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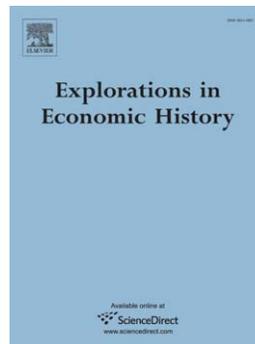
Deskilling and decline in skill premium during the age of sail: Swedish and Finnish seamen, 1751–1913

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Deskilling and Decline in Skill Premium during the Age of Sail: Swedish and Finnish Seamen, 1751–1913

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Abstract:

The study examines the evolution of skill premium and share at industry level in shipping during the age of sail. We argue that the period from the 1750s to the 1910s represented deskilling for the seamen working on sailing ships. The growth of international trade and shipping during the first era of globalization increased the overall demand for sailors but decreased the relative demand for skilled labor in favor of less skilled ones. This deskilling was associated with a decline in wage inequality, as the premium for high skilled seamen fell relative to mean wages in the shipping industry. The decline in skill premium may have facilitated the growth of trade and shipping, as the relative costs of transport declined. This in turn might have hastened the first era of globalization.

JEL classification: J31, N73, N74, N33, N34

Keywords: occupations; skill premium; deskilling, technological change; maritime history

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1. Introduction

Shipping was (and still is) an international activity in which the wage costs play an important role. Numerous studies have shown rising labor productivity in shipping (e.g. Lucassen and Unger, 2011; van Zanden and van Tielhof, 2009; van Tielhof and van Zanden, 2011).¹ Recently, van Lottum and van Zanden (2014) have illustrated that a sharp increase in man-ton labor productivity occurred during the eighteenth century. These increases were more common on ships with more literate and numerate crews. These recent findings appear to contradict a widely held view that sailors did not need any specialized skills, and that the majority of the men were young and rather inexperienced. (Alexander, 1980; Kaukiainen, 1997; Kindleberger, 1992; Sager, 1989; Vickers and Walsh, 1999)

This article analyzes skill shares and premia of sailors working on sailing ships between the middle of the eighteenth century and the First World War. With a rich dataset of seamen from various port towns in Sweden and Finland, we argue that the period witnessed deskilling and a decline in wage premia. In general, skill premia reflect both the supply and demand of skills in the eighteenth and nineteenth centuries, and thus one must take into account the increasingly globalized nature of the labor markets in shipping. Skill-biased technological changes, especially the change from sail to steam, reinforced the role of capital deepening in trade. Although this study provides evidence of changes in the labor composition and skill-specific wages using historical contract data on a specific industry, the findings can be linked to research on the overall evolution of skill premia in the long run. Based on the typology of high-, medium- and low-skilled maritime labor, we argue that the growth of international trade and shipping increased the aggregate demand for seamen, while also decreasing the relative demand for skilled labor. This development was associated with a decline in wage inequality, as the premium for high-skilled seamen fell. Moreover, the declining labor share, with an increasing relative wage of the middle-skill group implies that the supply decreased more than its relative demand. Finally, the rising labor share, along with increasing relative wage throughout the period, suggests that the demand for low-skill labor increased more than its relative supply.

The wage dispersion and changes in skill premia have recently been analyzed in the context of the change from sail to steam and the rise of Atlantic trade in the nineteenth century. (van Lottum and Poulsen, 2011; van Lottum and van Zanden, 2014) Thompson (2003), Chin et al. (2006), and Hynninen et al. (2013) argue that technological change increased wage dispersion among sailors. Chin et al. posit that the change created demand for new skilled occupations and had a deskilling effect overall. However, neither Thompson (2003), Chin et al. (2006), nor Hynninen et al. (2013) focus on the long-run distribution of wages or the development of the skill premium in shipping prior to the mid-nineteenth century.

The period from the mid-1750s to the First World War featured both the peak and decline of shipping by sail (Harlaftis et al., 2012). The first era of globalization increased the demand for shipping capacity, especially after the Napoleonic wars, but to a certain extent even before. As noted by North (1968), Harley (1971), and Kaukiainen (2009, 2012), the freight rates had been declining since the late eighteenth century. Trade costs in the late nineteenth century decreased

¹ For “classic” studies on this, see e.g., Davis, 1962; Harley, 1988; North, 1968.

as well, which accelerated globalization in this period (Jacks et al., 2008, 2010, 2011). The demand for maritime labor increased, creating larger international markets for sailors. The average wage costs declined as the productivity in shipping increased.

Both Sweden and Finland were typical late industrializing countries engaged in domestic and international shipping; both were dependent on exports and imports carried by sailing vessels, yet these ships – especially the large, ocean-going ones – were also used in international freight-carrying trades (Alanen, 1957; Högberg, 1969; Kaukiainen, 1993; Magnusson, 2000). Subsequently, the shipping tonnage of Swedish towns more than doubled between 1795 and 1850. In Finland, the increase was almost five fold. The Swedish tonnage increased even more rapidly, over nine fold, between 1850 and 1910, whereas the Finnish tonnage expanded only modestly at the same time. (Swedish Official Statistics, 1880, 367; 1910, VII)² The number of merchant seamen in Swedish towns (without Finland) was 5,500 in 1795, c. 8,000 in 1850, and increased to 27,500 by 1910. (Swedish Official Statistics 1850; 1910). Both Swedish and Finnish merchant tonnages per capita were among the largest ones in the world during the 1870s (Kaukiainen, 1991). The Swedish share was 2.5-3.0 percent of the world's total merchant fleet in the late nineteenth century and, therefore, substantially more than its share of the world GDP (circa 0.6 percent) and population (0.3 percent) (Fritz, 1980; Maddison, 2001).

Steam passed sail slowly in all seafaring nations during the late nineteenth century (Graham, 1956). As previous studies have suggested, technological changes – although incremental ones – had already occurred in shipping by sail before and during this slow leap from sail to steam and from wood to iron (North, 1958, 1968; Ojala, 1997). As Mokyr (1990) has argued, sailing vessels were completely redesigned between 1820 and 1860. The technological development during the age of sail may also have affected the demand for skills and, therefore, the skill-specific wages of maritime labor. As previous studies have shown, there was a depreciation of skill on merchant sailing ships from the eighteenth century onwards that was related to the simplification of rigging and ship types, increase in ship size, standardization of work processes, and increased security at sea. Moreover, the improvements in ports reduced turn-around times and the need for extra men on-board for loading and unloading (Frykman, 2014; North, 1968; Ojala, 1997; Rediker, 1987; Sager, 1989). The increase in Swedish and Finnish tonnages was mainly due to an increase in the number of sailing vessels until the 1880s. Thereafter, steamers represented an increasing share of the ships, which ultimately replaced sail in Sweden in 1899 and in Finland during the 1920s. By 1907, the steam tonnage was double the size of the sailing tonnage in the Swedish merchant fleet (Layton 1981, 245; Swedish Official Statistics 1880, 1910; Fritz, 1980; Kaukiainen, 1980, 1991). It was not until 1906 that more men were enrolled on steamers than on sailing ships in our data.

