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Women and Children in Factories: Did Mechanization Increase the Demand for Low-Cost Labor in Sweden?

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ABSTRACT: *Did mechanization affect the employment of women and minors in the late nineteenth century? In this paper, we explore the idea that early factories used mechanization to substitute women and children for adult men to save on labor costs. We use a survey conducted in Sweden in 1879 to build a cross-sectional dataset that consists of establishments across different industries. We show a positive association between establishment size and the employment of women and minors. However, we do not find a meaningful association between mechanization and the employment of women and minors independent of establishment size. Instead, we show that the effect of mechanization was more likely mediated through establishment size. Industry-specific factors also played an important role, as some industries had a long history of being female-intensive.* (**JEL CODES**: N34, N64, J24, J31)

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Mujeres y niños en las fábricas: ¿Aumentó la mecanización la demanda de mano de obra barata en Suecia?

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RESUMEN: *¿Afectó la mecanización al empleo de mujeres y menores a finales del siglo XIX? En este trabajo analizamos si las primeras fábricas utilizaron la mecanización para sustituir a los hombres adultos por mujeres y niños con el fin de ahorrar costes laborales. Para ello, nos basamos en una encuesta realizada en Suecia en 1879 para construir una base de datos que incluye establecimientos de diferentes industrias. Con esta información mostramos una asociación positiva entre el tamaño del establecimiento y el empleo de mujeres y menores. No obstante, no encontramos una relación entre la mecanización y el empleo de mujeres y menores independientemente del tamaño del establecimiento. En lugar de ello, se observa que la mecanización estuvo más condicionada por el tamaño del establecimiento. Los factores específicos de la industria también desempeñaron un papel importante, ya que algunas industrias tenían una larga tradición en el empleo de mujeres.* (**CODIGOS JEL**: N34, N64, J24, J31)

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1. Introduction

A notable characteristic of nineteenth-century industrialization was the rise of large-scale mechanized factories. There was a gradual transition from artisanal workshops to larger production units that involved a higher division of labour and mechanization (Berger and Ostermeyer, 2024; Goldin and Katz, 1998; Sokoloff, 1984). As Goldin and Sokoloff (1982) show, this transition from artisanal shops to factories was associated with greater employment of women and children – due to both greater division of labour and to deskilling technological change. Thus, the increased employment of women and children in factories as a corollary to mechanization is linked to the deskilling hypothesis of nineteenth-century technologies (Acemoglu, 2002). Women and children could be considered unskilled workers because they were, in general, less experienced than men. Their lack of experience was in turn a consequence of age (they were usually younger than men) and employment time (women in particular had a shorter working life than men).

Two complexities challenge the claimed deskilling attribute of mechanization. First, it is important to disentangle two effects of mechanization; besides decreasing the importance of muscle power, mechanization also served to replace the repetitive and manual tasks performed by unskilled labour, which implies that increased mechanization may equally well have spelled the end of child labour use and tempered the demand for female workers (Olsson, 1995). Second, in addition to the double-edged impact of mechanization, the size of the establishment and the degree of mechanization were positively correlated in the era when steam and water wheels were used to generate mechanical power, making it difficult to separate their respective roles in the changing composition of the workforce (Katz and Margo, 2014). If female and child employment increase in parallel with mechanization, the prime cause might instead be increasing establishment size.

This paper aims to differentiate between the relative roles of mechanization and the size of establishments in explaining the extent of female and child labour. To achieve this aim, we have employed cross-sectional plant-level data for Swedish manufacturing in 1879, provided by a public enquire by the so-called Tariff Commission, which include information on installed horsepower attributable to steam engines and hydropower. By then, Sweden was starting to catch up with the industrial core. Although Sweden is typically depicted as a country whose convergence with the industrial core occurred because of globalization and the technologies of the second industrial revolution, recent research traces the dynamic properties of manufacturing further back in time (Hamark and Prado, 2024). Early mechanization depended on waterpower because of the short domestic supply of coal. Steam engines were adopted rather late – the first one was installed in 1850 – but their diffusion was relatively fast, peaking at the end of the nineteenth century (Jörberg, 1961; Prado, 2014). Women and children made up a relatively large share of the Swedish industrial workforce. Women accounted for nearly 20 percent, whereas children accounted for five percent (Karlsson, 1996; Olsson, 1995). Public statistics, such as the annual industrial statistics, have a long history in Sweden, as well as public enquiries such as the one we draw upon. Therefore, it is worth examining the statistical

evidence provided by Sweden in order to gain additional insights into the effects of industrialization on the employment of female and child labour, especially if we take into account that few other countries provide data for the period under examination.

Our results show that large establishments were indeed more likely to have higher proportions of women and minors in their workforce. Even though this result is in line with the findings of Goldin and Sokoloff (1982) for the US in 1820–1850, we find no evidence that mechanization was associated with the employment of women and minors when we control for the effect of establishment size. The independent role attributed to establishment size also contrasts with Katz and Margo (2014: Table 1.2), who find a negative association between steam engines and female employment, after controlling for establishment size, for US manufacturing. They argue that mechanization required skilled workers for machine maintenance and installation, who were typically adult men.

Our interpretation is different. We argue that the association between establishment size and female workers had to do with labour division and industry-specific trajectories. First, larger establishments allowed for fine-grained labour division, which implied specialized and repetitive tasks quick to learn and master. This development shifted the demand for labour from men, who were skilled handicraft workers, to women and children, who had little to no previous experience in manufacturing work. Second, industry-specific factors played an important role, as some industries were more likely to employ women and children regardless of mechanization or plant size. This is particularly true for the textile industry, in which women started as home weavers and spinners before shifting to work in large textile factories (Karlsson, 1996; Nilsson, 2015; Schön, 1979). Many of the establishments in the textile industry had little mechanization but employed large numbers of workers.

Finally, our results also reinforce the view that women and minors were paid, on average, less than men. This result suggests that a potential reason why they were employed in both large and small establishments was the reduction of labour costs.[1] Others have argued that women were, on average, less productive than men because of their lower skills, explaining their inferior monetary gains (Burnette, 2015). Yet, for unskilled tasks, the productivity differentials may have been lower, and therefore, women with lower wages could have become an attractive option for saving on labour costs. This applied, above all, to large establishments because of their higher division of labour that favoured the demand for unskilled workers. We conclude, therefore, that the division of labour made possible by large plants, industry-specific trajectories, and cost advantage relative to male workers offer an explanation of why minors and women made up an important part of the labour force during nineteenth-century industrialization.

2. Mechanization and employment of women and children

Our point of departure is the study of Goldin and Sokoloff (1982) on the relationship between mechanization and the employment of women and children in the United States. Whi-

le the authors connect the increase in establishment size to mechanization, we consider these factors separately. In other words, we associate establishment size as an indication of a more intricate division of labour, which itself could drive the employment of women and children, and mechanization as an indication of technological advances in production methods.

