Figure 3 shows the 192 parishes that were connected to the central line along with the grid in 1926 (in blue). I will use annual data on the growth rate of agricultural output for the entire sample period 1885–1936, which I will use as the main outcome variable. The second outcome variable will be agricultural employment as a share of total population in each parish. In this way I shall be able to test if assignment to electrification resulted in a more rapid shift out of agricultural employment, or an increase in agricultural output, for electricity parishes compared to similar parishes who were not positioned on the line of grid expansion.

The sample consists of all municipalities in Sweden that had no access to electricity in 1900 and that gained access to electricity from the grid between 1900 and 1936 (see Molinder, Karlsson and Enflo (2021) for details). The exact threshold for a comparison parish (not part of the treatment group) s yet to be determined, but will involve some tests for pre-treatment similarity on observable characteristics such as employment composition, geographical characteristics and population.

Data sources

The data on agricultural output comes from the household production and animal husbandry statistics collected by SCB. These include detailed information at the parish level about how much land is devoted to each kind of crop, the ownership and tenure structure of this land, the output per crop, as well as some information on inputs like the number of people inhabiting each parish, it's agricultural land area, and the number of draft animals. This data is available at an annual level from 1885 until the mid 20th century, which will allow me to create a long series to test the parallel trends assumption required for difference-in-difference estimation.

To this production and input data, I will match and add more detailed information about the power provision in the parish, including its source (small-scale hydro, large hydro, coal, peat) and cost. This information is sourced from reports conducted by the committee for rural electrification, led by Nils Ekvall, and tasked with assessing the cost and difficulty of completing the electrification of Sweden's rural areas in the mid-1920s. These control variables will be added to the diff-in-diff regression described below.

Estimation

I will use a basic difference-in-difference regression, where the outcome variable is either agricultural output or agricultural employment, the treatment variable is assignment as an electricity parish, and the control variables include geographic controls and other observable unchanging characteristics.

I set up the equation as follows:

$y = \beta 0 + \beta 1 * Treatment + \beta 2 * Post + \beta 3 * Treatment * Post + \beta 4 * X + \varepsilon$

where y = agricultural output or agricultural employment, Treatment = 1 if parish has electricity, 0 if not, Post = 1 if year is after the introduction of electricity, 0 if not, X = a vector of control variables, and ε = error term. The control vector includes dummy variables for the county where the parish is located and the year. For simplicity the treatment is understood to be binary (connected to the grid or not) and simultaneous for all parishes along the central line.

Initial findings

It appears from an initial investigation that these parishes grew in population dramatically, more so than their non-electrified counterparts, and had higher incomes as measured in the 1930 census.[1] Interestingly, these parishes did not have higher levels of wealth than their non-connected counterparts, potentially indicative of a higher share of the returns going to labour rather than capital in these otherwise undistinctive 192 connected parishes. I have created a set of interactive maps for doing exploratory data analysis that you can find at

[1] It is important to note that the 1930 census is not yet completely digitized. Approximately 30% of the population is digitized in the 1930 census, covering 1058 of the 2500 parishes.

https://jonathan-jayes.shinyapps.io/Sweden-electrification-explorer/ . A screenshot of this data explorer is included as Figure 4, below. Please feel free to have a look at it.