In the following, we will first discuss the earlier studies on skill premia and skill shares in different types of industries. Then, we will elaborate on the data we used in this study. Section 4 describes the occupational groups, and Section 5 features analysis of the changes in the skill shares. In Section 6, we focus on changes in the skill premium. Finally, we will conclude with our main findings and speculate on future research challenges.

² See also: Swedish National Archives, Commercial Collegium's Annual Reports on Shipping, 1766-1807; Finnish Official Statistics; The Finnish National Archives: Archives of the Finnish Senate, Annual Reports on Shipping, 1815-1860.

2. Perspectives on the Study of Skill Premium and Share

Previous studies have shown that the share of skilled and unskilled workers in society and their wage differences has an impact on the aggregate economic growth rates. van Zanden (2009) has shown that European skill premium declined sharply in the fifteenth century and remained low compared to other parts of the world. Therefore, the decline in the skill premium aided long-run European economic growth prior to the industrial revolutions. Similarly, De Pleijt and Weisdorf (2016) have recently found evidence of an increase in the number of high-skilled and unskilled workers at the cost of semi-skilled ones in English data from the mid-sixteenth to mid-nineteenth century. On the other hand, several studies have tried to find correlations between high-skilled labor (education) and economic growth; namely, whether an investment in human capital pays off for a society or individual is a classic question for studies that analyze skill premium (Allen, 2009; Mokyr, 2002). At the industry level, skill shares and premia are studied especially during periods of disruptive technological changes. For example, the US case has been linked to skill-biased technological change, partially arising from the IT revolution (Autor et al., 2008). Another source of debate pertains to the role played by education in either mitigating or exacerbating the inequality between groups, and whether the choice over schooling is an exogenous or endogenous process (Acemoglu, 2002b; Chen, 2008).

Most of the analyses of skill shares and premia cover a relatively short time period, typically from the Second World War to the present. Studies focusing on periods prior to the First World War, especially during or before early industrialization, are rare (See, e.g., Acemoglu, 2002a, Acemoglu and Lyle, 2004, Piketty and Saez, 2003). Nevertheless, there is a growing number of studies analyzing the demand for skilled and unskilled workers in early modern England that try to explain the change from artisan workshops to factory production (For a review, see De Pleijt and Weisdorf, 2016). The studies concentrating on the period from the 1850s onward typically do not take into account the changes brought on by the nineteenth century globalization, and often, the data only cover the manufacturing sector or urban skilled (or unskilled) workers in a particular sector. These studies emphasize skill biases over crucial watershed moments such as various wars and crises, as well as the impacts of the industrial revolutions (Atack et al., 2004; Card and DiNardo, 2002; Goldin and Margo, 1992a, 1992b; Jones and Engerman, 1996; Katz and Autor, 1999).

Typically, skill intensity is analyzed using models such as the Goldin-Katz model, wherein establishment size, capital intensity, and energy use are the main explanatory variables. According to Atack et al. (2004), wages and skill intensity were increasing with capital intensity and the use of steam in the nineteenth century in the United States, with wages decreasing along with establishment size. Thus, in manufacturing, the labor force became deskilled (Atack et al., 2004). However, as observed by Betrán and Pons (2004), the period from 1870 to 1930 embodied different outcomes for different countries: wage inequality (=ratio of wages of skilled to wages of unskilled workers) increased in the United States and Spain prior to the First World War and decreased in France, Italy, and the UK. Until 1930, wage inequality increased only in Italy and Spain. Furthermore, globalization (trade and migration), along with technological and structural changes seemed to be the most important variables explaining the skill premium.

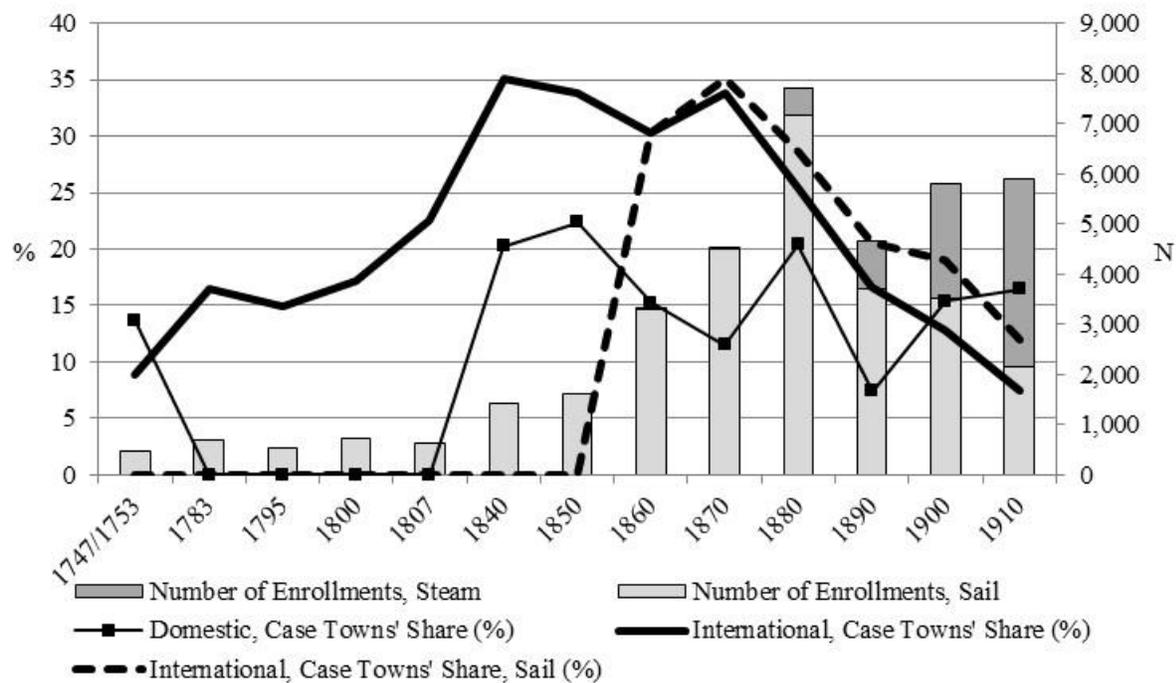
To study skill premia and shares, job types are usually divided into sub-categories, which is also what we have done in this study. The theory of technology-based polarization has focused on shifts in employment by three job types: high-skilled abstract jobs, middle-skilled routine jobs, and unskilled manual jobs. (see, e.g., Autor et al., 2003; Autor et al., 2008; Goos and Manning, 2007; van Reenen, 2011; Goos et al., 2014) This view is referred to as the routinization hypothesis since the model by Autor et al. (2003) suggests that technological advances can be both deskilling and skill-enhancing. This occurs if technological changes treat tasks non-monotonically, i.e., by decreasing the demand for routine tasks and increasing the demand for non-routine tasks. If the supply of labor is fixed, this also leads to changes in relative wages: non-routine jobs that are either at the top or at the bottom of the wage distribution both gain a wage premium in relation to tasks in the middle of the wage distribution. Hynninen et al. (2013) have argued that the technology-based polarization indeed occurred when steam slowly replaced sail in international shipping, leading to both skilling and deskilling.

