Did industrialization improve skill composition of the population? Evidence from Sweden, 1870 to 1930

Suvi Heikkuri, suvi.heikkuri@gu.se
University of Gothenburg

Abstract

This paper documents the changing skill composition during industrialization in Sweden using population censuses and HISCO/HISCLASS scheme. The results reveal a general shift from unskilled to more-skilled occupations, though the trend differs by gender and sector. First, within manufacturing, there was a shift from medium-skilled to low- and unskilled occupations, consistent with the *workshop-to-factory* shift. However, this trend is mirrored by skill upgrading within services, where the expansion of trade and transport introduced new low- and medskilled jobs. Second, the shift away from agriculture resulted in decreasing unskilled employment, which in principle would be consistent with the *farmwork-to-factory* shift. However, this paper highlights the role of *farmwork-to-services* shift, which was likely equally important driver of the decline in unskilled employment as the expansion of industrial employment. Finally, the paper shows that skill upgrading was more pronounced for women, who left agriculture for better job opportunities elsewhere.

Introduction

The objective of this paper is to document changes in the skill composition in Sweden during the industrialization period from 1870 to 1930. One of the striking differences between pre-industrial and post-industrial economies is the change in how people work. In pre-industrial economies, a large proportion of the labour force remained unskilled and engaged in small-scale family farming. Today, most people in industrialized and post-industrial economies possess marketable skills and an education beyond primary school. One possible explanation is skill-biased technological change. Goldin and Katz (1998) argue, that since the turn of the twentieth century, new technologies have increased the demand for skilled relative to unskilled workers. Prior to the twentieth century, they argue, technological change

was deskilling, as factory system replaced the existing small-scale crafts production.[1] But as the manufacturing sector expanded, so did the job opportunities outside farming. These occupations were often better-paid but physically demanding and required long hours in dimly lit factories (Frey, 2019). The typical narrative suggests that around the turn of the twentieth century, technological change became skill biased, and the new jobs at the time required education beyond basic primary school (Acemoglu, 2002; Goldin & Katz, 2008).

This periodization of deskilling in the nineteenth century followed by skill-biased technological change in the twentieth century has been questioned by more recent evidence. Atack, Bateman, and Margo (2004) examine nineteenth-century mechanization and the emergence of steam engines in manufacturing, suggesting that the demand for skills increased with steam engines but decreased with factory size. Similar results are provided by Ridolfi, Salvo, and Weisdorf (2022), who show that steam engine adoption resulted both in greater employment and higher wages. De Pleijt, Nuvolari, and Weisdorf (2020) argue, in line with Goldin and Katz (1998), that the *workshop-to-factory* transition was deskilling but a parallel *farmwork-to-factory* shift served to upgrade skills as farm workers found new jobs within industry. That is, since most – if not all – agrarian workers were unskilled, a decline in agricultural employment would by default result in skill upgrading (Federico, Nuvolari, Ridolfi, & Vasta, 2021).

This paper contributes to the literature on deskilling and skill-biased technological change during industrialization by exploring occupational structure and skill composition in Sweden between 1870 and 1930. Present-day Sweden is known as an egalitarian society with strong labour unions. However, at the turn of the twentieth century, it had at least as high income inequality as the other industrial economies (Roine & Waldenström, 2008). Recent evidence suggests that the foundations for equality were laid well before Sweden became a welfare state, and occupational

[1] It should be noted that this argument is not new. Classical economists such as Adam Smith and Karl Marx noted the role that factories and machines played in changing the composition of labour (Brugger & Gehrke, 2018). Furthermore, Hounshell (1984) described many labour-saving technologies that saved particularly on skilled labour in the United States. Braverman (1974) referred to the increasing mechanization as "degradation of work", as he saw the workers being reduced to a brainless machines by mechanization. Brown and Philips (1986) examined mechanization as not only labour-saving, but also reducing the power of skilled workers, as unskilled workers were easier to replace and thus did not have the same bargaining power as highly specialized skilled workers. Horrell and Humphries (1995) show that child labour in factories increased and the age at which children started working decreased during early industrialization in England.

structure may have played a role in it. Prado and Waara (2018) suggest that wage compression started before the introduction of the collective bargaining agreements and the so-called Swedish model. Bengtsson and Molinder (2023) suggest that some of the drop in income inequality was driven from bottom up as people shifted from low- to high-paying occupations in Stockholm, nation's capital. For Malmö, the third largest city in Sweden, Svensson and Bengtsson (2023) show that changes in the occupational composition among working classes explain some of the decline in income inequality. In other words, occupational changes may have driven decreasing income inequality even before solidaristic wage policies were in place.

To address changes in the skill composition of Swedish labour force, I use population censuses published every ten years by Statistics Sweden (SCB). Specifically, I use censuses between 1870 and 1930, which report broader occupations of the population. This period aligns with the industrial breakthrough in Sweden, dated by Jörberg (1965) to the 1870s. To make inferences about skills, I employ the HISCO/HISCLASS scheme, which allows the coding of occupations as high-, medium-, low-, and unskilled based on their title van Leeuwen and Maas (2011). To distinguish shifts within and between the main sectors of the economy, I employ a standard within-between decomposition, adopted from Berman, Bound, and Machin (1998). Finally, I compare the development of skill composition in Sweden to that in the United States, the leading economy at the time and most-studied context in the skill-biased technological change literature.

The results of this paper show that at the aggregate level, skill distribution in Sweden shifted from unskilled to more-skilled occupations. The greatest shift occurred from unskilled to low-skilled employment, though relatively speaking, high-skilled employment increased the most. The decomposition exercise shows that between-sector shifts explained most of this upgrading. The within-sector components were not however insignificant. Within manufacturing, employment shifted away from medium-skilled occupations. On the one hand, this resembles deskilling, but on the other hand, if one were to include managerial and professional workers within industry, the pattern resembles job polarization.[2] Compared to the United States, Sweden had a

[2] This pattern on employment growth has been documented for many developed countries in connection to the introduction of information and communication technologies, such as computers (Adermon & Gustavsson, 2015; Autor, Katz, & Kearney, 2006; Autor, Levy, & Murnane, 2003; Bárány & Siegel, 2018; Goos, Manning, & Salomons, 2009).

greater share of low- and unskilled workers and exhibited a slower growth in the white-collar (medium- or high-skilled) employment.

In conclusion, the present study finds some support for the *workshop-to-factory* transition being deskilling. This is largely related to the rise in factory employment rather than a decrease in artisan work, as the absolute number of artisans continued to grow over this period. That is, during the industrial breakthrough in Sweden, artisans were not strictly replaced, as Goldin and Katz (1998) suggest, but rather, industrial expansion increased the number of large manufacturing units and factories, as illustrated by Berger and Ostermeyer (2023). For the *farmwork-to-factory* transition, this paper offers mixed conclusions. It seems more plausible that unskilled workers shifted from farm work to factory work without occupational upgrading, as both farm workers and factory workers are considered unskilled by HISCLASS scheme. Finally, this paper brings forward an alternative channel for skill upgrading: *farmwork-to-services* transition. While it is not possible to follow individuals in the material, the patterns documented in this paper together with existing literature suggest that for many women, a shift from farm work to services resulted in occupational upgrading. While many of them found work as unskilled domestic servants, sufficiently many women found employment as shopkeepers and shop assistants, teachers, nurses, and office clerks to shift the skill composition away from unskilled and to more skilled employment. A similar conclusion is made by Bengtsson and Molinder (2024), who find that the decrease in domestic service resulted in decreasing income inequality in Stockholm. Unfortunately, some of the shifts in female employment are hidden by the insufficient documentation of women in official statistics, which plagues most studies on female employment before middle of the twentieth century.

Technological change and skills

This paper contributes to the literature on technological change and skills. In this literature, technological change is considered either skill-biased or unskilled-biased. Put simply, skill-biased technological change increases the demand for skilled workers by creating tasks that require greater skills and/or by eliminating tasks that do not require skills (Acemoglu & Autor, 2011; Autor et al., 2003). The opposite is true for unskilled-biased, or deskilling, technologies. In this framework, technologies can also result in so-called “hollowing out” pattern if a new technology replaces middle-skilled

tasks while complementing high-skilled tasks, with little to no influence on low-skilled tasks.

The idea that the nineteenth-century technological change was predominantly deskilling originates largely from the observation that factory production replaced artisans and skilled craftsmen with unskilled factory workers (e.g., Brown & Philips, 1986; Hounshell, 1984; James & Skinner, 1985). Goldin and Katz (1998) famously used this argument to date "the origins of the technology-skill complementarity" to the turn of the twentieth century. During the nineteenth century, capital in a form of machinery took over the production process previously performed by skilled artisans and craftsmen, and unskilled labour was needed for "hauling, conveying, and assembly tasks" (Goldin & Katz, 1998: p. 695).

There are two parallel mechanisms that could have influenced the demand for skills during the nineteenth century: the factory system and the adoption of steam engines. Atack et al. (2004) show that establishment size is negatively associated with wages, suggesting that greater division of labour and standardized products in factories increased the demand for unskilled workers. In contrast, wages were positively associated with steam engines, suggesting that mechanization could have served to increase the demand for skilled workers. Similar results are provided by Ridolfi et al. (2022), who show that steam engine adoption resulted both in higher wages and greater employment. Higher wages do not necessarily imply greater skill, but rather, higher wages could result from higher labour productivity, irrespective of worker skills.[3] Atack, Bateman, and Margo (2008) indeed show that steam engines were connected to higher labour productivity.

