Like moths to a flame

an individual level approach to technological change in 20th century Sweden

Jayes, Jonathan

2025

Document Version:
Publisher's PDF, also known as Version of record

Like moths to a flame

an individual level approach to technological change in 20th century Sweden

JONATHAN JAYES

LUND STUDIES IN ECONOMIC HISTORY 119 | LUND UNIVERSITY

Like moths to a flame

an individual level approach to technological change in 20th century Sweden

This thesis analyzes the effects of technological change using the case of electrification in 20th-century Sweden. It begins with a systematic literature review that identifies gaps in the quantitative research on historical job displacement before 1980. In Sweden, electrification enhanced labor and reduced income inequality. Analysis of 1930 census data shows that early electricity access raised incomes, particularly for lower-income and less-educated individuals.

The research reveals a labor market forked into two groups. High-skilled engineers, identified using AI analysis of historical biographies, were a mobile elite with international experience who implemented the technology. In contrast, the main economic benefits went to the local, less-skilled workforce.

The firm-level analysis investigated the impact of corporate leadership by treating U.S. management practices as a form of technology. Appointing the first U.S.-experienced engineer to a board had different effects depending on the era: before 1945, it led to hiring more workers, while after 1945, it led to workforce reductions and a smaller portion of company earnings going to workers. Directors with business backgrounds had no significant effect on labor in either period.

The thesis concludes that the societal impact of technology is not predetermined but is shaped by the technology itself and its institutional context (meaning the laws, union strength, and political climate of the time).

Printed by Media-Tryck, Lund 2025 NORDIC SWAN ECOLABEL 3041 0903

LUND UNIVERSITY

Department of Economic History
School of Economics and Management

Lund Studies in Economic History 119
ISBN 978-91-989642-4-0
ISSN 1400-4860

Like moths to a flame

Like moths to a flame
an individual level approach to technological change in 20th century Sweden

by Jonathan Jayes

LUND
UNIVERSITY

Thesis for the degree of Doctor of Philosophy in Economic History
Thesis advisors: Professor Kerstin Enflo, Associate Professor Jakob Molinder
Faculty opponent: Associate Professor Björn Brey, Norwegian School of Economics

To be presented, with the permission of the Lund University School of Economics and Management, for public criticism at *Holger Crafoords Ekonomicentrum* (EC2:101) on Friday, the 17th of October 2025 at 14:15.

Organization
LUND UNIVERSITY

Department of Economic History
Department of Economic History
Box 7083
SE–220 07 LUND

Document name
DOCTORAL DISSERTATION

Date of disputation
2025-10-17

Sponsoring organization

Author(s)
Jonathan Jayes

Title and subtitle
Like moths to a flame: an individual level approach to technological change in 20th century Sweden

Abstract
This thesis investigates how technological change impacts labor markets, skill demands, and income distribution, addressing a central challenge in economic history. It uses the case of 20th-century Swedish electrification to analyze the roles of human capital and corporate governance in mediating technology's effects.

A systematic review of historical literature confirms that technology-driven labor displacement is often a prolonged and costly process for workers, challenging narratives of smooth adjustment. However, the thesis finds that early electrification in Sweden was profoundly equalizing. Contrary to standard skill-biased technical change theory, access to electricity significantly raised incomes for lower-skilled workers and compressed the income distribution.

This paradoxical outcome was driven by a distinct cadre of high-skilled engineers who implemented the new technology. These individuals were characterized by their high mobility, elite technical training, and crucial career experience in the United States, acting as conduits for frontier knowledge. At the firm level, the impact of this imported "management technology" was contingent on the prevailing corporate governance regime. In the pre-1945 era of 'managerial capitalism,' the appointment of U.S.-experienced engineers is associated with workforce expansion. In the post-1945 era of 'investor capitalism,' the same event is linked to workforce rationalization and a declining labor share of revenue.

Ultimately, this thesis demonstrates that the distributional consequences of innovation are not technologically determined. They are shaped by the interplay between the nature of the technology, the specific human capital that deploys it, and the institutional framework of the firm, showing how a labor-enhancing technology could foster shared prosperity under a stakeholder-oriented corporate model.

Key words
technological change, electrification, labor displacement, labor markets, human capital, corporate governance, economic history, Sweden

Classification system and/or index terms (if any)

Supplementary bibliographical information

Language
English

ISSN and key title

ISBN
978-91-989642-4-0 (print)
978-91-989642-5-7 (pdf)

Recipient's notes

Number of pages
298

Price

Security classification

Like moths to a flame
an individual level approach to technological change in 20th century Sweden

by Jonathan Jayes

LUND
UNIVERSITY

A doctoral thesis at a university in Sweden takes either the form of a single, cohesive research study (monograph) or a summary of research papers (compilation thesis), which the doctoral student has written alone or together with one or several other author(s).

In the latter case the thesis consists of two parts. An introductory text puts the research work into context and summarizes the main points of the papers. Then, the research publications themselves are reproduced, together with a description of the individual contributions of the authors. The research papers may either have been already published or are manuscripts at various stages (in press, submitted, or in draft).

Cover illustration front: Cover art by the author, inspired by Sweden's electrification along the Western Line. Done in Inkscape using a combination of hand-drawn elements and digital techniques.

Funding information: The thesis work was financially supported by the Knut and Alice Wallenberg Foundation (KAW 2014.0138).

Lund University School of Economics and Management, Department of Economic History

ISBN: 978-91-989642-4-0 (print)
ISBN: 978-91-989642-5-7 (pdf)
ISSN: 1400-4860 Lund Studies in Economic History

Printed in Sweden by Media-Tryck, Lund University, Lund 2025

Media-Tryck is a Nordic Swan Ecolabel certified provider of printed material. Read more about our environmental work at www.mediatryck.lu.se

Printed matter 3041 0903

MADE IN SWEDEN

I enjoy some of the old and I enjoy the new

And if I can find a balance between it, that's where I find my satisfaction

From Anderson .Paak's *The Dreamer*

Featuring the Timan Family Choir & Talib Kweli

Contents

Scientific Publications

Appendix: Conference Poster

Acknowledgements

A dissertation is often seen as a solitary pursuit, yet this work would have been impossible without the extensive community of supervisors, colleagues, mentors, and friends who supported its creation.

This journey was first and foremost made possible by generous funding from the Knut and Alice Wallenberg Foundation (KAW 2014.0138), a grant awarded to my main supervisor, Professor Kerstin Enflo. I owe my deepest gratitude to Kerstin. Thank you for hiring me, and for giving me the space and encouragement to grow as a researcher, especially in areas where I initially lacked confidence. I appreciate all your guidance on this sometimes difficult journey. I am also immensely grateful to my additional supervisor, Jakob Molinder. Thank you for always being there to offer pointers and for sharing your sage wisdom, particularly when it came to the intricacies of Stata and the creation of replication files.

My path to Lund began long before I arrived, and for that, I must thank my Master's supervisor, Johan Fourie at Stellenbosch University. It was Johan who pulled me from competition economics into the world of economic history and encouraged me to apply for this PhD. Like many Stellenbosch economic history alumni, I am deeply indebted to him for setting me on this course.

The research itself was sharpened and improved by many brilliant minds. The first paper in this dissertation would not exist without my co-author, Benjamin Mungo Schneider. Thank you for collaboration and a wonderful friendship that began in Vienna in 2023. I extend my sincere thanks to Christian Vedel from SDU, who served as a fantastic opponent at my midway seminar. He has been an inspiration in the application of new technology to our field and was kind to introduce me to the rest of the gang at SDU. To Kristin Ranestad and Josef Taalbi, thank you for being my opponents at the final seminar; your useful feedback was instrumental in improving the third and fourth papers of this dissertation.

My time in Lund was improved a great deal by the fine environment at the Department of Economic History. I am particularly grateful to Anneli Nilsson Ahlm for her administrative wizardry; she assisted me with everything from my first residence permit to the final ISBN for this book. My thanks also go to Mats Olsson and Anna Tegunimataka for their leadership during my time here. Truly, a thousand flowers have bloomed under their leadership.

Within the department, I am deeply grateful to all my PhD colleagues, but especially to "the downstairs boys." My officemate, Anton Svensson, was the most exceptional office mate one could ask for, and from him, I learned what it truly means to be inspired by our field. Jonas Kreutzer and Youssouf Merouani helped cultivate in me a will to use intriguing new tools for economic history, and our conference sessions organised together were a highlight.

To Anders Larsson, I am immensely grateful for your constant willingness to answer my questions on everything from the intricacies of Swedish occupational titles, or great castles to visit in Scania, to the humble tradition of genealogical research. My thanks also to Alexandra L. Cermeño and Faustine Perrin for their kindness and for always looking out for me, and to Olof Ejermo for recommending the foundational work of Per-Olof Grönberg to use as a basis for my own research.

My academic world was broadened by many others beyond Lund. I owe a special debt to Suvi Heikkuri, who paved the way both in organizing the Swedish Economic History Meeting before me and in thinking deeply about Sweden's electrification. I look up to you a lot and hope we can work together soon! To William Skoglund, Bram Hilkens, Peter Courtney, and Tancredi Buscemi, thank you for your friendship and for deepening my appreciation for our field. The community at the University of Southern Denmark (SDU) has been particularly enriching; thank you to Greg Clark and Paul Sharp for making it such a great place to visit, and to the entire SDU team for the fun at Summer School and beyond. I am also grateful to the gang at the Forte Swedish Labor Mobility Lab for being so welcoming.

Finally, on a more personal note, this journey would have been impossible without the support of those closest to me. To my parents, Marian and Wayne, thank you for your constant love, support, and encouragement from South Africa. To Nick Wilkinson, thank you for your invaluable advice and friendship along the way. And to my wonderful girlfriend, Kathy Brown – without you in my life, I simply could not have completed this.

Popular summary in English

This thesis analyzes the effects of technological change using the case of electrification in 20th-century Sweden. It begins with a systematic literature review that identifies gaps in the quantitative research on historical job displacement before 1980. In Sweden, electrification enhanced labor and reduced income inequality. Analysis of 1930 census data shows that early electricity access raised incomes, particularly for lower-income and less-educated individuals.

The research reveals a labor market forked into two groups. High-skilled engineers, identified using AI analysis of historical biographies, were a mobile elite with international experience who implemented the technology. In contrast, the main economic benefits went to the local, less-skilled workforce.

The firm-level analysis investigated the impact of corporate leadership by treating U.S. management practices as a form of technology. Appointing the first U.S.-experienced engineer to a board had different effects depending on the era: before 1945, it led to hiring more workers, while after 1945, it led to workforce reductions and a smaller portion of company earnings going to workers. Directors with business backgrounds had no significant effect on labor in either period.

The thesis concludes that the societal impact of technology is not predetermined but is shaped by the technology itself and its institutional context (meaning the laws, union strength, and political climate of the time).

Populärvetenskaplig sammanfattning på svenska

Den här avhandlingen undersöker hur teknisk utveckling påverkar samhället, med elektrifieringen i 1900-talets Sverige som exempel. Först görs en genomgång av tidigare forskning som visar att det saknas kvantitativa studier om hur jobb försvinner eller förändras över tid innan 1980. I Sverige gynnade elektrifieringen arbetstagare och minskade inkomstskillnader. Analys av folkräkningen 1930 visar att tidig tillgång till el höjde inkomsterna, särskilt för personer med lägre inkomster och kortare utbildning.

Avhandlingen visar också att arbetsmarknaden delades i två grupper. Högutbildade ingenjörer (identifierade från historiska biografier med hjälp av AI-verktyg) var en rörlig elit med internationell erfarenhet som drev igenom tekniken. Samtidigt gick de största ekonomiska vinsterna till den lokala, mindre kvalificerade arbetskraften.

På företagsnivå undersöks hur sättet att leda och organisera företag påverkade utfallet. Amerikanska arbetssätt behandlas som en form av "teknik". När den första ingenjören med USA-erfarenhet trädde in i en styrelse blev effekterna olika över tid: före 1945 anställdes fler, efter 1945 minskade personalen och en mindre del av vinsterna gick till löner. Styrelseledamöter med affärsbakgrund gav inga tydliga effekter i någon period.

Slutsatsen är att teknikens samhällspåverkan inte är given i förväg. Den formas både av den specifika tekniken och av omgivningen—som lagar, fackens styrka och det politiska läget.

Kappa

1 Introduction

1.1 Aim

The question of whether technological advancements will lead to widespread joblessness and exacerbate inequality is arguably one of the most pressing concerns of our time (Autor 2022; Frey 2020). Fueled by rapid developments in artificial intelligence and robotics, anxieties about automation echo historical fears (Mokyr, Vickers, and Ziebarth 2015), perhaps best encapsulated by influential studies suggesting a large fraction of jobs are susceptible to computerization (Frey and Osborne 2017). The potential for increasing polarization of the labor market, illustrated starkly in analyses like Frey and Osborne's Figure 1, has only intensified these debates.

Understanding how societies navigate such profound shifts requires more than speculation; it demands empirical grounding and historical perspective. My own interest in this topic is quite personal, rooted in my family's history. The Jayes family were stocking knitters in Enderby, Leicestershire, their livelihoods intertwined with the cottage industry that characterized the region before the Industrial Revolution. The mechanization of knitting disrupted this way of life, forcing a move to London where opportunities lay in manual labor, shoveling coal from the barges supplying the growing metropolis. Seeking further opportunities, the family eventually migrated to South Africa. This history – of displacement caused by technological change, the painful adjustments required, and the concurrent creation of new, albeit different, opportunities – sparked my interest with the dynamics of technological disruption and its human consequences. It underscores that while technology can destroy, it also reshapes, creating new pathways forged through challenge and adaptation.

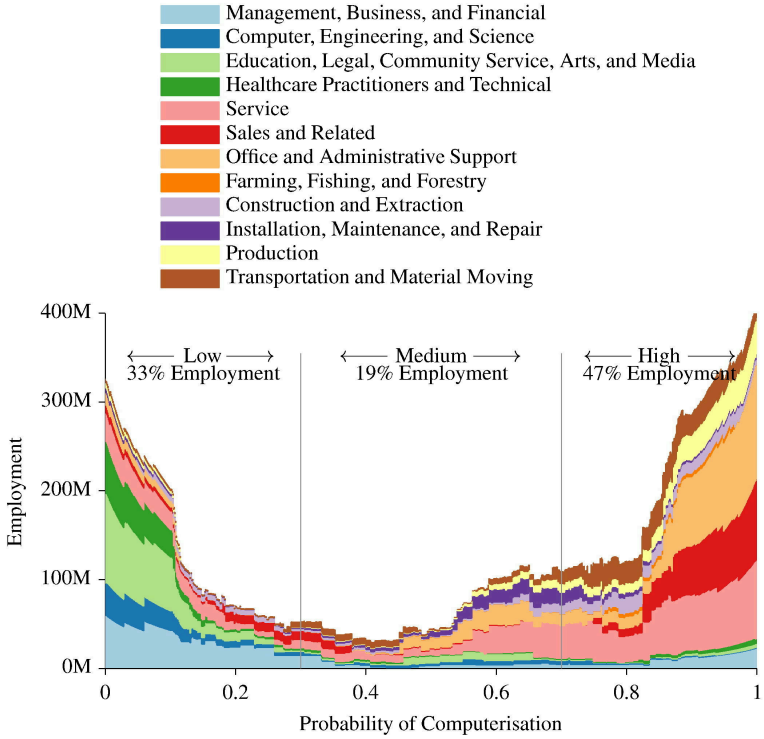


Figure 1: The Frey and Osborne (2017) chart displaying the probability of computerization of different occupations.

