IFN Working Paper No. 1462, 2023

Inventors among the "Impoverished Sophisticate"

Thor Berger and Erik Prawitz

Research Institute of Industrial Economics
P.O. Box 55665
SE-102 15 Stockholm, Sweden
info@ifn.se
www.ifn.se

Inventors among the “Impoverished Sophisticate” *

Thor Berger[†] Erik Prawitz[‡]

May 15, 2023

Abstract

This paper examines the identity and origins of Swedish inventors prior to World War I drawing on the universe of patent records linked to census data. We document that the rise of innovation during Sweden’s industrialization can largely be attributed to a small industrial elite belonging to the upper-tail of the economic, educational, and social status distribution. Analyzing children’s opportunities to become an inventor, we show that inventors were disproportionately drawn from privileged family backgrounds. However, among the middle- and working-class children that managed to overcome the barriers to entry, innovation was a path to upward mobility.

JEL Codes: O31, J62, I25

Keywords: Innovation, inventors, intergenerational mobility

*We are indebted to David Andersson for his contribution in shaping this paper at an early stage. We are also grateful for comments by Mike Andrews, Joel Mokyr, Alessandro Nuvolari, Otto Toivanen, Ivo Zander, as well as participants of the Baltic Connections conference, the Lund 2021 FRESH meeting, and the Uppsala University Entrepreneurship seminar. We also thank Linh Pham and Krystal Zhao Jansson for excellent research assistance. Funding from Riksbankens Jubileumsfond, Jan Wallanders och Tom Hedelius stiftelse, and The Lars Erik Lundberg Foundation for Research and Education is gratefully acknowledged.

†Swedish Collegium for Advanced Study (SCAS), Uppsala University. Department of Economic History & Centre for Economic Demography, School of Economics and Management, Lund University. Centre for Economic Policy Research (CEPR). Research Institute of Industrial Economics (IFN), Stockholm. E-mail: thor.berger@ekh.lu.se

‡Linnaeus University and the Research Institute of Industrial Economics.

1 Introduction

An influential literature has invoked broadly diffused human capital and an inclusive patent system — characterized by novelty examinations and low fees — as fundamental to the "democratization" of invention in the United States (Sokoloff and Khan, 1990; Khan, 2005). Innovation during early American industrialization was driven by broad swathes of the population, operating with basic knowledge and little formal training. Notably, this contrasts a recent literature that has emphasized the role of "upper-tail" human capital in generating growth and innovation during European industrialization (Mokyr, 2005; Squicciarini and Voigtländer, 2015; Hanlon, 2022).

Our paper turns to the case of Sweden that underwent a rapid industrial take-off driven by a "technological revolution" prior to World War I (Heckscher, 1941). Swedish inventors developed a wide range of new patented technologies that served as the foundation for world-renowned industrial enterprises.[1] Notably, Sweden was Europe's "impoverished sophisticate" and perhaps the only country that could compete with the United States in providing its population with basic skills such as literacy and numeracy (Sandberg, 1979). Moreover, it introduced a patent system in 1884 similar to that of the United States with technical examinations and low application fees. Were these similarities also mirrored in a democratization of invention in Sweden?

Our existing knowledge about the individuals that developed the inventions propelling growth during Sweden's industrialization is confined to individual case studies, often painting a contradictory picture of inventors' economic and social origins. On the one hand, many famous inventors hailed from elite backgrounds. For example, Alfred Nobel (1833–1896) was born to Immanuel Nobel, a prominent architect, engineer, and inventor. On the other, Frans Wilhelm Lindqvist (1862–1931) was the son of a soldier. Working as a toolmaker, he invented the first pressurized-burner kerosene stove founding the company *Primus*, which conquered a global market. However, while such anecdotal examples are suggestive, they are not necessarily informative about the broader inventor population or opportunities to pursue invention.

We provide systematic evidence on the identity and origins of Swedish inventors prior to World War I drawing on new data on the universe of Swedish inventors listed in patents granted between 1840–1914 by the Swedish Patent and Registration Office (PRV).[2] However, patent

[1] For example, Jonas Wenström's (1855–1893) three-phase electricity system (Asea), Gustaf de Laval's (1845–1913) cream separator (Alfa Laval), Gustaf Dalén's (1869–1937) sun valve (AGA), and Sven Wingquist's (1876–1953) self-aligning ball bearing (SKF).

[2] A well-known drawback of patents as a measure of innovation is that many inventions may never be patented and the propensity to patent differ between industries (Griliches, 1990; Moser, 2005). To mitigate such concerns, we explore the role of secrecy below.

records contain very limited information about inventors beyond basic information such as their name, occupation, and place of residence. Linking inventors to full-count population censuses 1880–1910 allows us to examine a rich set of inventor characteristics, as well to track (potential) inventors from birth into adulthood and thus shed light on the determinants of who becomes an inventor.

We first uncover descriptive facts about inventors during Sweden's industrialization. To do this, we draw on patent records linked to the 1910 population census to primarily identify the economic and social composition of inventors.[3] Swedish inventors predominately belonged to a small elite group, as inferred from the social status and income associated with their occupations.[4] About a third of all inventors belonged to the elite group, which constituted just about two percent of the population. Notably, the dominance of elite groups in innovation remained overall similar both before and after the 1884 patent reform, which suggests that the transition to an American low-cost examination system did not democratize innovation. However, we document a marked shift within the elite group during industrialization. The role of traditional administrative and military elites sharply declined as an industrial elite of factory owners and engineers grew to prominence. At the height of Sweden's industrial take-off in the 1870s, more than half of all active inventors belonged to this industrial elite.

Inventors belonging to elite groups were also more productive and developed more valuable technological inventions. We first document that they produced significantly more patented inventions than their middle- or working-class counterparts: more than half of all patents granted prior to World War I can be attributed to this small group of elite inventors. Using information on patent renewals, we then show that these patents are also of higher-quality. The productivity advantages of elite inventors in part reflects the fact that they specialized in invention, as reflected in their longer patenting careers.

Our findings reveal that Sweden's accelerated pace of innovation can be ascribed to the rise of inventors belonging to a small industrial elite. Yet two very different explanations could account for this fact. An optimistic interpretation is that talented children growing up in disadvantaged families — like Lindqvist — could enter elite groups and pursue a career in invention, as sometimes suggested both by contemporaries and later historical scholarship.[5] A pessimistic

[3]We also examine a rich set of demographic outcomes showing that the typical inventor was a married and middle-aged man. Inventors were also substantially more likely to have immigrated and were more geographically mobile within Sweden. In particular, they migrated to Stockholm, where about a third of all inventors resided.

[4]Throughout most of the paper, we use information contained in occupational titles translated into the HISCLASS social class scheme to measure social status (Van Leeuwen and Maas, 2011). As we describe in more detail below, we refer to HISCLASS groups 1 (Higher managers) and 2 (Higher professionals) as "elite".

[5]Contemporaries such as Henrik G. Tisell (1910, p.110), a technical officer (*byråingenjör*) at the PRV, argued that the characteristic involvement of industrial workers in American innovation was also increasingly becoming the case in Sweden. Taking Lindqvist as an example, Gårdlund (1942, p.174) argues that such rags-to-riches stories

explanation is that the dominance of elite groups reflects the fact that entry into invention was possible only for the children to a privileged few.

To identify the economic and social origins of inventors, we use linked father-son data between the 1880 and 1910 population census. A relatively large number of Swedish inventors hailed from middle- or working-class backgrounds, which has served as the basis for celebrated rags-to-riches stories like that of Lindqvist. However, the prevalence of inventors from more humble farming or working-class backgrounds mainly reflect the large size of these social groups.

Analyzing children's opportunity to become an inventor, we find that a child born to an elite family was about 17 times more likely to become an inventor than a child born to an unskilled father. We document a sharp non-linear relationship between parental income and the probability to become an inventor, which is strikingly similar to evidence from 20^{th}-century Finland and the United States (Bell et al., 2019; Aghion et al., 2017; Akcigit et al., 2017b). Exploring underlying mechanisms, we show that children born to families belonging to the economic and social elite were more likely to attain a higher technical education and gain exposure to innovation through their fathers or broader family, which has been emphasized as a key mechanism in shaping who becomes an inventor (Bell et al., 2019).[6]

An important question is whether children from less advantaged backgrounds produced inventions of lower quality. In other words, did the fact that relatively few working-class children pursued invention mean that Sweden lost out on valuable ideas? While inventors were disproportionately drawn from advantaged backgrounds, these inventors did not produce inventions of significantly higher quality than those by inventors from more humble origins. Thus, these results are suggestive of a significant misallocation of talent. Indeed, had children born to middle- and working-class families invented at the same rate as children born to elite families, the number of Swedish inventors before World War I would be about nine times as large.

Although barriers to pursuing invention were high, it remains an open question whether children born to middle- and working-class families that managed to overcome these hurdles could climb the economic and social ladder. Using the linked father-son data, we show that inventors exhibited significantly higher intergenerational income and occupational mobility. We corroborate these results by comparing mobility outcomes for inventors relative to their non-inventor brother(s), which partly reduces concerns that the results solely reflect a selection of inherently

were not uncommon ("you could be a worker one year and a factory owner the next") by the last decades of the 19^{th} century.

[6] A related mechanism is that higher-status families may reside in areas that are more conducive to innovation (Bell et al., 2019). While we find that children growing up in urban areas or areas with a higher density of inventors were more likely to pursue innovation as adults, the key role of family background persists when we compare children growing up in the same county, municipality, or parish.

more mobile individuals into innovation. Thus, for children from more humble backgrounds that managed to become an inventor — such as Lindqvist — invention was a path to upward mobility.

Our paper contributes to a recent literature that uses micro-level data to uncover historical facts about inventors (Akcigit et al., 2017b; Sarada et al., 2019; Billington, 2021; Hanlon, 2022).[7] These efforts build on and extend historical work leveraging biographical information to elucidate the background of "great" inventors in Britain and the United States (Sokoloff and Khan, 1990; Khan and Sokoloff, 1993, 2004; Meisenzahl and Mokyr, 2012; Khan, 2018; Bottomley, 2019).[8] The findings of our paper contrasts evidence from the Unites States where broadly dispersed human capital and an inclusive patent system has been argued to have "democratized" invention (Sokoloff and Khan, 1990; Khan, 2005).[9] Even though Sweden had a similar patent system with comparatively high levels of human capital (Sandberg, 1979) and social mobility (Berger et al., 2021a), individuals at the lower rungs of the economic and social ladder did seemingly not pursue inventive activity to a large extent. Instead, we find that Sweden's accelerated pace of invention prior to World War I can be ascribed to an emerging industrial elite, disproportionately drawn from privileged backgrounds. These results contribute to a growing literature emphasizing the key role of an elite with rare technical skills in driving growth and innovation during European industrialization (Mokyr, 2005; Mokyr and Voth, 2010; Squicciarini and Voigtländer, 2015; Hanlon, 2022; Maloney and Valencia Caicedo, 2022).[10]

2 Context: patent systems and independent invention

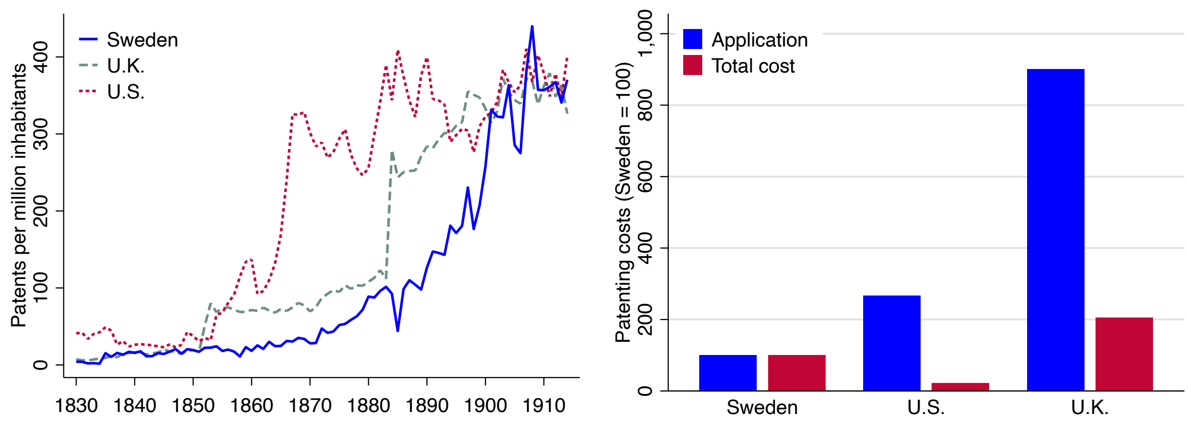
Although the very existence of patents were questioned during the 19^{th}-century "patent controversy", the argument that the patent system was crucial to promote national economic and technological progress had won the day by the outbreak of World War I (Machlup and Penrose,

[7] A recent literature similarly sheds light on the identity and origins of inventors in the 21st century by linking patent records to administrative data from Finland, Sweden, and the United States (Aghion et al., 2017; Bell et al., 2019; Jung and Ejermo, 2014).

[8] A closely related literature studies the contribution of independent inventors to innovation during the 19^{th} and 20^{th} century (Nicholas, 2010, 2011; Nuvolari and Vasta, 2015; Sáiz, 2012; Basberg, 2015).

[9] While this literature has primarily focused on early American industrialization, Sarada et al. (2019) show that white-collar occupations were underrepresented among American inventors relative to the population as late as 1900. Moreover, we document below that inventors belonging to the elite group dominated Swedish invention from the first half of the 19^{th} century and onwards.

[10] We also provide the first historical evidence on the link between innovation and intergenerational mobility. Akcigit et al. (2017b) and Aghion et al. (2019) document an association between social mobility and innovation across places within the United States. We instead document a direct link between innovation and mobility both in terms of income and occupation. In that sense, our results are similar to modern evidence by Aghion et al. (2017) showing that Finnish inventors exhibit high rates of both intra- and intergenerational mobility.



(A) Patents per capita

(B) Patent costs

Figure 1:
Patenting activity in Sweden, the UK, and the US.

Notes: This figure displays A: The number of granted patents per million inhabitants in Sweden, United Kingdom and Unites States based on WIPO historical IP statistics (Sáiz, 1999). B: Patent application costs in Sweden (1885), the U.K. (before the 1883 Patents Act), and the U.S. (in the 1880s) based on data in Andrée (1888) and the cost of holding a patent for the full length in 1900 based on data from Lerner (2002).

1950). However, there existed considerable differences in how patent systems were designed. European nations — e.g., Britain, France, and Italy — typically opted for a registration system, which only required certain formal requirements to be fulfilled and a fee to be paid to obtain a patent (Khan and Sokoloff, 2004; Nuvolari and Vasta, 2015). Because no examination for novelty was performed, establishing the validity of a patent was typically left to the court system. High application fees and uncertain legal costs meant that patenting was typically limited to a privileged few (Khan, 2018; Bottomley, 2019; Billington, 2021). American lawmakers designed a patent system characterized by novelty examinations and low patent fees, which aimed to extend the incentives to pursue inventive also to individuals from more humble origins (Khan, 2005). Consequently, American inventors tended to be drawn from a much broader cross-section of the population (Sokoloff and Khan, 1990; Sarada et al., 2019).[11]

Sweden transitioned from a "European" registration system to an "American" examination system over the course of the 19^{th} century.[12] In 1834, Sweden introduced a registration

[11]Technological examinations reduces both the uncertainty regarding validity and value of a patent, which may facilitate trade in technology (Khan and Sokoloff, 2004). Andersson et al. (2023) shows that a patent market emerged in Sweden in the latter half of the 19^{th} century as the railroad network connected agents, inventors, and firms across the country.

[12]The first Swedish patent law was introduced in 1819, which formalized the granting of exclusive privileges (*privilegia exclusiva*) for inventions that were not previously known in the country. See Andersson and Tell (2019) for an overview of Swedish patent legislation.

system, which simply required a correctly specified application for a patent to be granted. Because no novelty search was performed, the system was characterized by litigation rates of granted patents that reached above 20 percent (Andersson and Tell, 2019). While the system was reformed in 1856, it failed to deliver any significant changes. Despite the drawbacks of the patent law, Figure 1A documents a sustained increase in patenting in Sweden from the mid-19^{th} century onwards. However, against the backdrop of mounting criticism of the patent system, Sweden introduced its first modern patent law in 1884.