3. Data Considerations

We focus on analyzing the skill shares and premia of Swedish and Finnish seamen by using the Seamen's House data from 1751 to 1913. The Seamen's House was a formal, public institution introduced in Sweden in 1748, primarily to collect data on sailors available for military use in the event of war. Furthermore, according to Swedish (and Finnish) law, the hiring of men on board merchant vessels had to be carried out at Seamen's Houses. Therefore, all seamen were obligated to register themselves at a Seamen's House to get hired. The Seamen's Houses are sometimes considered among the first social security organizations in Sweden and Finland because they could offer small benefits to retired seamen and to the families of dead or deserted sailors. Funding for these services by the Seamen's Houses consisted mainly of the official payments by seamen and ship owners as well as donations (Frigren, 2016; Hoffman, 1974; Kaukiainen, 1997, 1998; Lybeck, 2012). As Finland was part of Sweden until 1809, this institution was introduced in Finland as well, and it remained in force throughout the nineteenth century in a similar vein as in the neighboring country. Thus, the data from these two countries are very similar and can be used as a joint sample in this study.

The Seamen's Houses kept various kinds of documents that contained data on individual sailors, and they reported annually to the local, provincial, and national authorities. These data are rich in detail and, according to previous studies, quite reliable. (Kaukiainen, 1997; 1998; Lybeck, 2012) In this article, we have used the Seamen's House enrolment records on individual sailors that offer information such as name, date and place of birth, age, marital status, salary, occupation on board, date of hire and return, specifications about the ship the man was hired to work on (name, tonnage, type, and captain), and the likely destination of the ship and information about the voyage, including possible deaths, sicknesses, and desertions. The number of individual sailors is lower than the number of enrolments as the same man usually was hired several times during his career. The men were hired for the duration of the voyage until the latter part of the nineteenth century; due to having to carry certain types of freight, the length of the voyage could be anything from few months to several years.

Figure 1. The Case Towns' Share of the Total Swedish Towns' Tonnage in Foreign and Domestic Trade (Left Axis, Percent) and the Number of Case Towns' Enrollments on Sail and Steam Vessels (Right Axis, N), in Selected Years (1747/1753-1910)



Sources: Almqvist, 1949; Swedish Official Statistics, Shipping, 1838-1910; Swedish National Archives, Archives of the Board of Trade, Annual Reports on Shipping, 1766-1807; Finnish Official Statistics, 1858-1914; Finnish National Archives, Archives of the Finnish Senate, Annual Reports on Shipping and Trade, 1815-1860.

Note: The tonnage owned by rural peasants in the coastal areas is not included in the figures. This so-called peasant tonnage (especially sailing tonnage) increased during the latter part of the nineteenth century. Kokkola is included in the Swedish tonnage before 1809.

In this study, we have used the Seamen's House database compiled by the Swedish National Archives' project that combined data from nine Swedish and one Finnish Seamen's House in this period. (See Map 1)³ The Seamen's House database covers the period from 1752 to 1950 and includes 649,627 hiring cases from Sweden (and Finland⁴), of which 380,551 (59 percent) were on sailing vessels. (See Table 1) The annual number of observations (i.e., the enrolments of individual men on ships) equals 500-1,000 from the mid-eighteenth century up to 1810s, approximately 1,000-2,000 from 1810s to 1850s, 2,000-4,000 during the 1850s and 1860s, and 4,000-6,000 during the end of the nineteenth century. There is a peak at over 8,000 annual cases in the first years of 1880s, and a decline to below 4,000 during the early years of the 1900s. (Figure 1) In this study, we used data up to 1913 because the First World War and steam ships profoundly changed shipping. Thus, the total number of enrolments on sailing ships from the period 1751-1913 comprised 344,790 men; of these, we have sufficient data to calculate wage premium for 158,981 enrolments.

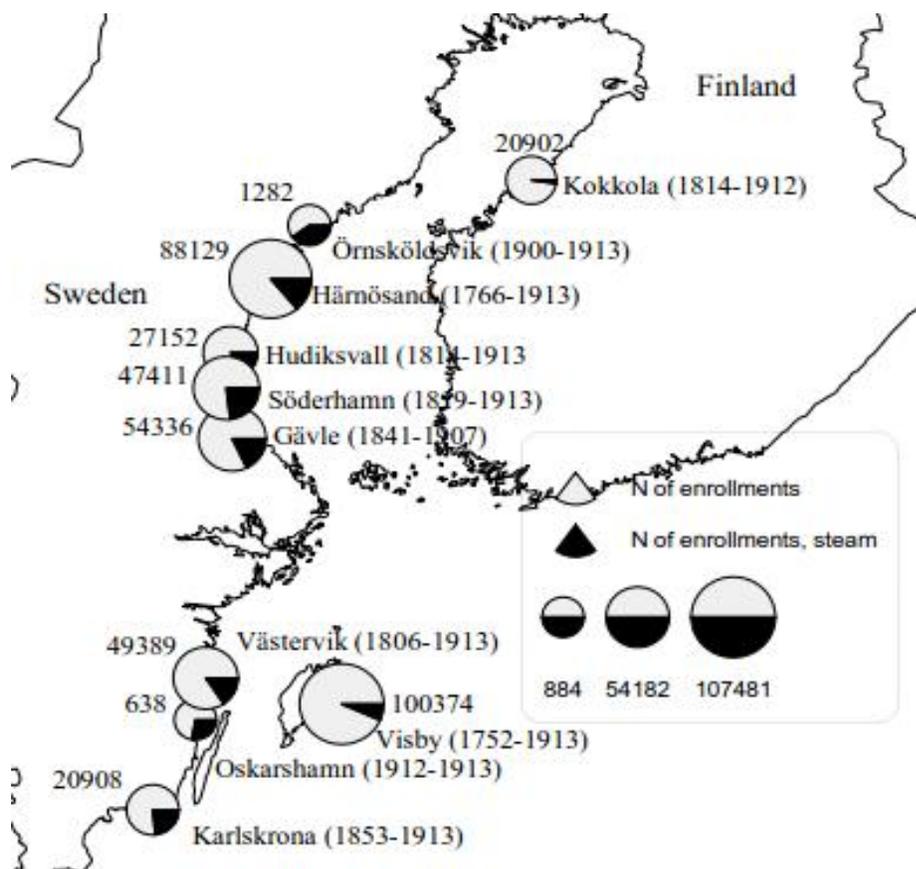
³ The database is available on the internet at: <https://sok.riksarkivet.se/sjomanshus>.