This thesis leverages historical experience to inform these contemporary concerns. It argues that previous transitions driven by major General Purpose Technologies (GPTs), technologies with the potential to fundamentally reshape economies, offer vital lessons (Crafts 2010). Specifically, this thesis investigates the impacts of one such pivotal GPT, electrification, on labor markets, skills, inequality, and corporate structures, using the historical case of Sweden during the late 19th and 20th centuries. By examining this specific historical context, the research aims to provide empirical depth and historical perspective relevant to current anxieties about automation and the future of work (Autor 2019; Crafts 2021a).

The investigation explores the interplay between the nature of electricity as a technology, the role of human capital (encompassing both medium-skilled workers and the high-skilled upper tail), the influence of institutional factors such as the rise of unions and the education system, and the impact of corporate governance structures (Högfeldt 2005) in shaping the outcomes of this technological transition. The research strategy reflects this mix, following a logical progression through the four papers. The first paper systematically surveys the historical literature to discover where quantitative evidence on labor displacement and replacement is lacking. Building on this context, the second and third papers turn to the Swedish case, examining how electrification, as an instance of technology potentially creating new jobs and opportunities, affected workers across the income distribution and investigating whether the high-skilled engineers driving this change were distinctive relative to the places experiencing transformation. Finally, the fourth paper analyses the firm-level consequences, exploring whether managers, based on their education and experience, made different choices regarding the deployment of capital and labor, thereby affecting workers' wages and employment.

1.2 Research Questions

The overarching research question guiding this thesis is:

How does technological change impact labor market outcomes, skill demands, income distribution, and firm-level dynamics, drawing on historical evidence from 20th century Sweden?

This investigation uses key technological transitions, primarily electrification, as case studies and considers the mediating roles of human capital and corporate governance.

This broad question is addressed through four specific sub-questions, each corresponding to one of the papers in the dissertation and following a sequence from general historical context to specific mechanisms within the Swedish case:

1. Under what conditions has historical technological change led to labor displacement, and what are the primary gaps in the quantitative evidence? (Paper 1)
2. Focusing on electrification as a specific instance of major technological diffusion in Sweden, how did early access to this technology impact individual labor market outcomes (income, employment, and inequality), for workers across the skill and income distribution? (Paper 2)
3. What were the defining characteristics (in terms of origin, education, and international experience) of the high-skilled engineers who implemented this technological shift? (Paper 3)
4. How did the backgrounds of corporate leaders influence firm-level labor outcomes, and how was this relationship mediated by Sweden's shifting corporate governance regimes? (Paper 4)

1.3 Limitations

While this thesis aims to provide robust empirical insights, the nature of historical inquiry and the specific methodologies employed inevitably introduce limitations that warrant careful consideration when interpreting the findings. The focus on Sweden during the 20th century, and primarily on electrification as the central case study of technological change, represents a deliberate research design choice. However, the generalizability of findings, particularly the specific labor market outcomes associated with electrification, to other national contexts or different types of technological transitions requires caution; Sweden was undergoing a period of equalization at the time and this is not attributable entirely to electrification. Similarly, the literature review in Paper 1, while broad historically, is

constrained by its reliance on English-language sources, potentially overlooking relevant comparative evidence.

Beyond these choices of scope, certain methodological challenges arise from the approaches used. Paper 1 adapts the GRADE-CERQual framework to assess confidence in the narrative synthesis of historical labor displacement. While this brings structure, GRADE-CERQual was developed primarily for contemporary qualitative evidence, such as in health research. Its suitability for evaluating the nuances and source-critical challenges inherent in diverse historical scholarship is an adaptation, and its application here requires acknowledgment as an exploratory methodological step in economic history.

Furthermore, Papers 3 and 4 rely heavily on biographical dictionaries (*Vem är Vem?*, *Vem är Det?*). These sources inherently capture an elite, non-representative segment of Swedish society, introducing selection bias. While perhaps less critical when studying board members, who are typically elites, this impacts the generalizability of findings about high-skilled engineers. A related concern is the varying level of detail within biographies; there is a potential, unmeasurable risk that this variation is systematic – for instance, if individuals in certain regions or roles provided less detailed information, it could bias analyses relying on extracting specific career or experience details, particularly affecting the granularity of findings in Paper 3. The incomplete matching rate between board members and biographical entries in Paper 4 also introduces potential bias if unmatched directors differ systematically.

The event-study design in Paper 4, examining the impact of appointing directors with specific backgrounds, faces potential endogeneity concerns. Board appointments are not necessarily exogenous events; firms might appoint directors with specific skills because of their current performance trajectory or strategic needs.

While firm and year fixed effects mitigate some concerns, the analysis lacks strong instruments to fully isolate the causal effect of board composition changes from underlying firm dynamics.

Finally, the research contends with standard challenges of historical data across the papers. These include the incomplete digitization of the 1930 census affecting sample size and potentially external validity in Paper 2; income data thresholds censoring lower earners; inconsistent financial reporting standards over the long time span affecting panel data quality in Paper 4; the sample bias towards large, listed firms in Paper 4; and sparse historical data for variables like union density.

Acknowledging these limitations is crucial. They temper the certainty with which causal claims can be made, particularly regarding the firm-level impacts of board composition, and highlight the specific context dependency of the findings related to electrification's distributional consequences and high-skilled labor mobility.

1.4 Roadmap and Mindmap

This introduction serves as the entry point to the dissertation. Section 2 provides the essential Economic Historical Context, detailing Sweden's industrialization, the crucial role of electrification, and the relevant economic, social, and institutional landscape of the period. Section 3 looks into Theory and Previous Research, connecting the thesis to core academic debates concerning technological change, labor markets, skills, inequality, human capital, institutions, and corporate governance. Section 4 outlines the Methods employed across the four papers, explaining the rationale and limitations of each approach. Section 5 describes the Data sources in detail, discussing their origins, compilation, content, and inherent challenges. Section 6 presents the main Results through extended executive summaries of each individual paper, linking findings back to the research questions. Finally, Section 7 offers a Concluding Discussion, synthesizing the overall findings, highlighting

the main contributions of the thesis, and suggesting fruitful avenues for future research.

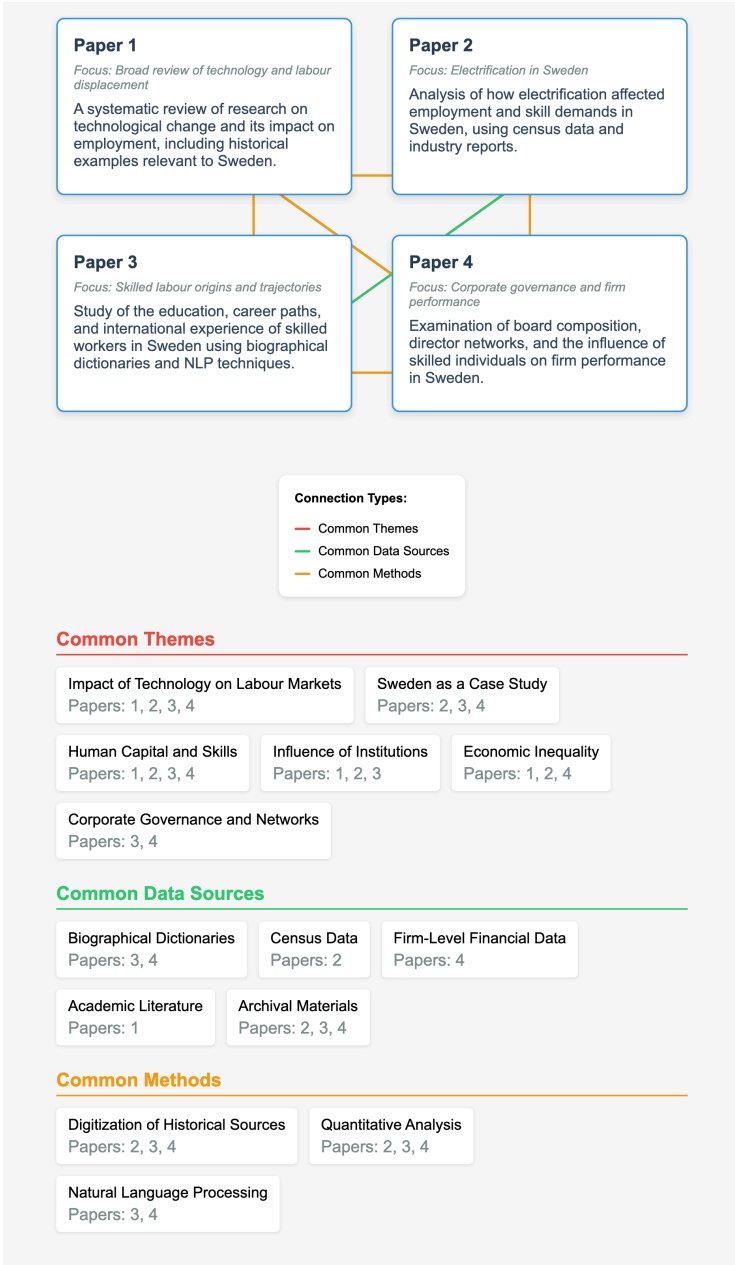


Figure 2: Mindmap of the thesis, showing the connections between the four papers and the overarching themes.

1.5 List of Papers and Author Contributions

This dissertation is based on the following four papers, where co-authors are abbreviated as follows:

Benjamin Schneider (BS), Kerstin Enflo (KE), Jakob Molinder (JM).

1. Paper 1: "Has technology destroyed jobs? A systematic review of historical labor displacement". This paper is co-authored with BS. I designed the search strategy, conducted the database searches, developed a software tool to facilitate screening, and contributed equally to the data extraction and writing of the paper. BS contributed the initial conceptualization, overall strategy, extraction, and writing.
2. Paper 2: "Power for progress: The impact of electricity on individual labor market outcomes". This paper is co-authored with KE and JM. I was responsible for the quantitative analysis in this paper. My primary role involved cleaning the data, coding the econometric models, creating the replication files, generating data visualizations and maps, and writing the analysis section. KE and JM served as project leaders. KE took the lead on writing and was instrumental in sourcing the 1930 census data. JM contributed specific data and figure creation.
3. Paper 3: "Praise the people or praise the place? Upper tail human capital in electrifying Sweden". This paper is single-authored.
4. Paper 4: "Technocrats to tycoons: The shift in Swedish corporate leadership and its economic consequences in the 20th century". This paper is single-authored.

These are displayed in Figure 3, which provides a summary of the papers, their research questions, data sources, and authorsip. Inspiration was drawn from Nick Ford's figure in his Kappa to create this, and I owe him a debt of gratitude for the idea.

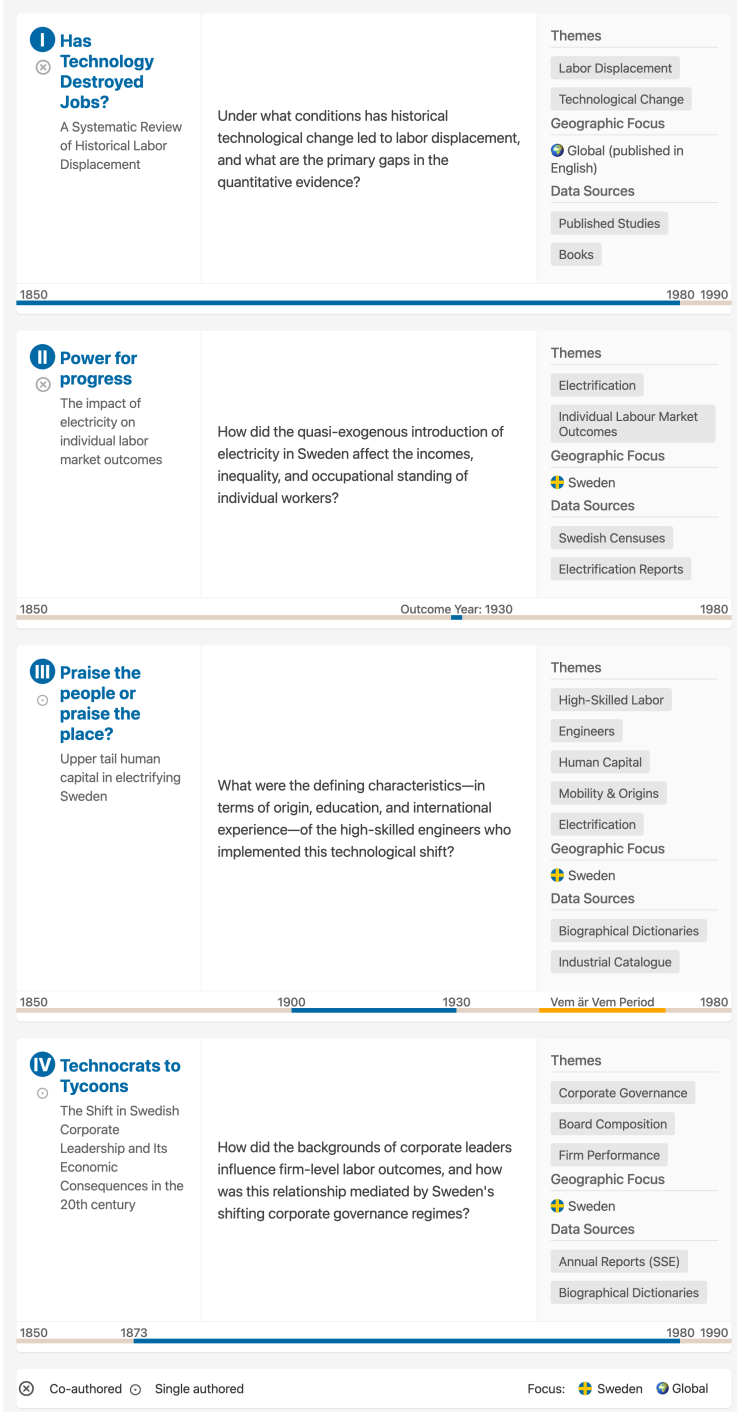


Figure 3: Paper information and timelines

1.6 Contribution of Research

This thesis contributes to the economic history of technological change through its methodological innovations and substantive findings. It provides an individual-level analysis of Swedish electrification, integrating insights across different levels of analysis and employing a range of methods to present a granular account of a major technological transition.

A primary methodological contribution is the development of a scalable data-generation pipeline using artificial intelligence to extract structured data from complex historical sources. Large Language Models and Natural Language Processing techniques were used to systematically parse thousands of entries from biographical dictionaries and over a century of corporate annual reports, converting unstructured text and images into analyzable datasets. This framework presents a replicable approach for unlocking similar historical archives in other national contexts. This work was complemented by the application of a systematic review framework to rigorously map the literature on labor displacement and identify specific gaps in quantitative research.

These methodological advances enable several substantive contributions. The research directly challenges the universal applicability of Skill-Biased Technological Change (SBTC) theories. The finding that electrification in Sweden was labor-enhancing and inequality-reducing, disproportionately raising the incomes of lower-skilled workers, serves as a significant historical counterexample to models that predict technological shifts are inherently polarizing.

