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

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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.



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

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 deeply 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.

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 (Schön 2000), the research aims to provide empirical depth and historical perspective relevant to current anxieties about automation and the future of work (Autor 2019; Crafts 2021).

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" (-Goldin and Katz 2007)), 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 analyzes 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. What does the historical literature reveal about the conditions under which technological change (broadly defined) has led to labor displacement and replacement, and where do the key gaps in our quantitative understanding lie? (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 – particularly for workers across the skill and income distribution? (Paper 2)

- 3. Given the observed impacts on the broader workforce during electrification, were the highskilled individuals (engineers) essential for implementing this technological shift distinctive in their origins, education, and mobility, suggesting specific human capital requirements for managing such transitions? (Paper 3)
- At the firm level, how did managers' backgrounds representing different forms of human capital and experience (e.g., technical vs. business education, international exposure) – influence firms' strategic choices, thereby affecting profitability and employment outcomes for workers during Sweden's industrial development? (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 ex-

ogenous 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 delves 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

This dissertation is based on the following four papers:

- Paper 1: "Has Technology Destroyed Jobs? A Systematic and Narrative Review of Historical Labor Displacement". This paper is co-authored with Benjamin Schneider. Benjamin Schneider contributed the initial conceptualization, overall strategy, and writing, driving the project forward; he also shared equally in the tasks of screening sources and extracting/writing up findings. My primary contributions involved designing the search strategy, conducting the database searches, developing a graphical user interface tool to facilitate the two-stage screening process, and contributing equally to the data extraction and writing of the results presented.
- 2. Paper 2: "Power for progress: The impact of electricity on individual labor market outcomes". This paper is co-authored with Jakob Molinder and Kerstin Enflo. Kerstin Enflo and Jakob Molinder served as project leaders, providing overall direction. Kerstin Enflo took the lead on writing and was instrumental in sourcing the crucial 1930 census dataset. Jakob Molinder contributed specific data and figure creation. My primary role focused on the quantitative analysis, including coding the econometric models and replication files in Stata, generating data visualizations and maps, and contributing to the analysis write-up.
- 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. I was inspired by Ford (2025) 's figure in his Kappa to create this, and owe him a debt of gratitude for the idea.

■ 1850	Has Technology Destroyed Jobs? A Systematic and Narrative Review of Historical Labor Displacement	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?	Themes Labor Displacement Technological Change Geographic Focus Global (published in English) Data Sources Published Studies Books 1980 1990
8	Power for progress The impact of electricity on individual labor market outcomes	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?	Themes Electrification Individual Labour Market Outcomes Geographic Focus Sweden Data Sources Swedish Censuses Electrification Reports
1850		Outcome Year: 1930	1980
	Praise the people or praise the place? Upper tail human capital in electrifying Sweden	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?	Themes High-Skilled Labor Engineers Human Capital Mobility & Origins Electrification Geographic Focus & Sweden Data Sources Biographical Dictionaries Industrial Catalogue
1850		1900 1930	Vem är Vem Period 1980
0	Technocrats to Tycoons The Shift in Swedish Corporate Leadership and Its Economic Consequences in the	What were the firm-level consequences of having board members with specific business and technical education, and international (U.S.) experience during Sweden's inductivitied development particularly.	Themes Corporate Governance Board Composition Firm Performance Geographic Focus
	Zuth century	concerning profitability and employment?	 Sweden Data Sources Annual Reports (SSE) Biographical Dictionaries
1950	20th century	concerning profitability and employment?	Sweden Data Sources Annual Reports (SSE) Biographical Dictionaries 1890 - 1990

Figure 3: Paper information and timelines

1.6 Contribution of Research

This thesis contributes to the economic history of technological change by providing an individual-level analysis of Swedish electrification. It integrates findings across different levels of analysis and employs various methods, including a systematic literature review, individual-level microeconometrics, analysis of high-skilled labor using novel biographical data generated via AI techniques, and firm-level panel data analysis of corporate governance.