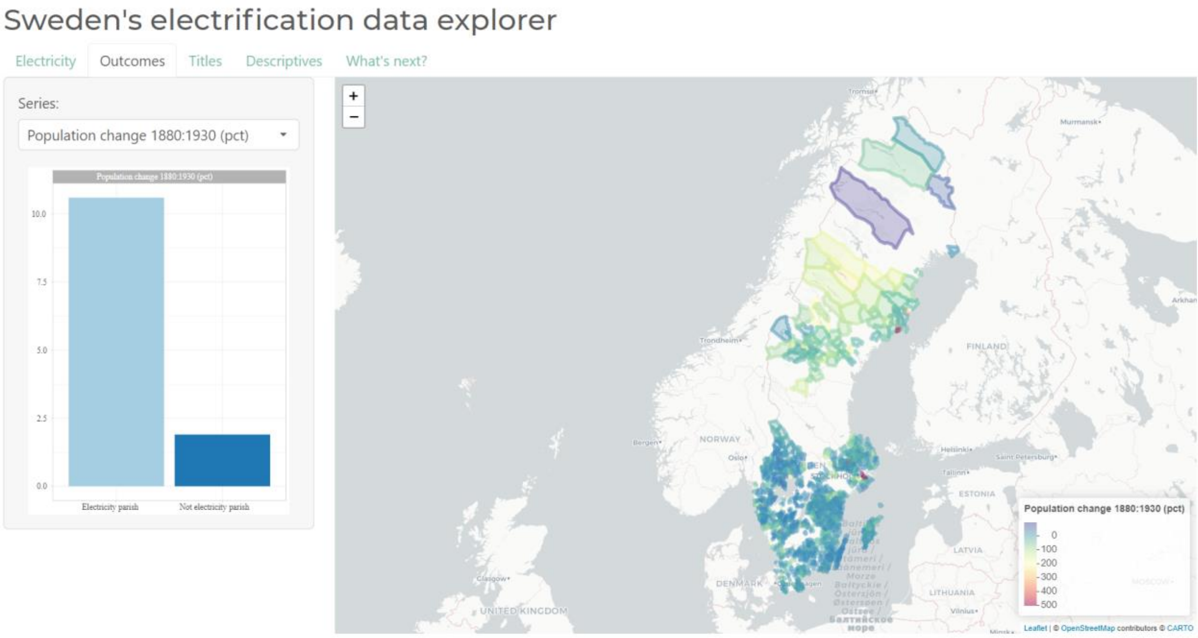

Figure 4: Screenshot of exploratory data analysis tool

A path forward

- Finished digitizing agricultural output and employment data from SCB with the help of a research assistant.
- Think carefully about how to control for spatial autocorrelation.
- This paper is intended to be complete by the end of the second year

This first paper is intended to set the scene for two more which follow in the same vein. By establishing that there were indeed differential outcomes for electricity parishes which received electricity by virtue of their location on the expansion path of the grid, the second and third papers in the dissertation will examine what factors facilitated these differential outcomes. These next two papers deal with skill distribution and migration respectively.

Paper 2

Worker skills and agglomeration economies

Research question:

How did the pre-existing distribution of skills in the electricity parishes impact their agricultural employment and agricultural output after being connected to the grid, and to what extent did skill clusters exist?

The focus in the literature on the future of the labour market considering technological changes today stresses the importance of cultivating a workforce with skills well-suited to the knowledge economy, and to gather these skilled individuals together geographically in order to foster knowledge sharing. The second paper will examine what impact differing skill distributions had on the parishes who received electrification in Sweden in the first half of the 20th century, and assess if any skill clusters already existed in these parishes.

Being blessed with high quality census data from the years 1880, 1890, 1900, 1910 and the recently released 1930 census, this paper will build on the results of the first paper by assessing the skills of workers in the electricity parishes compared to their comparators.

The questions I want to answer is "what kinds of people are better off as a result of electrification". The first part of answering this question involves looking at the occupational distribution in the electricity parishes prior to electrification. This involves creating a crosswalk from occupational strings and HISCO codes (which classify historical occupations into groups) to some metric for skill intensity. Once I have created this metric, I will track how it evolves over time in each of the electricity parishes.

In addition, I will assess whether there are clusters of specific skills in the electricity parishes, or geographically bordering parishes that persist after electrification.

The data and methodology in paper two are similar to paper one. The outcome variables will again be agricultural output and agricultural employment, but this time the variable of interest will be the skill intensity metric, and the sample will be only electricity parishes (rather than comparing treated and untreated units). Additional control variables will include variables captured in the 1930 census such as population growth, income and wealth, and levels of inequality within a parish.

Initial findings

While I have yet to create the skill metric from the occupational strings and HISCO codes, it is possible to postulate on the agglomeration effects from the 1930 census data and distinction between electricity parishes and all other parishes. Figure 5 shows the relationship between population and mean income in 1930 at the parish level. The lines are fitted with locally weighted smoothing. The electricity parishes line (in green) indicates that for parishes with a population between 200 and 10,000 the mean income for a given level of population is higher in electricity parishes than non-electricity parishes. In contrast, the orange line shows a kink at a population of 3,000, indicating agglomeration effects that raise income when population surpasses a threshold.