This evidence refines the narrative of Sweden's "Great Leveling" by identifying a specific micro-level mechanism contributing to the era's income compression. The research further reveals a bifurcated labor market, contrasting the locally-rooted, medium-skilled workforce that benefited directly from electrification with

the highly mobile, nationally-sourced engineers who implemented the technology. This distinction clarifies the heterogeneous roles and mobility patterns of different skill groups during a technological transition.

Finally, the thesis offers a long-run perspective on how corporate governance mediates the impact of new management 'technologies.' The analysis reveals that the influence of managerial human capital is highly context-dependent. It shows that the appointment of US-experienced engineers was associated with workforce expansion in the pre-1945 'managerial' era but was linked to workforce rationalization and a declining labor share in the post-1945 'investor' era, demonstrating that governance regimes can determine whether innovation's gains are shared with labor

2 Economic Historical Context: Sweden at the Turn of the 20th Century

Sweden's economic history across the nineteenth and twentieth centuries charts a course from a predominantly agrarian society through industrialization to a modern service-based economy. This transformation, however, was neither linear nor uniform. Rather, as Schön (2012) argues, it unfolded through distinct structural cycles, punctuated by crises around key junctures like 1890 and 1930, with each cycle displaying characteristic patterns of investment, technological emphasis, and institutional adaptation. Central to understanding these transitions is Schön (2012, p. 26)'s concept of "development blocks"; synergistic clusters of complementary activities centered on core innovations. "Complementarity is the basis of what Erik Dahmén calls development blocks," Schön notes, explaining that tensions emerge within these blocks, requiring investment and driving change. Enflo, Kander, and Schön (2008, p. 59) provide quantitative identification for such blocks, showing

how sectors co-evolve, often intensifying activity during periods of "creative destruction". Supporting this cyclical view, Taalbi (2021) finds that innovation activity, measured through patents and literature-based indicators, surged precisely during these periods of structural crisis and investment downturns, such as the 1930s. He suggests these crises acted as catalysts, activating competencies developed during preceding periods of "infrastructure build-out and industry rationalization," rather than landscape pressure alone explaining the surges (Taalbi 2021, p. 222). The era central to this thesis, primarily the late nineteenth century through the mid-twentieth century, corresponds largely to Sweden's second industrial revolution, a period shaped significantly by the development block surrounding electrification.

Electricity emerged as a defining General Purpose Technology (GPT) for Sweden during this period. Such technologies are characterized by their potential for pervasive use across many sectors, ongoing technical improvement, and their role in stimulating further "innovational complementarities" (Bresnahan and Trajtenberg 1995, p. 83). In Sweden's case, its specific resource endowment (abundant hydropower contrasting with scarce domestic fossil fuels) created a powerful incentive for early and widespread electrification, documented by Schön (2000), and demonstrated in Figure 4. This path dependence stands in stark contrast to neighbours like Denmark; Ranestad and Sharp (2023, p. 1342) detail Denmark's centuries-long, ultimately fruitless search for domestic coal, a "success through failure" that highlighted its reliance on imported energy and shaped its subsequent industrial choices. The development of high-voltage transmission technology in the 1890s proved pivotal for Sweden, enabling the industrial exploitation of its water power resources (Schön 2000). Quantitative studies confirm electricity's centrality: Enflo, Kander, and Schön (2008) identified development blocks linking the electricity sector with crucial industries like metals, machinery, railways,

chemicals, and pulp and paper, indicating strong, empirically observable intersectoral complementarities driving industrial transformation. Comparable microevidence from Switzerland shows early electrification generated long-run local development through innovation and human-capital channels (Brey 2025).

2.1 The Technology of Electrification

The practical application of electricity in the late nineteenth century was constrained by a fundamental technical problem: direct current (DC), the dominant early standard, could not be transmitted efficiently over long distances (Schön 2000). This limitation posed a significant barrier for Sweden, where the most abundant energy resources (the powerful waterfalls of the north, at e.g. Porjus) were located far from the industrial and population centers in the south. The solution to this geographical dilemma emerged from Swedish ingenuity, specifically through the work of engineer and inventor Jonas Wenström. In the 1890s, Wenström developed and patented a three-phase alternating current (AC) system, a technology that, when paired with transformers, solved the problem of long-distance, high-voltage transmission. This innovation was foundational, leading to the creation of Allmänna Svenska Elektriska Aktiebolaget (ASEA) in 1890, a company built upon Wenström's designs that would become a cornerstone of Sweden's electrotechnical industry (Fridlund 1993).

The viability of Wenström's three-phase system was demonstrated decisively in 1893. In a landmark project, ASEA constructed a transmission line to carry power from a hydroelectric plant at Hällsjön to the iron mines in Grängesberg, a distance of 15 kilometers (Hultström 1934; Fridlund 1993). This line, operating at 9.5 kV, was the first commercial application of the technology in Sweden and served as a crucial proof of concept. It confirmed that hydropower could be harnessed on an industrial scale, liberating factories from the need to be located directly adjacent to water sources and unlocking the nation's "white coal" (Hultström 1934). This

successful demonstration catalyzed the development of numerous private and municipal power plants, but the creation of a truly national system required investment and coordination on a much grander scale.

This next phase was spearheaded by the state-owned utility, Vattenfall, through the construction of the Western Main Line, or *Centralblocket*. This was a process of strategic investment and technological ambition. Completed in 1921, the line connected Vattenfall's two major, but previously separate, regional systems centered on the hydroelectric power stations at Trollhättan (Olidan) and Älvkarleby (Vattenfall 1948; Molinder, Karlsson, and Enflo 2022). Operating at a then-record voltage of 130 kV, the Western Line was a frontier project that required immense capital outlay and engineering expertise (Vattenfall 1948). Its completion established a robust transmission backbone through Sweden's industrial heartland, creating the core of the national grid.[1] This strategic investment was the essential technical prerequisite for the reliable and widespread distribution of electricity, enabling the productivity gains and profound social changes that define this era of Swedish history.

The century-long journey from isolated DC lighting to an interconnected, high-voltage nation was marked by a series of key technological, corporate, and policy milestones. The following table summarises this progression, highlighting the critical steps from the first local applications and foundational inventions to the creation of a national grid and the subsequent diversification of energy sources.

[1] On how local water-rights regimes can delay hydroelectric reorganization and grid build-out, see Brey & Weisdorf (work in progress).

Table 1: Milestones in the development of Sweden's electrification

Key Milestones in Swedish Electrification

YEAR	MILESTONE	SIGNIFICANCE
1885 (10 Dec)	First municipal DC street lighting in Härnösand, powered by the Gådeå hydropower station.	Sweden's first permanent electric street lighting; early hydropower-based urban application.
1893	First long-distance three-phase AC transmission Hällsjön/Hellsjön → Grängesberg (~15 km).	Breakthrough enabling use of remote hydropower and long-distance supply.
1909	Kungliga Vattenfallsstyrelsen (Royal Waterfall Board) established.	Placed large-scale hydropower and electrification under a state body.
1910–1915	Olidan (from 1910), Porjus (1915), Älvkarleby (1915) commissioned.	Built national base generation aimed at industry and railways.
1927	FERA (Association for the Rational Use of Electricity) formed.	Platform promoting household and rural adoption.
1937–1938	Vattenfall, Sydkraft & Krångede grids linked (1937); first nationwide joint operation (1938).	De facto national system; improved reliability and load balancing.
1952	First ~400 kV AC line (Harsprånget–Hallsberg) in service.	Landmark in transmission; expanded north–south transfer capability.
1964	Ågesta nuclear reactor enters operation.	Start of nuclear generation (district heat + power).
Mid-1960s	Electrification functionally complete.	Near-universal household access; main build-out ends.
1973–1974	Oil crisis.	Elevated strategic role of electricity; reinforced nuclear build; boosted electric and district heating.
1980 (23 Mar)	Nuclear power referendum.	Set policy toward gradual phase-out; shaped long-term energy politics.

Sources: compiled from Vattenfallsstyrelsen (1921), Hultström (1934), Söderbaum (1935), Hjulström (1940), Kaijser (1994), Stymne (2002), Högselius et al. (2013), and Kander, Malanima, and Warde (2013)

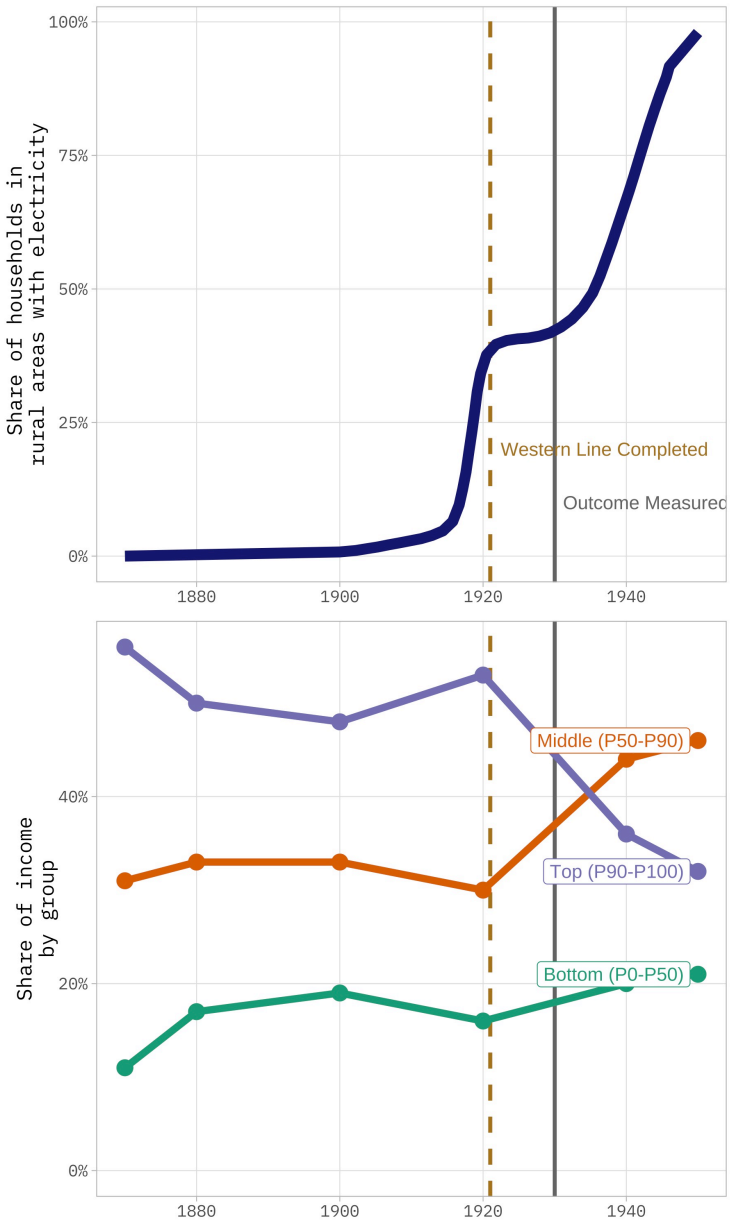
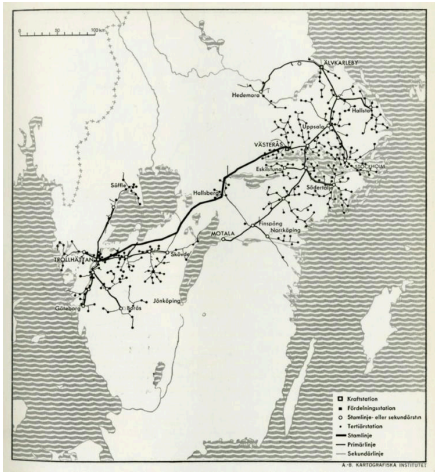
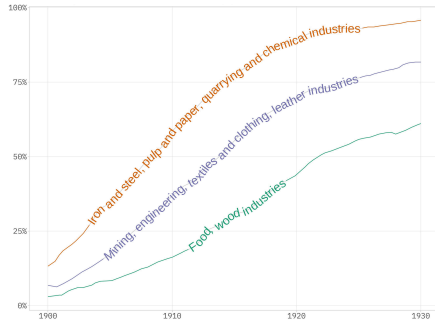


Figure 4: Evolution of income shares in Sweden and rural electrification rate. Source: Information on rural electrification from Vattenfall (1948) and information from income shares from Bengtsson and Molinder (2021).

The adoption of electric motive power was rapid, becoming widespread in industry by 1920. However, consistent with the nature of GPTs, realizing the full economic impact required time and significant complementary adjustments; as Crafts notes, realizing a GPTs potential often involves lags due to the need for widespread diffusion, complementary investments, and "fundamental changes in organization and practice" (Crafts 2021a, p. 22). Schön (2000) observes that significant leaps in electricity usage occurred in phases (e.g., 1900-1920, late 1930s-early 1950s), often correlating with falling relative electricity prices and periods of industrial renewal, which Taalbi (2021) also links to broader innovation surges following structural crises. While aggregate productivity effects can be delayed—an example of the "productivity paradox" Schön (2000, p. 175) discussed in relation to electricity, micro-level evidence presented by Heikkuri (2024, p. 5) suggests positive associations between electrification and establishment-level employment and wages in Sweden during this time. State-supported infrastructure, notably the Western Line transmission network connecting hydropower across the country between industrial centers in the south (see Figure 5), played a key role in facilitating this diffusion process, which was rapid across various industries, where electricity as a source of energy increased from an average of six percent in 1900 to above 50 percent for even the least electrified industry in 1930, in as shown in Figure 5b.



(a) A map from the Vattenfall archive showing the development of the electrical grid across the country from hydropower plant Olidan to Älvkarleby



(b) A figure adapted from Schön (2000) showing the speed at which different industries adopted electricity as a source of energy from 1900 to 1930

Figure 5: The rapid expansion of electricity across Sweden. Source: Figure 5a reproduced from Vattenfall (1948) and Figure 5b adapted from Schön (2000).

While industrial applications drove the initial large-scale infrastructure, the transformative power of electricity in the Swedish economy is equally evident in its slower, but socially profound, penetration into the countryside. Here, the key innovation was not the mobile unit-drive motor of the factory, but the versatile stationary electric motor (Jansson Myhr 2023). Early ambitions to rationalize fieldwork with machines like the electric plough proved largely unsuccessful. Instead, the true revolution occurred within the farmstead itself, where the stationary motor could be adapted to a myriad of tasks that had previously been dictated by the rhythms of intense manual labour or cumbersome mobile steam engines (Jansson Myhr 2023). This shift from field to farmstead was the crucial step in mechanizing Swedish agriculture.

The most immediate impact was felt in tasks that were previously bottlenecks of seasonal or daily labor. During the 1920s, electricity's primary agricultural use was for threshing grain, where a motor could power a threshing machine, dramatically increasing the speed and efficiency of the harvest and breaking a major seasonal labor constraint (Jansson Myhr 2023; Molinder, Karlsson, and Enflo 2022). Beyond this, motors were widely applied to drive other essential barn machinery, including grain crushers, root cutters, and other forms of feed preparation equipment, mechanizing the daily chore of processing animal fodder (Rasmussen 1962). Furthermore, the adoption of reliable electric water pumps was a significant development, not only for providing consistent water to livestock but also for bringing running water into many rural homes for the first time, representing a major leap in sanitation and quality of life (Pate 2021).