Goldin and Sokoloff (1982) argue that American manufacturing relied on female and child labour as an alternative to the more expensive male labour in the early nineteenth century. According to their argument, large-scale production methods facilitated both "more intricate division of labour" and "the substitution of unskilled for skilled labour" (p. 742-743). Women and children at the time were, on average, less skilled than men, either by default (in the case of children) or by custom (in the case of women). The authors show that women made up as much as 30 percent of the manufacturing labour force in the northeast of the United States in 1820, growing to a peak of 40 percent between the 1830s and 1840s, after which it fell to 21 percent in 1860. In comparison, one-fifth of the labour force in Sweden at the turn of the twentieth century were women, and almost an equal share were minors under the age of 18 (Karlsson, 1996). Children under the age of 14 made up as much as five percent of the labour force around the same time (Olsson, 1995).[2]

Katz and Margo (2014) test the idea that large, mechanized establishments would have employed more women and children in the late nineteenth-century US manufacturing. Their results show that while mechanization, proxied by steam power use, is positively and statistically significantly associated with the employment of women and children, this association turns negative once controlling for establishment size. The authors suggest that the installation and maintenance of the special-purpose machinery required skilled labour, which was typically male. Gregg and Matiashvili (2022) explore similar aspects in Imperial Russia's manufacturing sector and show that there was a negative association with capital intensity, which they use as a proxy for machinery, and female employment. However, factories with greater mechanization were more likely to employ children. The authors suggest that machinery was potentially more complementary to child labour, whereas women were substitutes for male workers.

The possible link between technological change and the substitution of women and children for adult male workers hinges on the assumption that technological change in the nineteenth century was deskilling. In the parlance of economics, workers' skills are considered a factor of production, and new technologies may favour one factor of production over another in the process of "directed technical change." In the instance of deskilling, machines (capital and technology) replace humans in processes that were previously performed by skilled artisans, leaving the menial tasks, such as carrying fuel and semi-finished goods across the factory floor, to the unskilled workers (Atack et al., 2004; Goldin and Katz, 1998). Many of these tasks were suitable for women and children (Humphries, 2013). Overall, the recent empirical research focusing on steam engines has offered mixed results in support of the deskilling hypothesis. De Pleijt and Weisdorf (2017) present evidence of de-skilling in Britain as labor moved from workshops to factories, whereas De Pleijt et al. (2020) show that steam engines themselves increased employment in skilled occupations but had a negative effect on schooling and literacy.

Franck and Galor (2021) show that steam engines resulted in greater human capital attainment in terms of primary school enrolment and literacy in France. Ridolfi et al. (2023) further show that steam engines had a positive impact on both employment and wages in France.

Equating "unskilled" with women and children and "skilled" with adult men is naturally a crude way to classify the two groups. Goldin and Sokoloff (1982) themselves admit that it is not necessarily true, at least not at the level of the individual. Atack et al. (2004), who also have objections, argue that since not all industries employed women, it would be hazardous to conclude that all adult men would be skilled workers. However, there are good reasons to believe that women and children were on average less experienced. This is true by default for child workers, and the contemporary social norm of women leaving work when they married meant that most female workers were in their late teens or early twenties.[3] The labour force participation of wives and mothers was much lower than that of single childless women (Karlsson, 1995). The age profile of female workers offers an explanation why they were more inexperienced and were therefore offered tasks that we classify as unskilled. Although high-skill positions were not entirely out of reach, most of the time women had to accept repetitive work that required little on-the-job training (Stanfors and Karlsson, 2011).

The influence of discrimination as a factor explaining the gender wage gap has been widely discussed. Burnette (2015) argues that the typical gender wage gap could well be attributable to a lack of information on unobservable characteristics that determine productivity. She further shows that wage discrimination did not take place until late in the nineteenth century, which is in line with Goldin (1990). The discrimination in the late nineteenth and early twentieth centuries was largely limited to white-collar female workers and did not extend to blue-collar workers. Stanfors and Karlsson (2011) and Stanfors et al. (2014) examine gender pay differences within the tobacco industry in Sweden. They conclude that women are paid less than men only in hourly rates, whereas piece rates were the same for both genders. On average, women tended to be younger, unmarried, and performed tasks that required less skill. Burnette (2015) shows that most of the gender wage gap in American manufacturing can be explained by women's lower productivity in comparison with men's. Burnette and Stanfors (2020) find that women in the Swedish printing industry earned about 70 percent of the male wage, and they argue that most of this gap is explained by individual- and job-specific characteristics. The gender wage gap thus seems to be explained mainly by differences in the tasks performed by men and women.

Goldin and Sokoloff seem reluctant to associate women and children with unskilled workers, and for good reasons. As this review of the deskilling hypothesis has shown, the intricacies of the relations between mechanization on the one hand and the division of labour and the composition of workers' skills on the other question both the deskilling hypothesis and the deskilling label conferred on female workers. In the following sections, we aim to bring some clarity to these complexities through a look at establishment-level data for Sweden in 1879.

3. The survey of the Tariff Commission

We have drawn on the survey conducted by the Tariff Commission, a governmental agency created to assess the impact of the changing Swedish trade policy of the 1860s. In 1880, the commission surveyed establishments across several sectors of the economy; in our study, however, we have considered only manufacturing.[4] Establishments were defined as one unit of production in one place. Though the survey asked establishments to retrospectively report figures back to 1860, we use the last year of observation, 1879, as our only cross-section. Earlier years suffer from underreporting, rendering the figures reported unreliable due to survival bias. We draw on the original returns preserved at the National Archive but digitized for a previous project (Collin et al., 2019).[5] In that project, the digitized returns were used to establish county-specific wages by industry. We have instead employed each return as a separate observation, which offers an opportunity to examine establishment-level data for manufacturing when Sweden stood on the brink of massive industrialization.

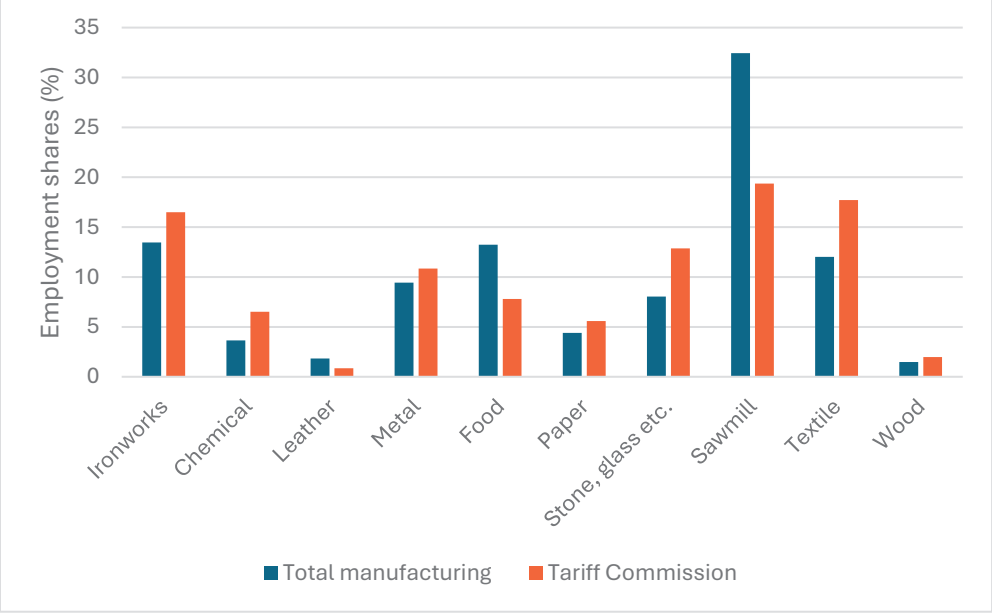
The commission's survey has some benefits. First, it asks 42 questions, covering aspects such as the composition of workers, product variety, intermediate consumption, wages, and state of market competition. Furthermore, it included all manufacturing industries. This encompassing nature of the survey sets it apart from the annual industrial statistics that left several industries – most notably the sawmills – out of account until it went through several revisions in 1913. Finally, we can observe the use of steam power and hydropower separately, whereas the industrial statistics only started to report horsepower attributed to different energy sources in 1897 (Prado, 2014).