⁴ The share of Finnish men that were living in Finland at the time of hiring was four percent.

The database was originally compiled for genealogical use, i.e., in as original form as possible. Thus, the original data are exact but also confusing at times. For example, the occupational categories, monetary units used, ship types and tonnages, and payment systems were not necessarily indicated clearly. For our purposes, we have modified the database by grouping the various different occupational names (described in detail below), used only wages paid in Swedish *kronas* for the premium calculations⁵, and converted all the wages into a monthly basis (in original data one can find also daily, annual, and voyage-based wages). However, the Seamen's House data do not include all the incomes the sailors received while serving onboard the ships. Namely, food and accommodation were part of the compensation that the men got. In this article we concentrated only on the paid salaries discerned from the data, as it is difficult to estimate the cost of these other types of compensation. (on estimations of food costs see: Ahlfors, 1971; Davis, 1962) Even classifying the ships as sail or steam ships was complicated, as the database features 691 different ship types in total. We classified ships with an indication of steam or motor in the ship type name as steam or fuel-powered vessels. This categorization is admittedly rough and excludes certain steam powered sailing vessels (like three-mast steam schooners); thus, we concentrated on vessels that were clearly *only* powered by sails. Furthermore, we excluded all ships that had auxiliary engines. After applying these limitations, 390 different ship types remained. Furthermore, obvious outliers (like typing errors) were removed from the data.

⁵ This means that we could not use the Finnish data for the wage premium analysis, but we can use the Finnish data for the wage share analysis in this article.

Map 1. The Number of Enrollments on Sail and Steam Ships in the Case Towns (Years of Data Coverage in Parenthesis), 1752 - 1913



Source: The Seamen's House database (www.svar.ra.se) **Note:** modern borders were used in the map.

During the nineteenth and early twentieth century, up to 85 to 95 percent of the tonnage in the nine Swedish case towns was engaged in international trade. The share of the case towns' tonnage of the aggregate Swedish international trade tonnage was 15 to 20 percent during the eighteenth century. This was due to the shipping restrictions at the time, as only a few towns were allowed to participate in international trade and shipping. Of the case towns, Visby, Gävle, Karlskrona, and Västervik already had these rights during the mid-eighteenth century (Almqvist, 1949), and from 1765 onwards, Kokkola and Härnösand also had them. The representativeness of the eighteenth century data is weakened by the fact that only data from Visby (from 1752) and Härnösand (from 1766) is contained in the database, and together, these towns made up around four percent of the Swedish tonnage engaged in international trade. However, Visby's shipping capacity was the third largest in Sweden during the mid-eighteenth century, right after Stockholm and Gothenburg (Högberg, 1969, p. 39).

The data are more accurate from the early nineteenth century onwards because more towns are included in the dataset (Västervik, 1806, Kokkola and Hudiksvall, 1814, and Söderhamn, 1819). The nine towns made up around one third of the Swedish tonnage used in international trade from the 1840s to 1870s and, at most, around one fifth of domestic tonnage around the same time (Figure 1). Gävle appears in the dataset in 1841. Gävle was the third largest shipping town in

Sweden during the nineteenth century, and in certain years, it was the second biggest as its tonnage bypassed Gothenburg or Stockholm. The case towns lost out in terms of their relative share again during the late nineteenth and early twentieth centuries as they could not compete with the major technological change from sail to steam; however, their share of the sailing tonnage was still quite high, although the sail share also declined to one fifth of the Swedish total sail tonnage by the turn of the century. However, the two small towns, Örnsköldsvik and Oskarshamn, were especially active in acquiring steam tonnage during the turn of the twentieth century. (Map 1; Layton, 1981) The Finnish data are based on Kokkola and counted in the Swedish figures up to 1808 when Finland was a part of Sweden. During the early nineteenth century, Kokkola was the most important shipping town in Finland with approximately 10 to 18 percent share of the Finnish tonnage from the 1810s to the 1830s. Thereafter, its share declined to below ten percent.⁶

The eighteenth century Swedish (and Finnish) shipping was concentrated onto two major port towns - Stockholm and Gothenburg - that are included in the Seamen's House database.⁷ Together, these towns made up to 40-50 percent of the Swedish international shipping. In 1747, before the staple system was dissolved, their combined share was up to 60 percent. The share of Stockholm and Gothenburg's tonnage declined during the early nineteenth century to below 40 percent and, in sailing vessels during the latter part of the century, below 30 percent. Stockholm and Gothenburg were, however, forerunners in steam technology. Their relative share of steam tonnage was over half throughout the late nineteenth century and the first years of the twentieth century. (Swedish Official Statistics, 1900, 1910).

The data we use, despite certain limitations pertaining especially to eighteenth century shipping, are thus representative of Swedish and Finnish shipping during the age of sail. Furthermore, as the case towns were situated all along the Swedish (and Finnish) Baltic coastline, the data are even more comprehensive. (Map 1). In fact, the data can be used, at least to a certain extent, to analyze Northern European shipping in general, as the ships in the case towns were mostly used in international trade. The Swedish and Finnish ships were also widely used in the international freight carrying trade. This was due to the competitiveness of the Nordic vessels: they were wood-hulled, mainly constructed from cheap domestic raw materials at the local shipyards and with low labor costs. In addition, they were relatively large (especially those ships designed to carry low-weight tar and timber cargoes), and the running costs were low due to modest wages when compared, for example, to the United Kingdom or the Netherlands (Press, 1981; North, 1997; Kaukiainen, 1991; Ojala et al., 2013; Ojala et al., 2014). Thus, the low labor costs were among the competitive advantages enjoyed by Nordic shipping at the time.

The ships were also used in domestic coastal trade, with an approximately 10 to 20 percent share of the total Swedish coastal shipping throughout the period. (Figure 1) Quite naturally, the ships in international commerce were larger, and the fact that ice covered the sea during the winter months made coastal shipping possible only for the short summer season. Moreover, coastal

⁶ From the 1880s on, shipping in Kokkola declined rapidly.

⁷ The sailors were hired mainly from the same town as the Seamen's House, yet occasionally men were hired from other Swedish and Finnish towns, and even from abroad. Therefore the database includes 14,860 enrolments of men on sailing ships in 1752-1913 that belonged either to Stockholm's or Gothenburg's Seamen's House.

shipping was traditionally carried out by smaller peasant vessels (Kaukiainen, 2002; Layton, 1981).