In the dairy sector, electric motors were first used to power cream separators; an important critical piece of equipment for producing a valuable commodity, and later, milking machines, which further reduced labor intensity and improved hygiene (Pate 2021; Rasmussen 1962). This on-farm mechanization was facilitated by a uniquely Swedish institutional model, where the state utility Vattenfall encouraged the formation of local cooperative electricity distribution associations (*distributionsföreningarna*) to build and manage local networks ("Den Svenska Lantbrukskooperationens Bakgrund, Framväxt Och Utveckling till 1930," n.d.). This cooperative, broad-based approach, combined with a technology that augmented a wide array of manual tasks rather than simply replacing them, had a powerful equalizing effect. It created new skilled occupations accessible to workers with only primary education and boosted incomes for those in the bottom half of the distribution.

2.2 Social, Economic, and Institutional Context

This technological transformation occurred within a dynamic economic landscape. Sweden's industrial core; comprising engineering, iron and steel, pulp and paper, and electrical equipment manufacturing—sectors often dominated by established players like those within the Wallenberg sphere or linked to Stockholms Enskilda Bank, as noted by Högfeldt (2005), were closely tied to the electricity development block identified by Enflo, Kander, and Schön (2008). These industries, frequently export-oriented, experienced significant growth. This expansion played a crucial role in absorbing labor migrating from a declining agricultural sector, aligning with Andersson and Gunnarsson (2004, p. 5) 's description of a "levelling" period from around 1870 onwards, driven by job creation in expansive industries. This profound structural shift provides the essential backdrop against which the specific impacts of electrification on labor markets unfolded.

The social and institutional context of late nineteenth and early twentieth-century Sweden presents a complex picture regarding equality. The traditional narrative of a Swedish "Sonderweg" characterized by continuous egalitarianism has been challenged by Bengtsson (2019, p. 124), who argues this view is largely a "national myth". Bengtsson points to evidence showing Sweden around 1900 was "severely unequal," with highly restricted suffrage and wealth concentration comparable to Britain, France, or even the more unequal United States. This high level of wealth inequality by 1900 is further detailed by Bengtsson et al. (2018), who document a continuous rise in wealth concentration from 1750 onwards, driven initially by rising inequality within the rural sector itself. It was this backdrop of inequality and political exclusion, that provided fertile ground for the powerful popular movements – unions, free churches, temperance groups – that mobilized from the 1870s onward. These movements were not merely continuing an egalitarian tradition but were crucial in forging the more egalitarian structures of the twentieth

century through their "huge organizational drive" and political activity (Bengtsson 2019, p. 157). Nonetheless, in the early 20th century, the income shares of the top 10 percent of Swedish society began to fall markedly, coinciding with the period of electrification, as shown in Figure 4. Regional economic disparities also evolved non-linearly; Enflo and Henning (2016) show that while overall regional GDP per capita inequality generally declined between 1860 and 1980 (albeit with periods of stability, notably 1910-1940), the specific drivers and patterns of regional convergence or divergence shifted across different industrial cycles. Similar themes are echoed in Nilsson's cluster research, which emphasizes how anchor firms in peripheral regions relied on extra-local collaborations and resource pooling to offset weaker local spillovers (Nilsson, Schubert, and Miörner 2023). The period thus saw Sweden undergo significant structural transformation, impacting different regions and social groups unevenly.

The interaction between technological change and human capital development proved important, often conceptualized through Tinbergen's framework of a "race between education and technological development," where the outcome for inequality depends on whether the supply of educated labor keeps pace with technology-driven demand (Tinbergen 1975, p. 16). While Sweden possessed widespread basic literacy early on, as noted by Ford, Ranestad, and Sharp (2022), the expansion of secondary and higher education accelerated significantly in the early twentieth century. Typically, such increases in the supply of educated workers contribute to compressing wage differentials, unless the pace of skill-biased technological change dramatically outstrips educational expansion (Goldin and Katz 2007; Katz and Murphy 1992). However, contrary to the expectation that major technological shifts like electrification would necessarily increase the relative demand for skills, evidence from Heikkuri (2024) suggests that during the main electrification period in Sweden, the skill premium actually decreased, driven

by faster income growth among lower-skilled production workers compared to high- and medium-skilled white-collar workers. This finding, consistent with micro-level studies indicating that research and development heavy technological change tended to reduce income inequality, such as Piva and Vivarelli (2018), might reflect the specific 'enabling' nature of electrical technology in this historical context, potentially complementing existing skills broadly, combined with the rapid expansion of educational supply occurring simultaneously (Goldin and Katz 2007). The nature of work shifted markedly, involving aggregate skill upgrading partly via women entering service roles, but also simultaneous deskilling trends within manufacturing, as evidenced by Heikkuri (2024). Furthermore, Andersson and Molinder (2024) demonstrate that cities themselves played a causal role in skill formation during this era; rural-urban migration significantly boosted workers' occupational standing through both better initial job matching and dynamic learning effects within the urban environment, with these benefits being particularly pronounced for initially less-skilled migrants. Concurrently, demand grew for "upper tail" human capital, notably engineers. This group, as documented by Grönberg for Sweden and Ranestad for Norway, formed a mobile elite facilitating knowledge transfer, often bringing back valuable international experience gained through "target migration" (Grönberg 2003, p. 31). Crucially, the ability of the domestic economy to effectively 'absorb' and utilize this transferred knowledge, rather than just being exposed to it - a concept emphasized by Kingsley, Bozeman, and Coker (1996) — depended significantly on the existing domestic skill base and institutional context, determining the ultimate impact on growth.

Institutional changes significantly mediated these economic and technological processes. The strengthening labor movement, coupled with democratization, culminated around 1920 in political reforms - such as universal suffrage and the eight-hour day - that Bengtsson (2014) identifies as contributing to a marked

rise in labor's share of national income. This underscores the argument made by Bengtsson and Karlsson (2017) that distributional outcomes arise crucially from the interplay of technology with prevailing political and social forces, rather than solely from economic structure. Simultaneously, and somewhat paradoxically, Sweden's corporate ownership structure remained highly concentrated within family or bank spheres. Högfeldt argues this persistence was linked to specific legal frameworks permitting dual-class shares and pyramids, distinct financing patterns reducing reliance on external equity, and notably, political accommodations where Social Democratic policies effectively guaranteed stable private control in exchange for "investment and cooperation" (Högfeldt 2005, p. 522). This concentrated model, as Steier and Morck (2005) note, contrasts with the dispersed ownership patterns of the UK or US but aligns with governance structures common elsewhere globally. This specific Swedish constellation; an era marked by technological dynamism, significant educational expansion, and evolving institutional settlements between increasingly organized labor and entrenched capital—aligns conceptually with (Frey 2020, p. 206) notion of a "Great Leveling". However, the broad sharing of benefits Frey associates with this period's enabling technologies appears, in the Swedish case, to have been significantly shaped not just by the technology itself but by the particular political accommodations identified by Högfeldt (2005) and the strengthening position of labor culminating in the institutional reforms around 1920, according to Bengtsson (2014). Indeed, the potentially 'enabling' nature of electrification, as suggested by Frey's framework, finds micro-level support in Heikkuri (2024) finding of a decreasing skill premium during this time.

Finally, the economic geography of Sweden was significantly reshaped during this era. Early infrastructure investments, particularly the first wave of railroads, established lasting spatial patterns through path dependence. As Berger and Enflo demonstrate, even "the transitory advantage of an early rail connection perma-

nently shifted the location of economic activity" across Swedish towns (Berger and Enflo 2017, pp. 125-126). Electrification, as a subsequent major infrastructure development, necessarily interacted with this existing spatial structure. Foundational New Economic Geography theories predict that falling transport costs—a plausible outcome of grid expansion and cheaper power—should typically foster agglomeration and spatial concentration by strengthening market access and scale economy effects (Ottaviano and Thisse 2004; Martinez-Galarraga and Tirado-Fabregat 2020). However, Sweden's historical trajectory, as documented by Enflo and Henning (2016), complicates this standard narrative. They reveal an unusual pattern of initial decentralization of population and production during its early industrial cycles (up to 1930), followed only later by the expected increasing metropolitan concentration. Therefore, understanding electrification's spatial impact requires moving beyond simple agglomeration models to consider these complex, non-linear dynamics and, as highlighted by Faggio, Silva, and Strange (2020), the diverse micro-foundations—such as labour pooling, input sharing, or knowledge spillovers—driving concentration, which vary significantly across different industries and regions.

2.3 The Role of the Firm and the Rise of the *Snilleindustrierna*

The preceding papers establish the profound impact of electrification on the Swedish labor market and identify the distinctive characteristics of the "upper tail" human capital—the engineers—who were central to this transformation. However, these high-skilled individuals did not operate in a vacuum. They were employed by, and ultimately directed, the firms that served as the primary engines of technological change. To fully grasp the societal consequences of this era, the analysis must therefore pivot from the individual level to the institutional, asking how the strategic decisions made within these firms shaped the outcomes of technological adoption, particularly for the broader workforce.

This shift in focus is essential because Sweden's second industrial revolution was overwhelmingly driven by a specific cohort of pioneering, export-oriented companies known as the *snilleindustrierna*, or "genius engineering firms" (Schön 2012; Berner 1999). Enterprises such as ASEA, Ericsson, Sandvik, and Alfa Laval became the primary engines of this transformation. Sandvik's trajectory illustrates how product and process innovation translated into global reach (Fagerfjäll 2012), while Gustaf de Laval's separator underpinned Alfa Laval's early competitive edge (Rietz 2021). The work of these firms reshaped the very fabric of urban life and labor markets in industrial cities like Gothenburg (Karlsson and Lundh 2022).

Crucially, the "genius" of these firms was not abstract but was embodied in the technical expertise of their engineers. As Berner (1999)'s classic work demonstrates, engineering became the central, defining activity of Swedish industry during this period of intense technological change. This reflected a broader professionalization, as the institutionalization of engineering as a formal science consolidated the profession's authority and indispensability (Sundin 1981). The emergence of this distinct class of technical experts can be traced in sources like

the biographical dictionaries of the Swedish Association of Engineers, such as *Vem är Vem* and *Vem är Det?* (Indebetou and Hylander 1937).

This centrality of technical expertise naturally extended to corporate decision-making. Strategic choices about capital investment, international expansion, and the organization of production were increasingly shaped by technically trained leaders and the "management technologies" they promoted. Swedish handbooks and professional networks helped translate international best practices for local adoption, while sectoral exemplars show how engineering circles diffused new organizational and production methods (Rosenberg 2018). This technocratic leadership was reinforced by patient, long-term ownership models in key industrial groups. Firm histories, such as Sandvik's, illustrate how governance arrangements and board composition—particularly the role of engineers on boards of directors—mediated the pace and direction of technological deployment and, consequently, how the gains from industrialization were created and distributed (Fagerfjäll 2012). Nilsson's (2025) work on "anchor firms" demonstrates similar mechanisms in a contemporary setting, showing how dominant companies shape opportunity structures and productivity in Swedish regions.

Paper 4 directly addresses this question, providing the crucial link between the high-skilled individuals studied in Paper 3 and the broader economic outcomes of the era. It investigates how managers' backgrounds influenced corporate strategy and, consequently, workers' wages and employment. By constructing a novel dataset on the board composition of major Swedish firms over a century, the paper analyses whether the presence of directors with technical education and international experience led to different choices regarding capital and labor. It distinguishes between two distinct eras of corporate governance: an early "Managerial Capitalism" phase, where technocratic, engineer-led leadership was

dominant, and a later "Investor Capitalism" phase, characterized by a growing emphasis on finance and shareholder value.

This analysis allows the dissertation to move beyond identifying the *impacts* of technological change to exploring the *mechanisms* of its implementation. It directly connects the expertise of the engineers to the strategic choices of the firms that shaped Sweden's 20th century economy. By examining the decisions made in the boardroom, Paper 4 makes the case that the societal distribution of gains from innovation is not predetermined by the technology itself, but is critically mediated by corporate governance and the priorities of those in power. This makes the paper not an outlier, but the logical and necessary culmination of the thesis's argument, bridging the gap from individual human capital to firm-level behavior and its ultimate consequences for labor.

Table 2: Key milestones in the era of the Swedish "Genius Engineering Firms"

Key Milestones in Swedish Engineering

YEAR	MILESTONE
1861	Svenska Teknologföreningen (The Swedish Association of Engineers) is founded, beginning the formal organization of the engineering profession.
1862	Sandvikens Jernverk (Sandvik) is founded by Göran Fredrik Göransson, pioneering the industrial use of the Bessemer method.
1883	AB Separator (later Alfa Laval) is founded by Gustaf de Laval and Oscar Lamm, commercializing the centrifugal separator.
1919	Ingenjörsvetenskapsakademien (IVA, The Royal Swedish Academy of Engineering Sciences) is established, institutionalizing engineering science at the highest level.
1921	Engineers Harry Nieckels and Tarras Sällfors publish *Modern verkstadsorganisation*, a key text for transferring Taylorist ideas to Swedish industry.
1937	The biographical dictionary *Svenska Teknologföreningen 1861-1936* is published, documenting the lives and careers of the era's leading engineers.
1955	Industrialist Axel Wenner-Gren (founder of Electrolux) donates funds to establish the Wenner-Gren Center, a scientific foundation housed in an iconic steel building.

Sources: Compiled from Berner (1999), Fagerfjäll (2012), Rietz (2021), Sundin (1981), Indebetou and Hylander (1937), and Karlsson and Lundh (2022).

3 Theory and Previous Research

This dissertation engages directly with key theoretical debates in economic history concerning technological change and its socioeconomic impacts. To analyse the impact of electrification in Sweden, this dissertation employs a joint analytical framework built on the concept of co-evolution. It argues that the outcomes of the Second Industrial Revolution (2IR) were determined by the interplay between its core **technology**, the **human capital** required to implement it, and the **governance structures** that mediated its diffusion. It is the specific nature of this co-evolution that distinguishes one historical time period from another and explains the varied consequences for labor.

This integrated approach allows the thesis to contribute to several scholarly debates. By systematically documenting historical patterns of technological labor displacement (Paper 1), it provides context for the broader question of technological unemployment. Through econometric analyses showing electrification's equalizing effects (Paper 2), it challenges the universal applicability of skill-biased technological change theories. By examining the distinctive characteristics of the high-skilled engineers driving this change (Paper 3), it sheds new light on the role of "upper-tail" human capital and knowledge mobility. Finally, by investigating the consequences of director backgrounds on corporate strategy (Paper 4), it contributes new historical insights into how governance structures mediate economic transformations.

The remainder of this section examines each of these co-evolving elements in greater depth, placing the dissertation's findings within this unified framework.

3.1 GPTs, Skills, and Labor Market Outcomes

The techno-economic engine of the 2IR was the transition to a new energy system, part of the broader shift from an organic to a mineral-based economy

(Kander, Malanima, and Warde 2013, vol. 46p. 15). Electricity was its uniquely flexible energy carrier, able to "be converted into a greater variety of useful work" than direct combustion (Kander, Malanima, and Warde 2013, vol. 46p. 192). Such transformative innovations are designated General Purpose Technologies (GPTs), characterized by their pervasiveness, potential for ongoing technical improvement, and their role in stimulating "innovational complementarities" across the economy (Bresnahan and Trajtenberg 1995, p. 83). Paper 2 of this thesis explicitly treats electrification as a case study of a GPT's diffusion and impact.