De Pleijt and Weisdorf (2017) use occupational titles coded into HISCO to show that there was indeed deskilling within manufacturing in England before and during the industrial revolution. Their evidence reveals an increasing share of unskilled workers particularly from 1650 to 1850. This finding suggests that deskilling within manufacturing may have preceded the factory system and steam engines. Using similar method of inferring skills from occupational titles, Katz and Margo (2014) show that the employment in manufacturing sector in the US from 1850 to 1910 exhibited a "hollowing out" pattern: the share of middle-skilled employment decreases as the

[3] Labour productivity can indeed be increased by raising the capital-to-worker ratio, which could result from introducing labour-saving machinery.

shares of high-skilled and unskilled increase. Gray (2013) shows the same to be true from 1900 to 1940s, when manufacturing sector was electrified.

Recent studies point to the possibility of steam engines being inducive to human capital. Both De Pleijt et al. (2020) and Franck and Galor (2021) show that regions in England and France, respectively, exhibit positive influence on human capital after adopting steam engines.[4] De Pleijt et al. suggest that the introduction of steam engines shifted employment from unskilled to low- and medium-skilled occupations through a *farmwork-to-factory* transition. That is, there is a local employment effect of shifting farm employment to industrial work, and consequently, upgrading their skills. This argument is similar to Leknes and Modalsli (2020), who show that introduction of electricity furthered the structural change in Norway, and Molinder, Karlsson, and Enflo (2021), who show that agricultural employment decreased and industrial employment shifted to more-skilled jobs in parishes that were connected to electric grid in Sweden. Ongoing research suggests that electricity increased incomes, upgraded occupations, and lowered income inequality in regions alongside the electricity grid (Jayes, 2023).

The existing studies on technological change and skill distribution have largely neglected the service sector. However, industrialization and service sector development go hand in hand. Ostermeyer (2023) shows that for each skilled job in the manufacturing sector, the corresponding increase in service sector is almost one. One reason for the neglect is that many of the technologies introduced in nineteenth and early twentieth centuries, namely steam engines and electricity, have been largely connected to factories. However, steam engines were consequential in transportation, as they fuelled ships and trains that transported both industrial goods as well as people. Chandler (1978) famously connected the developments in railways to the evolution of managerialism and increase in administration, mass production and mass distribution. Railways enabled greater geographical mobility for factories, as they no longer needed to locate themselves near raw material sources and/or water. Berger and Enflo (2017) show that railroads contributed to urban growth and economic activity, and Berger (2019) further shows that railroads enhanced structural change locally.

[4] However, for England, the effect of steam engines may have had a more negative impact on traditional measures of human capital, such as literacy and number of schools. Instead, steam engines show positive impact on average skills measured by occupational titles (De Pleijt et al., 2020).

Electricity was a fundamental innovation for many services, particularly in communication. The emergence of telegraphs and telephones made communication between people and factories almost instant. Furthermore, these services often employed women (Adam, 2010; Jepsen, 2000). Electricity transformed office work, as office machines, such as adding machine and typewriter, were introduced (Beniger, 1986; Goldin & Katz, 1995). The influence of these inventions on skills can go either way. On the one hand, they made office jobs less prestigious by creating a lot of repetitive tasks that were often performed by young women (Braverman, 1974). Whether directly resulting from office mechanization or not, during the early twentieth century, there was a loss of prestige in typical office jobs, such as secretary (Goldin & Katz, 2008). On the other hand, the expansion in office jobs did increase white-collar jobs, which typically required a higher education than blue-collar work (ibid.).

Even the unskilled service workers, such as domestic servants, were affected by technological change. Electricity brought with it a plethora of new household appliances, designed to liberate or by the very least ease the duties of housewives and the servants in the more affluent households. Many tasks such as laundry, cooking, and cleaning were made simpler through the inventions such as washing machines, electric ovens, and vacuum cleaners (Frey, 2019). While they reduced the number of tasks, such as carrying firewood to heat the stove, they were not the only reason as to why domestic servants exhibited a decline. Edvinsson and Söderberg (2010) suggest that many left domestic services because of the low status and poor working conditions, and the increasing opportunities elsewhere.

The existing evidence on the topic suggests that the shifts from workshop to factory and from agriculture to factory should be treated separately. The transition from artisan and crafts production to the factory system should reduce the demand for skills, as factories use more unskilled labour per unit of output (Atack et al., 2004; Goldin, 1998). However, shifting labour from agriculture to industry should result to at least some skill upgrading, if at least some farm workers upgrade their occupation to low- or medium-skilled. If the transition only shifts unskilled farm workers to unskilled factory jobs, there is no upgrade in skills, though this shift may result in higher incomes (Lundh & Prado, 2015). In a similar manner, shifting from farm to services should result in skill upgrading, if at least some workers upgrade their skill by switching to a skilled position.

Data and Methods

The study employs Swedish population censuses spanning from 1870 to 1930. These censuses list population tabulated by gender, status, urban and rural area, and broad occupation. A person's status refers to his or her role either as a household head or an owner or professional within a trade or service. For example, farmers are listed as the household heads, and their family members are listed under them as "assistants" (*biträde*). Below the assistants, servants are listed. Within manufacturing, the principal professional is often an owner or a manager, and his or her works are listed below that occupation with status "worker". For example, within sawmill industry, the "main person" (*huvudperson*) are the sawmill owners, and sawmill workers are listed under them. In artisan and crafts occupations, the main person is either self-employed or a workshop owner, and his or her workers are listed under him or her, as assistants (*deras arbetare*). While the HISCO scheme assigns both masters and their workers to the same code and therefore to the same skill level, I have utilized the status classification in HISCLASS to differentiate between them. From 1910 census onward, workers are separated into their own occupation rather than listed under their managers or the owners of the companies. The 1930 census is the first one to separate small and large entrepreneurs. For this census, I have assumed small entrepreneurs in artisan and craftsman trades to be working owners, kin to the "master" in censuses before 1910. Larger entrepreneurs are coded as general managers. In trades characterized by factorization, such as paper production, both types of entrepreneurs are considered as managers.[5]

Occupations are categorized into skill levels using the HISCO classification scheme developed by van Leeuwen and Maas (2011), which assigns numeric codes (HISCO) to occupations. This classification further allows assigning workers to twelve social classes (HISCLASS) and from there to four groups of skills: high, medium, low, and unskilled. Exceptions to this rule are apprentices or workers in artisan or craft occupations, who receive a skill-level below their masters. The benefits of using occupational titles to measure skills is that occupations should reflect the tasks of a worker at his or her current position, whereas education level remains the same after receiving the degree, despite the actual occupation. Furthermore, as De Pleijt and Weisdorf (2017) point out, literacy skills measure only the basic competences, and

[5] These occupations often include the word "fabrikör" in them, which translates to "manufacturer".

would not offer any variation among the literate population. In Sweden, almost everyone was literate in the late nineteenth century (Sandberg, 1979), but very few had any schooling beyond some years in the primary school (Ljungberg & Nilsson, 2009). Occupational titles capture changes in skills when people change their jobs, such as in the shifts from agriculture to industry or services.

However, this method has limitations. Census occupations are often broad and may not correspond directly to specific HISCO titles, leading to some generalizations. For example, T. Karlsson and Stanfors (2011) show that tobacco workers had both unskilled, semi-skilled, and skilled tasks. In the censuses, they are listed as “tobacco workers” and correspond to low-skilled in HISCO scheme. Accounting for working women has been a challenge in economic history, and this paper is not an exception. The older censuses tend to underestimate the labour input of married women, often labelling them simply as "wives”. This is both due to the contemporary attitudes towards women working (L. Karlsson, 1995) and due to the nature of earlier censuses listing the occupation of the household head instead of each individual on their own (Molinder, 2022). Additionally, the static nature of the HISCO/HISCLASS scheme means it does not capture skill changes within occupations, limiting the analysis to changes between occupations. The increase in the number of standardized titles in each census suggests the emergence of new, more specialized jobs in response to societal shifts from agrarian to industrial settings.

Table 1. Number of occupations on each census.

	1870	**1880**	**1890**	**1900**	**1910**	**1920**	**1930**
Census occupations	102	114	119	123	304	320	699
Standardized occupations	171	196	201	204	281	287	498
HISCO codes	98	107	109	110	138	132	171

Source: Statistics Sweden (1874, 1885, 1895, 1907, 1917, 1927, 1936)

After assigning occupational titles from the census to the HISCO/HISCLASS scheme, a total of 192 unique titles were identified, though the number of titles changes from one census year to another due to the changing occupational structure. Table 1 reports the number of occupations identified by year. The first row indicates the number of occupations listed by each census, the second row the number of standardized occupations, and the third row the number of unique HISCO titles. The number of standardized occupations is greater for earlier years, because servants, workers, and owners/artisans were listed under the same occupation. In later censuses, the

number of standardized occupations is lower as the same occupations were listed under different industries. For example, blacksmiths were listed a few times depending on which industry they worked in. However, in the HISCO classification, they are all coded with the same HISCO.

To accommodate comparisons with the United States, I use another occupational coding system which aligns with Katz and Margo (2014), who document occupational structure in the United States from 1850s onward. Their study uses occupational classification from IPUMS, which allows to distinguish white-collar, skilled blue-collar, and operative/unskilled workers.[6] In a similar manner, I code the occupations from the census using the "Alphabetical Index of Occupations and Industries" from 1950 (Census, 1950). This classification differs from the HISCO in that it has fewer occupational codes. Furthermore, it is based on the types of occupations that existed in 1950, which is relatively modern compared to HISCO. One of the potential issues is that many occupations that were more likely artisan or handicraft are considered manufacturing jobs in 1950. For example, hat makers are coded into unskilled operatives in the 1950 classification, whereas in 1870, they were more likely to be artisans. In general, the occupational classification from the 1950s results in larger unskilled employment than HISCO classification.