As described above, the original Seamen's House data, the case towns used, and the database do have certain limitations that should be considered when interpreting the outcomes of our research. We are confident, however, that the Swedish (and Finnish) Seamen's House enrolment records and the database provide sufficient data to study the skill shares and skill premia in Swedish and Finnish shipping, and, to some extent, to generalize about broader patterns in the North European context.⁸ Moreover, the number of cases in our dataset is high even after the limitations were applied – much higher, for example, than both in the widely used Prize Paper database (van Lottum and van Zanden, 2014), Ships and Seafarers of Atlantic Canada database (used e.g., by Chin et al., 2006; Sager, 1989; Thompson, 2003), or in the Cambridge Group's Family Reconstitution Data (e.g., Wrigley, 1997; De Pleijt and Weisdorf, 2016).

4. Occupational Groups in Shipping

There was quite a bit of variety among maritime occupations during the period we analyzed. As we indicated, we can distinguish 1,068 different occupational categories in the database. In this study, we examined the 16 occupational groupings that were created from those categories. Thereafter, we further aggregated these 16 categories into six, and then again into three skill-based groups. The six occupational groups were captains (with two subcategories, one engaged in deep sea and other in short distance shipping), mates (with three subcategories), boatswains and carpenters, able-bodied sailors (AB), ordinary seamen (with two categories, OS), and lastly, deck boys (including cooks and cabin boys). A similar type of classification was also used by van Lottum and van Zanden (2014). Table 1 summarizes the number of men in the six occupational groups. The largest groups were the ordinary sailors (one third of all hired men) and, respectively, able-bodied sailors (one fifth of the total). Moreover, the category "other" includes unclassified men, most of them most likely ABs and OSs as well. Following the lead of many scholars who have studied skill premium (e.g., Chin et al., 2006; Goldin and Katz, 1996), we divided these six occupations further into three skill groups: high-skilled abstract jobs, middle-skilled routine jobs, and unskilled manual jobs (see e.g., Autor et al., 2003, 2008; Goos and Manning, 2007; van Reenen 2011).

⁸ For the purposes of crosschecking the quality of the database, we had the possibility of using another database, compiled by us from the original archives, including the Seamen's House data from one town that can also be found in database (with ca. 20,000 hirings). This comparison showed that these two databases were a match and, thus, quite reliable.

Table 1. Number of Men in Different Occupation Categories in the Dataset, 1752-1913

	<i>Captain</i>	<i>Mate</i>	<i>Boatswain Carpenter</i>	<i>AB</i>	<i>OS</i>	<i>Cook, Boy</i>	<i>Together</i>	<i>Others</i>	<i>All men</i>
1752-1790	3,469	524	4,833	8,815	1,280	4,726	23,647	594	24,241
1791-1805	1,274	377	1,654	3,165	1,459	2,017	9,946	231	10,177
1806-1820	1,772	835	2,348	3,554	3,474	2,584	14,567	155	14,722
1821-1835	2,113	1,214	2,791	4,242	4,691	2,878	17,929	323	18,252
1836-1850	2,707	1,816	3,089	3,993	6,920	3,788	22,313	238	22,551
1851-1865	4,859	4,436	5,415	7,544	14,628	6,273	43,155	977	44,132
1866-1880	7,485	9,219	7,823	12,245	29,633	8,560	74,965	2,738	77,703
1881-1895	7,334	9,826	6,034	12,440	30,223	7,600	73,457	2,949	76,406
1896-1913	5,920	6,233	5,556	6,538	22,245	54,85	51,977	4,629	56,606
Sail to 1913	36,933	34,480	39,543	62,536	114,553	43,911	331,956	12,834	344,790
Data to 1950	62,990	47,997	53,184	91,245	138,939	64,169	458,524	191,103	649,627

Sources: see Figure 1.

Note: “Sail to 1913” includes sailing vessels only, while “Data to 1950” includes all ships (also steamers and vessels with diesel engines) from 1752 to 1950 in the Seamen’s house database. Category “Others” includes unclassified occupations and occupations that were not included in the categories above.

Additionally, in the merchant shipping industry during the age of sail the high-skill group consisted of trained and educated men performing abstract tasks on board. Officers on board, namely, ship captains and mates, were included in this group. Captains were the most experienced sailors, had some degree of formal education and were usually also the oldest men on board. According to Swedish law (1748, 1765), ship captains involved in foreign shipping had to pass an examination with the local magistrate to prove their knowledge of navigation. Moreover, the captains usually also had knowledge of bookkeeping and extensive language skills. In addition, captains had to have practical experience gained by working on board ships. From the late eighteenth century onwards, most captains also received some formal education at navigational schools (Kaukiainen, 1994). Captains were responsible not only for the ship and navigation but also the various business tasks on the ship. With the slow and unreliable communication channels as a hindrance, the captain was the representative of the ship owner in foreign ports, negotiated with shipping agencies over freights, sold and bought cargoes with the ship’s monetary reserves, and could even sell the entire ship if necessary (Kaukiainen, 1994; van Lottum and van Zanden, 2014). The captain also received the highest salary of the crew, and he typically also received a share of the profit from the voyage (so-called *caplake*, which usually was around five percent of the freight earnings). This profit was not included in the Seaman’s House data, and neither was the possible cargo the captain might transport in his own cabin at his own expense (Davis, 1962; Kindleberger, 1992). Therefore, these extra incomes were not included in this study as part of the wage premium. The average age of captains was approximately 40, and only the most experienced boatswains could match the experience and age of captains.

The mates were usually ranked in two or three categories. Of them, the first mate was the most experienced one, usually a man that had already been educated to be a captain but was lacking in practical experience (Kaukiainen, 1994). At the other end of spectrum were the third mates, or constables as they were called in Sweden. They were young men who had just started their

education to become officers in the merchant fleet. These constables usually received lower salaries than the most experienced seamen, such as boatswains and carpenters.