A key feature of GPTs is that their economic impact is subject to a significant delay, as their potential can only be realized through "widespread diffusion and a great deal of complementary investment and innovation" (Crafts 2010, p. 412). Crafts notes that such technologies often exhibit a productivity lag, observing that steam power had its "peak impact about a hundred years after Watt's famous invention" (Crafts 2004, p. 338). This lag corresponds to what Schön (2012) terms a transformation phase in a long structural cycle, a period during which a society makes the resource-intensive investments required to build out a new development block. This concept of a synergistic cluster of complementary innovations is not merely theoretical; its presence can be "statistically identified" through quantitative methods (Enflo, Kander, and Schön 2008, p. 57). The "productivity paradox" is the macroeconomic signature of a new development block under construction.

The nature of these new technological systems raises persistent questions about their impact on employment: a tension between labor-substituting and labor-complementing effects. Classical concerns about "technological unemployment," where Ricardo feared machinery could "render the population redundant" (Mokyr, Vickers, and Ziebarth 2015, p. 33), emphasize the direct displacement or "automation effect" (Autor 2019, p. 3). Counterbalancing this is the "compensation framework," which outlines mechanisms such as demand increases, new investment, and the

creation of entirely new tasks—the "reinstatement effect"—that can offset job losses (Vivarelli 2014). Recognizing this complexity, Paper 1 undertakes a systematic review of the historical literature to identify and catalogue documented instances of technological labour displacement, aiming to map this historical landscape to guide future empirical work.

The distributional consequences are often analysed through the lens of SBTC, which puts forward that innovations frequently complement skilled labor, increasing wage inequality in a race between technological development and education, as coined by Tinbergen (1975). More recent task-based models use this logic to explain the "job polarization" associated with the ICT revolution, where technology substitutes for routine tasks while complementing non-routine cognitive work (Autor, Levy, and Murnane 2001). However, this dissertation argues that the specific co-evolution of electrification—a broadly enabling, process-oriented GPT—with Sweden's particular institutional context and human capital endowments created a different outcome. The finding in Paper 2, that electrification had equalizing effects by disproportionately raising the incomes of lower-skilled workers, directly challenges a universal application of the SBTC framework. It suggests that the techno-economic paradigm of the 2IR, in this specific context, fostered a dynamic where the technology's complementary effects outweighed its substitutive ones, making it an equalizing rather than a polarizing force.

3.2 Social Capability and Knowledge Diffusion

The human capital response during the 2IR was shaped by the demands of its new science-based techno-economic engine. The ability of a nation to harness these technologies depended on its "social capability," a concept encompassing the institutions and skills necessary for the effective assimilation of new techniques (Crafts 2010, p. 416). While the First Industrial Revolution (1IR) established a "new method of invention," the 2IR fused this method with a scientific base, requiring a

new class of innovator (Crafts 2021b, p. 521). The shift from the experiential "shop culture" of the 1IR to the formal "school culture" of the 2IR was a crucial component of building this capability. The expansion of technical and public education widened the domestic skill base and created the engineers needed to operate at the intersection of scientific principles (Ω-knowledge) and commercial application (λ-knowledge).

The analysis of "upper-tail" human capital in Paper 3 is a direct investigation of this critical component of social capability, while the study of the broader workforce in Paper 2 examines how the existing skill base interacted with the new technology. Knowledge transfer is not automatic; successful diffusion depends on the 'absorptive capacity' of recipients—their ability to value, assimilate, and apply external knowledge (Kingsley, Bozeman, and Coker 1996). The mobility of skilled individuals is a key channel for facilitating this diffusion. As documented by Grönberg (2003) and Ranestad (2025), engineers moving between firms or returning from abroad can transfer vital tacit and codified knowledge. Paper 3 contributes directly to this debate by providing empirical evidence from Sweden's electrification, finding that engineers active in pioneering regions were significantly more likely to possess career experience gained in the USA. This suggests these mobile engineers served as key conduits for transferring internationally-sourced "upper tail knowledge," embodying the enhanced absorptive capacity needed to implement the new electrical technology effectively. Paper 3 provides insight into the kind of knowledge transferred, showing that US experience was often gained at the heart of the American technological frontier in firms like General Electric and was particularly concentrated in the electrical industry itself. Paper 4 conducts a close reading of the biographies in an attempt to better understand the kind of knowledge transferred.

However, the benefits of mobility and the capacity to absorb knowledge can depend on the institutional context and the existing domestic skill base; Ranestad notes that "discrepancies in institutions stimulating capacity building… largely explain the different employment patterns" within MNCs in Chile versus Norway (Ranestad 2020, p. 197). Paper 3 further paints the picture by documenting the distinct characteristics and mobility patterns of the high-skilled, internationally-connected engineering elite driving electrification, contrasting them with the broader, more locally-rooted medium-skilled workforce (examined in Paper 2), suggesting potentially segmented labor markets and highlighting the specific human capital ingredients required at the technological frontier. Furthermore, providing important context not directly explored in the papers of this thesis, recent research using longitudinal data suggests that cities themselves acted as engines of skill upgrading during Swedish industrialization; Andersson and Molinder find that "living in a city had a more pronounced effect on skill attainment for those who were relatively unskilled before moving compared to those who were relatively more skilled" (Andersson and Molinder 2024, p. 20).

3.3 Corporate Governance and Leadership

The way firms are owned, governed, and led influences their strategy, adaptability, and performance, particularly in response to technological change (Steier and Morck 2005; Toms and Wright 2002). Governance structures vary significantly across countries and time, reflecting historical path dependence, legal origins, and political economy (Steier and Morck 2005). Steier and Morck highlight the global prevalence of systems where "a handful of immensely wealthy families control almost all of a country's great corporations" (Steier and Morck 2005, p. 1), often through pyramidal structures, contrasting sharply with the dispersed ownership model common in the UK and US. Sweden's historical model, characterized by Högfeldt as having ownership concentrated within family or bank spheres despite

political shifts, combined with significant influence from professional managers, often engineers, represents a distinct case (Högfeldt 2005; Henrekson, Lyssarides, and Ottosson 2021). Högfeldt argues that this concentration persisted partly because political and legal structures facilitated it, noting the irony that "corporate ownership in Sweden is very concentrated not despite, but because of, persistent Social Democratic policies" (Högfeldt 2005, p. 522). This structure differs markedly from the Anglo-American model or group-based systems like Japan's postwar keiretsu, which Miyajima et al. found tended to increase "growth at the expense of profitability" (Miyajima, Omi, and Saito 2004, p. 47).

Theory suggests governance structures affect agency costs and firm objectives. For instance, stronger monitoring, perhaps resulting from legal reforms like Germany's 1884 act studied by Bayer and Burhop, might reduce managerial discretion or alter incentive contracts, leading to "a replacement of monetary incentives by other means of corporate governance" (Bayer and Burhop 2008, p. 466). Conversely, Toms and Wright argue that weak governance in mid-century Britain allowed "managerially determined strategies of diversification… [to proceed] without extensive monitoring by external stakeholders" (Toms and Wright 2002, p. 98). The background of leaders may also matter; engineers might prioritize technical development and long-term R&D, while finance-oriented leaders focus on profitability or restructuring (Henrekson, Lyssarides, and Ottosson 2021; Miyajima, Omi, and Saito 2004).

Paper 4 investigates these links in the Swedish context, examining the long-run evolution of corporate leadership and assessing the impact of board members' technical backgrounds and international experience (particularly US experience highlighted by Paper 3 and Grönberg (2003)) on firm performance and employment. While the broader literature finds mixed results on how board composition affects firm performance, Paper 4 contributes a crucial historical dimension by

focusing on the ultimate consequences for labor. Its findings show that while the immediate impact on core financial metrics was limited, the effect on labor outcomes was significant and historically contingent. The analysis demonstrates that the same type of managerial expertise was deployed for workforce expansion in one era and for workforce rationalization in the next, contributing to the debate by showing how corporate governance and prevailing ideology are critical conditions that determine how board human capital translates into firm-level outcomes

4 Methods

This thesis adopts a quantitative, cliometric approach (Diebolt and Haupert 2024) to investigate the different impacts of technological change—specifically Swedish electrification—on labor markets, skills, inequality, and corporate structures during the late 19th and 20th centuries. Recognizing that different questions necessitate different empirical strategies and data types, this dissertation employs an assorted range of methodologies across the four constituent papers. These methods span systematic literature review, quasi-experimental econometric analysis of individual-level census data, large-scale biographical data analysis using Natural Language Processing (NLP), and firm-level panel data econometrics. While quantitative analysis forms the core, the interpretation of results and motivation for the empirical strategies are informed by qualitative context drawn from historical sources, subject to careful source criticism regarding their potential biases and limitations.

A significant feature underpinning Papers 3 and 4 is the application of recently developed artificial intelligence (AI) tools, particularly Large Language Models (LLMs) and associated NLP techniques, as detailed in their great hands-on guide from Correia and Luck (2023). These advancements enable the extraction and structuring of information from vast historical archives—including textual biographies and image, based financial reports, at a scale and speed previously unattainable, thus opening new avenues for economic history research (Joyeux-Prunel 2024). This dissertation demonstrates the practical application of these tools, utilizing both supervised and unsupervised machine learning for tasks such as occupational classification (Dahl, Johansen, and Vedel 2024), while also acknowledging the novel challenges these methods introduce, particularly concerning long-term replicability.

4.1 Systematic Review (Paper 1)

Paper 1, "Has Technology Destroyed Jobs?" (co-authored with Benjamin Schneider), employs a mixed-methods design combining a systematic literature review with narrative synthesis, blending together the approaches taken by, for example, Lewin et al. (2018) and Hötte, Somers, and Theodorakopoulos (2022). The primary objective takes a novel approach within economic history; rather than solely summarizing known findings, its specific purpose is to systematically map the existing historical literature on technological labor displacement to identify and signpost specific historical episodes where displacement is documented qualitatively but lacks rigorous quantitative analysis. The ambition is to highlight promising avenues for future cliometric research, potentially leveraging the types of novel data generation methods explored in the subsequent papers of this dissertation. This represents a deliberate, if unconventional, methodological choice aimed at guiding future inquiry in the field.

The methodology adhered to a pre-registered analysis plan (see the preregistration on the Open Science Framework) and involved a rigorous, systematic search conducted across major academic databases and key economic history journals. Keywords related to "labor displacement" and "labor replacement" within a historical context (pre-1980 technology adoption) were used. Following protocols of the PRISMA guidelines, the identified sources underwent deduplication and a two-stage screening process against explicit inclusion/exclusion criteria. This process yielded the final set of studies included in the systematic and narrative components of the review.

To assess confidence in the qualitative evidence synthesized, the study adapted the GRADE-CERQual framework (Lewin et al. 2018). This involved evaluating the evidence supporting key narrative findings based on four components: methodological limitations of the primary historical studies, coherence across sources,

adequacy of the underlying data, and relevance to the review's specific questions. This structured assessment enhances the credibility and transparency of the narrative synthesis.

The systematic approach enhances transparency and aims for comprehensive coverage, reducing selection bias compared to traditional narrative reviews. However, the review is constrained by the availability and quality of existing published research. A significant limitation arises from the restriction to English-language sources. This decision was made due to the practical challenges of accurately translating and screening nuanced historical texts from a large volume of search results across multiple languages using current machine translation technology. This inevitably introduces a geographic bias towards North America and Western Europe, as reflected in the reviewed literature's focus. Defining consistent criteria across diverse historical periods also remains complex. The geographic coverage is shown in Figure 6

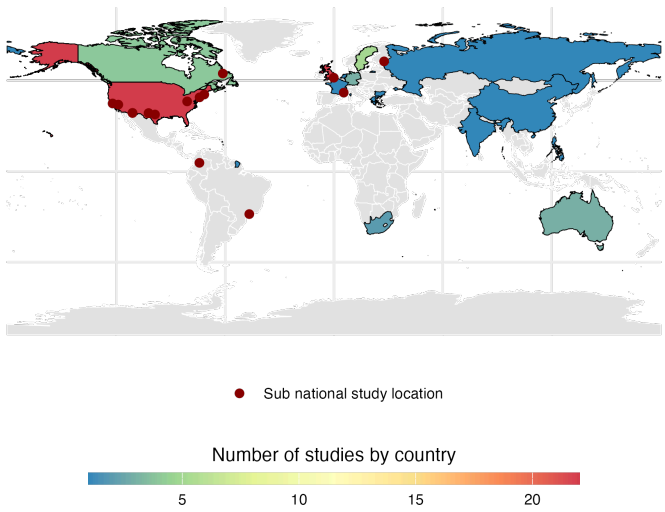


Figure 6: A map showing the geographic coverage of the systematic review

4.2 Econometric Analysis (Paper 2)

Paper 2, "Power for progress" (co-authored with Jakob Molinder and Kerstin Enflo), utilizes econometric methods on individual-level historical census data to estimate the impact of early electrification on labor market outcomes in Sweden. It specifically asks how access to electricity affected individual income, employment, and income inequality, addressing heterogeneity by skill level and local institutional context. The availability of individual-level income and education data for 1930 allows for a granular analysis of distributional effects often absent in studies of this historical period.

The core identification strategy relies on a quasi-experimental, spatial variation design leveraging the construction path of the "Western Line" grid (1909-1921) as

a source of plausibly exogenous variation in early electricity access. The analysis compares individuals born in parishes along this line ("treatment") with those born in nearby, off-line parishes ("control"), examining outcomes in the 1930 census. Comparability was assessed using pre-electrification balancing tests and slight trimming of the control group (Li 2013).

Ordinary Least Squares (OLS) regression serves as the baseline method to estimate average treatment effects, chosen for its interpretability. To investigate distributional impacts beyond the mean—essential for understanding inequality—Quantile Regression is employed, following Borgen, Haupt, and Wiborg (2023). This allows estimation of effects across the conditional income distribution. Additionally, Kitagawa-Oaxaca-Blinder (KOB) decomposition is used to disaggregate the average income effect into components attributable to changes in characteristics versus changes within characteristics (Oaxaca and Sierminska 2023). Spatial autocorrelation is addressed using Conley standard errors in parish-level robustness checks (Conley 2010).

The quasi-experimental design aims for causal identification, but its validity hinges on the exogeneity assumption (conditional on controls). A key limitation is the reliance on the partially digitized 1930 census (~30% parish coverage). While tests indicated comparability on pre-treatment observables, this incompleteness potentially reduces statistical power and might affect external validity. Other limitations include income data tax thresholds and geographically sparse historical union density data.

4.3 Biographical Data Analysis (Paper 3)

Paper 3, "Praise the people or praise the place?", analyses a novel dataset constructed from the *Vem är Vem?* and *Vem är Det?* biographical dictionaries (c. 1945-1968 and 1918-2000) to explore the characteristics and mobility of high-

skilled engineers during Sweden's electrification era. The methodology focuses on large-scale data processing using AI tools, followed by descriptive and probit analysis to investigate "upper tail human capital" (Mokyr 2018) and contrast findings with Paper 2.

The dataset creation involved scraping digitized text and employing an LLM (Gemini 2.0 Flash) with Pydantic schemas to structure the semi-structured biographical entries into analyzable format (Schmid 2025)[2]. Occupational and sectoral classification utilized NLP techniques, specifically character-level models like OccCANINE (Dahl, Johansen, and Vedel 2024) and semantic similarity analysis based on KB-BERT text embeddings, developed for the Royal Library by Rekathati (2021). Geographic mobility was studied after geocoding locations using Google Maps APIs. The analysis primarily uses descriptive statistics and probit regression models to compare engineers across different regions.