Distinguishing *workshop-to-factory* and *farmwork-to-factory* shifts requires a decomposition of the changes in occupational structure. A common way to study changes between and within groups is a standard within-between decomposition. I use a similar model to that in Berman, Bound, and Machin (1998) to study the within- and between-sector changes in the skill composition. Between-sector shifts can be interpreted as structural change, and within-sector shifts as technological change, though this assumes that technological change does not drive between-sector shifts. The standard within-between decomposition formula is

$$\Delta S_j = \sum_i \Delta W_i \overline{S_{ij}} + \sum_i \Delta S_{ij} \overline{W_i}$$

where $S_j = \frac{S_j}{\sum S_j}$ and $W_i = \frac{E_i}{\sum_i E_i}$. The term S_{ij} denotes the share of employment in skill j in industry i. The term E_i denotes the employment within an industry i. The between-component, or the first term of the right-hand side of the equation, assumes that the

[6] Katz and Margo use variable OCC1950 from IPUMS to code their micro-level data

skill composition remains fixed at the average level. That is, changes in the share of high-, medium-, low-, or unskilled changes only because employment shifts from one sector to another. The opposite is true for the within-component, which assumes that the sectoral composition is fixed at the average level, and changes in the skill composition occur because employment shifts from one skill to another within the sectors.

Changing skill composition in Sweden

During the period from 1870 to 1930, Sweden transitioned from a mainly agrarian economy to a mixed economy with thriving manufacturing and service sectors. Agricultural employment decreased from 67 to 34 percent, while manufacturing employment increased from 12 to 26 percent, excluding construction, where employment increased from 6 to 9 percent (Schön & Krantz, 2012). The remainder of labour force was employed by services. Growth in services was almost as impressive as in manufacturing: employment in transport increased from 1 to 6 percent, in private services from 10 to 18 percent, and in public services from 4 to almost 6 percent (Schön & Krantz, 2012).

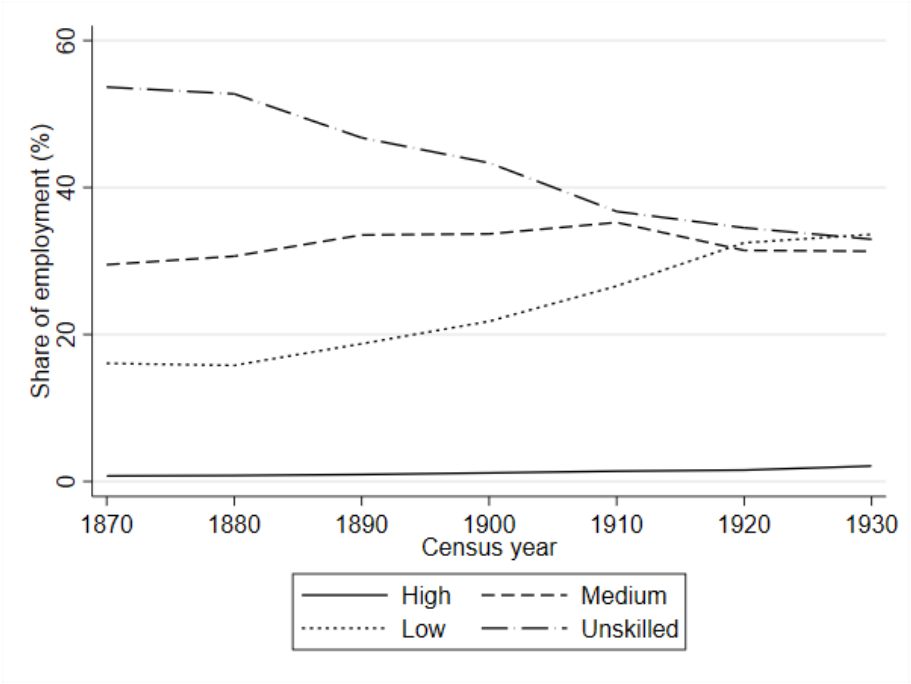

Figure 1. High-, medium-, low-, and unskilled employment as a percentage of total employment in Sweden, 1870–1930. Data source: Statistics Sweden (SCB).

Figure 1 displays the employment shares for all four skill groups. During the period from 1870 to 1930, the share of workers in unskilled occupations decreased from more than half to one-third. Employment in low- and high-skilled occupations increased, while medium-skilled employment remained relatively stable, increasing first from 30 to 35 percent between 1870 and 1910, and then decreasing to 31 percent by 1930. Figure 2 illustrates the relative changes in these shares. The change was most dramatic in high-skilled employment, which increased from a modest 0.75 percent to 2.1 percent. Low-skilled employment increased from 16 percent to more than 30 percent, effectively doubling its share. In 1930, skill composition is remarkably balanced with unskilled, low-, and medium-skilled all constituting just under one-third of the employment, leaving two percent of the employment to high-skilled occupations.

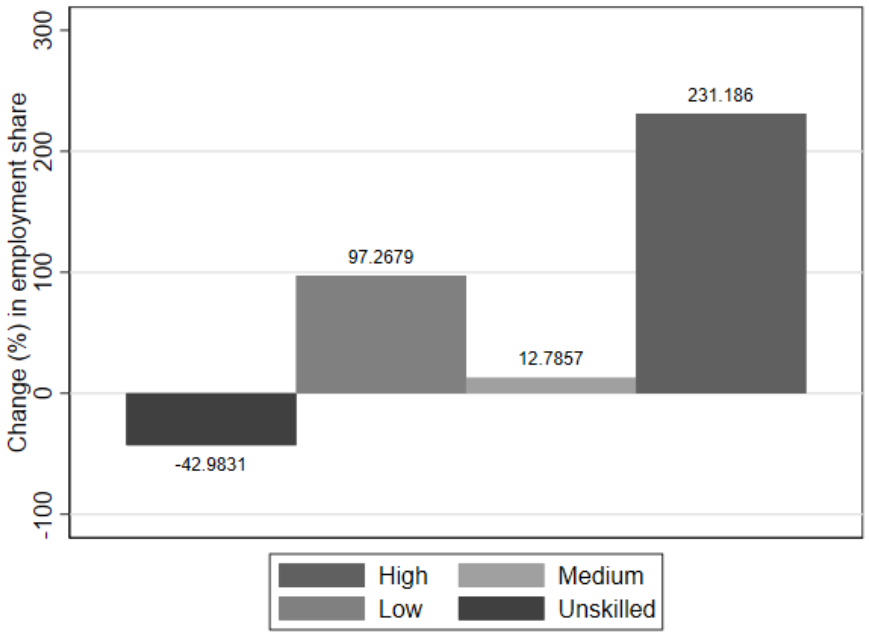

Figure 2. Relative change in the employment shares of high-, medium-, low-, and unskilled in Sweden, 1870–1930. Data source: Statistics Sweden (SCB).

The skill distribution here includes only farmers and their non-family workers. However, agriculture in Sweden was very much a family business, and the members of the family were an integral part of the farming activity, and therefore employment. In Appendix A, I re-calculate the skill composition of Swedish labour force by assigning farmers' wives to the same occupation as their husbands and assign their children

over the age of 15 who remain at home as farm workers. This does not alter the general trends observed in Figure 1, but it shows that the fall in medium- and unskilled employment is somewhat overstated by excluding the family members.

Gender differences in skill distribution

Comparison between men and women reveals that the decline in the unskilled employment was much more dramatic for women compared to men, decreasing from almost 90 percent to 44 percent (Figure 3a). Given the issues with reporting and capturing female workers, this is probably an overstatement. It is possible that many unmarried women were listed as domestic servants despite having another occupation, as shown by Vikström (2003). And many married women who would otherwise be more likely to have more experience and to hold better jobs, are listed merely as wives by censuses (Molinder, 2022). However, in many occupations the number of women increased very rapidly. Examples include low-skilled retail trade assistants (*butiksbiträde*), low-skilled seamstresses, medium-skilled primary school teachers, medium-skilled merchants, and high-skilled upper-level teachers. In 1870, the majority of women worked as unskilled farm workers, domestic servants, and labourers. The number of female farm workers decreases dramatically after 1880s, as young women left the countryside in masses to find better opportunities in towns and cities (Carlsson, 1968; Morell, 2011). Many of them ended up as domestic servants without upgrading their skills, but nevertheless earned higher income than as a farm worker (Bengtsson & Molinder, 2024; Nordlund Edvinsson & Söderberg, 2010). While the domestic servants exhibited a relative decrease in employment during the twentieth century, the employment increased in absolute terms at least until 1930. However, because the increase in employment in other skills more than offset the growing number of domestic servants, we see a sharp decline in unskilled employment share for women.

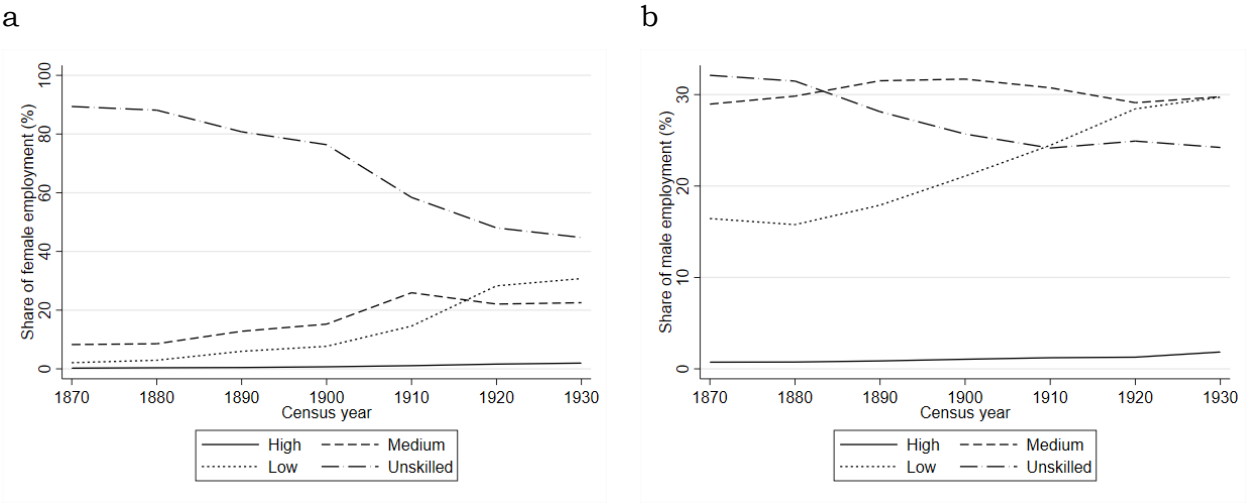

Figure 3. Employment shares in different skills among female (a) and male (b) workers, 1870–1930. Data source: Statistics Sweden (SCB).