Sweden's 1884 patent law introduced a rigorous examination system with novelty search performed by patent engineers, as only the third country in the world after the U.S. and Germany. The system was characterized by low application fees, but an increasing fee structure. After the 1884 reform, the patent application fee was 50 *kronor* (approximately $378 in 2015 USD), which was further lowered in 1893 by some 60 percent to 20 *kronor*. Figure 1B contrasts the patenting costs in Sweden with the U.K. and the U.S. in the late-19^{th} and early-20^{th} century. Application costs in Sweden were considerably lower than in both the U.K. and the U.S. Figure 1B also reports the relative cost of carrying a patent for its full length in 1900. Here the American system stands out in terms of its low cost, while the total cost in Sweden is higher though still much lower than in Britain.[13]

Together, these comparisons suggest that patenting in Sweden was comparatively cheap after the reforms in the 1880s and 1890s, which is further evident in the fact that Sweden experienced a catch-up in terms of patents per capita with the U.S. by the outbreak of World War I (see Figure 1A). The vast majority (approximately 90 percent) of patents in this period were granted to independent inventors, which motivates our focus on the economic and social origins of the individuals involved in innovative activity.[14] Moreover, the similarities — rigorous examinations and relatively low costs — between the American and Swedish patent system by the late-19^{th} century gives rise to the question whether Swedish inventors also increasingly were drawn from the lower rungs of the economic and social ladder.

[13]It is not obvious what matters for credit-constrained inventors: a low application fee, or a low cost to hold a patent for the full length. The fact that inventors could apply for and obtain a patent at a low cost in Sweden, without paying for the full patent length, presumably meant that also more disadvantaged individuals likely had access to the patent system. In the case that a patent was granted, it should have been relatively easy to raise capital or to transfer the rights given the property rights to the technology embodied in the patent.

[14]Similar patterns are evident in Britain and the United States, where independent inventors provided crucial contributions to the advancement of technological progress well into the 20^{th} century (Nicholas, 2010, 2011). Nuvolari and Vasta (2015), Sáiz (2012) and Basberg (2015) document similar patterns for Italy, Spain and Norway, respectively.

3 Data sources and samples

Our analysis uses three different samples of inventors. In the first part of our analysis, where we characterize descriptive facts of inventors, we mainly rely on a full sample of all inventors granted a PRV patent between 1885–1914 (we denote this the *full inventor sample*). To complement the inventor-specific information in the patent data, which is limited to location and occupation, we also characterize inventors using a subsample of inventors linked to the 1910 census (we denote this the *census sample*). In the second part of our analysis, where we study the family background of inventors, we make use of a sample of individuals observed in childhood in the 1880 census (below 16 years of age) and later on observed in adulthood in the 1910 census (we denote this the *linked father-son sample*). Defining inventors using links between the 1910 census and our patent data, we can characterize who becomes an inventor in terms of parental background as observed in their childhood home in 1880. We next describe the data sources and construction of these samples in more detail.

3.1 Patents

Our patent data is built up by the universe of all patents granted to Swedish inventors between 1840 and 1914 by the PRV. It was compiled and digitized from Swedish National Archives (*Riksarkivet*) and the PRV archives and include detailed information, such as patent duration, application and grant date, and patent class according to the German patent classification, *Deutsche Patentklassifikation* (DPK).[15] A total of 18,250 patents were granted by the PRV to individuals or firms residing in Sweden over the period. Moreover, the registers include name, address and occupation of the patent holders and inventors behind each patent. Due to the substantial overlap between patent holders and inventors, we define all individuals listed on the patent as inventors.[16] In total, the patent data includes information on roughly 10,000 Swedish inventors.[17] We code the occupation of each individual inventor and patentee using the Historical Interna-

[15]The patent data draws on a large effort in collecting Swedish historical patents organized by researchers at the Department of Business Administration at Uppsala University in collaboration with the Patent and Registration Office (PRV). See https://svenskahistoriskapatent.se as well as the Online Appendix Section B.1 for additional information.

[16]While we cannot fully differentiate between patent holders and inventors, the vast majority of individuals in our data are both patent holders and inventors: 81% of patents formally list the only individual on the patent as a patent holder. In Online Appendix Section A.2, we nevertheless explore the importance of this data limitation for our results.

[17]We include all listed independent inventors and patentees, but exclude firms, from our inventor data. However, we include all individuals listed as inventors or patentees on firm patents.

tional Standard Classification of Occupations (HISCO) (Van Leeuwen et al., 2002).[18] We then allocate inventors into the HISCLASS social class scheme (Van Leeuwen and Maas, 2011), which we aggregate into six broader groups as follows: elite (HISCLASS group 1–2), upper middle class (3–5), skilled (6–7), farmers (8), lower skilled (9–10), and unskilled (11–12).

We also collect data on USPTO patents granted to Swedish inventors from the Annual Reports of the Commissioner of Patents. USPTO patents presumably capture more valuable technological inventions, given that Swedish inventors sought patent protection for their inventions also in the US.The inventors are then manually matched to unique identifiers in the Swedish patent data. In total, we collect data on 1,749 USPTO patents granted to Swedish inventors.

With the patent data, we construct our *full inventor sample*, which includes the universe of all inventors ever granted a Swedish patent during the period 1885–1914. For these inventors, we then make use of additional data on all granted patents by the PRV from 1840 up to 1943, so that we essentially follow each individual inventor over their entire career.

3.2 Censuses

Using census data from the Swedish National Archives and the North Atlantic Population Project (NAPP), we link all individuals in the patent data to the 1910 Swedish population census to obtain our *census sample*. The data includes population-wide data on demographic variables such as family structure, civil status, and occupation.

To construct the *linked father-son sample* sample, we then use linked census data from Berger et al. (2021a) between the 1880 and 1910 census and restrict the sample to the subset of individuals that are linked from the 1910 census (when they are of working age) to the 1880 census (when they are children).[19] We here focus on a sample of sons, due to the small number of female inventors linked across censuses. These individuals are born 1865-1880 and reside in their family home in 1880, giving us information on their parents as well as other characteristics during their childhood. In a next step, we link individuals in the 1880 and the 1910 censuses to inventors from our *full inventor sample*. This provides us with information on which individuals in the *linked father-son sample* that are inventors, as well as who had a father that was an inventor.

The full linkage procedure is described in Appendix B, but we describe it shortly here. First of all, for each unique inventor, we evaluate census individuals that are of the same sex and at

[18]Occupations for inventors and patentees are defined as the modal occupation (or the earliest recorded patent whenever the modal is undefined).

[19]The linkage rate of this data is about 60 percent, which exceeds rates achieved for US and UK censuses Long and Ferrie (2013). The main reason is that candidates can be compared within smaller cells using information on birth parish (see Berger et al. (2021a) for a detailed discussion of these linkages).

least 15 years old at the time of the inventor's first patent application. We then use a step-wise procedure to establish links using information on names. In a first step, we consider a pair as a match if there is a unique identical match using the full list of first names (these range between one and five in our inventor data) and full last name. In a second step, we rely on string similarity of first and last names using the Jaro-Winkler algorithm. We consider a pair as a match if they have a string similarity above 0.95, on a scale between 0 (no similarity) and 1 (identical), for both first names and last name, as well as an average distance of at least 0.05 to the second best candidate. In a last step, we discard candidates that are residing in a different county in 1910 than in their modal patent application (or first application if a modal is not applicable).[20] Considering inventors that are active in the period 1880-1910, we link 31.1 percent to the 1910 census.

3.3 Other sources

To get a measure of individuals' higher technical education, we link census individuals 1880–1910 to a list of all members in the Swedish Association of Engineers and Architects—*Svenska Teknologföreningen, STF*. The association was initiated in the 1850s and founded more formally in 1861 (Ahlström, 1982). It was started as a student organization of the Royal Institute of Technology (KTH) in Stockholm, but came to include graduates from the other Swedish technical university, the Chalmers University of Technology in Gothenburg, as well as most professional engineers.

Similarly to the method used when linking inventors to the censuses, we make use of string similarity when comparing individuals in the member list to the censuses. However, since the STF data includes the birth year of all members it allows us to improve on the linkage rate by only comparing individuals born in the same year, reducing the number of candidate links. Following this procedure, we link approximately 75 percent of all members to the relevant censuses. We define the subset of the population that has received a technical education as all individuals that report engineer as an occupation in the patent records/census, or that appear as a member in STF.

Occupational income scores are based on data from individual-level tax registers for 1900 collected by Bengtsson et al. (2021). As described in Berger et al. (2021b), individual tax records are linked to the 1900 population census. We then use this linked data to predict the income of each individual in the 1880 and 1910 census based on age, 1-digit HISCO occupation, urbanity, and county of residence.

[20] Only four percent of linked inventors are added in this step. See Appendix B for additional details.

4 Analysis

Our analysis in this section focuses on the identity and origins of Swedish inventors prior to World War I. In the first part of the analysis, we draw on patent and census data to uncover descriptive facts about inventors during Sweden's industrialization. We show that inventors disproportionately belonged to an emerging industrial elite that was more productive than middle- or working-class inventors. In the second part of the analysis, we use linked census data to follow (potential) inventors from their childhood into adulthood. While a relatively large number of Swedish inventors hailed from modest backgrounds, children born to families at the top of the income and status distribution were substantially more likely to become inventors. However, among those that managed to overcome the hurdles in pursuing a career in invention, we find high rates of both income and occupational mobility suggesting that invention was a lever to climb the social ladder.

4.1 Inventors among the "impoverished sophisticate": descriptive facts

4.1.1 Demographic characteristics of inventors

We start by characterizing inventors in terms of basic demographic characteristics showing that the typical Swedish inventor was male, middle-aged, and married. Because demographic information is not contained in the patent records, we here rely on the *census sample*. Summary statistics for inventors and "star" inventors (i.e., inventors with more than 10 patents) as well as the broader population in the 1910 census are presented in Table 1.

The most striking demographic fact about Swedish inventors prior to World War I is the vast overrepresentation of men. Women made up less than one percent of inventors.[21] The share of female inventors increased in the beginning of the 20^{th} century, reaching roughly three percent (see Appendix Figure A.1A). However, from modern data we know that the gender gap in innovation is closing at a glacial pace. Indeed, by the early 21st century, the share of female inventors in Sweden still lingered below 10 percent (see Appendix Figure A.1B).

Turning to the age of inventors, the average Swedish inventor was roughly 43 years old and thus slightly older than the rest of the male population. Appendix Figure A.2 displays the share of inventors by age groups in the population showing that the probability to become an inventor increased from the late-20s to the early 40s. The average age of inventors prior to World War I is remarkably close to what is observed today: in the early 21st century, Swedish inventors

[21] We find a somewhat higher share of female inventors (1.7 percent) based on the number of inventors with a female first name in the full PRV data (i.e. the *full inventor sample*). This is most likely due to females being more difficult to link due to name changes following marriage, though most maiden names are stated in the censuses.

TABLE 1: INVENTORS: DESCRIPTIVE FACTS IN THE CENSUS SAMPLE.

	(1) Population	(2) Inventors	(3) Star inventors
Demographics			
Age	37.64	42.67	42.03
% aged 18-25	24.31	4.13	3.42
% aged 26-35	25.17	25.78	28.63
% aged 36-45	19.54	30.06	31.20
% aged 46-55	17.64	25.56	21.79
% aged 56-65	13.34	14.49	14.96
% female	51.40	0.84	0.00
% married	52.79	73.33	76.07
% single	42.15	22.92	19.23
% urban	26.06	48.91	60.68
% in Stockholm	12.17	31.89	50.43
Income, social class, and education			
Income score	6.61	7.00	7.18
Income percentile rank	50.49	75.82	86.55
% elite	0.02	0.28	0.65
% upper middle class	0.13	0.29	0.18
% skilled	0.15	0.20	0.08
% farmers	0.19	0.07	0.04
% lower skilled	0.20	0.09	0.03
% unskilled	0.32	0.06	0.01
% higher technical education	0.23	19.17	57.26
Migration			
% intercounty migrant	23.11	55.86	63.56
% international migrant	1.17	3.82	2.56
% born in United Kingdom	0.03	0.28	0.00
% born in Germany	0.18	1.15	1.28
% born in Denmark	0.20	0.78	0.85
% born in Norway	0.23	0.59	0.00
Observations	3077725	3224	234

Notes: This table provides descriptive characteristics from the census of 1910 using the *census sample*. Column 1 displays means in the total adult population, column 2 displays means for the linked inventor population, and column 3 displays means for linked star inventors (with more than 10 career patents). All individuals are between 18 and 65 years old in 1910. Income scores are not available for women, which are set to missing. Observations in the last row is given for all individuals in the three groups.

were on average 43.5 years old (Jung and Ejermo, 2014, Table 2).[22] The fact that inventors on average are older than the population is also consistent with a higher marriage rate (about 73 percent) among inventors (Table 1).[23]

4.1.2 Economic and social status of inventors

We next examine inventors' economic and social status. Figure 2A displays the social class of inventors in our *full inventor sample* grouped into six broad social classes: elite, upper middle class, skilled, farmers, lower skilled, and unskilled. About 40 percent of inventors that reported an occupation belonged to the elite group, while an additional 28 percent belonged to the upper middle class.[24] While the vast majority of inventors were male, female inventors also typically belonged to privileged groups.[25] In terms of patents, the dominance of the elite is even starker. Inventors belonging to the elite were responsible for 57 and 67 percent of all patents granted by the PRV and USPTO, respectively, which is particularly striking given that the elite group only constitutes about two percent of the adult population (see Table 1). At the same time, farmers and unskilled workers — constituting about 70 percent of the population — were heavily underrepresented among inventors accounting for about three percent of all patents before World War I.[26]

Figure 2B shows the share of the population in each social class that were inventors, using the *census sample*, revealing the sharp overrepresentation of the elite among inventors. Notably, individuals belonging to the elite were more than 20 times as likely to be an inventor compared to those belonging to the lower classes. A similar picture emerges if one instead considers the

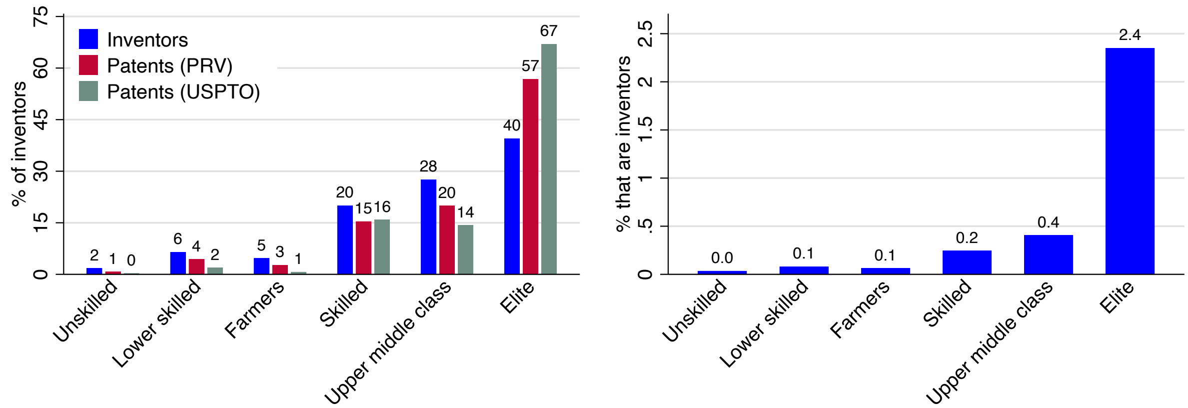
[22] Moreover, these results are similar to Sarada et al. (2019) documenting that the average American inventor was about 41 years old between 1870 and 1940, as well as modern evidence that inventive activity may peak around age 40 (Bell et al., 2019; Azoulay et al., 2020). More broadly, the fact that inventors are relatively older than the population is consistent with the notion that inventors may need to accumulate experience and invest in human capital to be able to develop technologies at the frontier (Jones, 2009, 2010).