Substantively, it offers new empirical evidence on the distributional consequences of a major GPT, demonstrating that electrification in early 20th-century Sweden had the potential to be laborenhancing and inequality-reducing. It sheds light on the distinct roles and mobility patterns of different skill groups during technological transitions. Further, it explores the long-term impact of board composition, particularly the role of engineers and international experience, on firm outcomes within the specific context of Swedish industrial development and corporate governance.

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 midtwentieth 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 inter-sectoral complementarities driving industrial transformation.



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 GPT's potential often involves lags due to the need for widespread diffusion, complementary investments, and "fundamental changes in organization and practice" (Crafts 2021, 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).

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. 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 education 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 supplv 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 permanently 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.

3 Theory and Previous Research

This dissertation engages directly with key theoretical debates in economic history concerning technological change and its socioeconomic impacts. While Sweden's historical experience serves as an empirical lens, the broader theoretical implications extend beyond national contexts. Specifically, the thesis contributes to scholarly debates about the displacement versus enabling effects of technological innovation, the implications of General Purpose Technologies (GPTs), the conditions fostering effective human capital mobility, and the role of corporate governance structures in shaping economic outcomes.

This dissertation contributes empirical evidence to these debates by systematically documenting historical patterns of technological labor displacement (Paper 1), and through econometric analyses showing that electrification in Sweden did not conform to the predictions of skill-biased technological change theories, instead generating broad-based income gains particularly benefiting lower-skilled workers (Paper 2). Further, engaging with the nature and impact of General Purpose Technologies (GPTs), the dissertation provides empirical evidence on how electrification functioned as an enabling rather than displacing force, facilitating widespread economic gains across sectors and skill groups, thereby suggesting context-dependence in GPT outcomes (Paper 2). It also sheds new light on debates around human capital, knowledge diffusion, and mobility by examining the distinctive characteristics and migration patterns of high-skilled engineers instrumental to Sweden's electrification, highlighting the role of international mobility - particularly exposure to technology and management practices from the United States - in transferring critical expertise and shaping regional technological trajectories (Paper 3). Finally, the dissertation addresses key theoretical discussions regarding corporate governance and leadership by empirically investigating the consequences of director backgrounds (technical education and international experience) on corporate structure, profitability, and employment outcomes, thus contributing new historical insights into how governance structures mediate technological and economic transformations (Paper 4).

The remainder of this section examines each of these core theoretical areas in greater depth, placing my findings in the context of existing literature and highlighting their significance for understanding the broader dynamics of technological change.

3.1 Technological Change, Labour Market Outcomes, and Skills

The impact of technological innovation on employment and wages is an often contentious question in economic history. Classical concerns about "technological unemployment," vividly expressed by thinkers like Ricardo who feared machinery could "render the population redundant and deteriorate the condition of the labourer" (Mokyr, Vickers, and Ziebarth 2015, p. 33);, persist in contemporary debates surrounding automation and AI as put forward by Frey (2020), Kolade and Owoseni (2022) and Lane and Saint-Martin (2021). This perspective, sometimes termed the "substitution framework" (Mondolo 2022), emphasizes the direct displacement effect (or "automation effect" (Autor 2019, p.3);) particularly when process innovations aim explicitly to reduce labor inputs per unit of output (Piva and Vivarelli 2018; Corrocher et al. 2023). As Marx argued, technological advancement might even be "intentionally led by capitalists in order to increase unemployment, as mean of control on the labor force" (Calvino and Virgillito 2016, p. 85);. Counterbalancing this is the "compensation framework" (Calvino and Virgillito 2016), or "augmentation effect" (Autor 2019, p.3);, which outlines market mechanisms that could potentially offset job losses. These include demand increases via lower prices or higher incomes, employment generated in producing the new capital goods, the reinvestment of profits, and, crucially, the creation of entirely new products and tasks – the "reinstatement effect" (Calvino and Virgillito 2016; Corrocher, Moschella, Staccioli, and Vivarelli 2023; Vivarelli 2014). However, the efficacy of these mechanisms is often questioned due to factors like market frictions, insufficient demand, or the specific nature of innovations (Vivarelli 2014; Ugur and Mitra 2017; Corrocher, Moschella, Staccioli, and Vivarelli 2023). Systematic reviews suggest compensating effects often outweigh displacement at the firm level, possibly due to "business stealing," but the picture is more ambiguous at sectoral or aggregate levels (Hötte, Somers, and Theodorakopoulos 2022; Montobbio et al. 2024). Indeed, meta-analysis indicates the net employment impact of recent technologies like robots may be negligible overall, after accounting for publication bias (Guarascio, Piccirillo, and Reljic 2024).