Figure 5: Scatterplot indicative of differing agglomeration effects

Source: 1930 census data from Riksarkivet

A path forward

- Get some help with calculating the skill metric and classifying HISCO codes
- Think carefully about how to assess clusters across parish boundaries

Paper 3

‘Praise the people or praise the place’: migration and skills

There is an interesting branch of scholarship focussing on the differential distribution of workers geographically. Enrico Moretti (2012) contrasts the movement of low-skilled workers to industrial towns in the United States to work in well-paying, unionized manufacturing jobs in the 1980s with the migration of college educated individuals today to a small set of geographic locations to work in the so called ‘innovation economy’. Paul Krugman's New Economic Geography (NEG) model has shown how the increased demand for highly educated workers in large cities drives the agglomeration of workers in those cities. Moretti's argument is that the migration of highly educated workers to large cities is the main driver of the Great Divergence.

It is evident that there is significant urbanization during the period of interest. In Figure 6 I show the population change between 1880 and 1910 in Ostergotlands county. It is clear that there is dramatic population growth around Norrkoping, Mjölby and Finspång. The latter had an iron mine which drew in labour to support the growing industry. In addition, the rural areas of the county are blue in colour, indicative of a decrease in population.

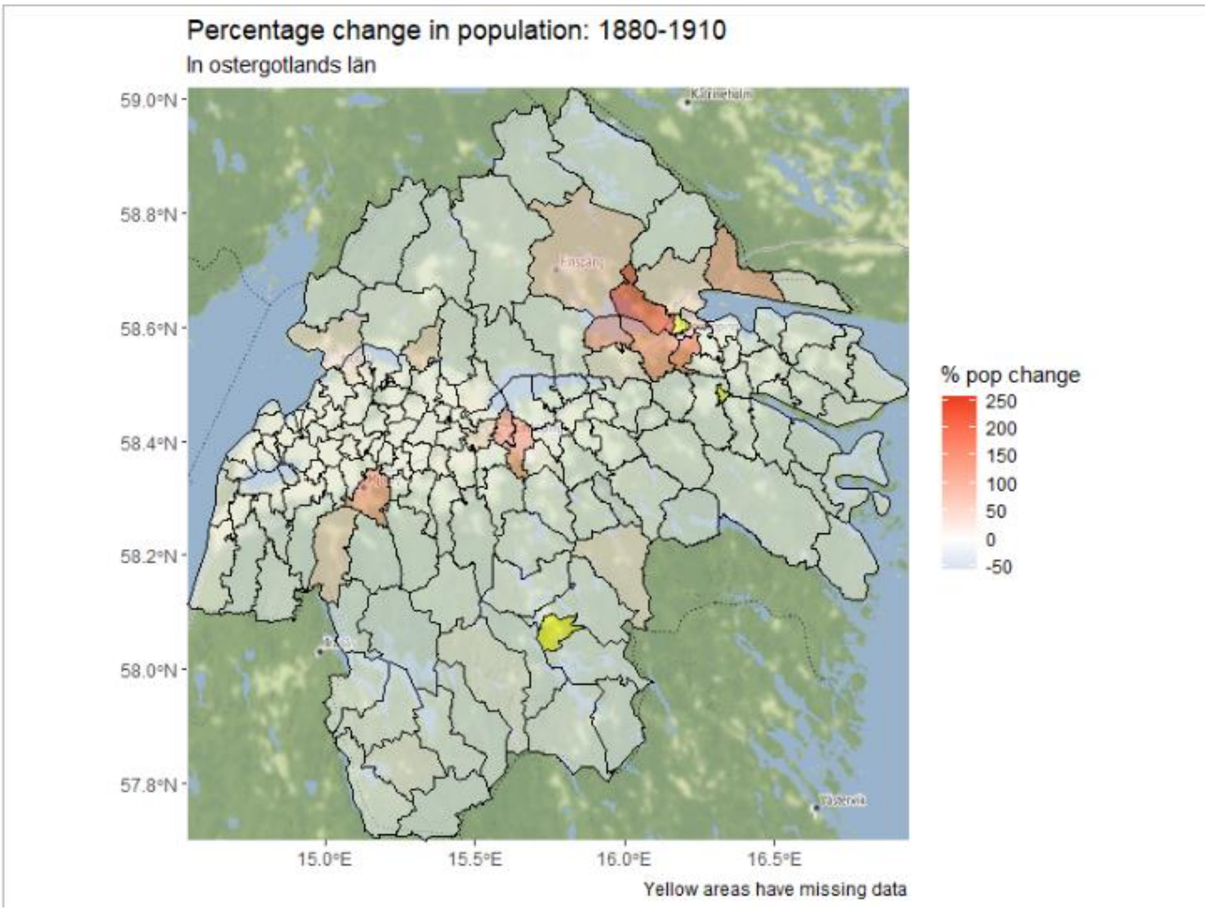

Figure 6: Map showing urbanization between 1880 and 1910 in Ostegotlands county

Source: Author’s own graphic based on the 1930 census from Riksarkivet

Figure 7 shows that the most common occupation in Risinge parish in 1930, in which Finspång is located was metal worker, indicative of the regional specialization that was taking place during this dynamic period.