The downside of the survey is its low response rate. Across all manufacturing industries, the average response rate was 19 percent. Thus, it is important to establish the reliability and validity of the evidence that the digitized survey provides. The response rate was calculated as the number of returns divided by the number of questionnaires sent out (Collin, 2016: p.199). In itself, the response rate does not reveal anything important about validity; therefore, in order to confirm the validity of the survey, we offer some indicative figures (Table 1). We compare the survey with the industrial statistics for 1879, on the one hand, and the estimated total for manufacturing, on the other. In the estimated total, the industrial statistics are combined with complementary information on output provided by Schön (1988) for Swedish historical national accounts (Hamark and Prado, 2024; Prado, 2008). The surveyed establishments account for 33 percent of the estimated total number of workers in manufacturing. We may compare this figure with that of the industrial statistics, which account for 55 percent of workers employed in manufacturing. Considering the distribution of employment across the different industries, in Figure 1 we compare the sample of the Tariff Commission with the estimated total. The sawmill industry is clearly underrepresented by the Commission's report, whereas the textile industry is overrepresented. For the other industries, the deviation is within reasonable error boundaries.

TABLE 1. **The Tariff Commission in comparative perspective, 1879**

		Estimated total		
	Tariff Commission	**Industrial statistics (BiSOS D)**	**Handicraft excluded**	**Handicraft included**
Workers (1000s)	44.4	74.2	134.2	255.0
Share of est. total (excl. handicraft)	33.1%	55.2%	100%	190%

FIGURE 1. **Employment by industry in the manufacturing sector vis-à-vis the Tariff Commission's sample**



NOTE: The employment figures of total manufacturing are constructed by adding the industrial statistics (BiSOS C and D) and contributions from Lindahl et al. (1937) and Schön (1988). A detailed description appears in Prado (2008, p. 197–227), with one notable exception: the extra output of grain milling that was added by Schön (1988) has not been included. The reason is that this output is attributable to very small grain mills that cannot be considered manufacturing plants.

In total, the dataset consists of 901 establishments, though due to missing values, not all of them are included in the analysis. The survey covers the number of workers in each establishment, divided into men, women, and children. The dataset includes 43,571 workers, of which 13 percent are women and 11 percent are minors. In comparison, Karlsson (1996) shows that 22 percent of employees in manufacturing were women and 16 percent were minors. Her percentages over-estimate the shares of females and minors because they are based entirely on the industrial statistics (BiSOS D), which at the time excluded mining, iron and steel and sawmills,

all of which were male-dominated industries accounting for more than half of total employment. Employment in mining, steel and iron industries was given in a separate publication (BiSOS C), whereas sawmills were first included in the industrial statistics (BiSOS D) in 1896.

The age of the children is not given, but in the original source they are often referred to as *gossar* (lit. boys), which refers to a young male worker, typically under the age of 14. In some cases, they were instead referred to as *minderåriga* (lit. underaged), which means under the age of 18. This inconsistency begs the question where to draw the line between a "child" worker and a young worker in his or her teens. Goldin and Sokoloff (1982) run into a similar issue, and they treat workers as child workers if they are under the age of 16 and male, or under the age of 15 and female. The child labor committee in Sweden referred to workers under the age of 15 as child workers but raised this limit to 18 years after 1863 (Olsson, 1995). Unfortunately, it is not possible to distinguish between workers under 15 years of age and those between 15 and 18 in our dataset. In the empirical part of this paper, we thus refer to these workers simply as "minors". Given the widespread use of child labor at the time, however, it is likely that a fair share of the underage workers was significantly younger than 18 years of age. In Sweden, the minimum working age at factories was 12 years after 1846 (Olsson, 1995).

For our study, the most important variables are establishment size, share of women and minors, and the use of inanimate power. Establishment size is measured as the number of workers employed, and mechanization is measured as steam power use. Overall, the average size of an establishment is just under 54 workers. We may compare that size with the industrial statistics (BiSOS D), in which the average establishment size was 18.6 workers in 1879. As previously mentioned, this figure results from a selection of industries that is different from the Tariff Commission's, excluding, most importantly, most of the iron and steel industry and sawmills altogether. The sawmills had a large average plant size, whereas the iron and steel industry had relatively small plants. In the Tariff Commission survey, there are 13 establishments with more than 500 workers, and five of them are sawmills. Excluding these would decrease the average establishment size by more than 10 workers. Because of the different coverage of the industrial statistics pre-1896, the true average establishment size for manufacturing at large is unknown. The average size for 1896 was 23 workers per establishment,[6] which indicates that the Tariff Commission has oversampled large establishments.[7]

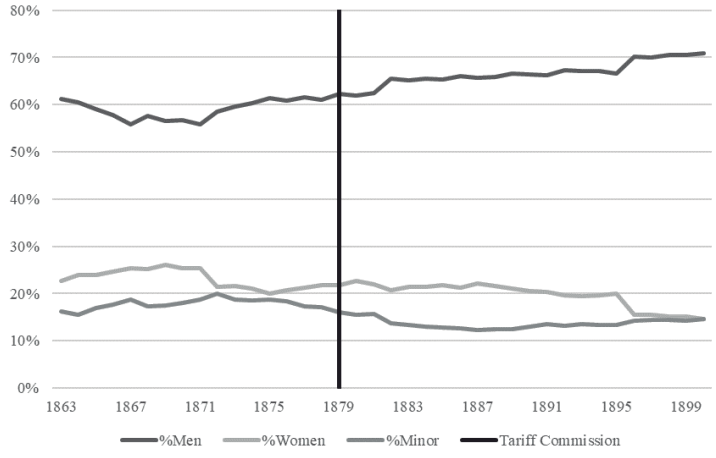
The survey includes three measures of capital. These three measures include the cost of fire insurance, the assessment value, and the acquisition value. None of them are perfect measures of capital, and they all appear in the returns with irregular frequency. The most frequently reported of them is the cost of fire insurance. Like Holmquist (2003), we use fire insurance as a measure of capital. We have employed it in all cases when it has been reported and imputed its value in all cases when it is missing and either of the other two measures have been reported. The imputation was done by regressing the log of fire insurance against the log of assessment value for all returns that included figures for both and controlling for county and industry. We then used the implied elasticity to impute a figure for the cost of fire insurance by multiplying the elasticity with the reported figure for assessment value (and adding the value of the county dummy and industry dummy).

On average, 9 percent of the workers in an establishment were women and 9 percent of them were minors, bringing their total share to 18 percent. About one-third of the establishments were steam-powered. On average, establishments used just under 14 horsepower of steam, and 31 horsepower of water. Thus, the total power usage was just under 49 horsepower. Capital per worker was on average 2,753 Swedish krona (SEK). The summary statistics are reported in Table A1 in the Appendix.