Recognizing this complex interplay of countervailing effects, the first paper in this thesis adopts a specific approach. Instead of aiming to estimate the net employment effect of technology, which modern reviews focusing on AI or recent decades often attempt (Hötte, Somers, and Theodor-akopoulos 2022; Guarascio, Piccirillo, and Reljic 2024), Paper 1 undertakes a systematic and narrative review of the historical literature (pre-1980). Its goal is explicitly to identify and catalogue documented instances of technological labour displacement across different sectors and contexts. By focusing on the pre-1980 period, before the widespread computer revolution that dominates current SBTC and automation debates, this paper seeks to deepen our understanding of the various conditions under which technologies have historically acted as labour-replacing forces and to highlight specific episodes and sectors where quantitative research on displacement effects is currently lacking. It thus aims to map the historical landscape of displacement to guide future empirical work, rather than directly contesting contemporary findings on net effects.

Beyond the quantity of jobs, technology's impact on the quality and nature of work is often analyzed through the lens of Skill-Biased Technological Change (SBTC). This hypothesis posits that innovations frequently complement skilled labor more than unskilled labor, increasing the relative demand for skills and contributing to wage inequality (Berman 2000; Vivarelli 2014). Tinbergen famously framed this as a "race between technological development and education" (Tinbergen 1975), where relative wages depend on whether the supply of educated workers keeps pace with rising demand (Goldin and Katz 2007). More refined task-based models, particularly influential since the computer revolution, suggest technology substitutes for workers performing routine tasks (both cognitive and manual) while complementing non-routine tasks (problem-solving, complex communication) (Autor, Levy, and Murnane 2001). This mechanism is used to explain "job polarization" – the hollowing out of middle-skill, routine-intensive jobs and the simultaneous growth of high-skill, non-routine jobs and low-skill, non-routine service jobs (Autor 2022; Goos 2018). As Autor, Levy, and Murnane (Autor, Levy, and Murnane 2001, p. 1) state, the argument is that computer capital "(1) substitutes for workers in performing cognitive and manual tasks that can be accomplished by following explicit rules; and (2) complements workers in performing nonroutine problem-solving and complex communications tasks."

However, the findings presented in this thesis, particularly in Paper 2, challenge a simple, universal application of the SBTC framework to all major technological shifts. The analysis of Swedish electrification suggests that this specific historical technology, in its specific context, had equalizing effects. Early access to electricity significantly raised incomes, but these gains were disproportionately concentrated among lower-income individuals and those with only primary education, leading to a reduction in local income inequality. This contrasts sharply with the predictions of standard SBTC models and the observed polarizing effects of later technologies like ICT. It suggests that electrification, in early 20th-century Sweden, may have acted more as an "enabling technology" (Frey 2020, p. 51);, broadly enhancing productivity across existing occupational structures, rather than primarily substituting for middle-skill routine tasks in a way that increased the relative return to higher education. This aligns with findings by Heikkuri (Heikkuri 2024, p. 5);, who notes that during this period, "despite rapid technological change, the skill premium decreased, largely because of the faster income growth of low- and unskilled production workers compared to high- and medium-skilled white-collar workers." Such results underscore critiques suggesting the SBTC narrative is not universal and that institutional factors or the specific nature of the technology matter significantly (DiNardo and Card, n.d.). Furthermore, the skill bias itself may be endogenous, shaped by relative factor supplies or the nature of imported technology (Behar 2016). Understanding the quality of jobs created or destroyed, beyond wages – incorporating dimensions like safety, control, and intensity (Schneider 2022) - is also crucial for a complete picture, though beyond the scope of the wage-focused analysis in Paper 2.