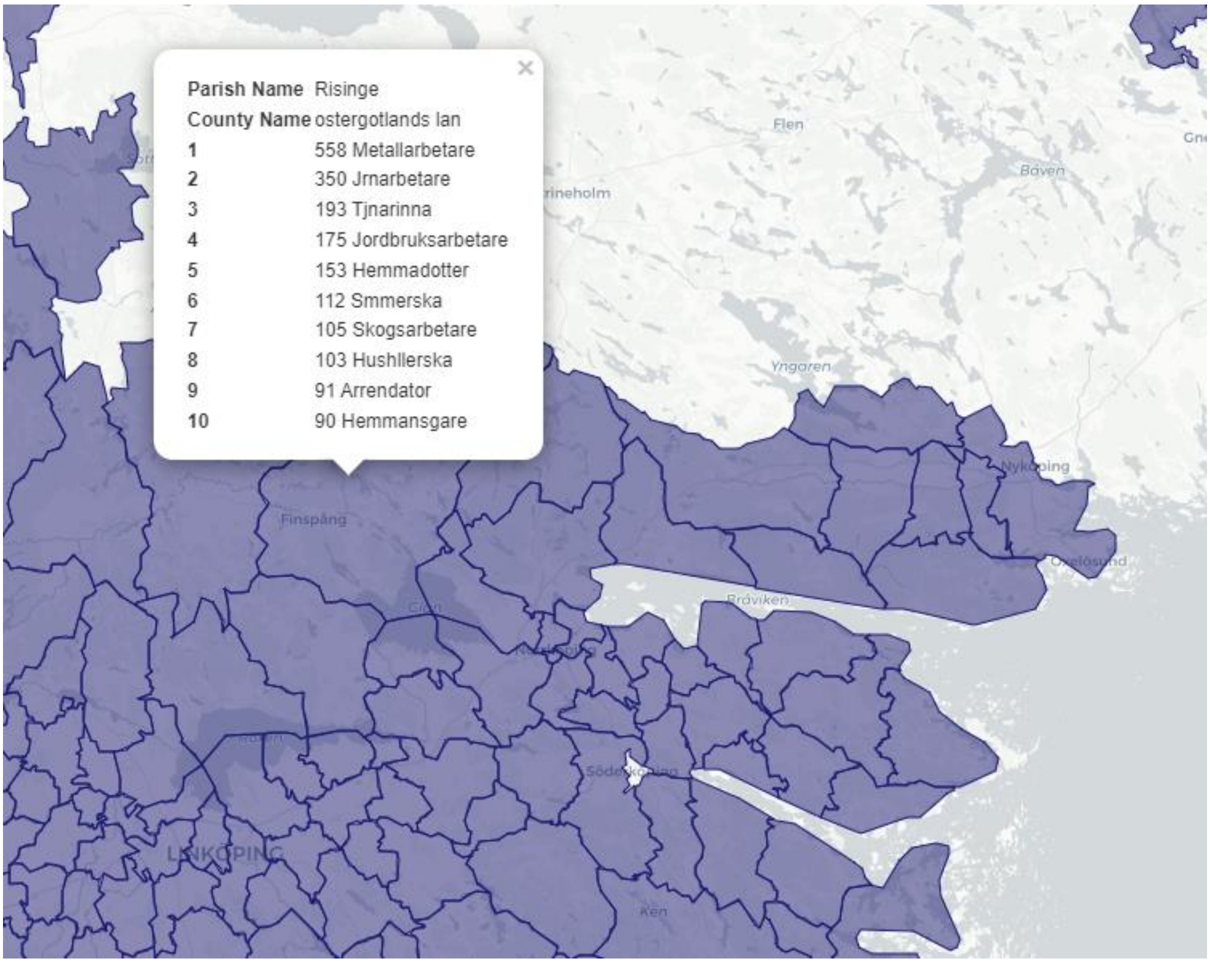

Figure 7:Occupational distribution in Risinge parish, home to Finspång in 1930

Source: Author's own graphic based on the 1930 census from Riksarkivet

Expanding on the task of paper two, to answer the question "what kinds of people are better off as a result of electrification", I must look at the patterns of migration that resulted in population growth within the electricity parishes. I want to distinguish between those who lived there originally, and those who moved into the electricity parishes after electrification.

The 1930 census is very rich in information about migration, including an individual's parish of birth, and a variable for parish of residence in 1925 if the individual moved into this parish in the prior five years.

Making use of this data on birthplace and migration in the prior five years, it will be possible to create a 'counterfactual' electricity parish, looking at the occupations and incomes of only those born in that parish. This counterfactual parish can be compared to the actual parish, including all who inhabit it, to assess whether the improved outcomes were driven by migration, or whether the new work could be done by individuals who were raised in the parish. This will allow a separation or the 'place effect' – by virtue of connection to the grid a parish was made better off – from the ‘people effect’ – those who inhabited the parish had important skills that they brought to work.

To estimate the effect and importance of migration, it will be possible to leverage the exogeneity of the expansion of the grid to create our electricity parishes, and simply compare the means of outcome variables like income and wealth, as captured in the 1930 census at the parish level.

A path forward

- Do the work
- Think about what it means to have just 30% of the population covered in the 1930 census

Paper 4

New technologies and new kinds of work

Research question

How do new technologies that spring from electrification result in new kinds of work in Sweden?