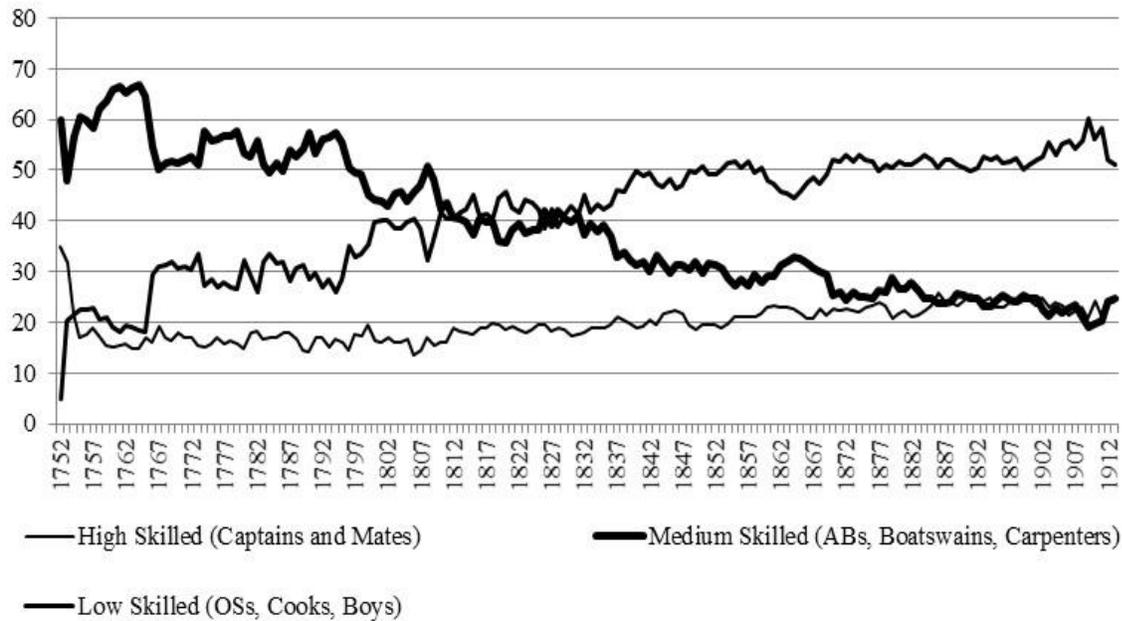
The middle-skill group consisted of men performing manual tasks, requiring intermediate skills. This second group included boatswains (bosuns), carpenters, and able-bodied (in Swedish: *matros*) seamen. These were experienced men with little or no education. Instead, they had a lot of practical training and experience on board. As the naming and classification practices differed somewhat in different countries, we have used the term “able-bodied” (AB) to describe the entire group. This AB group performed mainly routine tasks that required experience and certain artisan-type skills. Boatswains and carpenters were, on average, older and better paid than other sailors (besides captains and most experienced mates).

The “low-skill” group consisted of three main groups: ordinary sailors, deck/cabin boys, and cooks. Ordinary sailors were a compilation of young and inexperienced men performing physical tasks that required little skill on board. There is a plethora of Swedish terms that apply to this group (like *lättmatros* and *jungman*). We also included the ship’s cooks in this group, as they also performed other work on the ship and were usually the most inexperienced and low-skilled men on board (both in terms of cooking and sailing). Furthermore, the deck and cabin boys were included in this group. This latter group, though, was quite diverse: while the deck boys typically performed physical tasks along with the ordinary crew, the cabin boys were in many cases either sons of captains or even the owners and were picking up practical skills that would be needed in their possible future line of work as officers. What these two groups had in common was young age (usually between ten and fifteen) and low salary (if salary was paid at all).

5. Deskilling of Maritime Labor

The globalization and trade expansion of the nineteenth century had substantial impacts on the demand for specific types of skills. As we show in Figure 2, by separating the three occupational groups (high, middle, and low-skill) in our dataset, there was a substantial shift from middle-skilled seamen (ABs, boatswains and carpenters) on sail ships to low-skilled seamen (OSs, cooks, and boys) throughout the period. The period was predominantly one of deskilling, with larger vessels engaged in carrying international freights, for which the demand was increasing rapidly, needing more hands on board to perform manual tasks. This shift slowed down in the late nineteenth century. Thus, the change in the occupational structure of the Nordic shipping industry reflected a similar change that van Zanden reports for construction workers (van Zanden, 2009). A modest increase in the share of captains and mates over the period meant that larger vessels could hire up to three mates, whereas small coastal vessels could perform perfectly fine with just one (or none). Again, this change in the shares reflects a structural change in Swedish and Finnish shipping during this period.

Figure 2. Hired Men in the Three Skill-Based Occupation Groups, Percent Share, 1752-1913 (N=331,956)



Source: see Figure 1 and text.

Note: The data included 12,834 (3.7 percent) men in total hired on sailing vessels during the period that either did not fit into the three categories or their occupation was unclear. There were only a handful of women hired aboard the sailing ships.

To get a more precise picture of the skill shares between the groups, we focused on those mariners that we had information on wages and duration of voyage. This decreased the number of observations from 158,981 to 124,713. Table 2 illustrates the skill shares by two measures, the number of contracts and the number of contracts weighted by the average duration of a contract, thus providing a more detailed picture of the total use of the labor input.⁹ As usual, there was a trade-off: we lost more than 35,000 observations by using the weighted data. We chose to report the data as fifteen-year averages to display the patterns more clearly. As shown in Table 2, weighting with the duration of contracts did not change the overall picture. The major discrepancy between the measures related to the very last period (1896 to 1913), when the proportion of high-skilled mariners increased at the expense of medium-skilled mariners. The discrepancy stems from an increase in the number of small coastal vessels. Additionally, the share of high-skilled sailors was somewhat higher than in Figure 2. That implies that the wages were better represented in the data for the high-skilled group than proportionally for the medium- or low-skilled group. However, trends for the medium- and low-skilled groups were similar with both measurements, and with the high-skilled seamen, any of the differences appeared to be related to the nature of the data.

⁹ If contract duration varies systematically with vessel size (e.g., they were longer on bigger vessels) and vessel size is correlated with the skill structure on board (e.g., bigger vessel use more unskilled labor), the unweighted data yield biased estimates on the skill shares.

The evolution of the skill shares implied by this more precise data painted a similar pattern as in Figure 2 above: the deskilling of maritime labor on board sailing ships from the eighteenth to the twentieth century. This can be discerned from the fact that either with or without the weighting, the share of medium-skilled group diminished substantially, from circa half in the 1750s to one-fourth by the late nineteenth century (Table 2).

Table 2. Skill-group Shares (%) in the Sub-sample, 1756-1913: Estimates based on the proportion of contracts (N=158,981) and contracts weighted by their duration (N=124,713)

<i>Years</i>	<i>High-skilled whole/weighted</i>	<i>Medium-skilled whole/weighted</i>	<i>Low-skilled whole/weighted</i>
1756-1790	32.3 / 32.7	50.0 / 49.9	17.7 / 17.4
1791-1805	31.9 / 34.9	45.4 / 44.3	22.7 / 20.8
1806-1820	33.8 / 36.6	35.6 / 32.9	30.6 / 30.6
1821-1835	34.1 / 37.5	34.5 / 32.4	31.4 / 30.1
1836-1850	30.7 / 33.6	30.8 / 29.4	38.5 / 36.9
1851-1865	26.9 / 27.2	26.0 / 25.8	47.1 / 47.0
1866-1880	26.1 / 27.4	24.8 / 24.2	49.1 / 48.4
1881-1895	28.7 / 31.7	23.5 / 22.7	47.8 / 45.5
1896-1913	36.1 / 28.2	14.4 / 23.8	49.5 / 48.0
Total	30.0 / 31.7	28.1 / 27.1	42.0 / 41.2

Sources: see Figure 1 and text.