[23] However, the higher marriage rate among inventors arises already at younger ages and persist over the life cycle (Appendix Figure A.3). These findings contrast those of Akcigit et al. (2017b) showing that American inventors and other high-skill workers delayed marriage, which is interpreted as evidence of a trade-off between allocating time between a family and inventive activity.

[24] Appendix Figure A.4 documents only minor differences when including inventors that did not report an occupation in the patent records. The share of elite inventors is somewhat lower in the linked *census sample* presented in Table 1. This could be due selection in the linkage process, but also due to differences in reported occupations in the 1910 census as compared to those in the patent reports during our entire study period.

[25] Female inventors mostly were found in the upper middle class, rather than the elite group, working as a photographers, nurses, or teachers (see Appendix Figure A.1C).

[26] One concern is that elite inventors may have selected into sectors where patents are relatively more important to protect intellectual property, while less advantaged inventors may invent in sectors where alternative forms of protection is relatively more effective. We explore this issue in Online Appendix A.2, where we explore the role of secrecy (Figure A.5), as well as the role of firm patents (Figure A.6) and inventors not listed as patent holders (Figure A.7) in explaining our results.



(A) Social status of inventors

(B) Share inventors in population

Figure 2:
Economic and social status of Swedish inventors.

Notes: A: Distribution of social status among Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 (using the *full inventor sample*). B: The share of inventors in the adult population 1910 across social status groups (using the *census sample*). The different status categories are based on the HISCLASS social class scheme, as described in the main text.

position of inventors in the income distribution where there is a sharp overrepresentation among the top income groups (Appendix Figure A.8).

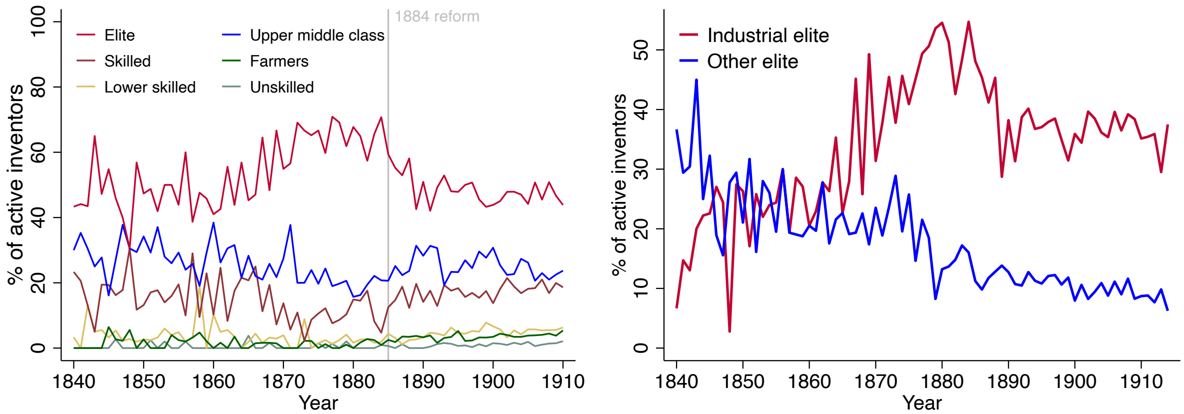
Inventors belonging to the top of the economic and status distribution can most aptly be described as an emerging industrial elite.[27] Almost 50 percent of inventors belonging to the elite group were engineers, while an additional 31 percent were factory owners or general managers (see Appendix Table A.1).[28] About one in five of inventors had obtained an higher technical education (see Table 1).[29] This number rises substantially to more than half if we consider the more prolific star inventors.

Inventors belonging to elite groups played an outsized role in innovation both before and after the 1884 patent reform. Figure 3A shows that the share of active inventors that belonged to

[27]Most inventors also among the middling and lower classes were intimately connected to the rapidly growing industrial sector. Among the upper middle class, the most common occupations among inventors were business owners, bookkeepers, and different types of foremen and supervisors (see Appendix Table A.1). Similarly, within the skilled group we find several occupations — carpenters, mechanics, and watch makers — that embodied crucial knowledge and skill for the development of increasingly sophisticated technologies during industrialization (Kelly et al., 2022; Mokyr et al., 2022).

[28]This is likely a downward biased measure of the role of engineers in innovation since engineers often held occupations such as “general manager” or “factory owner”, as suggested by Ahlström (1982).

[29]The rise of this new industrial elite can be exemplified by some well-known Swedish inventors. Gustaf de Laval was one of Sweden’s most prolific inventors who graduated from the Royal Institute of Technology in Stockholm in 1866. Dalén, the inventor of the sun valve and later Nobel Prize laureate, graduated with an engineering degree from Chalmers University of Technology in Gothenburg in 1896.



(A) SOCIAL CLASS OF INVENTORS

(B) INDUSTRIAL AND OTHER ELITES

FIGURE 3:
ECONOMIC AND SOCIAL STATUS OF INVENTORS, 1840–1914.

Notes: A: The distribution of social class among active Swedish inventors granted at least one patent between 1840 and 1914. We include one observation for each inventor that patented at least once in each given year. B: The share of active inventors that belong to the " industrial" and "other" elite among all active inventors in each year between 1840 and 1910 (using the *full inventor sample*). We define these groups based on occupations reported by inventors on the patent records. The industrial elite consists of engineers, factory owners, and general managers (**ingenjör**, *direktör*, *disponent*, *fabriksdirektör*, *fabriksdisponent*, *fabriksidkare*), while the other elite are the remaining occupations belonging to the elite group (mainly military and government administration).

the elite remained relatively stable from 1840 through 1914. Here we include one observation for each ("active") inventor that patents in each respective year. While there are short-term fluctuations, there is no considerable change in the social class of inventors after the 1884 reform.[30] Thus, the establishment of an examination system and the subsequent lowering of patent fees in 1893 did seemingly not lead to a democratization of invention. However, this stability conceals a marked shift within the elite group. Figure 3B displays the share of inventors that belonged to the elite disaggregated into an industrial elite, mainly consisting of engineers and factory owners, and the share of inventors belonging to a traditional elite, mainly consisting of administrative elites and military men. When the pace of industrial growth accelerated after mid-century, the new industrial elite played an increasingly important role in developing new patented technologies, while the role of the old elite in innovation gradually declined.

[30]The elite share declines after the 1884 reform to levels observed in the 1860s, yet a direct comparison should be made with care because occupational information was more accurately collected after the reform. Indeed, Appendix Figure A.9 shows that the share of active inventors that belonged to the elite remained broadly constant when including inventors with missing occupations.

4.1.3 Migration and the geography of inventors

Swedish inventors prior to World War I predominately clustered in urban areas, in particular in the capital Stockholm. While just about one in four Swedes lived in an urban area at the time of the 1910 census, almost half of all inventors resided in a city (Table 1). In particular, about a third of all inventors resided in Stockholm county that disproportionately was home to inventors belonging to elite groups (Appendix Figure A.10B).[31] The concentration in the capital likely reflects the well-documented agglomeration benefits from clustering, but also the fact that Stockholm provided central intermediary services since it was home to a large number of patent agents.

A concentration of inventors in Stockholm also reflects the substantially higher rates of geographic mobility among inventors. More than half of all inventors linked to the 1910 census had moved away from their county of birth, which can be compared with 23 percent among the adult population (Table 1).[32] In particular, inventors and other individuals holding elite occupations disproportionately migrated to Stockholm (Appendix Figure A.11D).

Inventors were also more mobile across countries. Almost four percent of the inventors that we observe in the 1910 census had been born outside of Sweden, which is more than three times the share observed in the adult population (Table 1). Inventors had most commonly immigrated from Denmark, Germany, and Norway. While prior work has documented the contribution of emigrant outflows during the Age of Mass Migration to domestic innovation in Sweden (Andersson et al., 2022), these findings are consistent with a large body of work emphasizing the historical overrepresentation of immigrants among inventors (Akcigit et al., 2017a; Sarada et al., 2019).

4.1.4 Inventor output and patent quality

Although inventors disproportionately belonged to an economic and social elite, it is an open question whether these inventors also produced more valuable technological inventions. We next examine whether patent output and quality differed across social classes. Table 2 reports that inventors belonging to the elite were granted almost seven patents by the PRV on average, while middle- and working-class inventors obtained around 2.5 granted patents. To gauge the

[31]We find a similar concentration when instead examining the county of residence reported on the patents granted by the PRV (Appendix Figure A.10). Notably, the relative advantage of Stockholm is even more pronounced when one adjusts for county differences in population size. A relatively large number of inventors are also located in *Göteborg och Bohuslän* and *Malmöhus* county that contain the large cities of Gothenburg and Malmö, as well as in the industrial area of *Gävleborg* county.

[32]Inventors were more mobile already at young ages, which persisted over the life cycle (Appendix Figure A.11A). Migration rates were similarly higher when focusing on shorter distance migrations across municipalities or parishes (Appendix Figure A.11B and A.11C).

TABLE 2: INVENTOR OUTPUT AND QUALITY: DESCRIPTIVE FACTS.

	(1) All	(2) Elite	(3) Upper middle	(4) Skilled	(5) Farmers	(6) Lower skilled	(7) Unskilled
Patent output							
Number of PRV patents	3.58	6.71	2.77	2.32	2.53	2.05	1.91
Number of USPTO patents	0.25	0.61	0.12	0.14	0.16	0.05	0.05
% with 1 PRV patent	53.13	35.71	57.61	60.20	61.42	64.31	65.57
% with $>$10 PRV patents	6.25	14.85	4.10	2.68	4.57	1.86	1.09
Patent characteristics							
Years patents renewed	4.15	4.99	4.15	3.76	3.55	3.29	3.64
% renewed for 15 years	3.15	5.08	2.57	2.69	1.50	1.89	2.64
% firm patents	8.81	14.65	6.90	5.92	5.90	7.36	6.44
% collaborative patents	28.01	28.49	27.73	27.19	30.64	22.83	28.74
% transfered patents	15.25	14.96	16.06	14.76	15.80	11.13	14.49
Career							
Age at first invention	35.57	34.68	36.07	35.54	37.15	34.78	34.50
Career length (years)	5.87	9.38	5.16	4.50	4.34	3.81	3.49
Observations	3215	815	854	598	197	269	183

Notes: This table reports mean outcomes for Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 for different groups (using the *census sample*). The different status categories are based on the HISCLASS social class scheme, as described in the main text.

quality of patents, we rely on information on the number of years a patent was renewed, a widely used proxy for the value of a patent (see e.g. Schankerman and Pakes, 1986; Hanlon, 2015).[33] Table 2 shows that inventors belonging to the elite on average renewed their patents for five years, which can be compared to a mean of about 3.5 years among inventors belonging to the lower classes. Similarly, the share of patents renewed for the maximum amount of 15 years was markedly higher among elite inventors. The fact that elite inventors were more likely to also obtain patents by the USPTO further suggests that they developed more novel and valuable technologies. Moreover, we document that firm patents were much more prevalent among elite inventors, which on average were of higher quality as measured by patent fees. In contrast, we show that collaborative patents were not more common in the elite group.[34] While the role of the patent market has been emphasized as crucial for disadvantaged inventors (Khan and Sokoloff, 2004), we similarly find that the share of patents that are transfered and sold were similar across all groups.

To more formally examine differences in patenting output and quality, we estimate inventor-level OLS regressions where the outcome is the lifetime number of patents, or the number of years patents are renewed on average. We include a set of indicators for the six social classes (where unskilled inventors are excluded as the reference group), the first decade that an inventor applied for a (subsequently granted) patent, and inventors' county of residence.

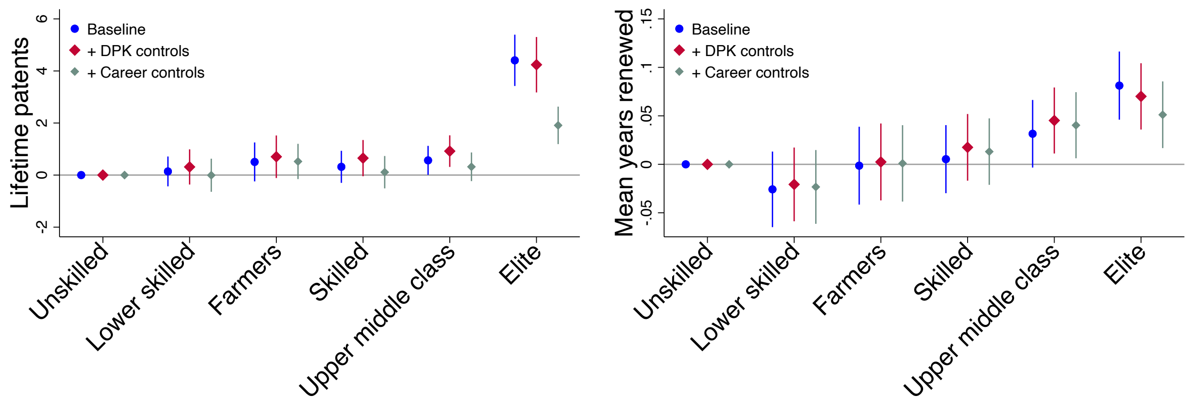
Figure 4A reports OLS estimates and 95 percent confidence intervals from these inventor-level regressions showing that inventors belonging to elite groups produced significantly more patents over their lifetime relative to inventors belonging to the farming-, middle-, or working classes.[35] A potential explanation may be that elite inventors were active in different industrial or technological fields where patenting rates vary (Moser, 2005). However, when controlling for the first technology class that each inventor patents in, estimated differences in patenting output are only moderately affected. Similarly, Figure 4B shows that elite inventors on average renewed their patents for about one year longer relative to unskilled inventors. Again, we find a sizable difference in renewals also when controlling for the first technology class an inventor patents in.

A potential explanation for differences in patenting output and quality across social groups

[33] Swedish patents could be renewed for a maximum of 15 years. Among the patents in our sample, a patent was on average renewed for approximately 4.2 years.

[34] However, this is consistent with recent evidence from Berger and Prawitz (2023) that collaboration was less related to complexity or quality of innovation during this era as compared to later periods.

[35] We provide additional evidence that inventors belonging to the elite group produced more and higher-quality inventions in Online Appendix Figure A.13 where we use data on USPTO patents and citations, a commonly used measure of patent quality. We also show that these results are similar using the *full inventor sample* in Online Appendix Figure A.14.



(A) PATENT OUTPUT

(B) PATENT QUALITY

FIGURE 4:
INVENTOR OUTPUT AND QUALITY BY SOCIAL CLASS.

Notes: Inventor-level OLS regressions of patent output and quality among inventors belonging to different social classes relative to inventors belonging to the unskilled class (using the *census sample*). A: The total number of granted patents over an inventor's lifetime. B: the average number of years patent fees were paid per patent. The baseline regressions (denoted by blue circles) include controls for the first decade in which an inventor applied for a (subsequently granted) patent and the county of residence. Additional specifications add controls for the first (DPK) technology class an inventor patents in (red diamonds) and career length (teal diamonds).

is differences in career dynamics. As a matter of accounting, differences in patenting output can be due to: (*i*) an earlier entry into innovation; (*ii*) a longer career as an inventor; or (*iii*) productivity differences conditional on career length. We first consider entry and the age at first invention. The last panel of Table 2 shows that inventors were on average 36 years old at the time of their first (subsequently granted) patent application.[36] However, there are no clear differences in the age at first patent across social classes. Despite an early entry into innovation, many inventors had relatively short inventive careers.[37] The average inventor had a career that lasted almost six years. Inventors belonging to elite groups, however, had considerably longer careers (9.4 years) compared to middle- or working-class inventors. Additional evidence that elite inventors were more specialized in innovation can be gleaned from Table 2 showing that two-thirds of elite inventors obtained more than one patent and that about 17 percent obtained more than 10 patents over their lifetime. Notably, controlling for career length in Figure 4A

[36]Swedish inventors were thus slightly younger at the time of their first invention than today. Jung and Ejermo (2014) show that first-time inventors in the early 21st century were on average 41 years old. Broadly, these differences are consistent with the notion that an increased "burden of knowledge" has led to a long-run increase in the age of first invention over the 20^{th} century (Jones, 2009, 2010).