3.2 General Purpose Technologies (GPTs)

Certain transformative technologies, often described as 'engines of growth' (Bresnahan and Trajtenberg 1995), such as steam power, electricity, and ICT, are designated General Purpose Technologies (GPTs). Bresnahan and Trajtenberg (Bresnahan and Trajtenberg 1995, p. 83) argue these are characterized by three core features: pervasiveness (potential for use in a wide range of sectors), inherent potential for ongoing technical dynamism and improvement, and innovational complementarities (IC), which give rise to increasing returns-to-scale (Crafts 2021; Bresnahan and Trajtenberg 1995; 1995, p. 83);. These technologies are often seen as driving long economic waves or structural epochs (Coccia 2017; Schön 2012). Most GPTs act as 'enabling technologies', opening up new opportunities rather than offering final solutions (Bresnahan and Trajtenberg 1995, p. 84);. The productivity gains associated with them often stem from downstream innovation they foster; for example, electric motors enabled more efficient factory designs, and microelectronics users innovate by "wrapping around the integrated circuits their own technical advances" (Bresnahan and Trajtenberg 1995, p. 84);. These innovational complementarities, where the "productivity of R&D in a downstream sector increases as a consequence of innovation in the GPT technology" (Bresnahan and Trajtenberg 1995, p. 84);, magnify the GPT's effects and propagate them through the economy, creating positive feedbacks between the GPT and its application sectors (AS) (Bresnahan and Trajtenberg 1995).

However, a key characteristic often observed is the lag between a GPT's introduction and its measured impact on aggregate productivity (Crafts 2010; 2021). This delay arises because realizing a GPT's potential requires widespread diffusion, significant complementary investments (in

infrastructure, machinery, skills), fundamental changes in organization and practice (Crafts 2021; Bresnahan and Trajtenberg 1995), and overcoming coordination challenges. Bresnahan and Trajtenberg (Bresnahan and Trajtenberg 1995) emphasize that because complementary innovative activities are dispersed, a decentralized economy relying on "arms-length market transactions between the GPT and its users may result in 'too little, too late' innovation" (Bresnahan and Trajtenberg 1995, p. 83, 103);. This stems from vertical externalities (neither the GPT innovator nor the AS innovator can fully appropriate the joint returns) and horizontal externalities (AS innovators don't fully account for the benefit their adoption provides to other ASs by inducing GPT improvements) (Bresnahan and Trajtenberg 1995). Some GPTs may also function as "inventions of a method of invention," accelerating innovation itself (Crafts 2021) – a concept Griliches applied to hybrid corn (Bresnahan and Trajtenberg 1995, p. 86);. While GPT is a powerful concept, its application requires care, as definitions can be broad, identification often happens ex-post, and historical analogies between different GPTs may be misleading (Field 2008; 2016).

Paper 2 of this thesis explicitly treats electrification in early twentieth-century Sweden as a case study of a GPT's diffusion and impact. Its rapid adoption across Swedish industry (Schön 2000) and its role as a key "development block" (Schön 2012, p. 15) align with GPT characteristics. The finding in Paper 2 that electrification led to broad-based income gains and reduced inequality, particularly benefiting lower-skilled workers, suggests that in the specific Swedish context of that era —characterized by increasing urbanization, nascent "levelling" forces counteracting high inequality, and a particular industrial structure—this specific GPT acted primarily as an "enabling technology" (Frey 2020, p. x-xi);. This contrasts with narratives emphasizing the displacement effects of the first Industrial Revolution or the polarizing effects of later ICT adoption (Frey 2020; Autor 2019), highlighting the context-dependency of GPT impacts. The results suggest that electrification's benefits diffused widely, perhaps improving productivity broadly within existing occupational structures more than driving immediate, large-scale occupational shifts, occurring during a period of rising labour mobilization that likely influenced the distribution of gains (Bengtsson 2012).