4. Mechanization and employment of women and children in Sweden

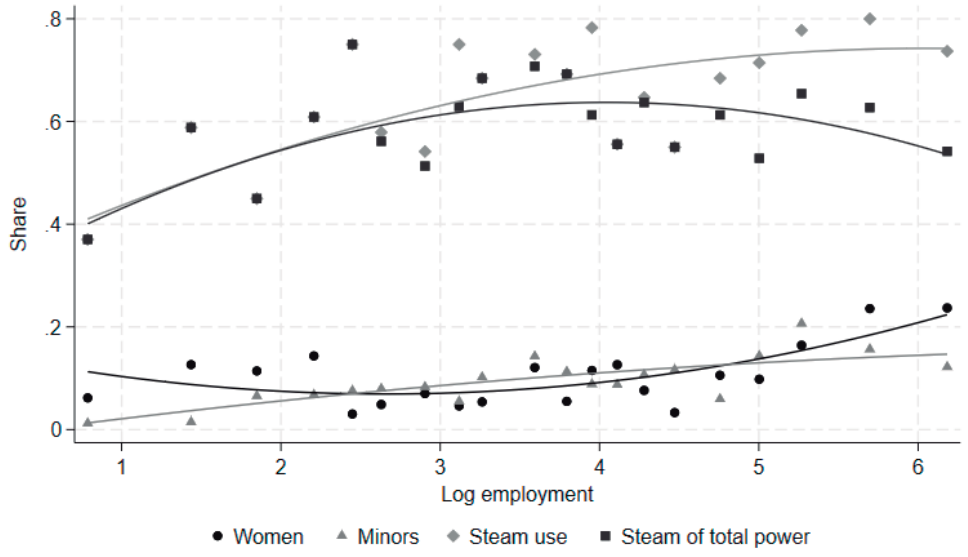
Women represented a significant share of manufacturing employment throughout the late nineteenth century. Between 1863 and 1895, their share hovered at or above 20 percent, after which it fell to around 15 percent (see Figure 2). The share of minors, which includes both boys and girls under the age of 18, was only slightly lower, ranging from 15 to 20 percent until the 1880s, during which the share fell to less than 15 percent. In fact, the composition of manufacturing employment remained remarkably stable with regard to gender and minors' shares across the last four decades of the century, considering total manufacturing employment increased almost ten-fold, from a mere 28,000 in 1863 to 257,000 in 1895 (Karlsson, 1996).

FIGURE 2. **Employment of men, women, and minors.**



NOTE: Minors are boys and girls under 18 years of age. The vertical line at the year 1879 represents the cross-sectional data from the Tariff Commission. Source: Karlsson (1996); BiSOS D

FIGURE 3. **Employment of women and minors, and steam use by establishment size, binned scatterplot.**



NOTE: The Y-axis represents the share of each variable. The X-axis is the log of the sum of all workers within an establishment. The share of women and minors reflects the number of female and underage workers divided by the total employment within establishments in each size bin. Steam use is the share of establishments using steam power in each size bin. The share of steam power is calculated by dividing steam power by the total power (measured in horsepower) in an establishment.

Our analysis begins by examining establishment size, mechanization, capital intensity and the percentages of women and minors in the workforce. Figure 3 shows that the relationship between size and the employment of women and children is not linear. Very large establishments were more likely to employ both women and minors. However, in smaller establishments, the pattern is not clear. Women were somewhat more likely to be employed in small establishments compared to medium and large establishments, whereas minors were more likely employed in medium-sized establishments.

Mechanization is the other factor possibly explaining the employment of women and minors. In Sweden, steam engines began to be used for mechanical power in sawmills by the mid-nineteenth century, gradually replacing water wheels before yielding to electric motors by the 1890s (Prado, 2014). For late nineteenth-century American manufacturing, Atack et al. (2008) show that establishment size and mechanization were positively related in such a way that large establishments were more likely to adopt steam engines than small ones. Furthermore, Berger and Ostermeyer (2024b) establish a positive connection between firm size and steam adoption in Sweden. Our evidence presented in Table 2 confirms their finding: steam power use increases by establishment size. Hydropower remained a viable option in

Sweden owing to the high number of waterfalls and rapids, which might have tempered the spread of steam engines. Indeed, steam power use made up just one-third of the total power use. By 1897, it was roughly half (Prado, 2014).

TABLE 2. **The share of women and minors (%) by establishment size and steam use.**

	Steam = 0				Steam = 1			
	N	Women and minors	Women	Minors	N	Women and minors	Women	Minors
Small (0-5)	239	13.7	8.0	5.7	23	19.9	19.9	0
Medium (6-15)	130	19.3	6.8	12.7	47	17.0	11.4	5.6
Large (16-99)	125	16.7	7.0	9.7	123	18.2	9.2	9.5
Very large (100+)	35	21.9	11.3	10.9	81	29.6	17.1	12.5

NOTE: Employment shares refer to the total employment by size and use of steam. The number of establishments is reported in the column "N". SOURCE: Tariff Commission

Table 2 shows cross-tabulation of steam engine use and establishment size together with the share of women and minors as a percentage of total employment. We use the same establishment size categories as Goldin and Sokoloff (1982), but with an added category for very large establishments, as in Katz and Margo (2014). Women and minors account for one-quarter of all the workers in the dataset, which is comparable to the United States in 1880, where they accounted for one-fifth of manufacturing employment (Goldin and Sokoloff, 1982: Table 1). In general, the share of women and minors was higher in steam-powered establishments. The opposite pattern is seen among medium-sized establishments, in which non-steam-powered establishments have a higher share of women and minors. Very large steam-powered establishments were most likely to employ women and children. In contrast, Berger and Ostermeyer (2024a) find that manufactories, which they define as large non-mechanized establishments, were more likely to employ women and children compared to mechanized factories. However, this is probably explained by the establishment size as their paper does not differentiate between small and large mechanized factories.

Mechanization and the employment of women and minors are positively correlated with establishment size (see Table A2 in the Appendix). The correlation between steam power use measured in horsepower and the employment of women and minors is weak. The analysis so far suggests that the difference is more meaningful between steam- and non-steam-powered establishments, whereas the degree of mechanization is less important. Furthermore, capital intensity is negatively correlated with the employment of both women and minors.

In Table 3, we adapt the regression specifications from Katz and Margo (2014: Table 1.2) to make comparisons with the United States. Their results suggest that steam power had a statistically significant positive association with female and child employment in the United States in 1870 and 1880 when controlling for waterpower and capital by value added. However, once adding establishment size as a control variable, the relationship with steam becomes

TABLE 3. OLS regression adapted from Katz and Margo (2014)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Percent women and minors**	**Percent women and minors**	**Percent women and minors**	**Percent women**	**Percent minors**
Steam power	5.312***	6.098***	-0.960	1.240	-2.200*
	(2.027)	(2.057)	(2.168)	(1.850)	(1.239)
Waterpower	-4.267**	-1.588	-4.290*	-3.686**	-0.604
	(1.823)	(2.287)	(2.187)	(1.702)	(1.371)
Log K/L		-4.416***	-3.413***	-1.852***	-1.561**
		(0.956)	(0.938)	(0.704)	(0.637)
Log Employment			4.116***	2.286***	1.830***
			(0.716)	(0.555)	(0.442)
Industry FE					
Ironworks		*reference*	*reference*	*reference*	*reference*
Chemical		9.598***	15.51***	9.723***	5.788**
		(3.604)	(3.699)	(2.328)	(2.644)
Leather		-4.740	2.840	3.531	-0.691
		(2.932)	(3.288)	(2.322)	(2.312)
Metal		0.905	2.692	-0.583	3.275*
		(2.316)	(2.380)	(1.379)	(1.894)
Food		18.21***	23.99***	21.75***	2.245
		(3.136)	(3.142)	(2.452)	(1.967)
Paper		21.28***	23.05***	9.687***	13.36***
		(4.010)	(3.888)	(2.839)	(2.938)
Stone, glass etc.		3.460	6.596**	1.534	5.062**
		(2.965)	(2.982)	(2.020)	(2.190)
Sawmill		-5.923***	-1.160	-1.660	0.500
		(2.215)	(2.453)	(1.604)	(1.814)
Textile		32.43***	34.65***	26.04***	8.611***
		(4.228)	(3.974)	(3.191)	(2.343)
Wood		17.65**	18.59**	11.10*	7.486
		(7.913)	(7.557)	(6.600)	(4.567)
Other		-2.427	-0.177	2.083	-2.260
		(5.310)	(5.354)	(3.505)	(3.105)
Region FE		Yes	Yes	Yes	Yes
Constant	16.88***	40.89***	21.68**	10.08	11.60*
	(1.506)	(8.115)	(8.554)	(6.543)	(6.237)
Observations	748	748	748	748	748
R-squared	0.025	0.297	0.334	0.312	0.180