For men, the occupational structure is more balanced between different skills (Figure 3b). Most men worked either in medium- or unskilled occupations in 1870, largely corresponding to the large shares of medium-skilled farmers and unskilled farm workers. The share of medium-skilled increases modestly until the turn of the twentieth century, after which there is an equally modest decrease. The share of unskilled decreases, but not as dramatically as it does for women. The share of low-skilled increases from less than 20 percent to almost 30 percent. At the aggregate level, men are generally shifting away from unskilled occupations to low-skilled, indicating a skill upgrading at the lower tail of the skill distribution. The stable trend in medium-skilled employment hides two offsetting developments. On the one hand, employment decreases in relative terms in artisan and craft occupations. On the other hand, employment increases in occupations such as machinists and many medium-skilled white-collar jobs.

While farm worker was a typical occupation for both men and women in 1870, their numbers fell much more greatly for women. In 1870, there were almost 140,000 female farm workers, but by 1930, their numbers were just 23,000.[7] Women were actively leaving the countryside for better pay and greater independence in urban areas, and often found work as domestic servants or in other services (Morell, 2011). A recent paper suggests that mechanization of dairy production, particularly milking

[7] Though, this figure excludes farm wives and daughters who remained home.

machines, replaced female labour in rural areas, forcing women out of agriculture (Ager, Goñi, & Salvanes, 2023). However, the wider spread of milking machines in Sweden took until the interwar era, and a breakthrough was only reached during the second world war (Kuuse, 1974). The flight from agriculture started already in the 1880s, and women led the way of this exodus (Carlsson, 1968; Morell, 2011). The number of male farm workers decreases, but not to the same extent than female farm workers. In 1870, there were 186,000 male farm workers, and by 1930, this had fallen to 147,000.

Women found work not only as domestic servants, which became the most popular occupation for women by 1930, but also in more-skilled occupations, such as in retail trade, sewing, and teaching. The 1870 census did not report any female workers in retail trade, but in 1930, there were almost 50,000 of them. For men, most popular occupations remained in agriculture, but many non-farm occupations became increasingly popular, such as machinist, carpenter, clerical worker, construction worker, sawyer, and factory worker.

Within-between decomposition

The shift from agriculture to industry or services could explain the falling share of unskilled employment in the aggregate economy. Because a large share of the agricultural employment was unskilled (47% in 1870), a decrease in agricultural employment should by default result in skill upgrading, provided that other sectors have lower shares of unskilled labour. That is, holding skill composition within sectors fixed, a shift from agriculture to industry or services should increase the average skills in the population, if at least some of these workers end up in more skilled jobs than what they had in agriculture. It should be noted, that throughout this section, sectors are considered as major sectors, and within-sector changes could still be driven by changes between different industries and services. Thus, the within component in this section should be interpreted as occupational shifts that occur within the main sector, but not necessarily a shift within a given industry or service.

The results of this decomposition exercise are presented in Table 3. Change in different skills are expressed in percentage points. As noted in Figure 1, the largest change occurs from unskilled to low-skilled employment. Low-skilled employment increases by 19.5 percentage points, and unskilled employment decreases by 22.8

percentage points. Both within- and between component explain these changes, but for both groups, the between-component is greater. This means that the change in the sectoral composition drives the shift away from unskilled and toward low-skilled employment more than occupational upgrading within sectors. In other words, there is support for the argument of structural change driving skill upgrading. However, we should not discount the within-sector component entirely. For the decrease in unskilled employment, roughly one-thirds of the total change is explained by changes within sectors. For low-skilled employment, the within component explains more than one-third of the total change.

Table 3. Standard within-between decomposition between main sectors.

	Change in employment share	Between-sector	Within-sector
	Panel A: 1870–1930		
High	1.3	1.0	0.3
Medium	2.0	2.0	-0.04
Low	19.5	13.1	6.3
Unskilled	-22.8	-16.2	-6.6
	Panel B: 1870–1900		
High	0.4	0.3	0.1
Medium	4.1	1.8	2.3
Low	7.7	6.0	1.7
Unskilled	-12.2	-8.1	-4.1
	Panel C: 1900–1930		
High	0.9	0.7	0.2
Medium	-2.1	0.2	-2.3
Low	11.8	8.2	3.6
Unskilled	-10.6	-9.0	-1.6

Note: The changes are expressed in percentage points

Panels B and C in Table 3 divide the aggregate period into two subperiods: the late nineteenth century and the early twentieth century. For the United States, Goldin and Katz (1998) argue that technological change became skill-biased around the turn of the century. This argument does not receive support at the aggregate level in Sweden. The evidence does not provide support for Katz and Margo (2014) either, as there is no clear pattern of "hollowing out", at least when using HISCO/HISCLASS to measure skills. Rather, Sweden seems to undergo a more monotonic shift from unskilled to

more-skilled employment during late nineteenth century. During the early twentieth century, the pattern is more mixed. On the one hand, there is an increase in low-skilled employment and a decrease in unskilled employment, but on the other, medium-skilled employment decreases as high-skilled employment increases. At the higher end of the skill spectrum, the changes appear slower. This is because the share of high-skilled is initially very low. Relatively speaking, high-skilled employment increases the most, as its share more than doubles from 1870 to 1930.

Table 4 reveals the between-composition in more detail. Panel A shows the average skill composition over the period 1870–1930. For example, 45 percent of agrarian workers were classified as unskilled, which implies that decrease in agricultural employment should result in decreasing unskilled employment. Panel B shows that agricultural employment made up 55.4 percent of the labour force in 1870, but only 27.6 in 1930. Panel C then shows the change in the sectoral share as percentage points and breaks it down to the same subperiods as in Table 3. During the late nineteenth century, growth in manufacturing was stronger than growth in services, but in the twentieth century, growth in services picks up and even exceeds that of manufacturing.

Manufacturing sector has a relatively high average share of low-skilled employment, which should translate to between-sector skill upgrading from unskilled to low-skilled, if employment shifts from agriculture to manufacturing. However, since agriculture has a higher employment in medium-skilled occupations, a shift away from agriculture could reduce medium-skilled employment on average. Service sector has a relatively high share of unskilled employment, but we do not observe an increase in the share of unskilled in the aggregate economy during the early twentieth century. That is, the average skill share over time likely hides a significant within-sector shift that offsets the between-sector shift from agriculture to services. These within-sector shifts are discussed in detail next.

Table 4. Changes in the sectoral share (in percentage points) in Sweden, 1870–1930.

	Agriculture	Manufacturing	Service
Panel A: Average skill (%)			
High	-	1.5	3.7
Medium	41.8	38.6	21.8
Low	14.4	46.5	30.3
Unskilled	43.8	13.4	44.2
Panel B: Sectoral share (%)			
1870	55.4	10.4	18.4
1930	27.6	36.1	35.5
Panel C: Change (pct points)			
1870–1930	-27.9	25.7	17.1
1870–1900	-12.5	14.5	3.9
1900–1930	-15.3	11.2	13.2

Note: The changes are expressed in percentage points

Table 5 illustrates the within-sector shifts. The figures reveal that within agriculture, employment in low- and unskilled employment decrease relative to medium-skilled employment. In Sweden, the number of farm workers falls quite dramatically, whereas the number of farms, and therefore farmers, remain relatively stable until 1930s (Morell, 2011). Breaking the changes down to the two sub-periods reveals that most of the relative growth in medium-skilled agricultural employment occurred in the late nineteenth century.

Within manufacturing, there is evidence of deskilling or job polarization, as medium-skilled employment decreases relative to high-, low-, and unskilled employment. While the share of medium-skilled manager and clerical employment increases, it is not enough to offset the relative decrease in medium-skilled worker occupations, such as tailors, shoemakers, or blacksmiths. The small increase in high-skilled employment reveals a potential "hollowing out" pattern comparable to that found by Gray (2013) and Katz and Margo (2014). For the United States, this trend can be explained through the disappearance of artisan shops and the emergence of large factories. However, in Sweden, the average establishment size remained relatively small, and even decreases. The Industrial Statistics show that the share of establishments with

less than 10 workers increased from 50 percent to 56 percent from 1913 to 1925.[8] For all industries, average establishment size decreased from 1913 to 1930 (Table C1, Appendix C). However, artisan workshops exhibited relative decline during the late nineteenth century, as the number of factories increased faster (Berger & Ostermeyer, 2023). The absolute number of artisans increased over time (Figure C1, Appendix C), but in relative terms, artisan share declined against industry workers and white-collar workers (Figure C2, Appendix C). These underlying figures explain why we observe a relative decrease in medium-skilled workers, and an increase in high- and unskilled workers within manufacturing.

Service sector exhibits the opposite trend in the nineteenth century compared to manufacturing; the employment shifts from unskilled to more-skilled occupations. This shift is largely explained by the relative decrease in domestic service and the increasing importance of trade. Increase in the employment of low-skilled shop assistants and warehouse porters together with a several fold increase in medium-skilled traders explain largely the increase in the middling skills. Another important service is transport. Employment in low-skilled occupations such as drivers and conductors increase by several folds. The increase in low-skilled service employment is greater in the early twentieth century, whereas medium-skilled employment decreases in relation during the same period. However, the pattern is kind of a "hollowing in" in the twentieth century, in which employment increase in low-skilled occupations while it decreases in other skills.