This approach leverages a rich historical source and demonstrates the efficiency of modern AI tools for processing large volumes of historical text. However, the *Vem är Vem?* and *Vem är Det?* sample is inherently an elite, non-representative group (predominantly male, socially prominent). Data consistency varies between entries, and the accuracy of AI-driven extraction and classification requires careful validation. The rapid evolution of LLMs also poses challenges for the long-term replicability of the data creation process in the social sciences, as explained carefully by Rossi, Harrison, and Shklovski (2024).

4.4 Firm-Level Panel Data Analysis (Paper 4)

Paper 4, "Technocrats to Tycoons", constructs and analyses a long-run firm-level panel dataset (1873-1980) for 71 Swedish firms to examine the relationship between

[2] A Pydantic data scheme is a way of specifying a data structure, with a name for each field, and rules about what it can contain. They are useful in validating data, as well as structuring raw data.

corporate board composition and firm / labor outcomes. A central aim is to test theories about the impact of managerial background (technical vs. business education, US experience) in a historical context potentially different from the modern shareholder-value era. The feasibility of this analysis relies significantly on novel data extraction methods using multimodal LLMs.

The methodology involved extracting financial data and board member lists from scanned historical annual reports using multimodal LLMs (Google's Gemini) capable of interpreting images, guided by Pydantic schemas, as demonstrated by Schmid (2025) from Google. Directors were matched to biographical data (from Paper 3) using fuzzy string matching (Chaudhuri et al. 2003), achieving a match rate of ~72%. Variables on director education and US experience were constructed based on the matched biographical information.

The core analytical strategy employs an event-study design, assessing firm outcomes and labor outcomes around the first appointment of directors with specific characteristics, similar in approach to recent studies examining board changes, basically emulating the work of Acemoglu, He, and Maire (2022) in a different time period. The panel regression specification includes firm and year fixed effects to control for unobserved heterogeneity and time trends.

This methodology creates a unique long-run dataset and applies modern AI and econometric techniques. However, limitations include the sample bias towards large, listed firms that are included in the Stockholm School of Economics archive, inconsistencies in historical reporting standards as the reports increase in length and details over time, and incomplete director matching. The event study identification rests on standard assumptions regarding the timing and exogeneity of board appointments, and we lack an instrumental variable approach like Acemoglu, He, and Maire (2022) to address potential endogeneity concerns. The analysis also

faces challenges in establishing causality due to the complex interplay of factors influencing firm performance and board composition.

The methods employed across this dissertation reflect an effort to leverage both established and innovative quantitative techniques to analyse diverse historical sources. The combination of systematic review, quasi-experimental analysis, large-scale text analysis using NLP and LLMs, and panel data econometrics allows for a multi-faceted investigation of the thesis's core themes. While each method carries specific strengths suited to the question at hand, they also come with inherent limitations, particularly concerning data availability, representativeness, and the challenges of causal inference in historical settings. The increasing power of computational tools, as demonstrated especially in Papers 3 and 4, offers exciting possibilities for economic historians to construct new datasets and revisit long-standing questions, albeit with careful consideration of the novel methodological challenges these tools present.

5 Data

The empirical analyses in this dissertation draw upon a various array of historical data sources, reflecting the different research questions addressed in each paper. These range from published academic literature and large-scale digitized census records to novel datasets compiled specifically for this thesis from biographical dictionaries and historical corporate annual reports. The compilation and processing of historical data is notoriously time-consuming, often requiring extensive digitization, standardization, and cleaning efforts. This section provides an overview of the primary data sources used in each paper, detailing their origins, key variables, compilation processes, and inherent limitations, while giving credit for the significant data work involved. More granular details on specific data construction steps and variables are available within the individual papers.

5.1 Data for Paper 1 (Systematic Review)

The data for the systematic and narrative review presented in Paper 1 consist of published academic studies, including journal articles, books, book chapters, and monographs. These sources were identified through a systematic search of four major academic databases and 16 economic history journals and 20 economics journals, as detailed in the Section 4.

Table 3: List of economic history and economics journals searched for in the systematics review, in addition to the database searches.

Journal Name
Economic history
African Economic History
Asia-Pacific Economic History Review
Cliometrica
Economic History of Developing Regions
Explorations in Economic History
Indian Economic and Social History Review
Industrial History Review
Irish Economic and Social History
Journal of European Economic History
Low Countries Journal of Economic and Social History
Research in Economic History
Rivista di Storia Economica
The Economic History Review
The European Review of Economic History
The Journal of Economic History
The Scandinavian Economic History Review
Economics
American Economic Review
Cambridge Journal of Economics
Econometrica
Economic Journal
Industrial and Labor Relations Review
International Economic Review
Journal of Comparative Economics
Journal of Development Economics
Journal of Economic Growth
Journal of Economic Perspectives
Journal of Labor Economics
Journal of Political Economy
Journal of Public Economics
Labour Economics
Oxford Economic Papers
Quarterly Journal of Economics
Research Policy
Review of Economic Dynamics
Review of Economic Studies
Review of Economics and Statistics

The compilation involved screening 3,087 initial search results against predefined criteria, a process undertaken collaboratively by myself and my co-author, Benjamin Schneider. 208 studies were advanced to the full-text review phase. 91 were excluded, and this resulted in a final dataset of 114 relevant sources that discuss or quantify historical labor displacement due to technology in the pre-1980 period. Of these, 71 studies contained quantitative information suitable for the systematic review, while 43 provided qualitative accounts used in the narrative synthesis. The dataset primarily consists of the textual content and findings reported within these publications.

5.2 Data for Paper 2 (Econometric Analysis)

Paper 2 combines individual-level microdata with parish-level information to analyse the impact of electrification.

The individual-level data are drawn from digitized Swedish Population Censuses. The 1890, 1900, and 1910 censuses, obtained via IPUMS International (Ruggles et al. 2025), provide complete counts. The 1930 census data, which uniquely includes income, wealth, and education variables, was generously granted access by Riksarkivet while their full digitization process is ongoing; this covers roughly 30% of parishes (Riksarkivet 2022). These census data provide rich information on individuals, including demographics, parish of birth, and occupation. Occupational information for 1930 was coded by the authors into HISCO and HISCLASS schemes (Leeuwen, Maas, and Miles 2002, Leeuwen and Maas (2011)) based on examples from the earlier IPUMS census data. The partial digitization of the 1930 census is a notable limitation, although extensive checks indicated that the available sample does not systematically differ from the control group based on pre-electrification occupational structures. Income data in the 1930 census are also subject to reporting thresholds based on tax regulations.

Parish-level data were compiled from various sources. Detailed information on electricity infrastructure circa 1924-1926 was digitized specifically for this research project by the paper's authors from the reports of the Royal Electrification Committee. Data on union density were obtained from the Social Movement Archive (Folkrörelsearkivet), though coverage is incomplete. Parish area data are derived from historical maps provided by Junkka (2024) in the histmaps package, and historical railway data are drawn from Molinder, Karlsson, and Enflo (2021). The compilation of these diverse sources into a linked individual- and parish-level dataset represents a significant data effort undertaken by the authors of Paper 2, supported by funding acknowledged in the paper.

5.3 Data for Paper 3 (Biographical Analysis)

Paper 3 utilizes a novel dataset constructed by myself specifically for this thesis, derived from the *Vem är Vem?* ('Who is Who?') and *Vem är Det?* ('Who is it?') biographical dictionary series, focusing on the editions published between 1945 and 1968 for the formers, and 1918 to 2000 for the latter. This source contains approximately 75,000 entries for notable Swedes active in the mid-20th century, providing details often unavailable in standard census records, such as specific educational institutions attended, detailed career progressions, international work or study periods, publications, memberships, and parental occupations.

The compilation process involved scraping the digitized scans of nine volumes made available online via Project Runeberg. Project Runeberg is a digital cultural archive initiative publishing free electronic versions of books significant to Nordic culture and history; the efforts of its volunteers, particularly its founder Lars Aronsson, in making these scans accessible are gratefully acknowledged. As detailed in the Section 4, the semi-structured text was then processed using LLMs (Gemini 2.0 Flash) and NLP techniques to extract key variables into a structured format suitable

for analysis. This complex data extraction and structuring work was performed by myself, representing original data work for this dissertation.

The primary limitation of this data source is its representativeness. *Vem är Vem?* and *Vem är Det?* capture an elite segment of Swedish society, heavily skewed towards men (~80%) and those with social prominence or the means and desire to be included. Comparison with the Swedish Biographical Lexicon (SBL) (Riksarkivet 2021) confirmed the elite nature of the *Vem är Vem?* and *Vem är Det?* sample. Furthermore, the level of detail is inconsistent across entries. Despite these limitations, the source provides unparalleled detail on the careers and backgrounds of a significant number of influential individuals during a key period of Sweden's development.

Table 4: Top Occupations in Biographical Dictionaries by Gender

Occupation (sv)	Count	Share (%)	HISCO Code	HISCO Description
Women				
Skådespelerska	740	6.27	17320	Actor
Författarinna	603	5.11	15120	Author
Författare	392	3.32	15120	Author
Journalist	373	3.16	15915	Journalist
Tandläkare	363	3.07	6310	Dentist, General
Operasångerska	333	2.82	17145	Singer
Professor	316	2.68	13100	University and Higher Education Teacher, Subject Unknown
Konstnär	281	2.38	16000	Sculptor, Painter, Photographer or Related Creative Artist, Specialisation Unknown
Skådespelare	273	2.31	17320	Actor
Rektor	197	1.67	13940	Head Teacher
Men				
Direktör	17,592	10.90	21110	General Manager
Professor	10,498	6.50	13100	University and Higher Education Teacher, Subject Unknown
Civilingenjör	5,088	3.15	2210	Civil Engineer, General
Professor Emeritus	3,684	2.28	13100	University and Higher Education Teacher, Subject Unknown
Advokat	2,954	1.83	12110	Lawyer
Konstnär	2,743	1.70	16000	Sculptor, Painter, Photographer or Related Creative Artist, Specialisation Unknown
Redaktör	2,708	1.68	15920	Editor, Newspapers and Periodicals
Författare	2,472	1.53	15120	Author
Överste	2,420	1.50	58320	Officer
Tandläkare	2,283	1.41	6310	Dentist, General

Source: *Vem är Vem?* (1945-1968) and Vem är Det? (1918-2001)

5.4 Data for Paper 4 (Firm-Level Panel)

Paper 4 relies on a unique historical firm-level panel dataset constructed by myself for this thesis, combined with the biographical data described for Paper 3.

The core firm data consists of information extracted from historical annual reports for 71 firms listed on the Stockholm Stock Exchange, spanning the years 1873-1980. These reports were accessed as scanned PDFs via the archives of the Swedish House of Finance at the Stockholm School of Economics, whose provision of

access is gratefully acknowledged. The data extracted, using multimodal LLMs as detailed in the Section 4, include key financial variables from income statements (revenue, net income, wages) and balance sheets (assets, liabilities, equity), as well as counts of total employees where available. The compilation of this century-long panel dataset from image-based historical reports represents significant original data work.

Board member information (names, positions) was also extracted from these annual reports. This list of directors was then matched, using fuzzy string matching techniques (Chaudhuri et al. 2003), to the biographical dataset compiled for Paper 3, extended with entries from the Vem är Det? series to improve coverage in later years. This matching process, achieving a rate of approximately 72%, allowed for the linking of director characteristics (such as educational background and US work experience) to the firm-level financial data.

The primary limitations relate to the scope and consistency of the data. The firm sample is restricted to large, listed companies, with a concentration in finance and industrial sectors, limiting generalizability. Reporting standards and the level of detail in annual reports evolved considerably over the 107-year period, leading to variations in data coverage for specific variables. Furthermore, the matching process between board members and biographical entries is imperfect and may introduce bias if unmatched directors differ systematically from matched ones.

6 Results

This section provides extended summaries of the four papers comprising this dissertation. Each summary outlines the paper's main findings, scientific merits, and clarifies how it addresses the specific research questions posed in the introduction. For the co-authored papers, the contributions of each author are also delineated.

6.1 Paper 1: Historical Labor Displacement

Paper 1, titled "Has technology destroyed jobs? A systematic review of historical labor displacement", is co-authored with Benjamin Schneider. This paper addresses the first sub-question: *What does the historical literature reveal about the conditions under which technological change has led to labor displacement, and what are the key gaps in our quantitative understanding of these episodes?* It does so by systematically reviewing existing historical research (pre-1980 technology adoption) on the topic, aiming specifically to highlight documented instances of labor displacement that lack quantitative investigation, thereby signposting avenues for future research.

The findings from Paper 1 provide a crucial historical corrective, arguing that a focus on **gross displacement** (the individual-level costs of job loss) is necessary to understand the true human consequences of technological change. Quantitative evidence for displacement is strongest in agriculture following mechanization (e.g., cotton pickers, tractors displacing millions in the US) and in clerical work due to early automation (e.g., telephone operators). Industrial automation and electrification also led to displacement, though often alongside wage growth for workers who adapted. The effects were consistently uneven, disproportionately impacting lower-skilled workers and regions with rigid labor markets or limited alternative employment opportunities. Crucially, the narrative review identified significant, yet unquantified, episodes of displacement, particularly in domestic service, cultural industries (e.g., musicians displaced by player pianos), and pastoral farming

(e.g., shepherds displaced by fencing in Australia/South Africa). By synthesizing the quantitative and qualitative evidence, the paper generates two novel, testable hypotheses: first, that the efficacy of worker resistance depends on its institutional power; and second, that managerial strategy, shaped by market conditions and labor relations, is the key variable determining worker outcomes.

The scientific merit of this paper lies in its novel mixed-methods approach within economic history, combining systematic review protocols (including pre-registration and GRADE-CERQual adaptation) with narrative synthesis to rigorously map a diffuse body of literature. By systematically identifying gaps, it provides a valuable resource and clear direction for future quantitative research on technological unemployment, particularly encouraging work that leverages new data sources and methods to study under-explored historical cases and regions. It directly answers RQ1 by outlining the conditions associated with historical displacement (technology type, sector, skills, institutions) and pinpointing specific areas (geographical, sectoral, demographic) where quantitative understanding remains underdeveloped.

6.2 Paper 2: Electricity and Individual Outcomes in Sweden

Paper 2, titled "Power for progress: The impact of electricity on individual labor market outcomes", is co-authored with Jakob Molinder and Kerstin Enflo. This paper addresses the second sub-question: *How did access to electricity impact individual labor market outcomes (income, employment, inequality) in Sweden, particularly for workers with different skill levels and in areas with varying institutional strength?* It utilizes a quasi-experimental design leveraging the rollout of the 'Western Line' high-voltage grid in the early 20th century and applies econometric analysis to unique individual-level Swedish census data from 1930.