In paper 3 I hope to show that labour in Sweden moved to areas that received electricity to seek new kinds of employment, jobs that did not exist in the parish of their birth but were matched to their skills. In this paper I want to quantify the new kinds of employment, and measure the rate at which new jobs are created, and old jobs destroyed.

Goldin and Katz (2008) explain the canonical model for labour augmenting technology and define skill biased technological change as a model in which new technologies favour high skilled workers. When new technologies are developed, they are either labour saving or labour augmenting. A labour saving technology is when a machine is introduced to replace a human being in a process of production. A labour augmenting technology is when a machine is introduced to increase the productivity of a human being in a process of production. The canonical model for labour augmenting technology explains that a labour saving technology can lead to an increase in employment for high skilled workers and a decrease in employment for low skilled workers. A labour augmenting technology can lead to an increase in employment for both high skilled and low skilled workers.

The definition of skill biased technological change is important because it helps to explain how new technologies can impact the labour market. When new technologies are developed, they can either be labour saving or labour augmenting. If a new technology is labour saving, it can lead to an increase in employment for high skilled workers and a decrease in employment for low skilled workers. If a new technology is labour augmenting, it can lead to an increase in employment for both high skilled and low skilled workers.

Acemoglu and Autor (2011) revise the model to account for polarization in the US labour market and introduce automation to the model. They define polarization as a model in which employment growth is concentrated in high-wage and low-wage jobs, while middle-wage jobs decline. They explain that automation can lead to a decrease in employment for middle-wage jobs, while high-wage and low-wage jobs are relatively immune to the effects of automation.