[8] Industrial Statistics in Sweden typically include only establishments with 10 or more workers. However, the number of establishments with less than 10 workers were reported in 1913, 1920, and 1925.

Table 5. Changes in the skill share (in percentage points) by sector

	Agriculture	Manufacturing	Service
Panel A: 1870–1930			
High	-	1.3	0.05
Medium	8.2	-23.4	6.7
Low	-1.7	10.5	16.3
Unskilled	-6.5	11.6	-23.1
Panel B: 1870–1900			
High	-	-0.3	1.0
Medium	6.1	-16.9	11.1
Low	-2.6	11.8	4.5
Unskilled	-3.5	5.4	-16.6
Panel C: 1900–1930			
High	-	1.6	-0.9
Medium	2.1	-5.7	-4.4
Low	0.9	-0.5	11.8
Unskilled	-3.0	4.5	-6.5

Note: The changes are expressed in percentage points.

Comparative analysis

Katz and Margo (2014) examine the technology-skill complementarity in the United States for both manufacturing sector and the aggregate economy. Their evidence shows that high-skilled employment increased relative to middle- and low-skilled employment from 1850 to 1910. Within manufacturing, the share of skilled blue-collar workers declines while the shares of operatives and white-collar employment increase. Katz and Margo interpret the trend in manufacturing as "hollowing out", which refers to employment growth in both high-skilled and unskilled occupations, but a decrease in the middle-skilled occupations.

Figure 4 compares the occupational structure in the United States to that in Sweden from 1870 to 1910. For this exercise, the occupations from the Swedish censuses are coded into same occupational coding system as used by Katz and Margo (2014). Figure 4a shows the skill composition for Sweden. High-skilled here consists of managerial, professional, and technical staff. Skilled blue-collar, farmers and farm managers, and clerical and sales are included in the middle-skilled group, leaving operators, unskilled

labourers, most manual service occupations and farm workers to the low-skilled category. Figure 4b shows the same for the United States, using data from Katz and Margo (2014). A full comparison with Katz and Margo study is included in Tables B1 and B2 in the appendix.

Comparison between the two countries reveals that Sweden has a greater share of low- and unskilled employment than the United States. It also remains quite stable, falling only by 1.9 percentage points between 1870 and 1910. Table B1 shows that the share remains stable at least until 1930. For the United States, the share of low/unskilled falls from 54 to 51.8 percent, though this is a continuum of a decline that started at least as far back as 1850, when 57.5 percent of the labour force was low- or unskilled. What is notable too is that while the share of middle-skilled remains relatively high in the United States through 1870–1910, it falls in Sweden, from 37.1 to 24.8 percent. Table B2 reveals that this is likely due to the fall in agricultural operative and supervisory employment rather than skilled blue-collar employment. After 1910, the shares of high- and middle-skilled remains quite stable at least until 1930.

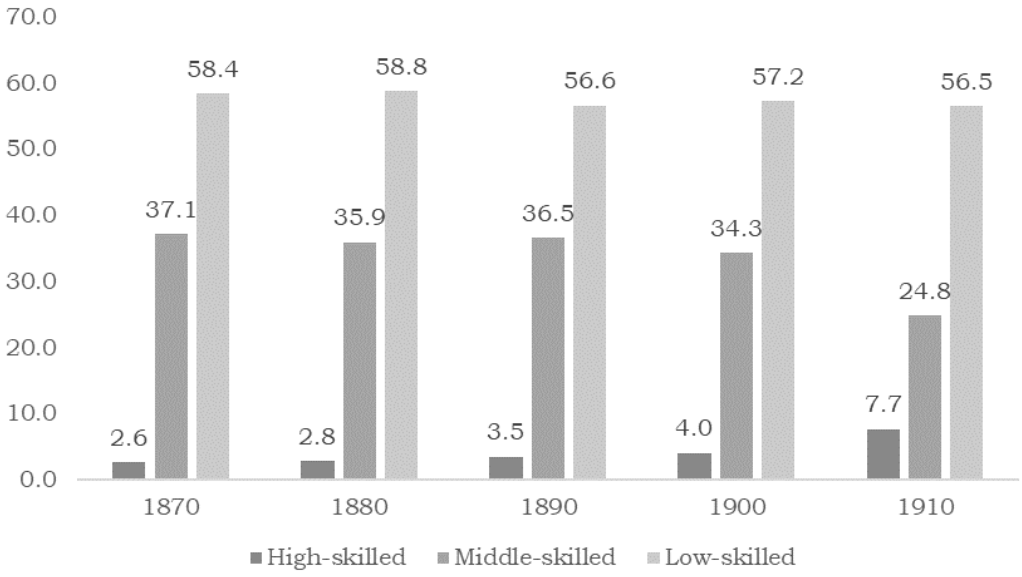

Figure 4a. Skill composition in Sweden. Data from Statistics Sweden.

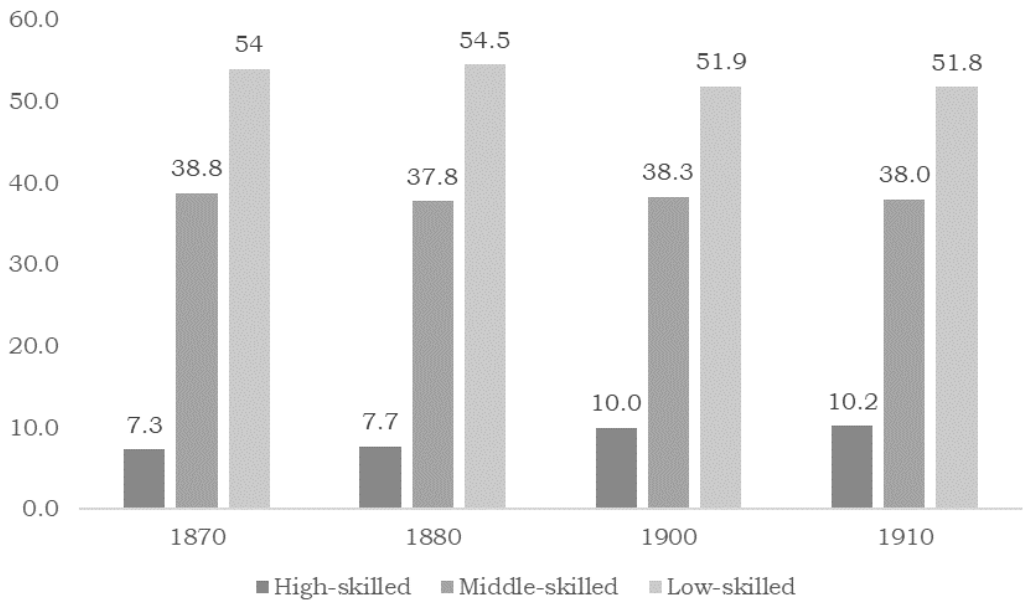

Figure 4b. Skill composition in the United States. Source: Katz & Margo (2014: Table 1.4)

Katz and Margo (2014) note that when excluding clerical and sales from the middle-skilled group, their share decreases (Table B1, Appendix B). The share of middle-skilled blue-collar workers and farmers falls from 35.6 percent in 1850 to 28.5 in 1910. In Sweden, the same trend occurs; the middle-skilled share falls from 37.1 percent in 1870 to 24.6 by 1930. That is, if clerical and sales employees were considered as high-skilled white-collar workers, the overall picture of the aggregate skill composition would correspond to the job polarization pattern more typically documented for late twentieth and early twenty-first centuries.

The comparison of the occupational structure between Sweden and the United States shows that employment shifted in general from agriculture and skilled blue-collar occupations to operative/unskilled/service and white-collar occupations (Table B2, Appendix B). In the United States, growth in white-collar occupations was faster than in Sweden. Furthermore, while Sweden exhibits a growth in skilled blue-collar employment until 1900, after which it decreases, the United States exhibits first a decrease until 1880 and then a slight increase from 1890 to 1910. In both countries, the share of operative/unskilled/service increases, but in Sweden this growth is faster. Both countries have some 32 percent employment share in 1870, but it increases to 44.2 percent by 1910 in Sweden (and continues to increase to 48.6 by 1930) whereas in the US, it increases only to 37.9 percent by 1910. In both countries,

the employment share in agriculture falls, but in Sweden, the share of farm workers decreases faster than in the United States. In summary, the occupational structure in both countries exhibit similar trends from agriculture to operative/unskilled/service and white-collar, though the United States exhibits stronger growth in white-employment and Sweden in operative/unskilled/services.

Finally, Katz and Margo examine the trends for the manufacturing sector separately. Comparing manufacturing employment in Sweden to that in the United States shows again that the trends are largely similar. In both countries, white-collar and operative employment increases at the expense of skilled blue-collar. In Sweden, skilled blue-collar employment decreases somewhat faster than in the US, starting from a greater level. The share in operative/unskilled occupations is greater in the United States initially, but Sweden takes over around 1900. The share in unskilled/operative manufacturing jobs is 73.7 percent in Sweden in 1910, whereas in the United States, it is 65.4 percent.

Concluding remarks

The process of industrialization has been viewed as a transition from agrarian to industrial economy, and eventually from industrial to service economy. The early stages of industrialization are characterized by the arrival of the factory and consecutive mechanization of production (Frey, 2019). In later stages, manufacturing became larger in scale, expanding to new products and avenues, but also more sophisticated. The new jobs emerging within manufacturing required, according to Goldin and Katz (2008), a high school diploma or equivalent knowledge (i.e., algebra, technical drawing, chemistry). The large-scale production further demanded a large administrative and managerial personnel (Chandler, 1978), which increased the demand for educated workers. In this paper, I have examined the occupational structure and skill composition in rapidly industrializing Sweden between 1870 and 1930 to test some of the arguments from current literature, which has largely focused on Britain and the United States.