3.3 Human Capital, Knowledge Diffusion, and Mobility

The creation, diffusion, and application of knowledge are central to economic development, with human capital playing a key role. Education enhances the ability to generate new ideas (Romer 1990) and, perhaps more importantly for diffusion, to adopt and adapt existing technologies (Nelson and Phelps 1966). While basic literacy and schooling provide a foundation (Ford, Ranestad, and Sharp 2022), "upper tail knowledge" embodied in highly skilled individuals like scientists and engineers is often seen as critical for driving innovation, particularly during industrial transitions (Mokyr 2005; Squicciarini and Voigtländer 2015). Paper 4 engages with this by examining the firm-level consequences of having directors with specific human capital attributes, such as technical education or international experience, on corporate performance and strategy. Measuring this upper-tail human capital historically is challenging, but sources like graduate biographies offer detailed insights into education, careers, and skills beyond simple metrics (Ford, Ranestad, and Sharp 2023; Ranestad 2021). As Ford et al. note, these biographies "were effectively mini-CVs covering entire careers, including work positions, travel, achievements, and more" (Ford, Ranestad, and

and Sharp 2023, p. 2);. Innovative recent work also highlights the potential of detailed historical student grade lists to construct more granular measures of human capital, allowing researchers "to deconstruct aggregate education into e.g. knowledge of science or humanities, as well as to measure the extent to which this was actually learned" (Ford, Ranestad, and Sharp 2022, p. 1);.

Knowledge transfer is not automatic; Robertson and Jacobson argue that "from an economic standpoint, the efficient diffusion of knowledge on new technologies is an essential characteristic of growth and development" 2011. Successful diffusion depends on the 'absorptive capacity' of recipients (Kingsley, Bozeman, and Coker 1996; Robertson and Jacobson 2011) - their ability to value, assimilate, and apply external knowledge. As Ranestad observes in the context of multinational mining companies, "limited knowledge transfer... reflects a low 'absorptive capacity' among local firms and industrialists" (Ranestad 2020, p. 207);. Mobility of skilled individuals is a key channel for facilitating diffusion (Ranestad 2025). As documented by Grönberg (Grönberg 2003) and Ranestad (Ranestad 2025), engineers moving between firms or returning from abroad can transfer vital tacit and codified knowledge, techniques, and organizational models. Ranestad finds, for instance, that in Norwegian mining, the "practice of job switching across branches... increased the likelihood of efficient knowledge transfer" (Ranestad 2025, p. 3);. Paper 3 contributes directly to this debate by providing empirical evidence from Sweden's electrification. It confirms the high mobility of the engineering elite, often involving international 'target migration' to gain specific skills (Grönberg 2003, p. 21);. Crucially, Paper 3 finds that engineers active in the pioneering Western Line parishes before 1930 were significantly more likely to possess career experience gained specifically in the USA compared to their peers. This US experience, described by Grönberg as "valuable symbolic capital" (Grönberg 2003, p. 35);, was often gained at leading firms like General Electric or Ford. Grönberg notes that while there was technical influence, "the knowledge gained from American companies consisted mainly of how to rationally organise workshops" (-Grönberg 2003, p. 11);. This finding from Paper 3 suggests that these mobile engineers served as key conduits for transferring internationally-sourced "upper tail knowledge," embodying the enhanced absorptive capacity needed by Swedish firms and regions to implement the new electrical technology effectively.

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, internationallyconnected 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" 2024.

3.4 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. Given the mixed empirical results found in the broader literature regarding the performance impact of specific governance metrics – for example, studies by Kajola 2008 and Achchuthan & Kajananthan 2013 found no significant relationship between board composition (NED proportion) and firm performance in Nigeria and Sri Lanka, respectively – Paper 4's preliminary findings of limited immediate impact from appointing directors with specific educational or US backgrounds on core financial metrics, while potentially hinting at lagged productivity effects, contribute to this ongoing debate about the specific conditions under which board human capital translates into measurable 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, I employ 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 incorporating network analysis. 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 [source: user request]. 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 [source: user request]. 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, Booth, Glenton, Munthe-Kaas, Rashidian, Wainwright, Bohren, Tuņcalp, Colvin, Garside, Carlsen, Langlois, and Noyes 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





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 [source: user request].