There was no significant increase in the share of the high-skilled group up to the 1850s, as it remained at approximately one third of the hired men. Thereafter, the dataset grew considerably, which might explain the decline of the contracts in the high-skilled (mainly officers) group, as more ocean-going vessels with large crews were included in the data. Deskilling was most likely associated with a change in the typical size of the ship: the average size of sail-only vessels increased from approximately 60 to 200 tons over the period, mainly due to the rise in the proportions of three-masted ships. The increase in size had an effect on the demand for skills and the number of workers: larger vessels required fewer men per ton than the smaller ones, although larger ships needed proportionally more low-skilled men to perform the physical tasks onboard. This development can be interpreted as a technological change of sorts. The finding is in line with Atack et al. (2004) on U.S. manufacturing, who concluded that in the mid-1850s skill intensity decreased as the establishment size increased. Indeed, as seen in Table 2, by the 1860s, the share of the low-skilled group rose to almost half of all the enrolled sailors, whilst this share was 20 percent points lower a few decades earlier. The average size of Swedish and Finnish sailing ships rose 45 percent from late eighteenth century to early nineteenth century, and further, the average size more than doubled during the latter part of the nineteenth century. However, during the first years of the twentieth century the average size of sailing ships decreased, as steam ships started to replace large sailing vessels.¹⁰ As a consequence of the increase in ship

¹⁰ The number of sailing ships in the Seamen's House database for the period 1752-1913, with information on tonnage, is 32,761, corresponding to 288,878 enrolments of individual seamen. The average size of sailing vessels in 1752-1799 in the dataset was 64 net register tons, whereas in 1800-1849 it was c. 90 net tons, c. 200 net tons in

size, the average number of men on board rose from roughly six in the mid-nineteenth century to ten by the early twentieth century.

To provide a more robust, although tentative, view on the relationship between skill shares and vessel size, we employed regression analysis. Using the contract data, we calculated how the probability of seamen to be in a certain skill group was associated with vessel size, measured by its gross capacity. The linear probability regressions controlled for the seamen's age and vessel type. (Table 3) The results imply deskilling, similar to Table 2. An increase in vessel size was associated with a decline in the probability of working in a high-skill or medium-skill task. In the former group, the doubling of vessel size lowered the probability of a high-skill job by 6.0 percent, with the uncontrolled estimate being as high as 7.3 percent. For the latter group, the estimate was 2.3 percent. The low-skilled occupations seemed, in turn, to benefit from the increase in vessel capacity. The corresponding estimate was positive, by 11 percent.¹¹ These results also imply that the skill positions of seamen were strongly related with age and vessel type. This was particularly evident for the low- and high-skilled: the explanatory power of the regression model (R^2) was modest without the covariates.

Table 3. Association between Skill Group and Vessel Size: Results from the linear probability model, 1756-1913

Dependent variable	High-skilled		Medium-skilled		Low-skilled	
Log of Vessel Capacity	-0.073*** (0.001)	-0.060*** (0.001)	0.0001 (0.000)	-0.023*** (0.0076)	0.110*** (0.010)	0.110*** (0.018)
Covariates	No	Yes	No	Yes	No	Yes
R^2	0.0294	0.078	0.000	0.013	0.046	0.096
N	212,522	208,260	212,522	208,260	212,552	208,260

Sources: see Figure 1 and the text.

Notes: Covariates consisted of ship type (Barque, Brigg, Schooner, or Coastal) and age of seamen (years).

6. Trends in Skill Premium

This section augments the preceding analysis by examining wages by skill groups. Are the observations on deskilling consistent with changes in the relative wages between different skill groups - namely, skill premium between different groups? As van Lottum and van Zanden (2014) recently noted, the skill premium during the eighteenth century between different maritime occupations were about the same in various European countries. Information on relative wages and labor shares together provides evidence on the relative demand for and supply of labor in the industry in the long run.

1850-1899, and about 176 net tons in 1900-1913. As it is not possible to distinguish individual ships from the data, we used the hiring of captains as a proxy to calculate the average ship sizes.

¹¹ To test whether the emergence of steam vessels affected the findings, we estimated the model separately for the pre-1870 and post-1870 periods. The results were similar to those reported in Table 3. The results are available from the authors by request.

Wage differentials were noticeable across the skill groups, as Table 4 illustrates. The high-skill group earned about a 50 percent premium above the average wage. The premium for the high-skilled group was at its highest in the late eighteenth century, at approximately 80 percent. The Swedish and Finnish deep-sea shipping experienced rapid growth at the time and, thus, a growth in the demand for especially skilled officers, which might explain the high premium at the time. In addition, at least in Finnish coastal towns, there was a shortage not only of capable captains that were hired even from abroad but also capable sailors. (Högberg, 1969; Kaukiainen, 1993).

The high-skill premium declined considerably during the nineteenth century - with the exception of the mid-century. Wage inequality, measured by the ratio of wages of the skilled to wages of the unskilled workers decreased markedly over the period, from approximately 3.7 in the late 1700s and early 1800s to approximately 2.0 in the mid-1850s. The relative wages of medium-skilled workers also increased throughout the period. Thus, the wage premium between the groups diminished during the age of sail. Moreover, the changes in the wage premium stabilized around the 1850s. After that, the high-skilled sailors received circa 50 percent and the medium-skilled sailors approximately 20 percent higher salaries than the average, and the unskilled ones received 30 percent lower wages than the average.

Table 4. Relative Wages by Skill Group, 15-year Periods, 1756-1913 (Average=1, N=158,981, Standard Errors in Parentheses)

<i>Years</i>	<i>High-skilled</i>	<i>Medium-skilled</i>	<i>Low-skilled</i>	<i>N</i>
1756-1790	1.79 (0.09)	0.87 (0.11)	0.38 (0.09)	16,585
1791-1805	1.59 (0.09)	1.01 (0.06)	0.58 (0.05)	6,460
1806-1820	1.45 (0.09)	1.07 (0.04)	0.72 (0.06)	7,331
1821-1835	1.48 (0.03)	1.06 (0.03)	0.69 (0.03)	7,393
1836-1850	1.46 (0.02)	1.14 (0.02)	0.78 (0.02)	10,293
1851-1865	1.52 (0.03)	1.21 (0.03)	0.77 (0.02)	18,592
1866-1880	1.49 (0.04)	1.23 (0.03)	0.73 (0.02)	37,493
1881-1895	1.45 (0.03)	1.22 (0.03)	0.70 (0.01)	33,251
1896-1913	1.41 (0.02)	1.24 (0.02)	0.73 (0.02)	21,583

Sources: see Figure 1 and text.