This paper shows that Swedish labour force did indeed become more skilled over time. The largest shift documented is from unskilled to low-skilled. However, in relative terms, high-skilled employment increases the most by more than doubling its share over the period under the study, but from a very low initial level. One could draw parallels to the increasing human capital stock through average years of schooling

(Ljungberg & Nilsson, 2009), which may have helped Swedish workers to become more skilled. However, given the lack of information on educational background by occupation, it is difficult to draw further conclusions. Most of the decrease in unskilled employment is explained by between-sector shifts, that is, shifting employment from agriculture to industry and services.

Within agriculture, the skill composition shifted away from unskilled labour. In agriculture, the number of farm workers decreased while the number of farmers remained stable, leading to a relative increase of medium-skilled employment. This conclusion is a product of the way HISCLASS defines farmers as medium-skilled and farm workers as unskilled. However, in Sweden, it might be difficult to assert that farmers were more skilled than farm workers, as majority of farms were small family farms with few hired workers. One could plausibly argue that farmers were on average older and more experienced, as it was customary for the young adults and teenagers to work as servants in other farms in the village before marrying and inheriting their own farm (Gadd, 2011; Lundh, 1995).

In manufacturing, an interesting pattern arises. Low- and unskilled employment increases relative to medium-skilled employment. In the late nineteenth century, this pattern reflects a monotonic deskilling, while in the early twentieth century, employment increases in both high- and unskilled occupations but decreases in the low- and medium-skilled occupations. In other words, there is some evidence supporting the deskilling effect of early factorization. Jörberg (1961) shows that the importance of large establishments as employers increased between 1903 and 1912. Berger and Ostermeyer (2023) show that artisan shops, defined as non-mechanized establishments with less than 7 workers, faced relative decline from 1864 to 1890. Meanwhile, the share of factories, defined as mechanized establishments, increased. Interestingly, the establishment size on average decreases between 1913 and 1930. The Industrial Statistics report the number of establishments with 10 or less workers only in 1913 and again in 1920 and 1925. For other years, only those establishments with at least 10 workers are included. These statistics show that the share of establishments with less than 10 workers increased from 50 percent to 56 percent from 1913 to 1925. The share of establishments with over 1000 workers remained very low, at 0.24 percent in 1913, 0.15 percent in 19120, and finally 0.22 percent in 1925 (Table C1, Appendix C).

The “hollowing out” pattern observed for the early twentieth century is in line with Katz and Margo (2014) and Gray (2013), who find similar pattern for the United States manufacturing. It is however in contrast to Molinder et al. (2021), who find occupational upgrading from unskilled to low- and medium-skilled occupations in Sweden in the early twentieth century. The contrasting result could arise from the regional focus Molinder et al. have as opposed to the aggregate view in this paper. That is, regions close to the electricity grid may have exhibited an employment pattern different to that in the aggregate economy.

Finally, I show that service sector employment shifted from unskilled to more-skilled occupations. This is particularly due to the relative decline of unskilled domestic service, documented also by Bengtsson and Molinder (2024). While the absolute number continued to grow until 1930s, after which it declines sharply (Nordlund Edvinsson & Söderberg, 2010), the relative importance decreased as new job opportunities in trade and transport expanded. Service sector was particularly relevant employer for women, who found new jobs as nurses, teachers, office clerks, telephone and telegraph operators, and shop assistants. The rise in services also relates to the ongoing urbanization. Andersson and Molinder (2024) show that rural-to-urban migration resulted in better initial job matching and further skill upgrading over time.

In conclusion, in this paper, I find some support for the *workshop-to-factory* shifts and deskilling. However, the shift *farmwork-to-factory* did not necessarily result to skill upgrading, as many new jobs in manufacturing were unskilled factory jobs. I cannot rule out shifts from unskilled farm work to low-skilled industrial jobs, which was likely the case for a subset of the farm-to-industry shifts. However, in this paper, I highlight an alternative transition, a *farmwork-to-service* shift. I argue that this shift was an important explanation to the dramatic decrease in unskilled employment among women, and the main source for occupational upgrading. Finally, this paper contributes to the literature on skills using occupational titles, which solves some of the issues of using incomes or education as a measure of skill.

References

Acemoglu, D. (2002). Directed technical change. *The Review of Economic Studies, 69*(4), 781-809.

Acemoglu, D., & Autor, D. (2011). Skills, tasks and technologies: Implications for employment and earnings. In *Handbook of labor economics* (Vol. 4, pp. 1043-1171): Elsevier.

Adam, A. (2010). Women as knowledge workers: from the telegraph to the computer. In *Work and Life in the Global Economy: A Gendered Analysis of Service Work* (pp. 15-32): Springer.

Adermon, A., & Gustavsson, M. (2015). Job polarization and task-biased technological change: Evidence from Sweden, 1975–2005. *The Scandinavian Journal of Economics, 117*(3), 878-917.

Ager, P., Goñi, M., & Salvanes, K. G. (2023). *Gender-biased technological change: Milking machines and the exodus of women from farming*. NHH Dept. of Economics Discussion Paper.

Andersson, J., & Molinder, J. (2024). *Did Cities Increase Skills During Industrialization? Evidence from Rural-Urban Migration*. Working Paper 2024/12. Unpublished manuscript. Department of Economic History. Uppsala University.

Atack, J., Bateman, F., & Margo, R. A. (2004). Skill intensity and rising wage dispersion in nineteenth-century American manufacturing. *The Journal of Economic History, 64*(1), 172-192.

Atack, J., Bateman, F., & Margo, R. A. (2008). Steam power, establishment size, and labor productivity growth in nineteenth century American manufacturing. *Explorations in Economic History, 45*(2), 185-198. doi:10.1016/j.eeh.2007.08.002

Autor, D. H., Katz, L. F., & Kearney, M. S. (2006). The polarization of the US labor market. *The American economic review, 96*(2), 189-194.

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly journal of economics, 118*(4), 1279-1333.

Bárány, Z. L., & Siegel, C. (2018). Job polarization and structural change. *American Economic Journal: Macroeconomics, 10*(1), 57-89.

Bengtsson, E., & Molinder, J. (2023). *Incomes and Income Inequality in Stockholm, 1870-1970: Evidence from Micro Data*. Lund Papers in Economic History.

Bengtsson, E., & Molinder, J. (2024). Incomes and income inequality in Stockholm, 1870–1970: Evidence from micro data. *Explorations in Economic History*, 101568.

Beniger, J. (1986). *The control revolution: Technological and economic origins of the information society*: Harvard university press.

Berger, T. (2019). Railroads and rural industrialization: Evidence from a historical policy experiment. *Explorations in Economic History, 74*, 101277.

Berger, T., & Enflo, K. (2017). Locomotives of local growth: The short-and long-term impact of railroads in Sweden. *Journal of Urban Economics, 98*, 124-138.

Berger, T., & Ostermeyer, V. (2023). Firm Survival and the Rise of the Factory. In V. Ostermeyer (Ed.), *Why Firms Grow, The Roles of Institutions, , Trade, and Technology during Swedish Industrialization*. Lund, Sweden: Media-Tryck.

Berman, E., Bound, J., & Machin, S. (1998). Implications of skill-biased technological change: international evidence. *The Quarterly journal of economics, 113*(4), 1245-1279.

Braverman, H. (1974). *Labor and monopoly capital : the degradation of work in the twentieth century* (25th anniversary ed. ed.). New York: Monthly Review.

Brown, M., & Philips, P. (1986). Craft labor and mechanization in nineteenth-century American canning. *The Journal of Economic History, 46*(3), 743-756.
Brugger, F., & Gehrke, C. (2018). Skilling and deskilling: Technological change in classical economic theory and its empirical evidence. *Theory and Society, 47*(5), 663-689.
Carlsson, S. C. O. (1968). *Yrken och samhällsgrupper: Den sociala omgrupperingen in Sverige efter 1866*: Almqvist & Wiksell.
Census, U. S. B. o. t. (1950). *Alphabetical Index of Occupations and Industries: 1950*.
Chandler, A. D. (1978). The visible hand: The Managerial Revolution in American Business.
De Pleijt, A., Nuvolari, A., & Weisdorf, J. (2020). Human capital formation during the first industrial revolution: evidence from the use of steam engines. *Journal of the European Economic Association, 18*(2), 829-889.
De Pleijt, A., & Weisdorf, J. L. (2017). Human capital formation from occupations: the 'deskilling hypothesis' revisited. *Cliometrica, 11*(1), 1-30.
Edvinsson, T. N., & Söderberg, J. (2010). Servants and bourgeois life in urban Sweden in the early 20th century. *Scandinavian journal of history, 35*(4), 427-450.
Federico, G., Nuvolari, A., Ridolfi, L., & Vasta, M. (2021). The race between the snail and the tortoise: skill premium and early industrialization in Italy (1861–1913). *Cliometrica, 15*(1), 1-42.
Franck, R., & Galor, O. (2021). Technology-Skill Complementarity in Early Phases of Industrialisation. *The Economic journal (London)*. doi:10.1093/ej/ueab056
Frey, C. B. (2019). *The technology trap: Capital, labor, and power in the age of automation*: Princeton University Press.
Gadd, C.-J. (2011). The agricultural revolution in Sweden: 1700-1870. In C.-J. Gadd & J. Myrdal (Eds.), *The Agrarian History of Sweden: From 4000 BC to AD 2000* (pp. 118-165). Lund, Sweden: Nordic Academic Press Lund.
Goldin, C. (1998). America's graduation from high school: The evolution and spread of secondary schooling in the twentieth century. *The Journal of Economic History, 58*(2), 345-374.
Goldin, C., & Katz, L. F. (1995). The decline of non-competing groups: Changes in the premium to education, 1890 to 1940. In: National Bureau of Economic Research Cambridge, Mass., USA.
Goldin, C., & Katz, L. F. (1998). The origins of technology-skill complementarity. *The Quarterly journal of economics, 113*(3), 693-732.
Goldin, C., & Katz, L. F. (2008). *The race between education and technology*: Harvard University Press.
Goos, M., Manning, A., & Salomons, A. (2009). Job polarization in Europe. *American economic review, 99*(2), 58-63.
Gray, R. (2013). Taking technology to task: The skill content of technological change in early twentieth century united states. *Explorations in Economic History, 50*(3), 351-367.
Horrell, S., & Humphries, J. (1995). " The exploitation of little children": Child labor and the family economy in the industrial revolution. *Explorations in Economic History, 32*(4), 485-516.
Hounshell, D. (1984). *From the American system to mass production, 1800-1932: The development of manufacturing technology in the United States*: JHU Press.
James, J. A., & Skinner, J. S. (1985). The resolution of the labor-scarcity paradox. *The Journal of Economic History, 45*(3), 513-540.
Jayes, J. (2023). *Shocking Technology: Impacts of new technology on individuals' income, location and occupation*. Department of Economic History. Lund University.