The findings demonstrate that early access to electricity via the Western Line generated substantial positive economic outcomes for individuals residing in affected parishes. By 1930, individuals born in these parishes earned significantly higher incomes—approximately 30-45% higher on average compared to controls, even after accounting for various individual and parish characteristics. Critically, quantile regressions revealed that these income gains were disproportionately concentrated among lower-income individuals and those with only primary education. This resulted in a measurable reduction in local income inequality within the early-electrifying parishes. The analysis suggests electricity acted as a broadly labor-enhancing technology in this context, as there was no evidence of increased unemployment; instead, occupational shifts indicated upgrading, with movements towards factory/electricity jobs and away from farm labor, alongside an increase in independent farmers. Decomposition analysis showed that most income gains occurred *within* broad occupational categories, rather than solely through structural shifts. Furthermore, these positive income and inequality-reducing effects were observed irrespective of local union density in 1930, suggesting the technology's benefits were not solely contingent on strong labor institutions in this later phase of adoption. Analysis comparing movers and stayers indicated that individuals born in the electrifying parishes who remained ("stayers") benefited more than those who moved into these parishes later.

The scientific merit of this paper lies in its use of rich, individual-level microdata—including income and education—linked to a plausible quasi-experimental source of variation in access to a major General Purpose Technology. This allows for a more granular analysis of the distributional consequences of historical technological change than is often possible. The finding that electrification in this specific context was labor-enhancing and inequality-reducing, particularly benefiting lower-skilled workers, provides important nuance to theories of Skill-Biased

Technical Change and highlights the heterogeneous potential impacts of different technologies. It directly answers RQ2 by quantifying the positive income effects of electricity, its inequality-reducing profile, its minimal impact on unemployment, and its apparent independence from union strength in driving these outcomes for the period studied.

6.3 Paper 3: High-Skilled Labor in Electrification

Paper 3, "Praise the people or praise the place? Upper tail human capital in electrifying Sweden", is single-authored work. It addresses the third sub-question: *To what extent were engineers relocating to early electrification areas distinguishable by their educational or network backgrounds compared to peers from the same study cohorts who moved to different locations or at later times?*

This paper constructs and analyses a novel dataset from *Vem är Vem?* and *Vem är Det?* biographical dictionaries covering approximately 75,000 notable Swedes active mid-century. It focuses on identifying engineers involved in electricity-related sectors and examining their backgrounds and mobility patterns, contrasting them with both other elite occupations within the dataset and the largely locally-sourced, medium-skilled workforce implied by Paper 2's findings. The methodology relies heavily on data structuring using LLMs and occupational/sector classification using NLP techniques.

The findings reveal a distinct pattern for high-skilled labor compared to the broader workforce during electrification. Engineers, particularly those in electrical and mechanical fields, exhibited high geographic mobility. They were often educated at elite institutions (like KTH or Chalmers) located far from their birthplaces and subsequently moved significant distances for work—an average of around 350km for electrical/mechanical engineers, much farther than the median worker or the stayers identified in Paper 2. This suggests a bifurcated labor market, with mobile

high-skilled "people" complementing the locally-rooted medium-skilled labor in the "place".

Probit analysis reveals that the pioneers active in the Western Line parishes before 1930 possessed a distinct profile compared to their peers elsewhere, even after controlling for cohort effects. They were significantly more likely to have technical education (specifically from KTH), career experience gained in the USA, and fathers from agricultural or production/transport/laborer backgrounds. A second analysis comparing locals ("Stayers") versus migrants ("Movers-in") within the pioneer group found that migrants were significantly more likely than locals to possess KTH degrees and general overseas experience, suggesting these hubs actively imported specific talent. Notably, US experience, while characteristic of the overall pioneer group, did not significantly differentiate migrants from locals within it

The scientific merit of this paper lies in the creation and analysis of a unique dataset on historical elites using modern computational techniques (LLMs/NLP) applied to a previously underutilized source. It provides empirical evidence for the concept of "upper tail human capital" and reveals the distinct mobility patterns of high-skilled technical labor during a major technological transition. By contrasting these patterns with those suggested for medium-skilled labor, it contributes to understanding the heterogeneity of technological impacts and the potential spatial mismatch between different skill groups during industrial development. It directly answers RQ3 by characterizing the high-skilled engineers as geographically mobile, nationally (and sometimes internationally) sourced talent, educated at specific hubs, whose mobility patterns differed starkly from medium-skilled workers, and whose recruitment to early-electrified areas seemed largely independent of social background but weakly correlated with US experience.

6.4 Paper 4: Board Composition and Firm and Labor Outcomes

Paper 4, titled "Technocrats to tycoons: The shift in Swedish corporate leadership and its economic consequences in the 20th century", is single-authored work. It addresses the fourth sub-question: What were the firm-level consequences of having board members with specific technical and international (US) experience during Sweden's industrial development, particularly concerning productivity and employment? This paper constructs a novel long-run panel dataset for 71 Swedish listed companies from 1873 to 1980, combining financial data extracted from historical annual reports (using multimodal LLMs) with information on board director characteristics derived from matching directors to biographical dictionaries (*Vem är Vem?*, Vem är Det?).

The successful digitization and matching represent key data contributions. Descriptive analysis shows shifts in director backgrounds over the century. The findings reveal a nuanced and historically contingent relationship between board composition and firm-level labor outcomes. The impact of appointing the first US-experienced engineer (a proxy for the adoption of American management technology) depends critically on the prevailing corporate governance era. In the pre-1945 'Managerial Capitalism' era, this appointment is followed by a statistically significant increase in total employment, consistent with a strategy of deploying the new management technology to expand production. In sharp contrast, in the post-1945 'Investor Capitalism' era, the same event is linked to a statistically significant decrease in employment and a decline in labor's share of revenue. This suggests a pivotal shift toward using the same management principles for rationalization and labor-saving efficiency.

Conversely, the appointment of the first director with a business or finance background shows a statistically insignificant impact on labor outcomes in either period. This null result challenges the universality of contemporary findings that

link business-educated managers to reduced rent-sharing, suggesting this may be a more recent phenomenon tied to the modern shareholder value paradigm.

The scientific merit includes the dataset construction using innovative techniques and the application of an event-study methodology to historical board human capital. While findings are preliminary, they offer initial insights. The results provide an answer to RQ4: based on this analysis, the impact of appointing directors with these specific backgrounds on core financial performance and labor outcomes appears limited or inconsistent in this historical context. The lack of significant effects, particularly the absence of a negative impact on the labor share proxy from business-trained directors, contrasts with findings from contemporary studies and supports the idea that the influence of managerial background is highly context-dependent. There is tentative evidence that US experience might positively influence labor productivity with a lag, suggesting channels warranting further investigation.

7 Concluding Discussion

This thesis has investigated the various impacts of technological change on labor markets, skills, inequality, and corporate structures, using the historical case of electrification in Sweden during the late 19th and 20th centuries. By integrating insights from a systematic literature review, individual-level microdata analysis, biographical data on high-skilled labor, and firm-level panel data, the research sought to understand how a major General Purpose Technology reshaped economic and social outcomes. The findings paint a complex picture, demonstrating that the consequences of technological transitions are highly context-dependent and vary significantly depending on the specific nature of the technology, the segment of the labor market examined, the institutional environment, and the level of analysis.

The systematic review in Paper 1 contextualized the study by revealing that while historical technologies have certainly displaced labor, particularly in agriculture and clerical work, significant gaps remain in our quantitative understanding. This general historical pattern of painful adjustment makes the central finding of Paper 2 (that Swedish electrification had surprisingly positive and equalizing distributional outcomes) all the more striking. Here electricity significantly boosted incomes, particularly for lower-income and less-educated individuals, thereby reducing local income inequality and acting as a broadly labor-enhancing technology in this setting. Paper 3 complemented this by examining the high-skilled engineers crucial to electrification, revealing they were a highly mobile workforce, distinct from the locally-rooted medium-skilled labor benefiting most directly from electrification, suggesting a bifurcated labor market dynamic. Finally, Paper 4 shifted to the firm level, exploring how corporate governance mediates the deployment of new management 'technologies.' It makes the case that the societal distribution of gains from innovation is not predetermined by the technology itself, but is criti-

cally shaped by the priorities of those in power. The analysis demonstrates that the appointment of US-experienced engineers drove workforce expansion under the 'Managerial Capitalism' regime before 1945 but led to workforce rationalization and a declining labor share under the 'Investor Capitalism' regime that followed. This finding shows that the 'rules of the game' within the firm can fundamentally alter how a technology affects workers, offering a vital historical perspective for today's debates on labor and innovation.

Taken together, this dissertation offers several main contributions to the economic history of technological change and related fields. First, it provides robust empirical evidence from the Swedish case challenging the notion that all major technological advancements are inherently skill-biased or inequality-inducing. The findings from Paper 2 suggest that electricity, in the context of early-to-mid 20th century Sweden, acted to enhance labor and compress the income distribution. Second, the thesis highlights the critical importance of differentiating between skill groups during technological transitions. The contrasting mobility patterns and apparent labor market segmentation between the high-skilled engineers (Paper 3) and the broader, less-skilled workforce (Paper 2) underscore the heterogeneous nature of technological impacts. Third, the research offers a nuanced perspective on the role of institutions. While historical context emphasizes the importance of factors like unions and education, the findings suggest that the inherent characteristics of electricity technology itself played a significant role in its positive distributional outcomes in the 1930s Swedish setting (Paper 2), and that formal higher education was not a prerequisite for individuals to benefit economically. Fourth, the thesis provides initial insights into the long-term evolution of Swedish corporate governance, suggesting through event-study analysis (Paper 4) that the immediate impact of specific board member types on depends on the period, and it not fixed across time. Finally, the dissertation demonstrates the value of methodological

pluralism and, particularly, the potential of novel data creation techniques using modern AI tools (LLMs, NLP) to unlock rich historical sources like biographical dictionaries and archival corporate reports (Papers 3 and 4).

The historical findings presented here resonate with several contemporary debates. As societies grapple with the potential impacts of artificial intelligence, automation, and the ongoing digital transformation, the Swedish experience with electrification serves as a reminder that technological trajectories and their societal consequences are not predetermined. The fact that a major GPT like electricity could, in a specific historical context, be inequality-reducing offers a counterpoint to predominantly pessimistic forecasts about AI's impact on labor markets. It underscores the potential importance of factors such as the nature of the technology itself, the existing institutional framework (including the role of the state, as Sweden saw early state involvement in electrification), and the specific skill demands relative to the population's capabilities. The findings on labor market bifurcation (Paper 3 vs. Paper 2) also speak to current discussions about skills gaps, regional inequalities, and the effectiveness of place-based versus people-based policies in managing economic transitions. While the uniqueness of the Swedish historical context—early state-led rollout, subsequent strong institutions—must be acknowledged, the analysis suggests that policy choices and institutional configurations can significantly mediate the outcomes of technological change.

This research opens several fruitful avenues for future work. The systematic review in Paper 1 explicitly aimed to identify gaps in the quantitative literature on historical labor displacement. This work can serve as a direct guidepost, encouraging research that applies quantitative methods to the understudied episodes.

Furthermore, the novel biographical dataset compiled for Paper 3, containing structured information on ~75,000 notable Swedes, holds potential far beyond its

use in this thesis. This dataset, covering details on education, career trajectories, mobility, family background, and more, is made publicly available on GitHub (github.com/j-jayes/who-is-it) under a permissive license. Researchers are encouraged to utilize this resource for a wide range of studies in economic history, sociology, historical geography, and beyond, provided appropriate credit is given to the author and the original source dictionaries (*Vem är Vem?* and *Vem är Det?*).

Building directly on the papers presented here, future research could extend the individual-level analysis in Paper 2 to later periods if further census data become available, or examine other outcome dimensions such as wealth accumulation or health. The analysis of high-skilled workers in Paper 3 could be deepened by attempting to link engineers more directly to specific innovation outputs (e.g., patents) or firm creation events. The firm-level analysis in Paper 4 requires further development, particularly the integration of network analysis and exploration of potential interaction effects between board characteristics and firm strategies over longer time horizons. Finally, comparative studies contrasting Sweden's experience with electrification and its labor market consequences with those of other nations could yield valuable insights into the role of national contexts in shaping the impact of General Purpose Technologies.

Bibliography

Acemoglu, Daron, Alex Xi He, and Daniel le Maire. 2022. “Eclipse of Rent-Sharing: The Effects of Managers' Business Education on Wages and the Labor Share in the US and Denmark”. *Working Papers*, no. 22–58 (December).

Andersson, Jonatan, and Jakob Molinder. 2024. “Did Cities Increase Skills During Industrialization? Evidence from Rural-Urban Migration”. Uppsala University, Department of Economic History.

Andersson, Martin, and Christer Gunnarsson. 2004. *Egalitarianism in the Process of Modern Economic Growth - The Case of Sweden*. Background Paper for World Development Report 2006. World Bank.

Autor, David H. 2019. “Work of the Past, Work of the Future”. *AEA Papers and Proceedings* 109 (May):1–32. https://doi.org/10.1257/pandp.20191110.

Autor, David H. 2022. “The Labor Market Impacts of Technological Change: From Unbridled Enthusiasm to Qualified Optimism to Vast Uncertainty”. Rochester, NY: Social Science Research Network.

Autor, David, Frank Levy, and Richard Murnane. 2001. “The Skill Content of Recent Technological Change: An Empirical Exploration.”

Bayer, Christian, and Carsten Burhop. 2008. “Corporate Governance and Incentive Contracts: Historical Evidence from a Legal Reform”. Rochester, NY: Social Science Research Network. https://doi.org/10.2139/ssrn.1133443.

Bengtsson, Erik. 2014. “Labour's Share in Twentieth-Century Sweden: A Reinterpretation”. *Scandinavian Economic History Review* 62 (3): 290–314. https://doi.org/10.1080/03585522.2014.932837.

Bengtsson, Erik. 2019. “The Swedish Sonderweg in Question: Democratization and Inequality in Comparative Perspective, C.1750–1920*”. *Past & Present* 244 (1): 123–61. https://doi.org/10.1093/pastj/gtz010.

Bengtsson, Erik, and Tobias Karlsson. 2017. “What We Know and What We Don't Know About Swedish Labor Market History: Reflections on Spelets Regler”. *Essays in Economic & Business History* 35 (1): 15–36.

Bengtsson, Erik, and Jakob Molinder. 2021. “What Happened to the Incomes of the Rich during the Great Levelling? Evidence from Swedish Individual-level Data, 1909–1950”. *What Happened to the Incomes of the Rich during the Great Levelling? Evidence from Swedish Individual-Level Data, 1909–1950*, Lund Papers in Economic History,.

Bengtsson, Erik, Anna Missiaia, Mats Olsson, and Patrick Svensson. 2018. “Wealth Inequality in Sweden, 1750–1900”. *The Economic History Review* 71 (3): 772–94. https://doi.org/10.1111/ehr.12576.

Berger, Thor, and Kerstin Enflo. 2017. “Locomotives of Local Growth: The Short- and Long-Term Impact of Railroads in Sweden”. *Journal of Urban Economics*, Urbanization in Developing Countries: Past and Present, 98 (March):124–38. https://doi.org/10.1016/j.jue.2015.09.001.

Berner, Boel. 1999. *Perpetuum mobile? : teknikens utmaningar och historiens gång*. Arkiv förlag.

Borgen, Nicolai T, Andreas Haupt, and Øyvind Nicolay Wiborg. 2023. “Quantile Regression Estimands and Models: Revisiting the Motherhood Wage Penalty Debate”. *European Sociological Review* 39 (2): 317–31. https://doi.org/10.1093/esr/jcac052.

Bresnahan, Timothy F., and M. Trajtenberg. 1995. “General Purpose Technologies `Engines of Growth'?”. *Journal of Econometrics* 65 (1): 83–108. https://doi.org/10.1016/0304-4076(94)01598-T.