[37]We define career length as the number of years between an inventor's first and last patent application. We assign inventors with only one patent a career length of one year.

and 4B reduces differences in patent output and quality. Thus, the productivity advantages of elite inventors partly can be ascribed to the fact that they specialized in invention and had longer inventive careers.

4.2 Economic and social origins of Swedish inventors

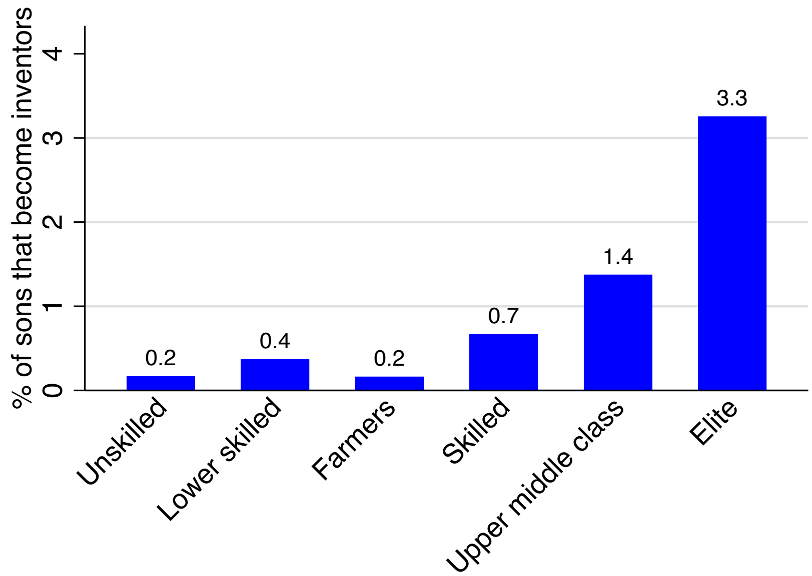
Our findings in the previous section showed that Swedish inventors before World War I were heavily overrepresented among the economic and social elite, which raises questions about their economic and social background: Did inventors mainly hail from economic and socially advantaged families like Alfred Nobel, or could middle- and working-class children like Frans Wilhelm Lindqvist rise to the top if they had valuable ideas?

4.2.1 Who becomes an inventor? The role of family background

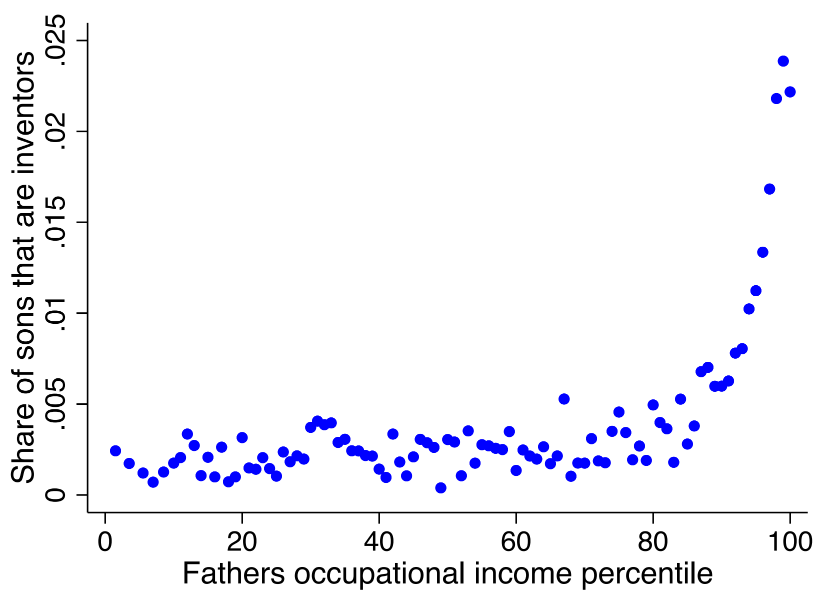
To shed light on the economic and social origins of inventors, we first examine whether family background shaped a son's probability to become an inventor in adulthood. We here rely on our sample of linked fathers and sons between the 1880 and 1910 census.

A relatively large number of Swedish inventors came from somewhat humble origins. The majority of inventors are born to fathers from the upper middle, skilled, and farmer classes (see Appendix Figure A.15). Thus, many inventors were seemingly upwardly mobile given that they as adults primarily belonged to the elite and upper middle class groups (see Figure 2). However, the relatively large number of inventors from middle- and working-class families mainly reflect the fact that these social groups are vastly overrepresented in the population (see Table 1).

Figure 5A displays the share of sons born to fathers across the status distribution that become inventors as adults. A son born to a father belonging to the elite group was 17 times more likely to become an inventor than a son born to an unskilled father. Thus, while many inventors hailed from (upper) middle-class backgrounds, sons to the elite were substantially more likely to become inventors. Figure 5B reinforces this notion, by plotting the probability that a son becomes an inventor and their father's occupational income score. The probability of becoming an inventor remains relatively flat up to about the 90^{th} percentile with a sharp increase among children born to fathers in the top income percentiles. Sons born to fathers in the top income percentiles are about 10 times as likely to become inventors compared to sons born to fathers below the 80th percentile. Notably, despite vast differences in economic, educational, and social conditions, these patterns are strikingly similar to patterns documented in early- and late-20^{th} century United States (Akcigit et al., 2017b; Bell et al., 2019), as well as present-day Finland (Aghion et al., 2017).



(A) FATHER'S SOCIAL CLASS



(B) FATHER'S INCOME

FIGURE 5:
SOCIAL AND ECONOMIC ORIGINS OF INVENTORS.

Notes: This figure displays the probability that a son becomes an inventors based on his father's social class and income (using the *linked father-son sample*). A: The distribution of social status among fathers to inventors in our *linked father-son sample*. The different status categories are based on the HISCLASS social class scheme, as described in the main text. B: The non-parametric relationship between an indicator capturing whether a son becomes an inventor in adulthood and his father's occupational income in 1880. Observations are sorted into 100 groups of equal size and the circles indicate the mean probability of a son becoming an inventor in each group.

Together, these results show that children to parents at the top of the economic and social ladder were more likely to become inventors as adults. We next explore potential mechanisms that may explain the role of family background in accounting for this relationship.

Potential mechanisms A large set of mechanisms may explain the fact that children to parents belonging to the economic or social elite are more likely to become inventors. First, these parents are also likely to have been more highly educated, which in turn may lead to a greater investment in their children's human capital (Akcigit et al., 2017b; Aghion et al., 2017; Celik, 2023). Second, parents at the top of the status distribution are more likely to be inventors themselves that may increase children's exposure to innovation, for example, by enabling the parents to pass on useful institutional knowledge and innovative skills or through role model effects (Bell et al., 2019). Third, families belonging to elite groups may have resided in areas more conducive to innovation, or may have lowered credit constraints thus enabling their children to move to such places (Akcigit et al., 2017b; Bell et al., 2019).

A descriptive account seemingly lends support to these mechanisms. First, sons born to fathers at the top of the income distribution are more likely to also have a father with a higher technical education, while the sons themselves are also more likely to have attained such a degree (Appendix Figure A.16A and A.16B). Second, sons born to rich fathers are more likely to have had a father that was also an inventor, or being exposed to inventors within the broader family (Appendix Figure A.16C and A.16D).[38] Third, children born to parents at the top of the income distribution were more likely to grow up in urban areas and areas with a higher density of inventors (Appendix Figure A.16E and A.16F), as well as being more geographically mobile (Appendix Figure A.16G).

Table 3 more formally examines these mechanisms by presenting individual-level OLS regressions using the *linked father-son sample*. Here the outcome variable is an indicator taking the value one if a son became an inventor in adulthood. We first document the statistical significance of the patterns depicted in Figure 5. Table 3, columns 1 and 2 include indicators capturing whether a father belonged to the top-10 percent of the income distribution and the elite. A son born to a father belonging to the top-10 percent was about 1.2 percentage points more likely to become an inventor in adulthood. Similarly, having an elite father increases the probability of becoming an inventor by about 2.2 percentage points. Notably, both the economic and social

[38]To measure exposure to innovation within the broader family, we use the fraction of inventors holding the same surname as a proxy for broader family networks. We define this measure based on the surnames of all inventors that were granted a patent by the PRV between 1865–1880 (i.e., prior to when sons reached adult age). First, we calculate the number of unique inventors for each surname. Second, we use the 1880 population census to calculate the share of individuals holding each surname that appears in the patent records of the PRV.

TABLE 3: WHO BECOMES AN INVENTOR? THE ROLE OF FAMILY BACKGROUND.

	Panel A. Extensive margin					Panel B. Intensive margin		
Dependent variable:	Son becomes an inventor (=1)					Star (=1)	Patents	Renewals
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Father's economic and social class								
Father top-10% (=1)	0.012***	0.008***	0.008***	0.006***	0.004***	-0.002	1.109	-0.135
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.027)	(1.120)	(0.314)
Father elite (=1)		0.022***	0.019***	0.019***	0.013***	-0.025	-1.670	-0.090
		(0.003)	(0.003)	(0.003)	(0.003)	(0.028)	(1.548)	(0.327)
Family exposure to innovation								
Father higher technical education (=1)			0.063***	0.062***	0.038*	0.183	7.221	0.429
			(0.019)	(0.019)	(0.022)	(0.144)	(5.430)	(0.850)
Father inventor (=1)			0.051***	0.050***	0.044***	-0.021	-1.590	0.710
			(0.008)	(0.008)	(0.007)	(0.043)	(1.317)	(0.573)
Share inventors with surname, 1865-1880			0.002***	0.002***	0.002***	0.005**	0.197	0.016
			(0.001)	(0.001)	(0.000)	(0.002)	(0.127)	(0.013)
Local exposure to innovation								
Born in urban area (=1)				0.003***	0.002**	-0.007	-0.195	0.357
				(0.001)	(0.001)	(0.025)	(0.691)	(0.252)
Share inventors in municipality, 1820-1880				0.001***	0.001***	0.001	0.112**	-0.031
				(0.000)	(0.000)	(0.002)	(0.053)	(0.027)
Son's education and location								
Son higher technical education (=1)					0.122***	0.118***	4.129***	1.145***
					(0.010)	(0.027)	(0.946)	(0.260)
Migrant, 1880-1910 (=1)					0.004***	0.017	0.254	-0.218
					(0.000)	(0.012)	(0.620)	(0.258)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Childhood county FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	284644	284644	284644	284644	284644	1055	1055	1048
Mean dep. var.	0.004	0.004	0.004	0.004	0.004	0.051	3.365	4.481

Notes: The table reports individual-level OLS regressions using the *linked father-son sample* between the 1880 and 1910 census. The outcome in columns 1–5 is an indicator taking the value one if a son becomes an inventor in adulthood. In columns 6, 7, and 8 the outcome is an indicator taking the value one if an inventor is a star inventor (i.e., obtains more than 10 patents), the number of lifetime patents, and the mean number of years that an inventor's patents were renewed. All regressions include a full set of fixed effects for county of birth. Individual controls include cubic functions in the age of the father in 1880 and the son in 1910, respectively. Standard errors are given in parentheses and are clustered at the county of birth level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

status of fathers remain significant in column 2 suggesting that they partly capture different dimensions of family background.

We next consider the role of fathers' education and exposure to innovation within the family. Table 3, column 3, shows that having an inventor father and a father with a technical education increase the probability of becoming an inventor with 5.1 and 6.3 percentage points, respectively. Similarly, a higher share of inventors holding the same surname, capturing the prevalence of inventors in the broader family network, is positively associated with a son's probability to become an inventor in adulthood. Together, these results suggest that exposure to innovation via the family may have been an important determinant of whether a son becomes an inventor.

To what extent are these effects driven by the fact that sons from privileged backgrounds are more likely to grow up in areas more conducive to innovation? To examine this question, we add a variable capturing the share inventors within the birth municipality and an indicator for residing in an urban area in childhood. Both of these factors increase the probability of being an inventor in adulthood, although by relatively small magnitudes compared to family exposure. For instance, a standard deviation increase in the share of inventors in the municipality increases this probability with 0.1 percentage points. The fact that the prior coefficients are barely affected by this inclusion is also suggestive of a minor role of location for sons from affluent and technically savvy backgrounds.[39] While we cannot disentangle all underlying mechanisms, these results are consistent with higher-status families providing their children with access to institutional knowledge (e.g., about the patent system) or financial and social networks, regardless of the location.

We lastly examine the educational attainment and migration of sons in Table 3, column 5. Migration is positively correlated with becoming an inventor, which reduces the role of family background presumably due to well-off fathers easing credit constraints facilitating geographic mobility. Notably, sons that attained a higher technical education were about 12 percentage points more likely to become inventors. While the educational choice of sons is endogenous to their backgrounds, the drop in magnitude of our coefficient for the father's technical education is interesting. It suggests that the role of father's education is to a large extent mediated through the educational choice of their sons.

Extensive vs intensive margin Our analysis has focused on the extensive margin (i.e., whether a son becomes an inventor or not), but the question remains whether family background also mattered on the intensive margin (i.e., in terms of patent output and quality). In other words,

[39] We strengthen this notion by showing that the role of family background remains stable when comparing children growing up in the same county, municipality, or parish in Appendix Figure A.17.

were inventors from advantaged family backgrounds more prolific and productive than those that came from more humble origins?

Table 3, panel B, examines the link between family background and inventor productivity and quality.[40] Family background seemingly mattered little on the intensive margin: inventors born to fathers belonging to the top-10 percent or the elite were not significantly more likely to become star inventors (i.e., obtain more than 10 patents), produce more patents, or produce patents of higher quality as reflected in the number of years patents were renewed. Notably, these results contrast those in Figure 4 showing that inventors belonging to elite groups produced more and higher-quality patents.

Taken together, while family background was a key determinant of who became an inventor, these results suggest that the inventors from middle- and working-class backgrounds were not significantly less productive than those that hailed from advantaged families. Thus, these findings are suggestive of a significant misallocation of talent.[41] Broadly, these results are also consistent with recent theoretical models of occupational choice that emphasize the role of exposure as an important determinant of who pursues innovation (Bell et al., 2019).

4.2.2 Was innovation a path to upward mobility?

Was innovation an avenue to upward mobility among those that managed to pursue a career as an inventor? As described in the introduction, the example of Frans Wilhelm Lindqvist is instructive. Born to a soldier father and starting off his career working as a toolmaker, Lindqvist appears in the patent records of the PRV as a business executive (*direktör*) after his invention of the Primus stove. Was the upward mobility experienced by Lindqvist typical for inventors?

Figure 6 displays the association between sons' and fathers' income ranks separately for inventor and non-inventor sons in the *linked father-son sample*. Along the horizontal axis, we plot the income percentile among the fathers in our sample, while the vertical axis captures the mean income among sons born to fathers at each percentile of the income distribution. Inventors on average achieved higher rates of absolute mobility, as reflected in higher incomes compared to non-inventors conditional on their fathers' income. Inventors also exhibit higher levels of relative mobility, as evident from the lower rank-rank slope among inventors compared to non-

[40] Appendix Table A.3 provides additional specifications.

[41] A simple counterfactual can be constructed by assuming that sons to non-elite fathers in our *linked father-son sample* would have gone on to invent at the same rate as elite sons (as in Figure 5A): the counterfactual would then imply that the number of Swedish inventors would have been about nine times higher. While such a counterfactual highlights potential misallocation, it abstracts away from other potential determinants of becoming an inventor (e.g., ability differences) that may vary by family background, as well as general equilibrium effects that would likely be important if the number of inventors had increased that dramatically.