Jepsen, T. C. (2000). Reclaiming history: Women in the telegraph industry. *IEEE Technology and Society Magazine, 19*(1), 15-19.
Jörberg, L. (1961). *Growth and fluctuations of Swedish industry 1869-1912 : studies in the process of industrialisation.* Diss. Lund : Univ.,
Jörberg, L. (1965). Structural change and economic growth: Sweden in the 19th century. *Economy and History, 8*(1), 3-46.
Karlsson, L. (1995). *Mothers as breadwinners: myth or reality in early Swedish industry?* : Företagsekonomiska institutionen.
Karlsson, T., & Stanfors, M. (2011). In the footsteps of their fathers? Occupational following among Swedish tobacco workers. *Continuity and Change, 26*(1), 45-68. doi:10.1017/s0268416010000330
Katz, L. F., & Margo, R. A. (2014). Technical change and the relative demand for skilled labor: The united states in historical perspective. In *Human capital in history: The American record* (pp. 15-57): University of Chicago Press.
Kuuse, J. (1974). *Interaction between agriculture and industry: case studies of farm mechanisation and industrialisation in Sweden and in the United States 1830-1930*.
Leknes, S., & Modalsli, J. (2020). Who benefited from industrialization? The local effects of hydropower technology adoption in Norway. *The Journal of Economic History*.
Ljungberg, J., & Nilsson, A. (2009). Human capital and economic growth: Sweden 1870–2000. *Cliometrica, 3*(1), 71-95.
Lundh, C. (1995). Households and families in pre-industrial Sweden. *Continuity and Change, 10*(1), 69-66. doi:10.1017/S0268416000002496
Lundh, C., & Prado, S. (2015). Markets and politics: the Swedish urban-rural wage gap, 1865-1985. *European Review of Economic History, 19*(1), 67-87. doi:10.1093/ereh/heu022
Molinder, J. (2022). *Historical roots of the dual-earner model: Women's labour force participation in Sweden, 1870–1960*. Lund Papers in Economic History.
Molinder, J., Karlsson, T., & Enflo, K. (2021). More Power to the People: Electricity Adoption, Technological Change, and Labor Conflict. *The Journal of Economic History, 81*(2), 481-512. doi:10.1017/S0022050721000127
Morell, M. (2011). Agriculture in industrial society. In J. Myrdal & M. Morell (Eds.), *The agrarian history of Sweden : from 4000 BC to AD 2000* (pp. 165-213). Lund, Sweden: Nordic Academic Press.
Nordlund Edvinsson, T., & Söderberg, J. (2010). Servants and Bourgeois Life in Urban Sweden in the Early 20th Century. *Scandinavian journal of history, 35*(4), 427-450. doi:10.1080/03468755.2010.520241
Ostermeyer, V. (2023). Local multipliers and the growth of services: evidence from late nineteenth century USA, Great Britain, and Sweden. *European Review of Economic History, 27*(1), 70-90.
Prado, S., & Waara, J. (2018). Missed the starting gun! Wage compression and the rise of the Swedish model in the labour market. *Scandinavian Economic History Review, 66*(1), 34-53.
Ridolfi, L., Salvo, C., & Weisdorf, J. (2022). The impact of mechanisation on wages and employment: evidence from the diffusion of steam power.
Roine, J., & Waldenström, D. (2008). The evolution of top incomes in an egalitarian society: Sweden, 1903–2004. *Journal of public economics, 92*(1-2), 366-387.
Sandberg, L. G. (1979). The Case of the Impoverished Sophisticate: Human Capital and Swedish Economic Growth before World War I. *The Journal of Economic History, 39*(1), 225-241. doi:10.1017/S0022050700096418
Schön, L. (2012). *An economic history of modern Sweden*: Routledge.

Schön, L., & Krantz, O. (2012). Swedish historical national accounts 1560-2010. *Lund Papers in Economic History, 123*(2012), 1-34.

Svensson, A., & Bengtsson, E. (2023). Income inequality in an industrial city during the great levelling: micro level evidence from malmö, 1900–1950. *Scandinavian Economic History Review, 71*(1), 80-95.

van Leeuwen, M. H. D., & Maas, I. (2011). *HISCLASS : a historical international social class scheme*. Leuven: Leuven : Leuven University Press.

Vikström, L. (2003). Different Sources, Different Answers: Aspects on Women's Work in Sundsvall, Sweden, 1860–1893. *Interchange (Toronto. 1984), 34*(2), 241-259. doi:10.1023/B:INCH.0000015903.29859.c1

Official publications

Statistics Sweden (1874). *Befolknings-statistik, 1870* (BiSOS A)

Statistics Sweden (1885). *Befolkningsstatistik, 1880* (BiSOS A)

Statistics Sweden (1895). *Befolknings-statistik, 1890* (BiSOS A)

Statistics Sweden (1907). *Befolknings-statistik, 1900* (BiSOS A)

Statistics Sweden (1917). *Folkräkningen, 1910*: III. Folkmängdens fördelning efter yrken.

Statistics Sweden (1927). *Folkräkningen, 1920*: Yrkesräkningen II: Yrke, inkomst och förmögenhet kombinerade inbördes samt med kön, civilstånd och ålder.

Statistics Sweden (1936). *Folkräkningen, 1930*: III. Folkmängden efter yrke, inkomst och förmögenhet.

Appendix A. Alternative skill composition

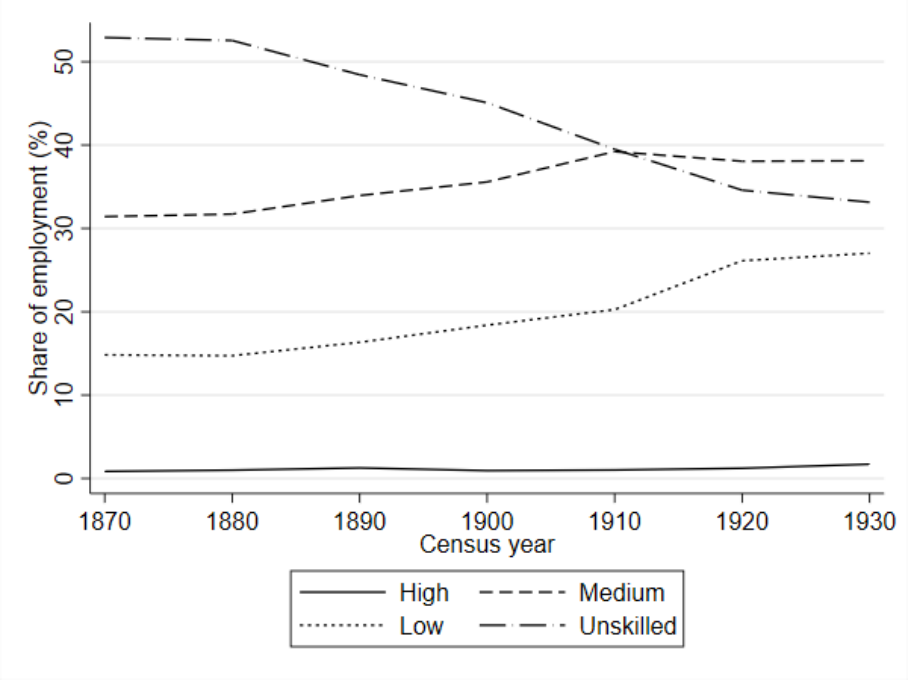

Figure A1. Alternative skill composition 1870–1930 where farmers' wives and children are counted into the labour force.

Appendix B

Table B1. Skill composition in Sweden and the United States, 1850 – 1930. Data for Sweden is from population censuses 1870 to 1930. Data for the United States is from Katz and Margo (2014).

		Skill groups, aggregate								
	Year	1850	1860	1870	1880	1890	1900	1910	1920	1930
High skill 1	SWE			4.5	5.3	6.9	8.4	18.7	18.7	18.0
	USA	6.9	8.3	10.6	11.6		17.1	19.7		
High skill 2	SWE			2.6	2.8	3.5	4.0	7.7	7.4	7.4
	USA	5.4	6.2	7.3	7.7		10.0	10.2		
Middle skill 1	SWE			37.1	35.9	36.5	34.3	24.8	24.7	24.6
	USA	35.6	34.3	35.5	33.9		31.1	28.5		
Middle skill 2	SWE			39.0	38.4	39.9	38.7	35.8	35.9	35.2
	USA	37.1	36.2	38.8	37.8		38.3	38.0		
Low skill	SWE			58.4	58.8	56.6	57.2	56.5	56.7	56.7
	USA	57.5	57.4	54	54.5		51.9	51.8		

Notes: Numbers in percentages. High-skill 1 consist of all white-collar occupations: professional, technical, managerial, clerical, and sales. High-skill 2 excludes clerical and sales. Middle-skill 1 consists of skilled blue-collar workers and agricultural operatives and supervisors. Middle-skill 2 includes clerical and sales with the previous group. Finally, low-skill group consists of operative workers, unskilled labourers, service workers, and farm workers.