NOTES: Steam and Water are binary variables, taking the value of 1 only if an establishment has steam or hydro power, and zero otherwise. Log capital per worker is the log of the value of capital stock divided by the number of workers. Log employment refers to the log of the number of workers per establishment. Robust standard errors in parentheses, It should read like this: *** p<0.01, ** p<0.05, * p<0.1. SOURCE: Tariff Commission.

negative, though remains statistically significant. Our results suggest the same for Sweden in 1879, but the coefficient for steam power loses its significance after adding establishment size as a control. The coefficient for waterpower, however, becomes statistically significant at a 90-percent confidence level once controlling for establishment size. Waterpower seems to be negatively associated with the employment of women and minors, possibly due to the role played by heavy industries, an issue we return to in the next section. A potential reason for the inconsistency in the coefficient for steam power is revealed when we separate women and minors: the association appears positive for women and negative for minors. The association is not statistically significant for women due to high standard error, but it is statistically significant at a 90-percent confidence level for minors. Our results are in line with Gregg and Matiashvili's (2022: Table 6), who show that machine power per worker, which they use as a proxy for capital intensity, has a negative association with female employment. We show that capital-per-worker has likewise a negative association with both female and minor employment. Capital intensity could potentially capture mechanization not directly linked to the use of inanimate power.

TABLE 4. **Mediation analysis using OLS regression.**

	(1)	(2)	(3)
Variables	**% of women and minors**	**Log employment (mediator)**	**% of women and minors**
Steam power (1/0)	5.497***	1.470***	0.323
	(1.915)	(0.106)	(2.048)
Log employment			3.520***
			(0.755)
Industry FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Constant	11.11**	3.396***	-0.838
	(5.559)	(0.349)	(6.784)
Observations	790	790	790
R-squared	0.25	0.48	0.27

NOTES: For variables, see Table 3. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. SOURCE: Tariff Commission

The use of steam power and establishment size are positively correlated with each other (Atack et al., 2008; Berger and Ostermeyer, 2024b), which means that separating their effects is challenging. If women and minors are more likely to be employed by large establishments, they are also more likely to work in a steam-powered establishment. In Table 4, we perform a simple mediation analysis based on OLS regression (Baron and Kenny, 1986).[8] First, we regress the share of women and minors against steam power. Column (1) shows that there

TABLE 5. OLS regressions by size group.

	(1)	(2)	(3)	(4)
VARIABLES	**Small**	**Medium**	**Large**	**Very large**
	Dependent variable: Percent women and minors			
Steam power	3.821	1.540	-0.234	-3.502
	(6.078)	(4.280)	(3.996)	(3.787)
Waterpower	-16.94***	-2.265	1.145	11.63*
	(4.116)	(4.074)	(4.375)	(6.311)
Log K/L	-6.153***	-1.888	-3.302**	1.945
	(1.982)	(1.712)	(1.517)	(3.844)
Industry FE				
Ironworks	Reference	Reference	Reference	Reference
Chemical	-32.47***	15.37*	31.37***	66.94***
	(10.68)	(8.583)	(7.951)	(13.64)
Leather	-37.21***	-1.800	-0.346	
	(11.00)	(6.745)	(7.474)	
Metal	-19.49*	7.775	7.860**	0.336
	(11.70)	(6.684)	(3.141)	(6.095)
Food	-11.31	17.83***	28.13***	29.95*
	(10.25)	(6.247)	(5.938)	(16.77)
Paper	-5.597	22.29***	25.78***	26.99***
	(14.07)	(7.823)	(5.433)	(9.478)
Stone, glass etc.	-32.80***	9.880	6.833	25.82***
	(12.51)	(6.274)	(4.622)	(9.668)
Sawmill	-34.03***	-1.632	2.377	11.87**
	(11.19)	(5.166)	(3.990)	(5.722)
Textile	1.206	17.47**	35.18**	54.89***
	(13.07)	(7.363)	(15.79)	(7.851)
Wood	-22.19*		27.32***	4.728
	(11.42)		(9.693)	(12.62)
Other	-28.44**	-11.52	4.500	-32.85***
	(12.99)	(9.293)	(9.204)	(8.930)
Region FE	Yes	Yes	Yes	Yes
Constant	88.67***	26.36*	39.92**	-33.93
	(19.98)	(15.47)	(15.82)	(22.98)
Observations	228	169	239	112
R-squared	0.438	0.354	0.371	0.692

NOTES: Steam and waterpower use is measured as a dummy-variable. Their reported use is indicated by value of one, and zero otherwise. Log capital per worker is the value of capital stock divided by the number of workers. Small (1-5 workers), Medium (6-15 workers), Large (16-99 workers), Very large (100+ workers). Robust standard errors in parentheses, *** p<0.01,

is indeed a positive relationship between steam use and employment of women and minors. As suspected, the relationship between the two could be driven by establishment size, which is also positively associated with steam power use, as shown in Column (2). Finally, in Column (3), where we regress the share of women and minors against both steam use and establishment size, the coefficient for steam use becomes nonsignificant, suggesting almost full mediation.

To further explore the role played by steam and waterpower on the employment of women and minors, we run the regressions for each size group separately. Table 5 shows that the association with steam power varies by size: it is positive for small establishments and negative for very large establishments, but none of the coefficients are statistically significant due to large standard errors. The relationship is reversed for waterpower: it is (strongly) negative for small establishments and positive for very large establishments.

There is little evidence that mechanization would independently explain variations in the employment of women and minors. We find instead establishment size to have a stronger positive association with women and minors, which is in line with Goldin and Sokoloff (1982). Large establishments had a more intricate division of labor, which implied more strictly defined tasks requiring only basic training, as argued by Atack et al. (2005). However, the relationship is not linear, and industry-specific factors could explain why small establishments were more likely to employ women and minors compared to medium-sized establishments. We will discuss these drivers further in the next section.

5. Accounting for variations across industries

The employment of women and minors varied across industries, and for reasons other than mechanization and establishment size. Figure 4 shows the use of steam power and the employment of women and minors by industry. On average, establishments within the textile industry were the largest, and well over half the workers in the industry were women or minors. However, the textile industry was not the greatest user of steam power. Establishments within sawmills and wood industries were more likely to use steam power. Overall, the figures reveal why there was no clear relationship between steam power and the employment of women and minors at the aggregate level: their shares depended more on the industry itself than on the level of mechanization. In this section, we will discuss historical and other economic factors that could explain why some industries employed more women and minors.