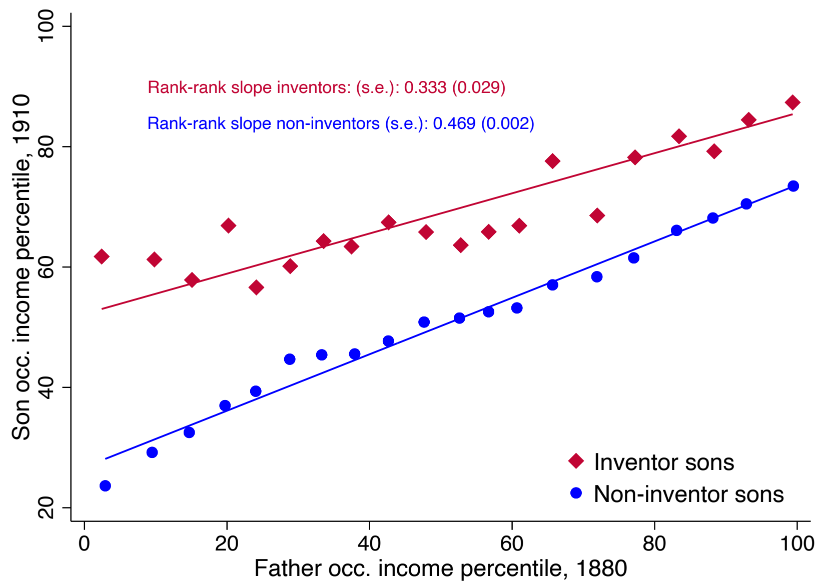


FIGURE 6:
INTERGENERATIONAL INCOME MOBILITY AMONG (NON-)INVENTORS.

Notes: The figure displays the non-parametric relationship between sons' occupational income in 1910 and their fathers' occupational income in 1880 separately for inventors and non-inventors (using the *linked father-son sample*). For each group, observations are sorted into 20 groups of equal size and the circles/diamonds indicate the mean income in each group. Linear regression lines based on the underlying (un-grouped) data where we include controls for cubic functions in the age of fathers and sons are also shown. We report the slope from these underlying rank-rank regressions in the figure with standard errors clustered at the father level.

inventors.[42] Thus, innovation weakened the relationship between fathers' and sons' places in the income distribution.

To substantiate these results, Table 4 reports estimates of individual-level OLS regressions where we compare inventors to non-inventors in terms of their income rank in 1910. The estimate in column 1 shows that inventors on average placed 24 percentile ranks higher in the income distribution compared to non-inventors.[43] The higher mobility among inventors could reflect a selection of inherently more mobile individuals into innovation, or a causal link be-

[42]We present additional estimates of traditional IGEs (i.e., where we regress sons' ln income on the ln income of fathers) as well as our preferred rank-rank measures in Appendix Table A.2. The IGE estimates similarly show that the elasticity between fathers and sons incomes is lower among inventors than among non-inventors.

[43]We document in Online Appendix Tables A.4 and A.5 that inventors are similarly more mobile in terms of ln incomes, or when measuring mobility by an indicator capturing whether a son surpasses his father's income rank in adulthood. Additionally, while we focus on intergenerational *income* mobility, a growing historical literature studies the extent to which occupations and social status is transmitted across generations (e.g, Long and Ferrie, 2013; Pérez, 2019; Berger et al., 2021a). In Online Appendix A.6 we present an analysis of the intergenerational occupational mobility of inventors, where we estimate so-called Altham statistics that reveal that inventors also exhibit a higher rate of occupational mobility.

tween innovation and mobility. To discern between these explanations, we next compare brothers where one became an inventor while the other(s) did not. Crucially, this allows us to net out selection due to factors that vary between families that we showed were a key determinant of who became an inventor above. Table 4, column 2, includes father fixed effects and thus compare inventors to their non-inventor brother(s). Mobility gains are reduced in magnitude, which is consistent with an important role of family background in accounting for the higher mobility of inventors. However, inventors on average placed about 5 percentile ranks higher in the income distribution relative to their non-inventor brothers, which suggests that at least part of the association between invention and mobility may reflect a causal link.

A higher mobility among inventors may not appear surprising given that inventors presumably are a more mobile subset of the population, which are further selected on successfully having applied for a patent. Table 4, column 3, includes two separate indicators for inventors that obtained their first patent before and after 1910, when we observe their occupation and income score. Notably, inventors that were granted at least one patent prior to 1910 experienced high rates of upward mobility, while the estimates for those that obtained their first patent later are small in magnitude and not statistically significant. That is, individuals were not more mobile *prior* to becoming an inventor. Additionally, column 4 shows that the mobility gains are negligible among one-time inventors, while star inventors (with more than 10 patents) experienced relatively high rates of mobility. Together, these results further suggest that the higher mobility among inventors reflect a causal link between innovation and intergenerational mobility.

We lastly examine mobility gains among inventors that hailed from the lower-end and the top of the income distribution. In the final two columns of Table 4 we split the sample into sons born to fathers in the bottom-three quartiles of the income distribution and those born to fathers in the top quartile. Notably, mobility gains are concentrated among inventors that hailed from relatively more disadvantaged backgrounds.

In sum, our findings above showed that individuals from more humble backgrounds were less likely to pursue a career in invention compared to children that hailed from privileged backgrounds. However, the results in this section shows that those who managed to overcome the hurdles in pursuing a career in innovation — such as Lindqvist — experienced significantly higher intergenerational mobility. At least for some, innovation was thus a path to upward mobility.

TABLE 4: INVENTION AND INTERGENERATIONAL INCOME MOBILITY

Dependent variable:	Son's income rank, 1910					
Sample:	All	All	All	All	Bottom-75%	Top-25%
	(1)	(2)	(3)	(4)	(5)	(6)
Inventor (=1)	24.483***	4.873***			8.435***	1.868
	(1.176)	(1.323)			(2.220)	(1.517)
Inventor: pre-1910 (=1)			6.501***			
			(1.770)			
Inventor: post-1910 (=1)			2.704			
			(1.915)			
Inventor: 1 patent (=1)				3.065*		
				(1.811)		
Inventor: 2-9 patents (=1)				6.546***		
				(1.923)		
Inventor: 10+ patents (=1)				11.003***		
				(3.829)		
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Father FE	No	Yes	Yes	Yes	Yes	Yes
Observations	140448	140448	140448	140448	103658	36790
Mean dep. var.	50.81	50.81	50.81	50.81	44.78	67.82

Notes: Individual-level OLS regressions using the *linked father-son sample* between 1880 and 1910. The dependent variable is a son's occupational income rank in 1910. Individual controls correspond to a cubic in sons' age in 1910. We restrict all samples to sons where we observe at least one brother. Standard errors are given in parentheses and are clustered at the father level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

5 Concluding discussion

Understanding the onset and spread of modern economic growth is ultimately a question of why a growing number of individuals developed new ideas and technologies that propelled growth and productivity. Both contemporaries and later scholarship has partly ascribed America's economic and industrial rise to the contributions of inventors from humble backgrounds, which in turn has been attributed to its inclusive patent system and broadly dispersed human capital. Interestingly, Sweden — Europe's "impoverished sophisticate" — had similarly high levels of broadly dispersed human capital and introduced an inclusive patent system in the late-19^{th} century. However, drawing on census and patent data we show that inventors during Sweden's industrialization predominately belonged to a small industrial elite, both before and after the patent reform in 1884. These findings suggest that broadly dispersed human capital and an inclusive patent system may be a necessary but not sufficient condition to enable a broad cross-section of the population to participate in innovation.

What can explain the lack of democratic invention in Sweden despite the apparent similarities with America? In our view, at least three explanations deserve further examination. First, patent systems differ in subtle ways that may shape *who* patents. For example, contemporary Swedes complained that the existence of patent working requirements constituted a significant barrier to patenting among poorer inventors (Andrée, 1888; Hamilton, 1889). In contrast, American lawmakers consciously opted not to introduce a working requirement, which may have been important in facilitating access to the patent system among poorer inventors. The U.S. system also extended property rights to a much wider range of inventions than in Europe (Khan, 2005). Indeed, contemporaries noted that American inventors from humble backgrounds, often to the surprise of Europeans, were granted patents for what appeared to be simple technical and mechanical improvements.[44] The role of such subtler differences in patenting systems may be important in accounting for differences in the economic and social origins of inventors across countries. Second, Sweden's transition to an examination system took place during the Second Industrial Revolution when innovation was becoming increasingly more complex and reliant on scientific advances (Mokyr, 1992). A growing role of upper-tail technical skills in developing patentable inventions at the technological frontier may have limited opportunities for working-class individuals to contribute to innovation.[45] Third, our evidence is consistent with Bell et al. (2019) showing that exposure to innovation is a key determinant of who becomes an inventor. Thus, financial incentives or changes in patent laws may have limited effects on entry because it only affects those individuals that are exposed to innovation in the first place. One can speculate that exposure to innovation was more diffused in the U.S. because a broader cross-section of people and places were involved in innovation, while innovation in Sweden was disproportionately confined to an elite residing in the capital Stockholm thus limiting exposure.

Our findings that a small group of creative individuals were crucial in driving innovation in Sweden contrasts the American case, but resonates with an emerging literature emphasizing the key role of upper-tail human capital during European industrialization (Mokyr, 2005; Squicciarini and Voigtländer, 2015; Hanlon, 2022). As summarized by Mokyr and Voth (2010, p. 30): "[T]he Industrial Revolution was carried not by the skills of the average or modal worker, but by

[44] Tisell (1910, p.110) quotes the American consul general in Frankfurt who in 1898 reported back home that Europeans had been surprised that the U.S. government so willingly granted patents for simple and relatively minor mechanical and technical improvements, which in many cases were developed by the workers involved in using or manufacturing a particular machine.

[45] Indeed, American and British invention was also increasingly driven by individuals with high technical human capital in this period (Khan and Sokoloff, 2004; Khan, 2018), even though white-collar inventors seem to have been underrepresented in the U.S. well into the 20^{th} century (Sarada et al., 2019).

the ingenuity and technical ability of a minority." Similarly, the accelerated pace of innovation during Sweden's rapid industrial take-off can largely be ascribed to the ingenuity of a small educational, economic, and social elite that developed the inventions that were vital for the rise of Swedish industry.

References

Aghion, Philippe, Ufuk Akcigit, Antonin Bergeaud, Richard Blundell, and David Hemous, "Innovation and Top Income Inequality," *Review of Economic Studies*, 2019, *86* (1), 1–45.

_ , _ , Ari Hyytinen, and Otto Toivanen, "The social origins of inventors," Technical Report, National Bureau of Economic Research 2017.

Ahlström, Göran, *Engineers and Industrial Growth: Higher technical education and the engineering profession during the nineteenth and early twentieth centuries: France, Germany, Sweden, and England*, Vol. 34, Routledge Kegan & Paul, 1982.

Akcigit, Ufuk, John Grigsby, and Tom Nicholas, "Immigration and the rise of American ingenuity," *American Economic Review*, 2017, *107* (5), 327–31.

_ , _ , and _ , "The rise of American ingenuity: Innovation and inventors of the golden age," Technical Report, National Bureau of Economic Research 2017.

Andersson, David E and Fredrik Tell, "From Fighting Monopolies to Promoting Industry: Patent Laws and Innovation in Sweden 1819–1914," *Jahrbuch für Wirtschaftsgeschichte/Economic History Yearbook*, 2019, *60* (1), 123–156.

Andersson, David, Mounir Karadja, and Erik Prawitz, "Mass migration and technological change," *Journal of the European Economic Association*, 2022, *20* (5), 1859–1896.

_ , Thor Berger, and Erik Prawitz, "Making a market: Infrastructure, integration, and the rise of innovation," *The Review of Economics and Statistics*, 2023, *105* (2), 258–274.

Andrée, S. A., *Uppfinningarna i Sverige åren 1870–84*, Samson & Wallin: Stockholm, 1888.

Azoulay, Pierre, Benjamin F Jones, J Daniel Kim, and Javier Miranda, "Age and high-growth entrepreneurship," *American Economic Review: Insights*, 2020, *2* (1), 65–82.

Basberg, Bjørn L, "Amateur or professional? A new look at nineteenth-century patentees in Norway," *Scandinavian Economic History Review*, 2015, *63* (1), 24–44.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen, "Who becomes an inventor in America? The importance of exposure to innovation," *The Quarterly Journal of Economics*, 2019, *134* (2), 647–713.

Bengtsson, Erik, Jakob Molinder, and Svante Prado, "The Swedish transition to equality: income inequality with new micro data, 1870–1970," Machine-readable data file, Lund University 2021.

Berger, Thor and Erik Prawitz, "Collaboration and Connectivity: Historical Evidence from Patent Records," *CEPR Discussion Paper No. DP18031*, 2023.

_ , Per Engzell, Björn Eriksson, and Jakob Molinder, "Social mobility in Sweden before the welfare state," *CEPR Discussion Paper No. DP16595*, 2021.

_ , _ , Björn Eriksson, and Jakob Molinder, "Income scores for Swedish census data," *Mimeo*, 2021.

Billington, Stephen D, "What explains patenting behaviour during Britain's Industrial Revolution?," *Explorations in Economic History*, 2021, *82*, 101426.

Bottomley, Sean, "The returns to invention during the British industrial revolution," *The Economic History Review*, 2019, *72* (2), 510–530.

Celik, Murat Alp, "Does the cream always rise to the top? The misallocation of talent in innovation," *Journal of Monetary Economics*, 2023, *133*, 105–128.

Griliches, Zvi, "Patents Statistics as Economic Indicators: A survey Journal of Economic Literature, 18 (4)," *December*, 1990, *1661*, 1707.

Gårdlund, Torsten, *Industrialismens samhälle*, Tiden, 1942.

Hamilton, Hugo E. G., *Underdånig berättelse angående Kongl. Patentbyråns verksamhet åren 1885–1888*, K.L Beckman: Stockholm, 1889.

Hanlon, W Walker, "Necessity is the mother of invention: Input supplies and Directed Technical Change," *Econometrica*, 2015, *83* (1), 67–100.

_ , "The rise of the engineer: Inventing the professional inventor during the Industrial Revolution," Technical Report, National Bureau of Economic Research 2022.

Heckscher, Eli Filip, *Svenskt arbete och liv: från medeltiden till nutiden*, Bonnier, 1941.

Jones, Benjamin F, "The burden of knowledge and the "death of the renaissance man": Is innovation getting harder?," *The Review of Economic Studies*, 2009, *76* (1), 283–317.

_ , "Age and great invention," *The Review of Economics and Statistics*, 2010, *92* (1), 1–14.

Jung, Taehyun and Olof Ejermo, "Demographic patterns and trends in patenting: Gender, age, and education of inventors," *Technological Forecasting and Social Change*, 2014, *86*, 110–124.

Kelly, Morgan, Joel Mokyr, and Cormac O Grada, "The Mechanics of the Industrial Revolution," *Journal of Political Economy*, 2022, *0* (ja), null.

Khan, B Zorina, *The Democratization of Invention: patents and copyrights in American economic development, 1790-1920*, Cambridge University Press, 2005.

__ , "Human capital, knowledge and economic development: evidence from the British Industrial Revolution, 1750–1930," *Cliometrica*, 2018, *12* (2), 313–341.

__ **and Kenneth L Sokoloff**, ""Schemes of practical utility": Entrepreneurship and innovation among "great inventors" in the United States, 1790–1865," *The Journal of Economic History*, 1993, *53* (2), 289–307.

Khan, Zorina and Kenneth L Sokoloff, "Institutions and Democratic Invention in 19th-Century America: Evidence from "Great Inventors," 1790-1930," *American Economic Review*, 2004, *94* (2), 395–401.

Leeuwen, Marco HD Van and Ineke Maas, *HISCLASS: A historical international social class scheme*, Universitaire Pers Leuven, 2011.

__ **,** __ **, and Andrew Miles**, *HISCO: Historical international standard classification of occupations*, Leuven Univ Pr, 2002.

Lerner, Josh, "150 years of patent protection," *American Economic Review*, 2002, *92* (2), 221–225.

Long, Jason and Joseph Ferrie, "Intergenerational occupational mobility in Great Britain and the United States since 1850," *American Economic Review*, 2013, *103* (4), 1109–37.

Machlup, Fritz and Edith Penrose, "The patent controversy in the nineteenth century," *The Journal of Economic History*, 1950, *10* (1), 1–29.

Maloney, William F and Felipe Valencia Caicedo, "Engineering Growth," *Journal of the European Economic Association*, 2022, *20* (4), 1554–1594.

Meisenzahl, Ralf R. and Joel Mokyr, *The Rate and Direction of Invention in the British Industrial Revolution: Incentives and Institutions*, University of Chicago Press, April

Mokyr, Joel, *The lever of riches: Technological creativity and economic progress*, Oxford University Press, 1992.