Table 4 also shows that the low-skill group improved its relative wage position from the 1750s to the 1850s, from less than 38 percent to 78 percent of the average wages. The increase exceeded the respective increase in the group's labor share (approximately 20 percent, see Table 2). Such gains indicated a substantial increase in the relative demand of low-skilled labor in the maritime labor market. The latter period, from 1850 onwards, featured similar outcomes. There was a 5 percent decline in the group's relative wages, which was associated with an approximately 10 percent increase in the group's skill share.

The findings of deskilling are supported by the results for highly skilled labor. The average wage premium for the highly skilled seamen declined substantially, particularly over the period 1756-1820. Thus, when the group's occupation share increased modestly, its relative wages declined. The findings suggest that the group's relative supply exceeded the relative demand. Since 1850, the wage premium of the group stayed at 50 percent and the labor share close to 30 percent.

The results for the skill premium might be related to the different structure of shipping in the different port towns in the dataset. To get a more precise picture, we selected one town (Visby) and one ship type (full-rigged three-mast ship, *frigate*) for a further analysis. Visby was the only town in our sample for which we have data for the whole period (1756-1913), and a *frigate* represented an ocean-going cargo carrier, also used throughout the period. In Visby, small coastal vessels were typical, as the town is located on the island of Gotland – thus, all connections to mainland Sweden were handled with these coastal vessels. Although the number of cases was fairly low (3,127), the results did confirm the decline in wage premium (Table 5).

Table 5. Relative Wages of High Skill, Medium Skill, and Low Skill Seamen in Visby Onboard Frigates, 1753-1913 (Standard Errors in Parentheses)

<i>Years</i>	<i>High-skilled</i>	<i>Medium-skilled</i>	<i>Unskilled</i>	<i>N</i>
1756-1805	2.07 (0.21)	0.94 (0.18)	0.45 (0.14)	773
1806-1850	1.73 (0.28)	1.30 (0.27)	0.78 (0.09)	349
1851-1875	1.89 (0.16)	1.43 (0.10)	0.80 (0.15)	342
1876-1890	1.80 (0.05)	1.28 (0.06)	0.69 (0.05)	1,087
1891-1913	1.67 (0.10)	1.32 (0.07)	0.76 (0.08)	918
Average/sum	1.82	1.21	0.67	3,469

Sources: See Table 4 above and text.

For Visby and the *frigate* case, we estimated wages for the high- and low-skilled seamen and for four aggregated periods. The result indicated that the relative wages of those enrolled on the Visby *frigates* followed the same general pattern as reported in Table 3, i.e., the relative wages of the high-skill group decreased and the relative wages of the low-skill group increased over time. Therefore, the findings reinforced the robustness of the aggregate analysis that used five different Seamen's Houses and different types of vessels. The relative wages of the high-skill and low-skill groups employed on frigates in Visby were, however, somewhat higher than those in other towns and on other vessels. The demand for officers aboard this type of ocean-going vessel and, thus, their salaries, were higher than for the vessels on average. For highly skilled seamen, the average wage premium for the pre-steam period in the Visby case was 0.3-0.4 percent higher than the average for the period 1753-1870 in the entire sample (see Table 5). Moreover, the Visby case also confirmed the demand for high-skilled sailors during the late eighteenth century, as seen in the high premium paid to the officers of Visby *frigates*. Deskilling before the steam era can be seen in the decline of this premium before the 1850s, and yet again, the demand for high-skilled sailors increased premium from the 1850s to the 1870s.

7. Conclusions

This article is part of a broader trend in economic history to investigate the long-run development of wages, incomes, and impact of technological changes. Nonetheless, relatively few scholars have attempted to analyze the long-run changes in the skill shares and premia in particular industries and professions, especially beyond the mid-nineteenth century and outside the manufacturing sector. Recent research suggests that European skill premium was lower than in other places in the world since the early modern period and that the industrial revolutions and the first period of globalization accelerated technological changes. Our study is unique because it examines the skill premium in a sector intricately connected to trade, namely, shipping, and that we have a rich dataset – though with certain limitations – going back to the eighteenth century. Moreover, we were able to go beyond the usual typology between high or low-skill (urban) workers with our data, and instead, we used a three-level typology of high, medium and low-skilled maritime labor.

Technological change increased skill premium during the late nineteenth century both in industries (Goldin and Katz, 2008; Katz and Margo, 2013) and in the maritime sector on steam-powered vessels (Chin et al., 2006; Hynninen et al., 2013; Thompson, 2003). Shipping by sail was an older, fading technology by the turn of the twentieth century. Nevertheless, even the sailing ships changed profoundly from the eighteenth century to the First World War. Most importantly, the average size of ships increased and more simplified riggings were used. These technological changes decreased the number of men per ton onboard on the one hand and decreased the demand for skill on the other hand. Our article shows that the period from the 1750s to the 1910s represented deskilling for the seamen working on sailing ships. During this period, the growth of international trade and shipping during the first era of globalization increased the overall demand for sailors but decreased the relative demand for skilled labor in favor of less skilled labor. The deskilling was also associated with a decline in wage inequality, as the premium for high-skilled seamen, captains, and mates fell relative to mean wages.

In terms of relative demand for and supply of labor, we would argue that, first, the decreasing labor share and declining wage premium indicated that the demand for *high-skill* labor decreased more than its supply. Second, the declining labor share, with an increasing relative wage of the *middle-skill* labor suggested that the supply of this skill group decreased more than its relative demand. Third, the rising labor share with increasing relative wages throughout the period implied that the demand for *low-skill* labor increased more than the relative supply. The decline in skill premium might have even facilitated the growth of trade and shipping, as the relative costs of transport declined. This may have hastened the beginning of the first era of globalization. Thus, our conclusions are in line with the findings by van Zanden (2009) on early modern construction workers, as he argued that the decline in wage premium might have facilitated economic growth. On the other hand, the Allen (2001) data suggested that the skill premium even increased slightly in nineteenth century European cities because urbanization took immense strides. However, outside the major cities, the competition for low-skill workers was most likely quite strong.

Obviously, there are issues that could be investigated further, including the exact reasons why and how the wages of sailors varied in comparison with other occupations over time. We intend to examine those issues in future work. Moreover, we acknowledge the limits of our data: Our

data are limited to Sweden and Finland, which were minor players in world trade. It would be interesting to compare them to major seafaring nations in Europe, such as Great Britain and the Netherlands. We hypothesize that the broad trends in our data also held elsewhere, at least in Northern Europe. Similarities between the ships and the cargo types in the Baltic Sea area as well as the fact that both Swedish and Finnish merchant fleets actively took part in international shipments suggest that these results have broader validity.

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Highlights:

- We argue that the period from the 1750s to the 1910s represented deskilling for the Nordic seamen working on sailing ships.
- This deskilling was associated with a decline in wage inequality.
- The decline in skill premium was related to the growth of trade and shipping.
- Growth of international trade and shipping during the first era of globalization increased the overall demand for sailors, but decreased the demand for skilled labor.