In Table 6, we interact steam power use with the industry fixed effects, which shows great variation across industries as to whether the association between mechanization and the employment of women and minors is positive or negative. We observe a statistically significant positive association in the chemical and textile industries; for textiles, however, it is only at the 90 percent confidence level. Both these industries have historical roots in employing women and children but are also highly mechanized. For ironworks, the association is statistically significant and negative, mainly because the use of steam power was relatively uncommon.

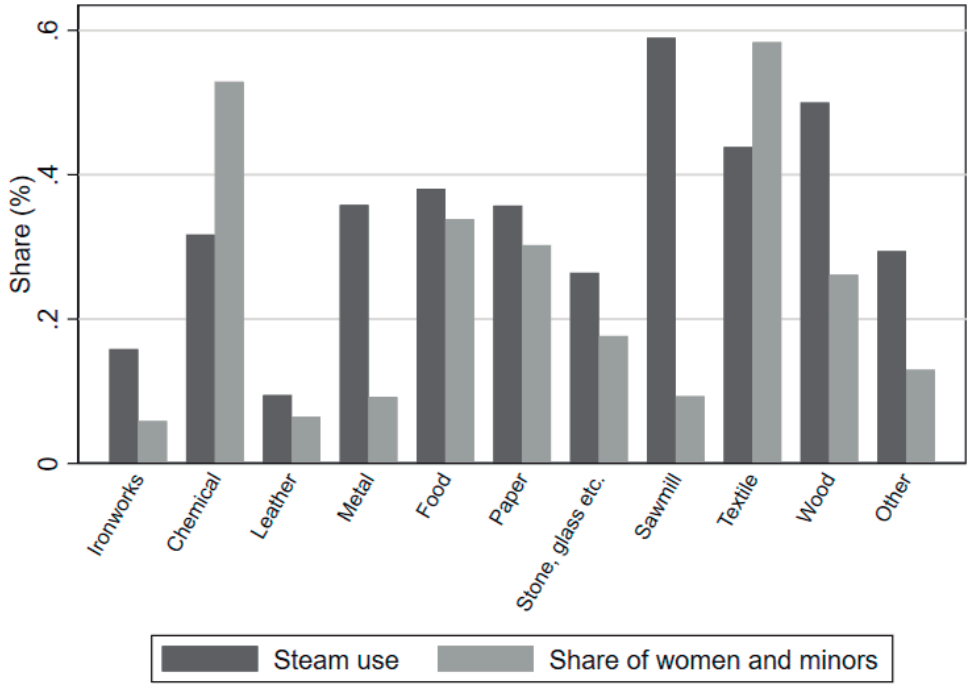
TABLE 6. **Industry interactions with steam power**

VARIABLES	**Share of women and underage**	
	Coefficient	**Robust standard error**
Steam (1/0)	-6.754***	(1.823)
Industry FE		
Ironworks	*Reference*	
Chemical	4.562	(3.835)
Leather	-0.205	(3.364)
Metal	3.324	(2.886)
Food	22.32***	(3.697)
Paper	25.55***	(4.911)
Stone, glass etc.	6.040*	(3.293)
Sawmill	1.345	(2.746)
Textile	29.79***	(4.930)
Wood	23.05**	(10.23)
Other	0.632	(7.502)
Industry-interactions		
Ironworks	*Reference*	
Steam x Chemical	31.48***	(5.929)
Steam x Leather	7.219	(5.201)
Steam x Metal	0.0128	(4.218)
Steam x Food	5.375	(5.157)
Steam x Paper	-3.975	(7.126)
Steam x Stone, glass, etc.	3.046	(4.851)
Steam x Sawmill	-1.603	(3.402)
Steam x Textile	13.41*	(8.072)
Steam x Wood	-6.157	(14.50)
Steam x Other	-0.243	(7.572)
Water (1/0)	-5.086**	(2.284)
Log K/L	-3.342***	(0.930)
Log Total Employment	3.663***	(0.714)
Constant	23.61***	(8.646)
Observations	748	
R-squared	0.369	

NOTES: Steam and waterpower use is measured as a dummy-variable. Their reported use is indicated by value of one, and zero otherwise. Log capital per worker is the value of capital stock divided by the number of workers. Log total employment is the log of the sum of all workers within an establishment. The interaction terms represent the coefficients for steam use by industry. Reference group is ironworks. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. SOURCE: Tariff Commission.

However, the industry did employ minors, presumably boys. Almost no women worked within ironworks.

FIGURE 4. **Steam use and the employment of women and minors by industry.**



NOTE: The share of steam is calculated using a binary variable for steam use by establishment. The share of women and minors is from the total industrial employment. SOURCE: Tariff Commission.

The relatively high share of women and minors in the chemical industry was largely explained by the large match factories (Beglund, 1982).[9] *Jönköpings tändsticksfabrik* employed as many as 211 women and 275 minors in its factory of almost 900 workers, where they also used steam engines to power the belts running machinery.[10] Olsson (1995) describes the work of child workers in match factories as repetitive and manual, such as making match boxes. This work was almost completely manual, and as the process was mechanized, the demand for child labor decreased. Before the emergence of textile factories, women usually produced fabrics and clothing at home for their own use and for sale (Nilsson, 2015). It was therefore a natural transition to use the existing skill base and employ women in textile factories (Schön, 1979). The textile industry employed almost half of the total female industrial labour force (Karlsson, 1996). Olsson (1995) argues that in both textile and match factories, mechanization at the end of the century reduced the need to employ child workers. Because of the cross-sectional nature of our data, we cannot rule out the possibility that the implementation

of steam engines within these industries would ultimately reduce the demand for female and child labor. In our data, large textile mills and match factories were both using steam engines and employing many women and minors.

While the food and beverage industry was female-intensive, it was not particularly mechanized in the late nineteenth century. Women, who had so far been responsible for cooking and baking at home, put their skills to work in the emerging food industry. Stanfors and Karlsson (2011) show that many unskilled tasks within the tobacco industry were almost entirely female-dominated, even though this unskilled bias did not rule out women from holding positions that required higher skills. However, while the industry employed great numbers of women and minors, the evidence of steam engine use is more mixed. Some large tobacco factories reported no use of steam power, but in sugar mills and breweries the use of steam power was more common, which explains the large standard error for the food industry in Table 6.

Up to one-third of jobs in the paper industry were held by women or minors. They were often employed by larger paper mills, but it is unclear what kind of tasks they performed. The industry was divided somewhat evenly between mechanized and non-mechanized establishments, which makes the association with the employment of women and minors inconsistent. For example, more than half of the 126 workers at *Holmens pappersbruk* were women or minors even though the factory did not use steam engines. In contrast, nearly all of the 72 workers at the steam-powered *Bergviks trämassefabrik* were men.

Heavier industries such as ironworks, sawmills, and metal working were defined by the demand for physical strength prior to large-scale mechanization. As Karlsson (1995) argues, contemporaries viewed female labor in manufacturing as undesirable because strenuous work could render women less fit to be wives and mothers and incline them to sacrifice their household duties. Heavy industries did, however, use large amounts of both hydro- and steam-power. For sawmills, steam engines were fundamental in removing the constraints imposed by sites located by streams. Using steam engines allowed them to be located closer to the ports on the coast, facilitating transportation. In the iron industry, processing of metal in large blast furnaces required much energy, which is why we see a large average use of energy within ironworks. Most of this energy came from waterpower in 1880. At that time iron production was still dominated by relatively small production units scattered across Bergslagen, an area in the middle of Sweden known for its iron deposits. The development of the iron industry from then onwards saw a dramatic increase in the average plant size and the explosive growth of the entire industry. With the innovation of a new charcoal-based method for producing bar iron, often referred to as the Swedish Lancashire process, along with the expansion of railways allowing long-distance transportation of charcoal, it became beneficial to increase establishment size. As a result, large swaths of smaller production units disappeared within a few decades (Rydén, 2005). But men continued to dominate the workforce. Upstream in the value-added chain, mechanical workshops adopted steam power to run installations such as steam hammers, matchmaking machines and milling machines. But this profession, too, remained male-dominated.