_ , "Long-term economic growth and the history of technology," in "Handbook of economic growth," Vol. 1, Elsevier, 2005, pp. 1113–1180.

_ **and Hans-Joachim Voth**, "Understanding growth in Europe, 1700-1870: theory and evidence," *The Cambridge economic history of modern Europe*, 2010, *1*, 7–42.

_ **, Assaf Sarid, and Karine van der Beek**, "The Wheels of Change: Technology Adoption, Millwrights and the Persistence in Britain'S Industrialisation," *The Economic Journal*, 02 2022, *132* (645), 1894–1926.

Moser, Petra, "How do patent laws influence innovation? Evidence from nineteenth-century world's fairs," *American economic review*, 2005, *95* (4), 1214–1236.

_ , "Innovation without Patents: Evidence from World's Fairs," *The Journal of Law Economics*, 2012, *55* (1), 43–74.

Nicholas, Tom, "The role of independent invention in US technological development, 1880–1930," *The Journal of Economic History*, 2010, pp. 57–82.

_ , "Independent invention during the rise of the corporate economy in Britain and Japan," *Economic History Review*, 2011, *64* (3), 995–1023.

Nuvolari, Alessandro and Michelangelo Vasta, "Independent invention in Italy during the Liberal Age, 1861–1913," *The Economic History Review*, 2015, *68* (3), 858–886.

Pérez, Santiago, "Intergenerational occupational mobility across three continents," *The Journal of Economic History*, 2019, *79* (2), 383–416.

Sáiz, Patricio, *Invención, patentes e innovación en la España contemporánea*, OFICINA ESPAÑOLA PATENTES MA, 1999.

_ , "Social networks of innovation in the European periphery: exploring independent versus corporate patents in Spain circa 1820-1939," *Historical Social Research/Historische Sozialforschung*, 2012, pp. 348–369.

Sandberg, Lars G, "The case of the impoverished sophisticate: human capital and Swedish economic growth before World War I," *The Journal of Economic History*, 1979, *39* (1), 225–241.

Sarada, Sarada, Michael J Andrews, and Nicolas L Ziebarth, "Changes in the demographics of American inventors, 1870–1940," *Explorations in Economic History*, 2019, *74*, 101275.

Schankerman, Mark and Ariel Pakes, "Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period," *The Economic Journal*, 1986, *96* (304), 1052–1076.

Sokoloff, Kenneth L and B Zorina Khan, "The democratization of invention during early industrialization: Evidence from the United States, 1790–1846," *The Journal of Economic History*, 1990, *50* (2), 363–378.

Squicciarini, Mara P and Nico Voigtländer, "Human capital and industrialization: Evidence from the age of enlightenment," *The Quarterly Journal of Economics*, 2015, *130* (4), 1825–1883.

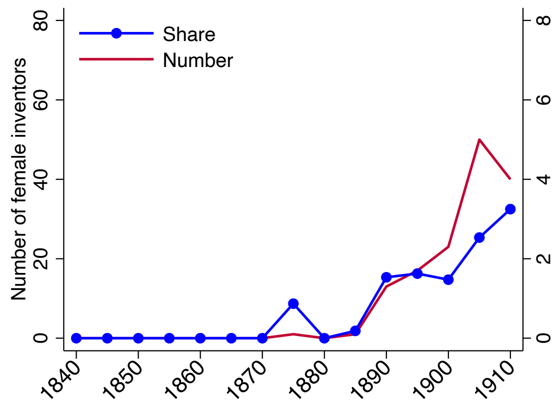
Tisell, Henrik G., "Undersökning öfver uppfinnareverksamhetens variationer inom olika industriklasser i Sverige, Tyskland, Frankrike, England, Österrike och Ungern," *Statsvetenskaplig Tidskrift*, 1910, *13* (November).

Online Appendix (not for publication)

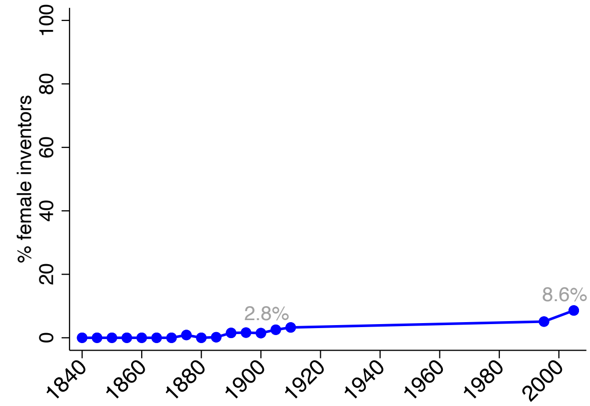
Inventors among the "Impoverished Sophisticate"

A Additional material

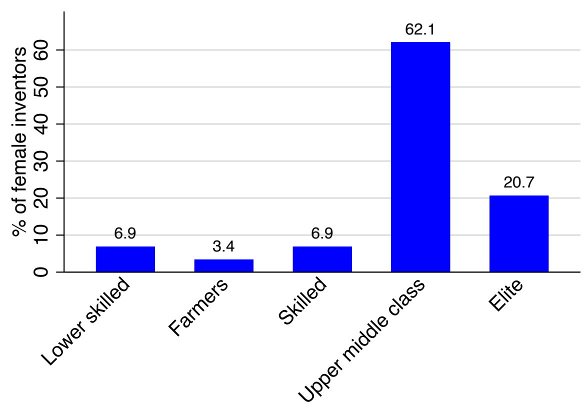
A.1 Demographic characteristics



(A) FEMALE INVENTORS, 1840–1914



(B) FEMALE INVENTORS, 1840–2005



(C) SOCIAL CLASS, 1885–1914

FIGURE A.1:
FEMALE INVENTORS

Notes: A: The number and share of female inventors denoted on the PRV patent records for all inventors that were granted a patent between 1840–1914. B: The share of female inventors denoted on the PRV patent records for all inventors that were granted a patent between 1840–1914 and modern data from Jung and Ejermo (2014). C: The social class of female inventors based on the PRV patent records for all inventors that were granted a patent between 1885 and 1914 (*full inventor sample*).

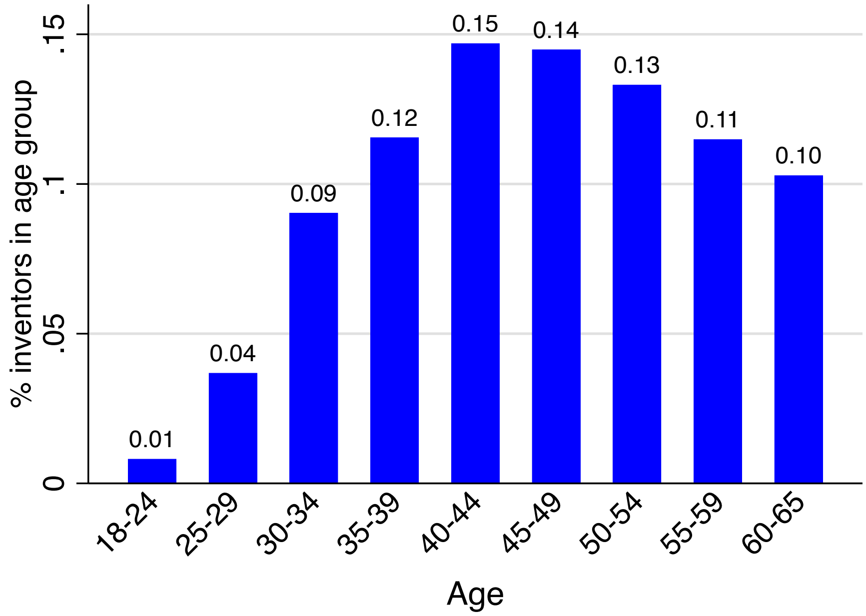
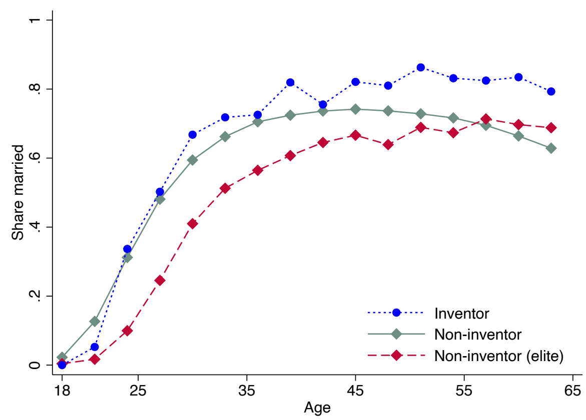
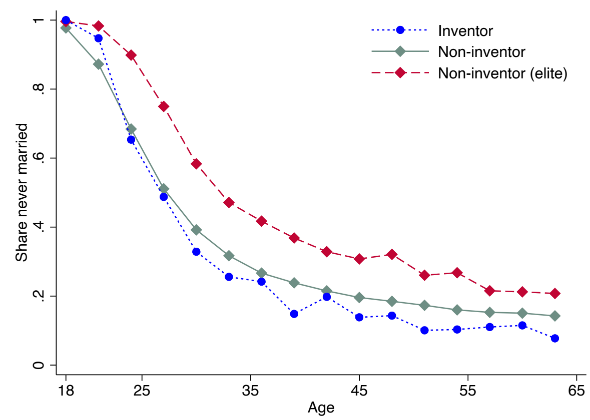


FIGURE A.2:
PROBABILITY TO BE AN INVENTOR BY AGE.

Notes: The figure displays the share of inventors in each age group using the *census sample* that includes inventors that were granted at least one patent by the PRV between 1885 and 1914.



(A) SHARE MARRIED



(B) SHARE NEVER MARRIED

FIGURE A.3:
MARRIAGE RATES AMONG INVENTORS AND NON-INVENTORS.

Notes: A: Share of adult male (non-)inventors that are married by age. B: Share of adult male (non-)inventors that are never married by age. Both figures uses the *census sample*.

A.2 Income, occupations, and social status

TABLE A.1: MOST COMMON OCCUPATIONAL TITLES AMONG INVENTORS, 1885–1914.

	Freq.	Percent	Cum.
Elite			
Engineers	1283	46.72	46.72
General Manager	844	30.74	77.46
Officer	154	5.61	83.07
Mining Engineer	36	1.31	84.38
Building Architect	35	1.27	85.65
Upper Middle Class			
Working Proprietor	619	31.69	31.69
Production Supervisor or Foreman	297	15.21	46.90
Contractor	128	6.55	53.46
Bookkeeper	92	4.71	58.17
Production Manager	50	2.56	60.73
Skilled			
Machinery Fitter or Machine Assembler	260	18.39	18.39
Carpenter	220	15.56	33.95
Blacksmith	200	14.14	48.09
Tool and Die Maker	55	3.89	51.98
Watch and Clock Assembler or Repairer	55	3.89	55.87
Farmers			
General Farmer	224	93.72	93.72
Horticultural Farmer	14	5.86	99.58
Other Specialised Farmers	1	0.42	100.00
Lower Skilled			
Ship's Fireman	155	34.14	34.14
Metal Processor	51	11.23	45.37
Building Painter	45	9.91	55.29
Blacksmith	23	5.07	60.35
Dairy Product Processor	16	3.52	63.88
Unskilled			
Factory Worker	44	34.65	34.65
Worker	43	33.86	68.50
Labourer	8	6.30	74.80
Chimney Sweep	6	4.72	79.53
Farm Worker	6	4.72	84.25

Notes: This table shows the five most common occupational titles among Swedish inventors within each of the six broad social classes we examine (based on the HISCLASS social class scheme) using the *full inventor sample*.

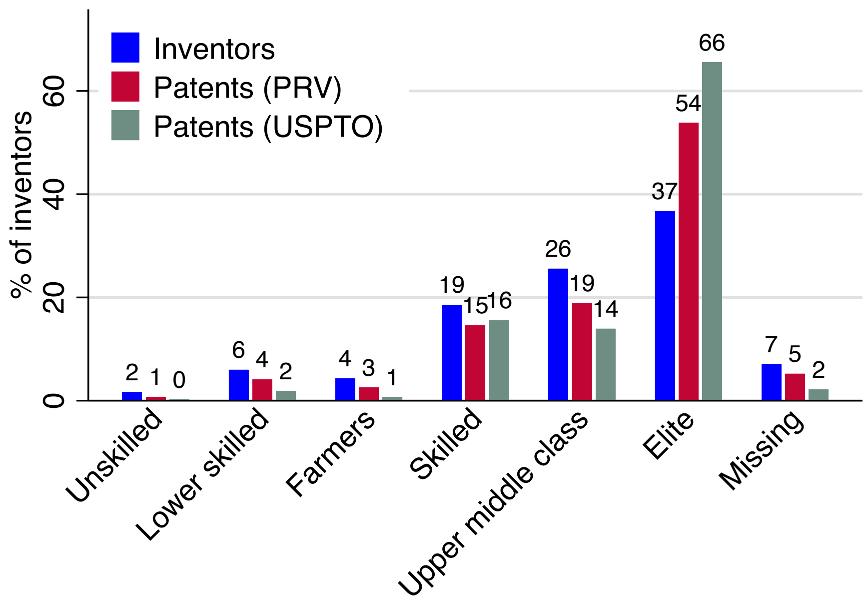


FIGURE A.4:
ECONOMIC AND SOCIAL STATUS OF INVENTORS INCLUDING INVENTORS WITH MISSING OCCUPATION

Notes: Distribution of social status among Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 (using the *full inventor sample*). Social status is based on the occupation recorded in the census of 1910.

Secrecy. One potential explanation is that elite inventors selected into formal patenting due to other factors, e.g., better social networks or some form of institutional knowledge, whereas less skilled groups chose to invent in sectors protected by secrecy. To explore this possibility, we study to what extent elite inventors were similarly overrepresented in sectors better protected by secrecy. Under the assumption that inventive activity in these sectors would spill over to patenting, we can explore to what extent the skill background of inventors differs between these two sectors. Figure A.5 compares the social status distributions within chemical and machinery patents, as examples of sectors protected by high (chemical) and low (machinery) secrecy, showing a roughly similar pattern.[46] Although, we cannot rule out the importance of secrecy, this suggests that elite inventors were overrepresented also in sectors where formal patenting was less prominent.

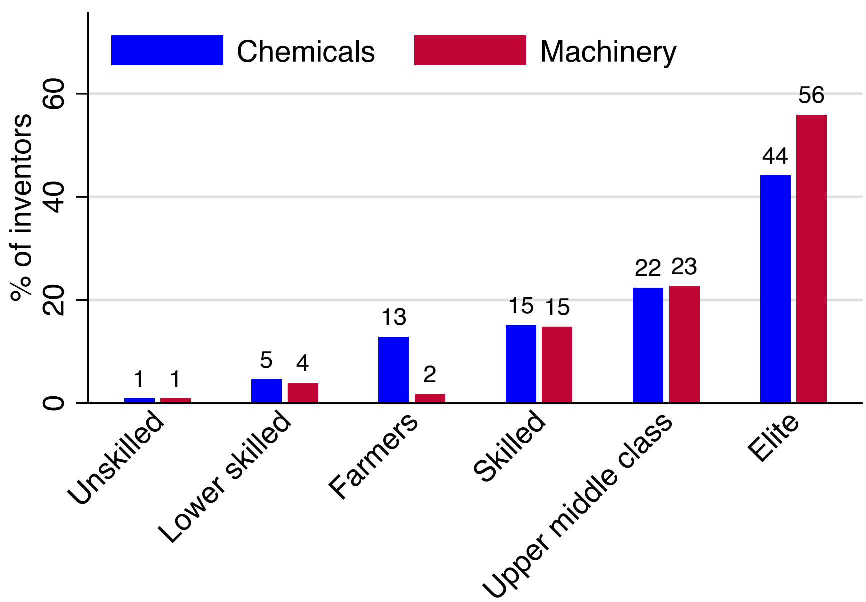


FIGURE A.5:
SOCIAL STATUS OF INVENTORS AND SECRECY.

Notes: This figure displays the distribution of social status among Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 (using the *full inventor sample*) separately for machinery and chemical patents.

[46]While secrecy became less prominent in the chemical industries towards the turn of the century (Moser, 2012), the bulk of patenting activity took place in a period marked by differential patenting rates (Moser, 2005).