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 [source: user request]. 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?", analyzes a novel dataset constructed from the Vem är Vem? biographical dictionaries (c. 1945-1968) 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 (GPT-4o-mini) with Pydantic schemas to structure the semi-structured biographical entries into analyzable format (Schmid 2025). 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? 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 analyzes a long-run firm-level panel dataset (1873-1980) for 71 Swedish firms to examine the relationship between corporate board composition and firm performance. A central aim is to test theories about the impact of managerial background (technical vs. business education, U.S. 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 U.S. experience were constructed based on the matched biographical information.

The core analytical strategy employs an event-study design, assessing firm outcomes (net income, ROA, employment, revenue per worker) 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. Bipartite network analysis is also used to map director-firm connections and explore the role of interlocks and centrality, guided by Pavlopoulos et al. (2018).

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 Stocholm 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 I do not have 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 analyze 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 (Literature Review)

The data for the systematic and narrative review presented in Paper 1 consist of published academic studies, including journal articles, boosk, 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 Methods section.

Table 1: 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 3,172 initial search results against predefined criteria, a process undertaken collaboratively by myself and my co-author, Benjamin Schneider. This resulted in a final dataset of 140 relevant sources that discuss or quantify historical labor displacement due to technology in the pre-1980 period. Of these, 38 studies contained quantitative information suitable for the systematic review, while 102 provided qualitative accounts used in the narrative synthesis. The dataset primarily consists of the textual content and findings reported within these publications. Its main limitation stems from the inherent biases within the existing published literature itself, such as potential publication bias and the identified geographic skew towards North American and European cases, particularly in quantitative studies.

5.2 Data for Paper 2 (Econometric Analysis)

Paper 2 combines individual-level microdata with parish-level information to analyze 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 (Jayes, Molinder, Enflo) 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 Johan Junkka's histmaps package (Junkka 2024), and historical railway data are drawn from Molinder et al. (2021) (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?') biographical dictionary series, focusing on the editions published between 1945 and 1968. 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 Methods section, the semi-structured text was then processed using LLMs (GPT-4o-mini) 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? captures 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? 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.

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			

Table 2: Top Occupations in Biographical Dictionaries by Gender

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 Methods section, 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, Ganjam, Ganti, and Motwani 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 U.S. 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 and Narrative Review of Historical Labor Displacement", is co-authored with Benjamin Schneider. Benjamin Schneider contributed the initial conceptualization, overall strategy, and writing, driving the project forward; he also shared equally in the tasks of screening sources and extracting/writing up findings. My primary contributions involved designing the search strategy, conducting the database searches, developing a graphical user interface tool to facilitate the two-stage screening process, and contributing equally to the data extraction and writing of the results presented. It should be noted that this paper is currently in a working stage, with plans to present it for feedback at the World Economic History Congress in Lund before further refinement.

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 sign-posting avenues for future research.

The findings confirm that historical technology *has* indeed destroyed jobs, but the context is crucial. 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). The review also highlights a strong geographic bias in existing quantitative studies towards North America and Europe, leaving large gaps in our understanding of displacement dynamics in the Global South and in non-English speaking regions.

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. Kerstin Enflo and Jakob Molinder served as project leaders, providing overall direction. Kerstin Enflo took the lead on writing and was instrumental in sourcing the crucial 1930 census dataset. Jakob Molinder contributed specific data and figure creation. My primary role focused on the quantitative analysis, including coding the econometric models and replication files in Stata, generating data visualizations and maps, and contributing to the analysis write-up.