Unlike the heavy industries, the leather industry was dominated by small workshops, such as tanneries with an average of five to six workers. Most of these were adult men. We assume that the reasons are historical: artisans and craftsmen were typically male, because there were major barriers for women to enter such occupations. In general, women may have preferred industries where they had pre-existing skills, and which were perceived as appropriate for women. These did not include ironworks, leather, metalworking or sawmills.

To conclude, we see different uses of steam engines across industries, which impacts the association between mechanization and the employment of women and minors. Historical roots and path dependency also explain why some industries were more likely to employ women or minors. In other words, we cannot assert that mechanization alone would increase the demand for female and child labor.

6. Relative wages of women and minors

One of the potential arguments for employing more women and minors is cost-saving (Goldin and Sokoloff, 1982). The division of labor in larger establishments plays a role in the motivation for low-cost labor: as tasks become simpler and therefore easier and faster to learn, low-cost labor becomes more attractive. Previous research has shown that women had an inferior status when it came to earnings in the nineteenth century, although we lack systematic evidence (Bagge et al., 1933; Burnette and Stanfors, 2020; Hamark et al., 2024). In Sweden, women earned, on average, 50 percent of male wages in the textile industry during the late nineteenth century (Prado, 2010).

We can offer new evidence of pay differentials for men, women and minors drawing on the Tariff Commission's cross-section of 1879. The low number of observations that include information on daily wages poses a limit on our analysis and the conclusions we can draw from it. Given this limitation, the industry averages have a rather large error bound. We have 395 establishments that reported information both on daily wages and on employment. Of these cases, 239 reported male wages, 167 female wages, and 150 underage wages. Only 40 establishments reported both male and female wages. This small sample of gender wage ratios makes it challenging to assess the significance of establishment-specific factors. Establishments that reported information on wages were, on average larger, used more inanimate power, and had larger capital stock (see Table A3).

The weighted averages are calculated by multiplying the number of workers of a specific group (male/female/child) in an establishment, l_{je}, with the corresponding wage paid in that establishment, w_{je}, so the numerator becomes the sum product for each industry, i. The denominator represents the sum of all workers of group j in establishment e in each industry. The weighted average wage for men, women, and children for each industry is given by the quotient of the sums:

$$W_{ij} = \frac{\sum w_{je} l_{je}}{\sum l_{je}}$$

TABLE 7. **Daily wages across industries in 1879 (in Swedish kronor)**

Industry	Men	Women	Minors	$\frac{w_w}{w_m}$	$\frac{w_c}{w_m}$
Ironworks	2.31 (60)	0.58 (1)	0.99 (12)	0.25	0.43
Chemical	1.81 (14)	1.02 (15)	0.71 (11)	0.56	0.39
Leather	2.06 (17)	0.84 (1)	1.25 (1)	0.41	0.61
Metal	1.98 (23)	0.83 (3)	0.80 (14)	0.42	0.40
Food	2.11 (15)	1.35 (58)	0.72 (24)	0.64	0.34
Paper	1.85 (11)	0.82 (11)	0.77 (14)	0.44	0.42
Stone & glass	2.35 (32)	1.07 (26)	0.65 (28)	0.46	0.28
Sawmills	2.57 (45)	0.84 (8)	1.04 (16)	0.33	0.41
Textile	1.65 (16)	1.02 (38)	0.72 (22)	0.62	0.44
Wood	1.81 (4)	1.33 (5)	0.91 (6)	0.73	0.50
Other	2.17 (2)	0.75 (1)	0.80 (2)	0.35	0.37
Total	2.21 (240)	1.08 (167)	0.76 (150)	0.49	0.34

NOTES: Wages weighted by the size of the establishment. Number of observations in parentheses. SOURCE: Tariff Commission.

By calculating this weighted average for three types of labor, for men, women, and children, across all 11 industries, we arrive at the average wages presented in Table 7. On average, adult men earned a daily wage of 2.21 Swedish krona (SEK) across industries, whereas women earned 1.08 and children 0.76 SEK. The highest-paying industries for men were sawmills, stone and glass, and ironworks. These industries were also among the most male-dominated. For women, the highest-paying industries were food and beverage, and wood processing. For the food and beverage industry, we have more observations, lending reliability to our findings, while for wood processing, we only have five observations for female wages. In male-dominated industries, such as ironworks and sawmills, women were worse off earnings-wise. For underage workers, the best-paying industries were leather and sawmills, whereas the lowest-paying industries were chemical, food and beverage, and textiles.

Is mechanization associated with higher or lower wages? Our earlier analysis implies that the impact of mechanization on the employment of women and minors varies by industry. Table 8 shows that steam engines do not have a statistically significant association with wages, but hydropower has a negative association with female wages. This is likely driven by the high energy use in ironworks industry, which also employs mostly men. However, we do observe a positive relationship between capital intensity and both male and female wages, which suggests that capital investments in general likely spurred labour productivity and thereby wages. Furthermore, we observe a positive association between total employment and both male and female wages, which is opposite of what Atack et al. (2004) observe for the United States between 1850 and 1880. Our results, though limited by the availability of wage observations, thus suggest that larger plant size is not associated with lower skill intensity, defined as the establishment wage by Atack et al. (2004).

TABLE 8. **Wage regressions.**

	(1)	(2)	(3)
	Dependent variables are expressed in logs		
VARIABLES	**Male wages**	**Female wages**	**Underage wages**
Steam power	-0.00985	0.0543	-0.0313
	(0.0556)	(0.0632)	(0.0752)
Waterpower	0.0228	-0.0925	-0.119
	(0.0655)	(0.0776)	(0.107)
Log Employment	0.0356**	0.0611***	-0.000277
	(0.0165)	(0.0196)	(0.0356)
Log K/L	0.0436*	0.0297	0.0954**
	(0.0255)	(0.0247)	(0.0371)
Industry FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Constant	0.315	-0.756***	-0.857**
	(0.252)	(0.237)	(0.337)
Observations	220	155	141
R-squared	0.386	0.560	0.378

NOTES: Steam and waterpower use is measured as a dummy-variable. Their reported use is indicated by value of one, and zero otherwise. Log capital per worker is the value of capital stock divided by the number of workers. Log total employment is the log of the sum of all workers within an establishment. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1, SOURCE: Tariff Commission.

The low wages of female and underage workers offered an attractive and feasible solution to slashing labor costs. We have supported the previous evidence showing that the relative wages of female workers were low; on average, female workers earned about half of the wage of male workers (Prado, 2010; Hamark et al., 2024). This gap was even larger than in agriculture, which means that the wage gap increased as the employment share of the industrial sector grew at the expense of the sectoral share of agriculture (Molinder et al. 2022). We must consider these wage ratios as raw figures, however, because we are unable to account for labor heterogeneity. Research on the tobacco industry and printing industry has shown that accounting for the effects of formal education, on-the-job training and the nature of work narrows the pay gap between male and female workers (Burnette and Stanfors, 2020; Stanfors et al., 2014). On the shop floor, where men and women performed the same labor services, the hourly wage rates barely differed by sex. However, women were excluded from higher positions, which explains the average female-male wage gap at the industry level. In general, female and male workers rarely performed the same tasks because of the gender-segregated labour market, so it is difficult to apply the tobacco case to the labor market at large. The female to male wage ratio in manufacturing was at any rate probably inherited from agriculture. If it was customary to pay female farm servants and casual workers significantly less than their male peers, factory owners have probably been very tempted to perpetuate that practice in order to economize on labor costs.