Firm patents. As firm patents became increasingly prominent during the decades prior to World War I, we explore their role in explaining our results. If elite inventors were more likely to be employed in firms, their patenting could potentially partly be concealed by a rise in firm patents. However, Online Appendix Figure A.6 suggests that elite inventors were more commonly involved in firm- than non-firm patents, which largely reduces such concerns.

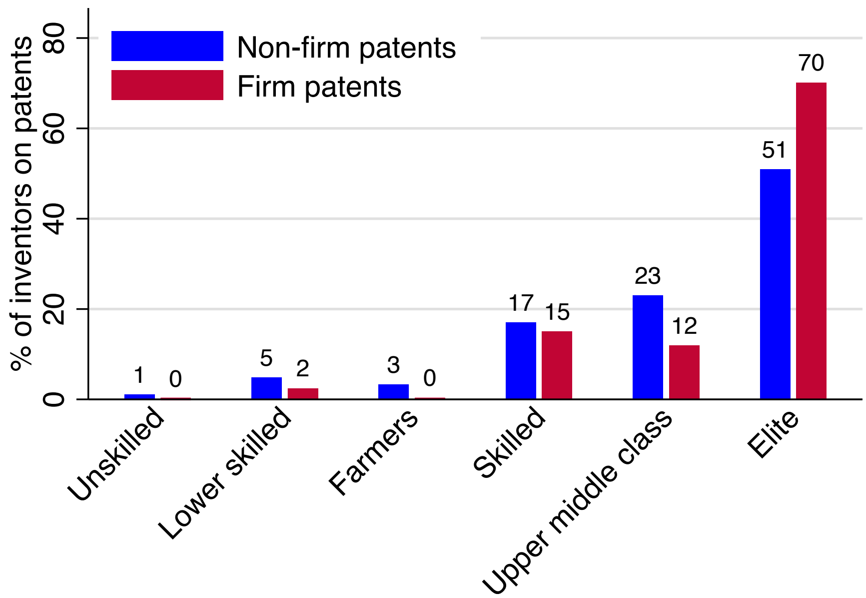


FIGURE A.6:
SOCIAL STATUS OF INVENTORS ON FIRM- AND NON-FIRM PATENTS.

Notes: This figure displays the distribution of social status among Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 (using the *full inventor sample*) separately for firm- and non-firm patents. Firm patents are defined as patents that list at least one firm as a patentee.

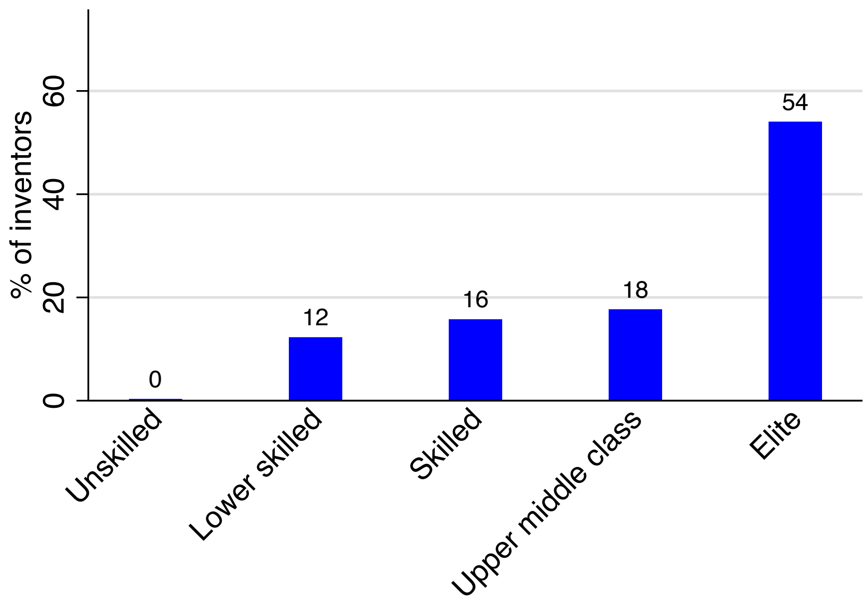


FIGURE A.7:
SOCIAL STATUS OF INVENTORS NOT LISTED AS PATENT HOLDERS.

Notes: This figure displays the distribution of social status among Swedish inventors not listed as patent holders that were granted at least one patent by the PRV between 1885 and 1914 (using the *full inventor sample*).

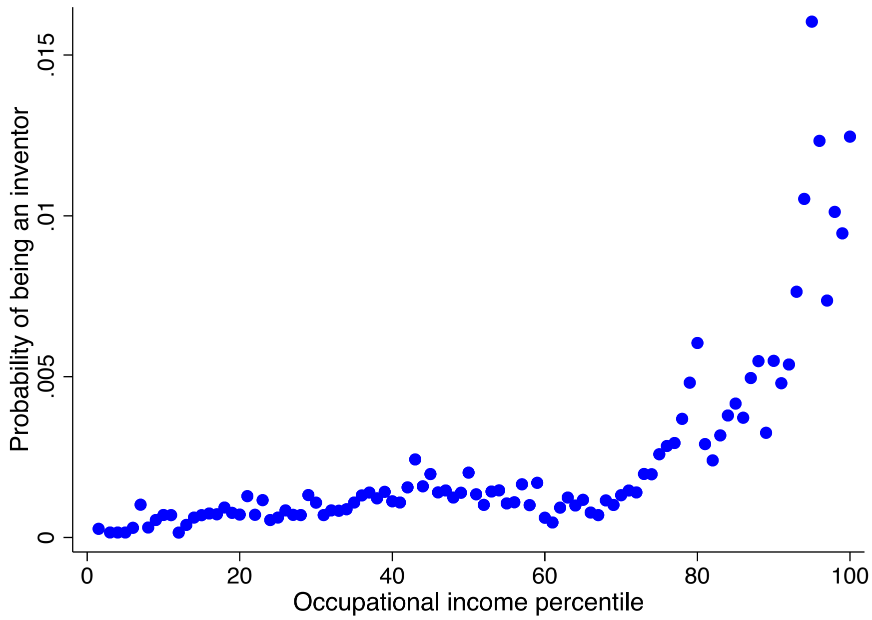


FIGURE A.8:
INCOME DISTRIBUTION OF INVENTORS

Notes: Distribution of social status among Swedish inventors that were granted at least one patent by the PRV between 1885 and 1914 (using the *census sample*).

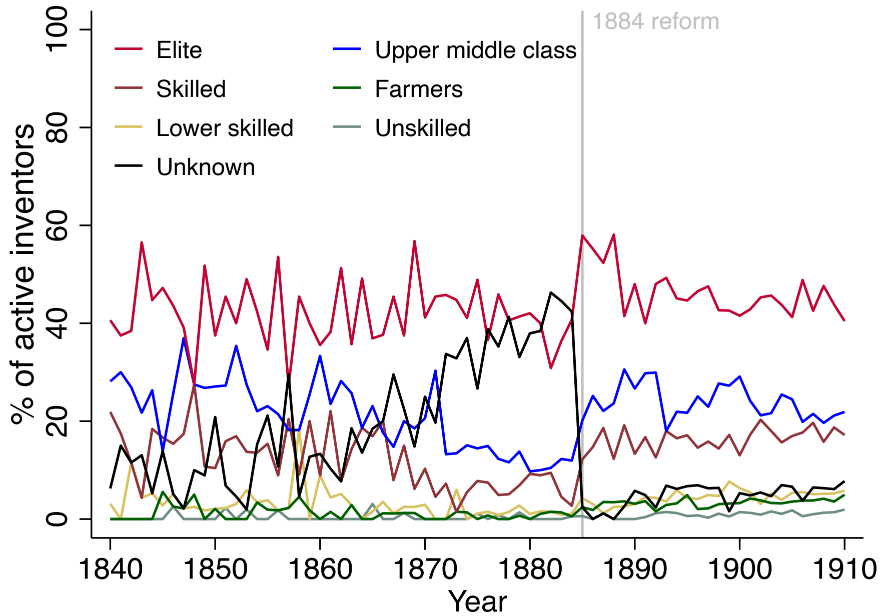
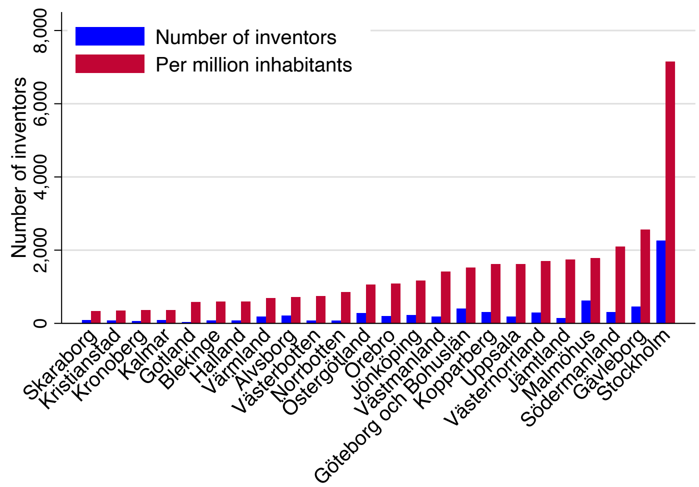


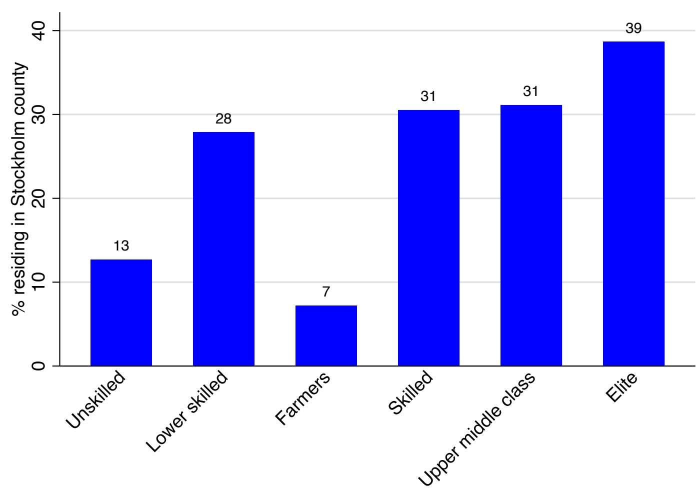
FIGURE A.9:
SOCIAL STATUS OF INVENTORS DURING INDUSTRIALIZATION.

Notes: This figure displays the distribution of social status among active inventors granted at least one patent between 1840 and 1914. We include one observation for each inventor that patented at least once in each given year. We include and report the share of active inventors with missing occupational information.

A.3 The geography of inventors



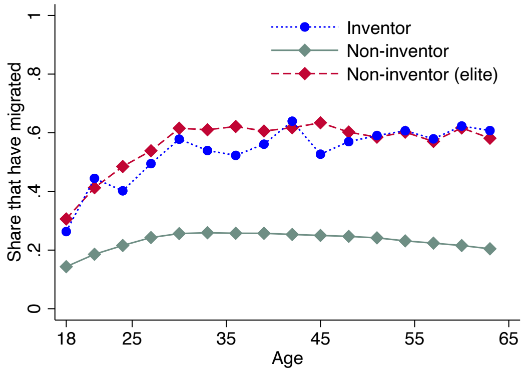
(A) INVENTORS BY COUNTY



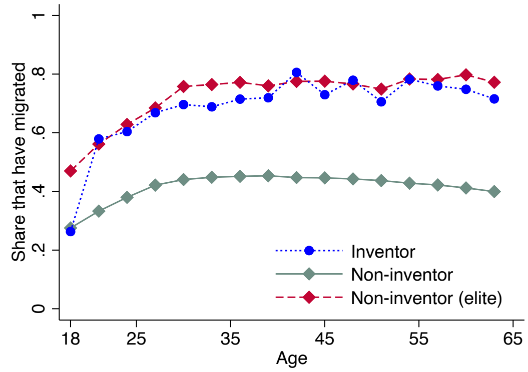
(B) SHARE OF INVENTORS RESIDING IN STOCKHOLM

FIGURE A.10:
THE GEOGRAPHY OF INVENTORS

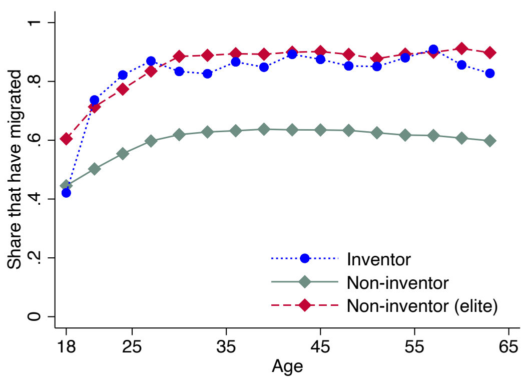
Notes: A: This figure displays the county of residence denoted on the patent records for all inventors that were granted at least one patent by the PRV between 1885 and 1914. Inventors per million inhabitants is based on population data from Statistics Sweden for 1880. B: The share of inventors that resided in Stockholm county all inventors that were granted at least one patent by the PRV between 1885 and 1914. Both figures uses the *full inventor sample*.



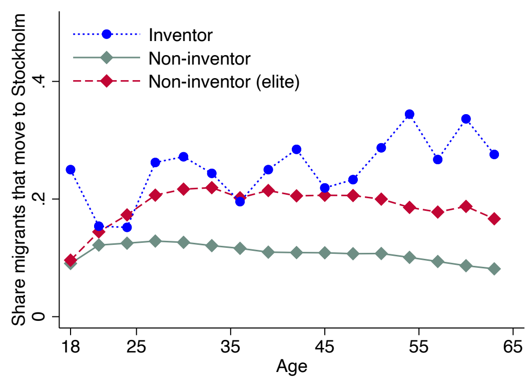
(A) ACROSS COUNTIES



(B) ACROSS MUNICIPALITIES



(C) ACROSS PARISHES



(D) TO STOCKHOLM

FIGURE A.11:
GEOGRAPHIC MOBILITY OF (NON-)INVENTORS OVER THEIR LIFE CYCLE

Notes: Share of (non-)inventors that reside in a different county (A), municipality (B), or parish (C) than their place of birth in the 1910 census by their age in 1910. Panel D display the share of migrants that move to Stockholm by their age in 1910. All figures uses the *census sample*.

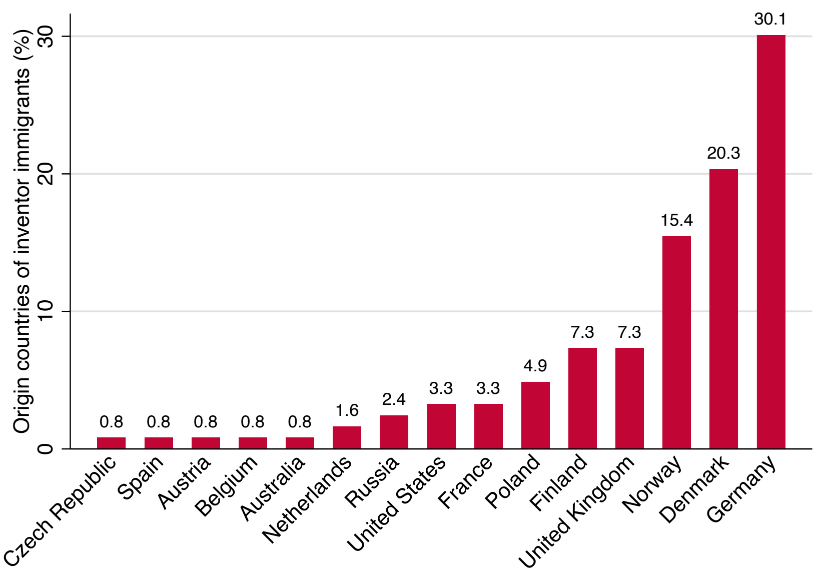
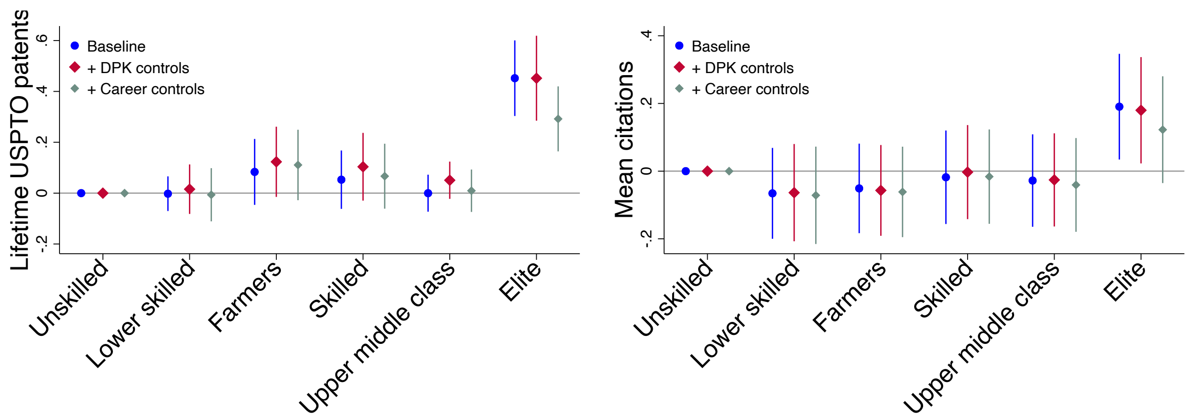


FIGURE A.12:
COUNTRY OF ORIGIN OF IMMIGRANT INVENTORS.