Brey, Björn. 2025. “Sparking Knowledge: Early Technology Adoption, Innovation Ability and Long-Run Growth”. *Journal of the European Economic Association*. https://doi.org/10.1093/jeea/jvaf034.

Chaudhuri, Surajit, Kris Ganjam, Venkatesh Ganti, and Rajeev Motwani. 2003. “Robust and Efficient Fuzzy Match for Online Data Cleaning”. In *Proceedings of the 2003 ACM SIGMOD International Conference on Management of Data*, 313–24. SIGMOD '03. New York, NY, USA: Association for Computing Machinery. https://doi.org/10.1145/872757.872796.

Conley, Timothy G. 2010. “Spatial Econometrics”. Edited by Steven N. Durlauf and Lawrence E. Blume. *Microeconometrics*. London: Palgrave Macmillan UK. https://doi.org/10.1057/9780230280816_33.

Correia, Sergio, and Stephan Luck. 2023. “Digitizing Historical Balance Sheet Data: A Practitioner's Guide”. *Explorations in Economic History*, Methodological Advances in the Extraction and Analysis of Historical Data, 87 (January):101475. https://doi.org/10.1016/j.eeh.2022.101475.

Crafts, Nicholas. 2004. “Steam as a General Purpose Technology: A Growth Accounting Perspective”. *The Economic Journal* 114 (495): 338–51.

Crafts, Nicholas. 2010. “The Contribution of New Technology to Economic Growth: Lessons from Economic History”. *Revista De Historia Economica - Journal of Iberian and Latin American Economic History* 28 (3): 409–40. https://doi.org/10.1017/S0212610910000157.

Crafts, Nicholas. 2021a. “Artificial Intelligence as a General-Purpose Technology: An Historical Perspective”. *Oxford Review of Economic Policy* 37 (3): 521–36. https://doi.org/10.1093/oxrep/grab012.

Crafts, Nicholas. 2021b. “Artificial Intelligence as a General-Purpose Technology: An Historical Perspective”. *Oxford Review of Economic Policy* 37 (3): 521–36.

Dahl, Christian Møller, Torben Johansen, and Christian Vedel. 2024. “Breaking the HISCO Barrier: Automatic Occupational Standardization with OccCANINE”. arXiv. https://doi.org/10.48550/arXiv.2402.13604.

Diebolt, Claude, and Michael Haupert, eds. 2024. *Handbook of Cliometrics*. Second Edition 2019. Cham, Switzerland: Springer.

Enflo, Kerstin, and Martin Henning. 2016. “The Development of Economic Growth and Inequality among the Swedish Regions 1860–2010: Evidence from Regional National Accounts”. *Structural Analysis and the Process of Economic Development*. Routledge.

Enflo, Kerstin, Astrid Kander, and Lennart Schön. 2008. “Identifying Development Blocks—a New Methodology”. *Journal of Evolutionary Economics* 18 (1): 57–76. https://doi.org/10.1007/s00191-007-0070-8.

Fagerfjäll, Ronald. 2012. *The Sandvik Journey : the First 150 Years*. Stockholm : Max Ström.

Faggio, Giulia, Olmo Silva, and William C Strange. 2020. “Tales of the City: What Do Agglomeration Cases Tell Us About Agglomeration in General?”. *Journal of Economic Geography* 20 (5): 1117–43. https://doi.org/10.1093/jeg/lbaa007.

Ford, Nicholas, Kristin Ranestad, and Paul Sharp. 2022. “Leaving Their Mark: Using Danish Student Grade Lists to Construct a More Detailed Measure of Historical

Human Capital". *Rivista Di Storia Economica*, no. 1/2022 . https://doi.org/10.1410/102500.

Frey, Carl Benedikt. 2020. *The Technology Trap: Capital, Labor, And Power in the Age of Automation*. Princeton University Press.

Frey, Carl Benedikt, and Michael A. Osborne. 2017. "The Future of Employment: How Susceptible Are Jobs to Computerisation?". *Technological Forecasting and Social Change* 114 (January):254–80. https://doi.org/10.1016/j.techfore.2016.08.019.

Fridlund, Mats. 1993. "The `Development Pair'as a Link between Systems Growth and Industrial Innovation: Cooperation between the Swedish State Power Board and the ASEA Company". *Stockholm: Royal Institute of Technology, Department of History of Science and Technology*.

Goldin, Claudia, and Lawrence F. Katz. 2007. "The Race between Education and Technology: The Evolution of U.S. Educational Wage Differentials, 1890 to 2005". National Bureau of Economic Research. https://doi.org/10.3386/w12984.

Grönberg, Per-Olof. 2003. "Learning and Returning : Return Migration of Swedish Engineers from the United States, 1880-1940."

Heikkuri, Suvi. 2024. "Technological Change, Skills, And Occupational Structure in Sweden, 1870-1950", May.

Henrekson, Magnus, Odd Lyssarides, and Jan Ottosson. 2021. "The Social Background of Elite Executives: The Swedish Case". *Management & Organizational History* 16 (1): 65–87. https://doi.org/10.1080/17449359.2021.1950553.

Hjulström, Henning Filip. 1940. *Sveriges Elektrifiering. En Ekonomisk-geografisk Studie Över Den Elektriska Energiförsörjningens Utveckling. [With a Summary in English, And with Maps.].*

Hultström, Karl. 1934. *Kungl. Vattenfallsstyrelsen 1909-1934. En Återblick På Tjugofem Års Verksamhet.*. Centraltryckeriet.

Högfeldt, Peter. 2005. "The History and Politics of Corporate Ownership in Sweden". *NBER Chapters*, 517–80.

Högselius, P., A. Hommels, A. Kaijser, and E. van der Vleuten. 2013. *The Making of Europe's Critical Infrastructure: Common Connections and Shared Vulnerabilities*. Springer.

Hötte, Kerstin, Melline Somers, and Angelos Theodorakopoulos. 2022. "Technology and Jobs: A Systematic Literature Review". arXiv. https://doi.org/10.48550/arXiv.2204.01296.

Indebetou, Govert, and Erik Hylander. 1937. *Svenska Teknologföreningen 1861-1936 : Biografier*. Stockholm: Svenska teknologföreningen [distributör].

Jansson Myhr, Karin. 2023. "How Electricity Conquered the Countryside."

Joyeux-Prunel, Béatrice. 2024. "Digital Humanities in the Era of Digital Reproducibility: Towards a Fairest and Post-Computational Framework". *International Journal of Digital Humanities* 6 (1): 23–43. https://doi.org/10.1007/s42803-023-00079-6.

Junkka, Johan. 2024. "Junkka/histmaps."

Kaijser, Arne. 1994. *I Fädrens Spår : Den Svenska Infrastrukturens Historiska Utveckling Och Framtida Utmaningar*. Stockholm: Carlsson.

Kander, Astrid, Paolo Malanima, and Paul Warde. 2013. *Power to the People: Energy in Europe over the Last Five Centuries*. Vol. 46. Princeton University Press. https://doi.org/10.2307/j.ctt4cgb93.

Karlsson, Tobias, and Christer Lundh. 2022. "Liv i rörelse". Nordic Academic Press. https://doi.org/10.21525/kriterium.34.

Katz, Lawrence F., and Kevin M. Murphy. 1992. "Changes in Relative Wages, 1963–1987: Supply and Demand Factors". *The Quarterly Journal of Economics* 107 (1): 35–78.

Kingsley, Gordon, Barrt Bozeman, and Karen Coker. 1996. "Technology Transfer and Absorption: An `R & D Value-Mapping' Approach to Evaluation". *Research Policy* 25 (6): 967–95. https://doi.org/10.1016/0048-7333(96)00890-6.

Leeuwen, Marco H. D. van, and Ineke Maas. 2011. *Hisclass: A Historical International Social Class Scheme*. Universitaire Pers Leuven.

Leeuwen, Marco H. D. van, Ineke Maas, and Andrew Miles. 2002. *HISCO: Historical International Standard Classification of Occupations*. Leuven University Press.

Lewin, Simon, Andrew Booth, Claire Glenton, Heather Munthe-Kaas, Arash Rashidian, Megan Wainwright, Meghan A. Bohren, et al. 2018. "Applying GRADE-CERQual to Qualitative Evidence Synthesis Findings: Introduction to the Series". *Implementation Science* 13 (1): 2. https://doi.org/10.1186/s13012-017-0688-3.

Li, Mingxiang. 2013. "Using the Propensity Score Method to Estimate Causal Effects: A Review and Practical Guide". *Organizational Research Methods* 16 (2): 188–226. https://doi.org/10.1177/1094428112447816.

Martinez-Galarraga, Julio, and Daniel A. Tirado-Fabregat. 2020. “Economic Geography and Economic History: A Literature Overview”. *An Economic History of Regional Industrialization*. Routledge.

Miyajima, H., Yusuke Omi, and Nao Saito. 2004. “Corporate Governance and Performance in Twentieth-Century Japan”. In.

Mokyr, Joel. 2018. “Bottom-up or Top-down? The Origins of the Industrial Revolution”. *Journal of Institutional Economics* 14 (6): 1003–24.

Mokyr, Joel, Chris Vickers, and Nicolas L. Ziebarth. 2015. “The History of Technological Anxiety and the Future of Economic Growth: Is This Time Different?”. *Journal of Economic Perspectives* 29 (3): 31–50. https://doi.org/10.1257/jep.29.3.31.

Molinder, Jakob, Tobias Karlsson, and Kerstin Enflo. 2021. “More Power to the People: Electricity Adoption, Technological Change, And Labor Conflict”. *The Journal of Economic History* 81 (2): 481–512. https://doi.org/10.1017/S0022050721000127.

Molinder, Jakob, Tobias Karlsson, and Kerstin Enflo. 2022. “Social Democracy and the Decline of Strikes”. *Explorations in Economic History* 83 (January):101420. https://doi.org/10.1016/j.eeh.2021.101420.

Nilsson, Magnus, Torben Schubert, and Johan Miörner. 2023. “The Productivity Effects of Regional Anchors on Local Firms in Swedish Regions between 2007 and 2019 – Evidence from an Expert-informed Machine-Learning Approach”. *Papers in Innovation Studies*, no. 2023/8 (October).

Oaxaca, Ronald L., and Eva Sierminska. 2023. “Oaxaca-Blinder Meets Kitagawa: What Is the Link?.”

Ottaviano, Gianmarco, and Jacques-Fraņcois Thisse. 2004. “Chapter 58 - Agglomeration and Economic Geography”. Edited by J. Vernon Henderson and Jacques-Fraņcois Thisse. *Handbook of Regional and Urban Economics*. Cities and Geography. Elsevier. https://doi.org/10.1016/S1574-0080(04)80015-4.

Pate, Linda. 2021. “Historic Context Study of Farms 1820-1960 - Cultural Resources - MnDOT.”

Piva, Mariacristina, and Marco Vivarelli. 2018. “Technological Change and Employment: Is Europe Ready for the Challenge?”. *Eurasian Business Review* 8 (1): 13–32.

Ranestad, Kristin. 2020. “Multinational Mining Companies, Employment and Knowledge Transfer: Chile and Norway from Ca. 1870 to 1940”. *Business History* 62 (2): 197–221. https://doi.org/10.1080/00076791.2017.1407313.

Ranestad, Kristin. 2025. “Job Switching and Knowledge Transfer: The Case of Norwegian Mining and Metallurgy, 1787–1940”. *Business History*, March.

Ranestad, Kristin, and Paul Sharp. 2023. “Success Through Failure? Four Centuries of Searching for Danish Coal”. *Business History*, November.

Rasmussen, Wayne D. 1962. “The Impact of Technological Change on American Agriculture, 1862–1962”. *The Journal of Economic History* 22 (4): 578–91. https://doi.org/10.1017/S0022050700066778.

Rekathati, Faton. 2021. “Introducing a Swedish Sentence Transformer – The KBLab Blog.”

Rietz, Peter. 2021. “Gustaf De Laval - The Milk-Cream Separator.”

Riksarkivet. 2021. “Svenskt biografiskt lexikon”. Riksarkivet.

Riksarkivet. 2022. “Riksarkivet 1930 Census”. Riksarkivet.

Rosenberg, Frida. 2018. “The Construction of Construction : The Wenner-Gren Center and the Possibility of Steel Building in Postwar Sweden.”

Rossi, Luca, Katherine Harrison, and Irina Shklovski. 2024. “The Problems of LLM-generated Data in Social Science Research”. *Sociologica* 18 (2): 145–68. https://doi.org/10.6092/issn.1971-8853/19576.

Ruggles, Steven, Lara L. Cleveland, Rodrigo Lovatón Dávila, Sula Sarkar, Matthew Sobek, Derek Burk, Dan E. Ehrlich, Quinn Heimann, Jane Lee, and Nate Merrill. 2025. “Integrated Public Use Microdata Series, International: Version 7.6”. Minneapolis, MN: IPUMS. https://doi.org/10.18128/D020.V7.6.

Schmid, Philipp. 2025. “From PDFs to Insights: Structured Outputs from PDFs with Gemini 2.0.”

Schön, Lennart. 2000. “Electricity, Technological Change and Productivity in Swedish Industry, 1890–1990.”. *European Review of Economic History* 4 (2): 175–94. https://doi.org/10.1017/S1361491600000046.

Schön, Lennart. 2012. *An Economic History of Modern Sweden*. Taylor & Francis.

Steier, Lloyd, and Randall Morck. 2005. “The Global History of Corporate Governance: An Introduction”. Rochester, NY: Social Science Research Network.

Stymne, Per. 2002. *Stamnätet under ett sekel: berättelsen om hur det svenska stamnätet byggdes upp : en bok till Svenska kraftnäts tioårsjubileum 2002*. Svenska kraftnät.

Sundin, Bo. 1981. *Ingenjörsvetenskapens tidevarv: Ingenjörsvetenskapsakademin, Pappersmassekontoret, Metallografiska institutet och den teknologiska forskningen i början av 1900-talet*. Universitetet i Umeå.

Söderbaum, Carl Fredrik. 1935. *Härnösands Stads Elektricitetsverk 1885-1935*. Härnösand: Härnösands boktryckeri.

Taalbi, Josef. 2021. "Innovation in the Long Run: Perspectives on Technological Transitions in Sweden 1908–2016". *Environmental Innovation and Societal Transitions* 40 (September):222–48. https://doi.org/10.1016/j.eist.2021.07.003.

Tinbergen, Jan. 1975. *Income Distribution: Analysis and Policies*. North-Holland Publishing Company.

Toms, Steve, and Mike Wright. 2002. "Corporate Governance, Strategy and Structure in British Business History, 1950-2000". *Business History*, July. https://doi.org/10.1080/713999280.

Vattenfall. 1948. "Procentuellt Antal Elektrifierade Hushåll". Vattenfall.

Vattenfallsstyrelsen, Sweden. 1921. *State Power-plants in Sweden, 1921: General Description*. Almqvist & Wiksells.

Vivarelli, Marco. 2014. "Innovation, Employment and Skills in Advanced and Developing Countries: A Survey of Economic Literature". *Journal of Economic Issues* 48 (1): 123–54.

"Den Svenska Lantbrukskooperationens Bakgrund, Framväxt Och Utveckling till 1930." n.d.

Scientific publications