7. Concluding discussion

In this paper, we have shown that there was a positive link between establishment size and the employment of women and minors in Sweden in the late nineteenth century. This result is in line with the evidence from the United States (Goldin and Sokoloff, 1982; Katz and Margo, 2014) and suggests that larger establishments had a more intricate division of labor, which itself may have enabled the greater use of women and children as workers. However, we fail to find a statistically significant association between mechanization and the employment of women and minors, independent of capital intensity and establishment size. This result suggests that there might not be a reason to believe that employing inanimate power would increase female and child employment independently of the degree of labor division.

Our results raise the question whether women and minors were employed disproportionately in larger establishments or whether establishments that employed more women and minors became larger over time? Eriksson and Stanfors (2015) suggest that female employment offered a competitive advantage to firms because of low female wages during the turn of the twentieth century. This argument, however, rests on a case study from the tobacco industry, which had a relatively high share of women and minor workers. If women and minors offered a competitive advantage, why did not all industries employ them to a greater extent? We may attribute the higher share of women and minors in certain industries to both contemporary attitudes and historical developments. Women were thought of as being primarily wives and mothers, and there was a fear that their employment, especially in factories, would impair their qualities in these roles (Karlsson, 1995). Historical contingencies explain why certain industries employed many female and underage workers. As in the textile industry, where women were gainfully employed in the so-called putting-out system well before the rise of textile factories (Schön, 1979). The fact that many women had acquired manual dexterity in textile production explains why they continued to be employed in textile production after the formation of textile factories. The historical legacy of female employment in the production of yarn and fabric dwarfs the importance of mechanization, which offers no clues to understanding the predominance of female workers in the textile industry. This conclusion runs counter to the idea that mechanization is the propelling force in the increase of female labor force participation.

The same argument has a bearing on the up-and-down swings in the share of underage workers in the nineteenth century. It was the increased division of labor, entailing larger establishments, that enhanced the share of underage workers. Increasing mechanization in the late nineteenth century, by contrast, served to reduce the share of underage workers, as did the law regulating working conditions for minors in manufacturing and handicrafts that were issued in 1882. Olsson (1995) shows that the share of child labor in many industries declined before the law had entered into force.

Regarding the deskilling hypothesis, we cast doubt on the widely held belief that the steam engine increased the use of unskilled workers. The steam engine features often in discussions about the deskilling attribute of technology in the First Industrial Revolution. It is argued to have enabled a substitution of skilled handicraft workers with unskilled workers (Goldin and

Katz, 1998). At first sight, this notion seems to carry some sense. The first reason is that the production of goods through craftsmanship required a great deal of work experience. Adolescents were apprenticed to master craftsmen over many years to acquire the skills necessary to become a master and be able to trade skills to produce goods and services. This was a lengthy process often supervised and regulated under the guild system. In contrast, some menial tasks in a factory could be learned within a few days. The contrasting images of the refined skills of master craftsmen on the one hand and the drudgery of the factory on the other have perpetuated the deskilling notion of the industrial revolution.

The second reason is the very design of factories before the deployment of small electric motors. A factory powered by a single, centrally located prime mover, be it a steam engine or a water wheel, required a complex web of iron and steel line shafts as well as pulleys and leather belts, sometimes extending over several floors and even buildings (Devine, 1983). The entire system was in motion when the engine was running, and no matter how many machines were being operated by workers. In large factories, this complex system of moving parts required time-consuming maintenance, such as filling the drip oilers or repeatedly tightening the belts that otherwise would become too loose. Yet we have not seen any evidence that this labor service was commonly done by women and minors. Rather, it is more likely that the installation and maintenance work required skilled technicians and machine engineers. Atack et al. (2004) for example, show that mechanization is associated with increasing wages, implying that more skilled workers were employed.

On a final note: can we characterize female workers as unskilled because of their wage disadvantage relative to their male peers? The answer to this question has implications for the debate about deskilling, which often uses wages as a proxy for skills. We are inclined to respond in the negative, leaning towards an argument that is twofold. First, to equate the low wage level of female workers with inferior labor productivity, or unskilled labor services, is tautological: output is measured by value added, which equals the sum of wages and profits, the proportions of which vary by industry and establishment. Venturing to suggest that low wages are explained by low labor productivity is like saying that the low wages of female workers depend on their low wages, which is clearly nonsensical. Second, the cost of female workers was probably exogenously determined, deeply ingrained in the pre-industrial society, and carried over to the industrial society. This cost-benefit made them highly attractive for tasks that either did not require physical strength or required skills that women had previously acquired, which we argued was the case in the textile and garment industry. We should therefore eschew the notion that female workers' inferior pecuniary gains should confer on them the label of unskilled.

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Notas

1. Women were on average less productive than men, which have been due to their lower average skills (Burnette, 2015). For unskilled tasks, the productivity differentials may have been lower, and therefore women with lower wages could have become an attractive option as saving on labor cost. However, with the data used in this paper, we cannot reliably estimate labor productivity differences.
2. The share of children in the labor force should be considered lower bound, as the actual figure could be underreported (Olsson 1995). In Sweden, attempts to regulate child labour were initiated in the mid-1850s but failed because of resistance from vested interests in manufacturing. The issue was raised again in the mid-1870s, resulting in the appointment of a committee tasked with preparing a regulation covering manufacturing and handicraft that came into force in 1881. A much more comprehensive law was passed in 1900, banning the use of child labour across all sectors of the economy (Olsson, 1995).
3. Karlsson (1995) does find of working women surveyed in Stockholm in the late nineteenth century (N = 3200), 14 percent were married, and 7 percent widowed, and as many as 22 percent had children.
4. The survey included the following activities: manufacturing, sawmills, mining, handicraft, agriculture, and home-based craft production. When we refer to manufacturing, we also include sawmills and mining.
5. The reference to the published version of the enquiry: Tullkommittén (1882). Tullkommitténs underdåniga betänkande af år 1882. Bihang, Statistiska tabeller öfver Sveriges industriela utveckling åren 1860–1879. Stockholm. The reference to the primary returns: Archive: Tullkommittén 1876. Sammandrag av svar och frågeformulär; vol. 3–6. Ref. code: SE/RA/310791
6. Tabulated industrial statistics (BiSOS D) reports 202,293 industrial workers and 8,812 factories, giving an average of 22.9 workers per factory.
7. This may possibly leave out small, mechanized establishments. However, if our sample of small establishments is representative of all small establishments at the time in Sweden, the share of steam engine use was relatively low. As we report later in the paper, less than nine percent of small establishments reported using steam engines. Berger and Ostermeyer (2024) show that the average size of a mechanized establishment was 44 workers, suggesting that size and mechanization are positively correlated.
8. Specifically, we use a Stata package developed by Mize (2022).
9. The industrial classification used by Swedish statistics includes match factories into chemical-technical (*kemisk-teknisk*) industry due to the chemicals such as phosphorus used in the production process.
10. As illustrated at the factory, which is currently a museum in Jönköping, Sweden: https://matchmuseum.jonkoping.se/