Table B2. Occupational structure in Sweden and the United States, aggregate economy. Data for Sweden is from population censuses 1870 to 1930. Data for the United States is from Katz and Margo (2014).

		Aggregate economy								
	Year	1850	1860	1870	1880	1890	1900	1910	1920	1930
White collar	SWE			**4.5**	**5.3**	**6.9**	**8.4**	**18.7**	**18.7**	**18.0**
	USA	**6.9**	**8.3**	**10.6**	**11.6**		**17.1**	**19.7**		
Professional-technical	SWE			1.3	1.6	2.3	2.7	4.1	4.3	4.3
	USA	2.3	2.6	2.9	3.4		4.3	4.6		
Manager	SWE			1.3	1.2	1.2	1.3	3.5	3.2	3.1
	USA	3.1	3.6	4.4	4.3		5.7	5.6		
Clerical/sales	SWE			1.9	2.5	3.4	4.4	11.0	11.3	10.6
	USA	1.5	2.1	3.3	3.9		7.2	9.5		
Skilled blue-collar	SWE			**8.4**	**8.4**	**9.8**	**10.8**	**7.3**	**9.4**	**9.3**
	USA	**12**	**11**	**10.7**	**9.1**		**11.0**	**11.9**		
Operative/unskilled/service	SWE			**32.3**	**36.7**	**34.9**	**38.5**	**44.2**	**48.5**	**48.6**
	USA	**29**	**30**	**32.4**	**37.7**		**36.4**	**37.9**		
Agriculture	SWE			**54.9**	**49.5**	**48.4**	**42.2**	**29.8**	**23.4**	**23.4**
	USA	**53**	**51**	**46.4**	**41.6**		**35.3**	**30.5**		
Operative/supervisory	SWE			28.8	27.5	26.7	23.5	17.5	15.2	15.3
	USA	23.9	23.2	24.8	24.8		20.0	16.6		
Farm labourers	SWE			16.4	17.9	13.3	11.2	6.8	8.3	8.3
	USA	28.8	27.3	21.6	16.8		15.5	13.9		

Notes: Numbers in percentages. Groups in bold are major groups, of which white collar and agriculture are broken down to minor groups. That is, white collar consists of professional-technical, manager, and clerical-sales, and agriculture consists of operative/supervisory and labourers.

Table B3. Occupational structure within manufacturing sector in Sweden and the United States. Data for Sweden is from population censuses 1870 to 1930. Data for the United States is from Katz and Margo (2014).

		Manufacturing								
	Year	1850	1860	1870	1880	1890	1900	1910	1920	1930
White collar	SWE			1.8	2.0	2.5	2.8	4.3	8.0	10.2
	USA	3.1	3.2	4.8	4.7		6.8	11.9		
Prof-tech-manager	SWE			1.8	1.5	2.2	2.5	3.5	4.4	5.9
	USA	3	3.1	4.2	4.0		5.2	5.6		
Clerical-sales	SWE			0.0	0.5	0.3	0.3	0.8	3.6	4.3
	USA	0.1	0.1	0.6	0.7		1.6	6.3		
Skilled blue collar	SWE			49.1	45.0	38.8	32.0	21.5	15.8	18.3
	USA	39.4	38.5	31.8	29.2		28.7	22.8		
Middle skill (skilled blue-collar + clerical/sales)	SWE			49.1	45.5	39.1	32.3	22.3	19.3	22.5
	USA	39.5	38.6	32.4	29.9		30.3	29.1		
Operative/unskilled	SWE			49.1	53.0	58.7	65.2	73.7	75.7	70.4
	USA	57.5	58.3	63.4	67.8		64.5	65.4		

Notes: Numbers in percentages. White-collar includes professional, technical, managerial, clerical, and sales within manufacturing. Middle skill group consists of both skilled blue-collar and clerical and sales personnel.

Appendix C: Absolute versus relative changes between artisans, workers, and white-collar employees

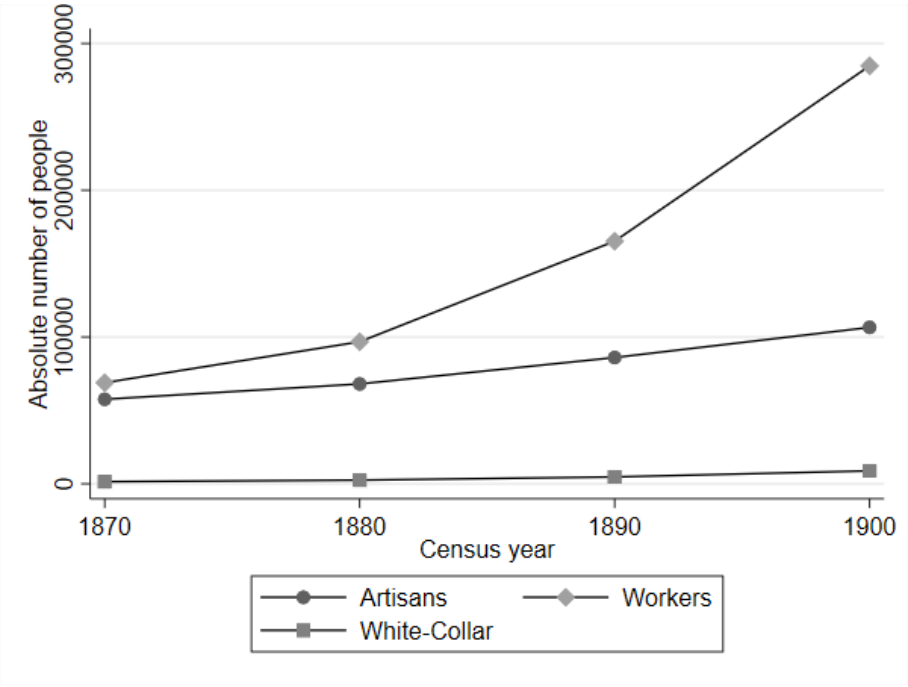

Figure C1. Employment of artisans, workers, and white-collar employees in absolute numbers, 1870–1900. Data from Statistics Sweden, author's own calculations.

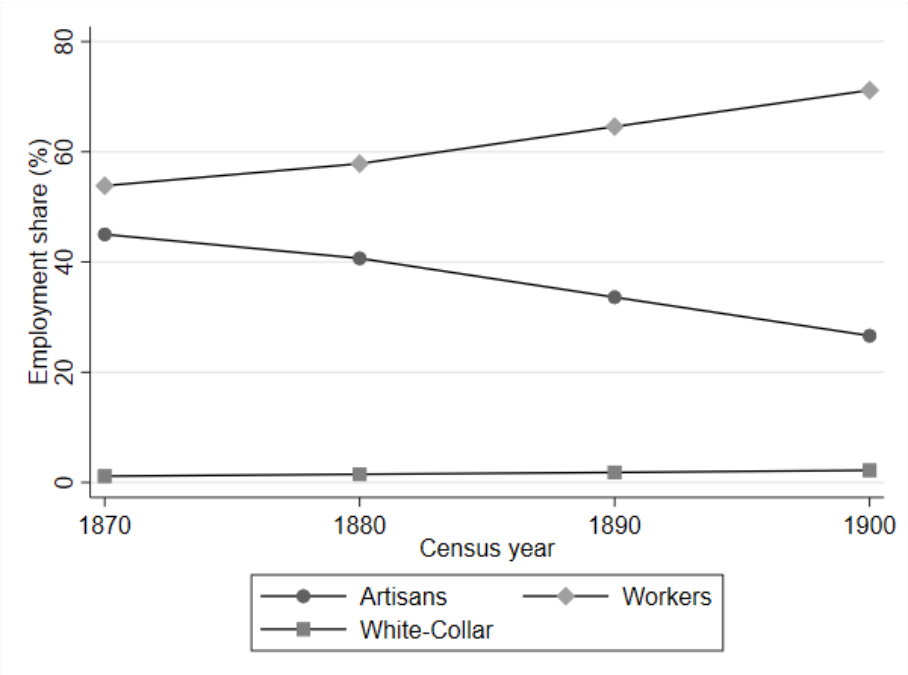

Figure C2. Employment of artisans, workers, and white-collar employees in relative shares, 1870–1900. Data from Statistics Sweden, author's own calculations.

Table C1. Relative changes in number of establishments, employment, and establishment size, 1913–1930. Data from Industrial Statistics, author's own calculations.

Industry	**Year**	**Establishments**		**Nonproduction workers**		**Production workers**		**Establishment size***	
		N	%-change	N	%-change	N	%-change	N	%-change
Metal & Mining	1913	1427		9667		110651		84.3	
	1930	2801	96%	19925	106%	144145	30%	58.6	-31%
Quarrying	1913	992		2096		44189		46.7	
	1930	1285	30%	2550	22%	44650	1%	36.7	-21%
Wood	1913	1628		3550		57680		37.6	
	1930	2682	65%	3592	1%	61640	7%	24.3	-35%
Paper & Printing	1913	694		3308		37285		58.5	
	1930	1091	57%	6198	87%	56602	52%	57.6	-2%
Food & Beverage	1913	3088		5148		35868		13.3	
	1930	4307	39%	6105	19%	43713	22%	11.6	-13%
Textile & Clothing	1913	493		3244		43755		95.3	
	1930	742	51%	5626	73%	61178	40%	90.0	-6%
Leather, hair, rubber	1913	310		1207		12835		45.3	
	1930	519	67%	2405	99%	20624	61%	44.4	-2%
Chemicals	1913	285		1391		14398		55.4	
	1930	381	34%	2576	85%	15110	5%	46.4	-16%
Energy	1913	349		1263		4083		15.3	
	1930	802	130%	2531	100%	7054	73%	12.0	-22%

*) Establishment size calculated by (nonproduction + production workers)/establishments