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 analyzes a novel dataset from *Vem är Vem?* 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 labor market adjustments 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 Performance

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 subquestion: What were the firm-level consequences of having board members with specific technical and international (U.S.) 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 core analysis employs an event-study methodology to examine how firm performance metrics (net income, Return on Assets (ROA), employment, revenue per worker, and a wage bill/revenue proxy for labor share) change around the first appointment of directors with specific backgrounds: business education, technical education, or U.S. work experience.

The successful digitization and matching represent key data contributions. Descriptive analysis shows shifts in director backgrounds over the century. The event study analyses yield primarily null results regarding the impact of these board composition changes. Specifically, the first appointment of a director with a business education, technical education, or U.S. engineering experience did not show a statistically significant, consistent effect on firm net income, ROA, total employment, or the wage bill/revenue ratio in the years immediately following the appointment. The analysis did find tentative evidence suggesting a potential small positive effect on labor productivity (revenue per worker) emerging several years after the first appointment of a director with U.S. work experience.

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 businesstrained 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 U.S. 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, especially outside North America and Europe and in service or cultural sectors. Paper 2 then provided a detailed micro-level analysis of Swedish electrification's impact via the Western Line, finding surprisingly positive distributional outcomes: 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 the link between corporate governance—specifically board composition—and firm performance, finding limited immediate impact of directors' educational backgrounds or U.S. experience on key financial metrics in event studies, though hinting at potential lagged effects on productivity.

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 earlyto-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 preliminary event-study analysis (Paper 4) that the immediate impact of specific board member types on standard financial metrics may be less pronounced than sometimes assumed, pointing towards more complex drivers of firm

performance. 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. Following feedback at venues such as the World Economic History Congress in Lund, this work can serve as a direct guidepost, encouraging research that applies quantitative methods to the understudied episodes, regions (especially the Global South), and demographic groups (e.g., gendered impacts) highlighted in the review.

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?).

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 full integration of the 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.

8 Appendix

8.1 Definitions of Fundamental Concepts

To ensure clarity, several fundamental concepts are defined as follows:

Labor Displacement/Technological Unemployment refers to the permanent separation of workers from their jobs due to technological change, where the job itself disappears or is fundamentally transformed (Acemoglu and Restrepo 2019). This is distinguished from temporary unemployment or job reallocation, and conceptually contrasted in modern frameworks with the "reinstatement" effect, where technology also creates new tasks.

Skill-Biased Technical Change (SBTC) is the hypothesis that technological advancements tend to complement high-skilled labor more than low-skilled labor (Katz and Murphy 1992), thereby increasing the relative demand for skilled workers and potentially widening wage inequality. Related concepts include Routine-Biased Technical Change (RBTC), which suggests automation substitutes for routine tasks often performed by middle-skilled workers (Autor, Levy, and Murnane 2001), leading to job polarization (Goos 2018).

General Purpose Technology (GPT) denotes a class of technologies characterized by their potential for pervasive use across multiple sectors of the economy, their capacity for ongoing technical improvement, and their role in enabling and stimulating further innovation in complementary technologies and organizational forms (e.g., steam power, electricity, ICT) (Bresnahan and Trajtenberg 1995).

Human Capital encompasses the skills, knowledge, experience, and health embodied in individuals that contribute to economic productivity. This thesis considers human capital acquired through formal education and on-the-job training. Specific attention is given to "upper tail human capital," referring to the advanced skills and expertise possessed by highly educated individuals like engineers, crucial for innovation and complex management (Mokyr 2005; Squicciarini and Voigtländer 2015).

Corporate Governance refers to the systems, principles, and processes by which companies are directed, controlled, and held accountable (Steier and Morck 2005). This thesis focuses specifically on board composition—including the educational backgrounds (technical vs. business) and international experience of directors—and its potential influence on firm strategy, performance, and employment decisions (Högfeldt 2005).

Bipartite Networks describe a type of network analysis used in Paper 4 involving two distinct sets of nodes (e.g., company directors and the firms they serve on) (Pavlopoulos, Kontou, Pavlopoulou, Bouyioukos, Markou, and Bagos 2018). Analyzing the connections between these sets allows for the study of phenomena like interlocking directorates and the influence of central actors within the corporate system.

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