The definition of polarization is important because it helps to explain how new technologies can impact the labour market. When new technologies are developed, they can either lead to an increase in employment for high skilled workers or a decrease in employment for middle-wage jobs.

Autor, Salomons, Seegmiller (2022) attempt to measure the kinds of technologies that replace labour and the kinds that boost labour productivity. They use occupational titles, occupation descriptions and census data.

The study by Autor et al. (2022) is important because it provides a detailed analysis of the types of technologies that are associated with different labour market outcomes. The study finds that technologies that replace labour are associated with a decrease in employment, while technologies that boost labour productivity are associated with an increase in employment.

Methods

Following the methodology of Autor *et al* (2022), I will compare the similarity of a measure for labour outputs (occupation titles) and labour inputs (a description of what the worker does) with the new kinds of technology being brought to market (e.g. patents).

I will use natural language processing to compare the words used in the occupational titles and occupational descriptions to the corpus of patent data. If a technology is more similar to an occupational title, then it is classified as complement their outputs ('augmentation'). If, rather, the technology is described as more similar to tasks, then it is classified as substitute for labour inputs ('automation')

Data sources

The occupational titles and descriptions come from Riksvakanslistan – vacancy lists produced by the state weekly between 1915 and 1958. These record the number of vacnacies by occupational title and region. Less common occupations are included in a free text section below the matrix of more common occupations. For some occupations that are multiple ranks within the same occupation, for example dairy students, dairy girls and dairy maids. The patent data comes from the Swedish Patent Registration office, where 5,960 patents include the term electricity all the way from 1880 until 1970.

A path forward

- Digitize Riksvakanslistan
- See if there is geographical information on which technologies were used by different firms

Works cited

Aghion, P., Antonin, C., Bunel, S., 2019. Artificial Intelligence, Growth and Employment: The Role of Policy. Econ. Stat. 510, 149–164. https://doi.org/10.24187/ecostat.2019.510t.1994

Author's own figure, 2021. NBER working paper term frequency explorer [WWW Document]. URL https://jonathan-jayes.shinyapps.io/NBER-Explorer/?_ga=2.79488919.248273629.1662576480-1689327085.1652352785 (accessed 9.7.22).

Bureau of Labor Statistics, 2017. Employment and Wages, Annual Averages 2017 [WWW Document]. URL https://www.bls.gov/cew/publications/employment-and-wages-annual-averages/2017/home.htm (accessed 9.7.22).

Destatis, 2018. Statistisches Jahrbuch 2018 712.

Frey, C.B., 2019. The technology trap: capital, labor, and power in the age of automation. Princeton University Press, Princeton, New Jersey.

Fujita, M., Krugman, P., 2004. The new economic geography: Past, present and the future, in: Florax, R.J.G.M., Plane, D.A. (Eds.), Fifty Years of Regional Science, Advances in Spatial Science. Springer, Berlin, Heidelberg, pp. 139–164. https://doi.org/10.1007/978-3-662-07223-3_6

Furman, J., Seamans, R., 2019. AI and the Economy. Innov. Policy Econ. 19, 161–191. https://doi.org/10.1086/699936

Kroll, H., Horvat, D., Jäger, A., 2018. Effects of automatisation and digitalisation on manufacturing companies' production efficiency and innovation performance (Working Paper No. 58). Fraunhofer ISI Discussion Papers - Innovation Systems and Policy Analysis.

Minnesota Population Center, 2020. Integrated Public Use Microdata Series, International: Version 7.3. https://doi.org/10.18128/D020.V7.3

Office for National Statistics, 2018. UK labour market statistics: March 2018 [WWW Document]. URL https://www.ons.gov.uk/releases/uklabourmarketstatisticsmar2018 (accessed 9.7.22).

Susskind, R.E., Susskind, D., 2015. The future of the professions: how technology will transform the work of human experts, First edition. ed. Oxford University Press, Oxford, United Kingdom.

Ullman, E.L., 1954. Amenities as a Factor in Regional Growth. Geogr. Rev. 44, 119–132. https://doi.org/10.2307/211789