Notes: This figure displays the country of birth among inventor immigrants based on the *census sample*. For example, 30 percent of immigrant inventors were born in Germany.

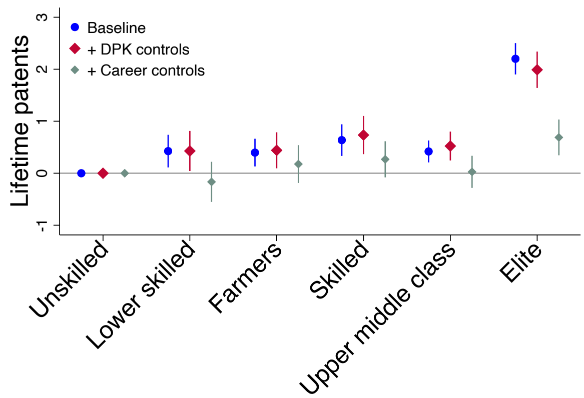
A.4 Inventor productivity



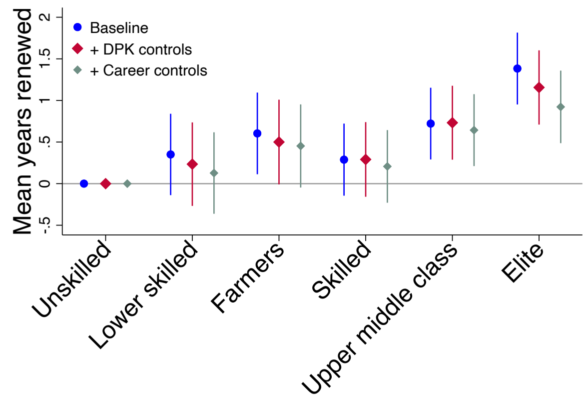
(A) PATENT OUTPUT (USPTO) (B) MEAN CITATIONS (USPTO)

FIGURE A.13:
INVENTOR OUTPUT AND QUALITY BY SOCIAL CLASS.

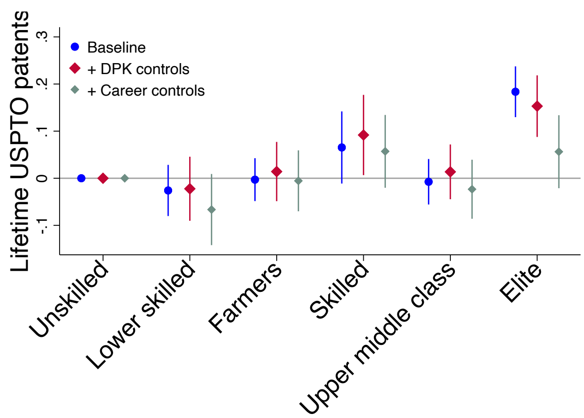
Notes: Inventor-level OLS regressions of patent output and quality among inventors belonging to different social classes relative to inventors belonging to the unskilled class (using the *census sample*). A: The total number of granted USPTO patents over an inventor's lifetime. B: The average number of patent citations. The baseline regressions (denoted by blue circles) include controls for the first decade in which an inventor applied for a (subsequently granted) patent and the county of residence. Additional specifications add controls for the first (DPK) technology class an inventor patents in (red diamonds) and career length (teal diamonds).



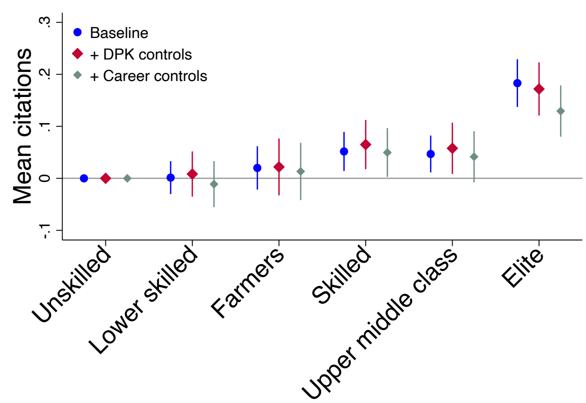
(A) PATENT OUTPUT (PRV)



(B) PATENT QUALITY (PRV



(C) PATENT OUTPUT (USPTO)



(D) MEAN CITATIONS (USPTO)

FIGURE A.14:
INVENTOR OUTPUT AND QUALITY BY SOCIAL CLASS.

Notes: Inventor-level OLS regressions of patent output and quality among inventors belonging to different social classes relative to inventors belonging to the unskilled class (using the *full inventor sample*). A: The total number of granted patents over an inventor's lifetime. B: the average number of years patent fees were paid per patent. C: The total number of granted USPTO patents over an inventor's lifetime. D: The average number of patent citations. The baseline regressions (denoted by blue circles) include controls for the first decade in which an inventor applied for a (subsequently granted) patent and the county of residence. The baseline regressions (denoted by blue circles) include controls for the first decade in which an inventor applied for a (subsequently granted) patent and the county of residence. Additional specifications add controls for the first (DPK) technology class an inventor patents in (red diamonds) and career length (teal diamonds).

A.5 Family background of inventors

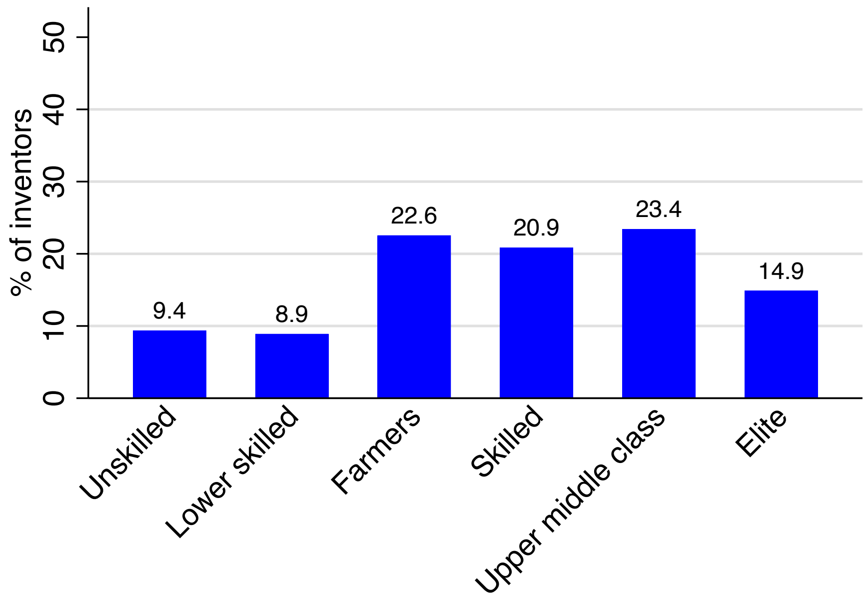
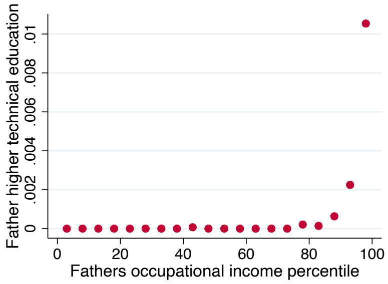
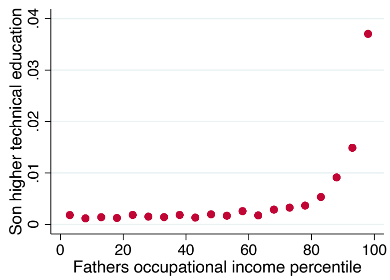


FIGURE A.15:
SOCIAL ORIGINS OF INVENTORS.

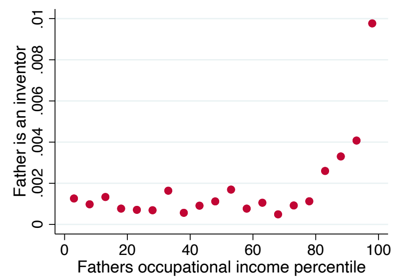
Notes: This figure displays the distribution of social status among fathers to inventors in our *linked father-son sample*. The different status categories are based on the HISCLASS social class scheme, as described in the main text.



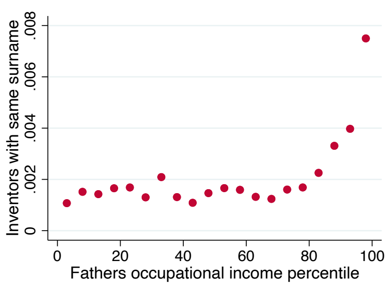
(A) FATHER: EDUCATION



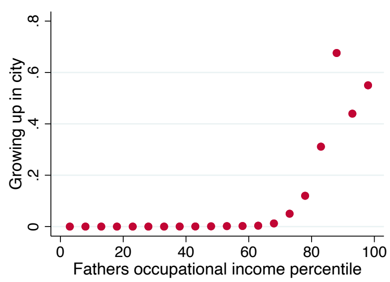
(B) SON: EDUCATION



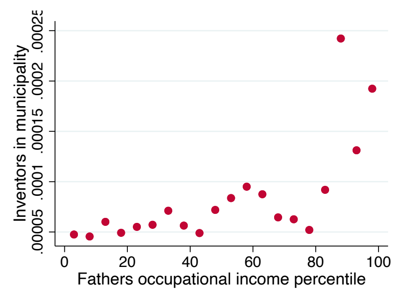
(C) FATHER: INVENTOR



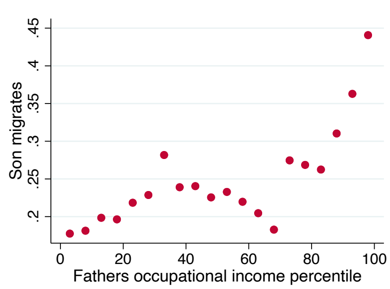
(D) INV. WITH SAME SURNAME



(E) LIVES IN CITY



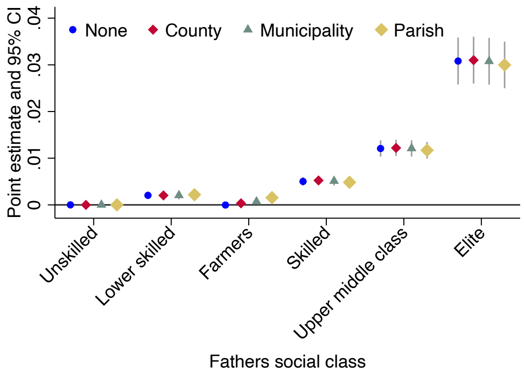
(F) INVENTORS IN MUNICIPALITY



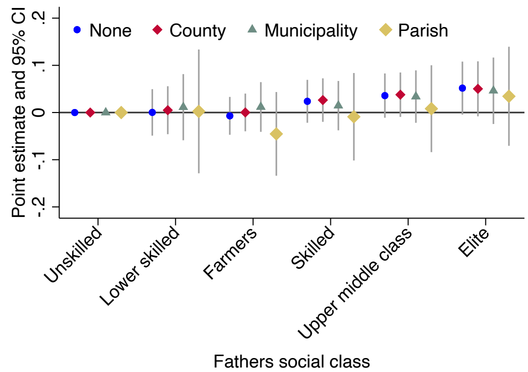
(G) SON: MIGRATES

FIGURE A.16:
FATHERS INCOME AND OUTCOMES FOR FATHERS AND SONS.

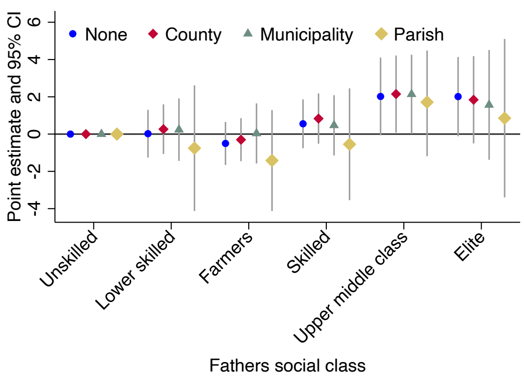
Notes: The figure displays the non-parametric relationship between an indicator capturing outcomes for sons or fathers and the father's occupational income in 1880 (*linked father-son sample*). Observations are sorted into 20 groups of equal size and the circles indicate the mean of each outcome within each group.



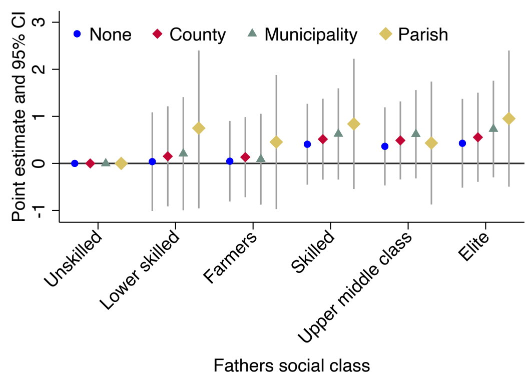
(A) INVENTOR



(B) STAR INVENTOR



(C) PATENT OUTPUT



(D) PATENT QUALITY

FIGURE A.17:
FAMILY BACKGROUND AND BECOMING AN INVENTOR - CONTROLLING FOR THE LOCATION AT BIRTH

Notes: This figure displays the relationship between father's social status and the probability of being an inventor in adulthood (A), a star inventor with more than 10 patents (B), the number of patents (C), and the mean fees paid per patent (D), while controlling for different location at birth fixed effects. The different status categories are based on the HISCLASS social class scheme, as described in the main text. All specifications include cubic functions in the age of the father in 1880 and the son in 1910, respectively. Figure A uses the *census sample*. Figure B, C, and D uses the *census sample* with only inventors.

TABLE A.2: INTERGENERATIONAL INCOME MOBILITY AMONG (NON-)INVENTORS: IGE AND RANK-RANK ESTIMATES.

Dependent variable:	Son's income (ln)			Son's income rank		
	Inventors (1)	Non-inventors (2)	All (3)	Inventors (4)	Non-inventors (5)	All (6)
Father's income (ln)	0.372***	0.522***	0.522***			
	(0.029)	(0.003)	(0.003)			
Inventor (=1)			1.211***			24.563***
			(0.194)			(2.361)
Income (ln) $\times$ Inventor (=1)			-0.143***			
			(0.028)			
Father's income rank				0.333***	0.469***	0.462***
				(0.029)	(0.002)	(0.002)
Rank $\times$ Inventor (=1)						-0.120***
						(0.029)
Sons age	Yes	Yes	Yes	Yes	Yes	Yes
Fathers age	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1055	283589	284644	1055	283589	284644
Mean dep. var.	7.01	6.63	6.63	75.07	50.38	50.47

Notes: The table reports individual-level OLS regressions using the *linked father-son sample* between the 1880 and 1910 census. Standard errors are given in parentheses and are clustered at the household level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

TABLE A.3: WHO BECOMES AN INVENTOR - INTENSIVE MARGIN

Dependent variable:	Star inventor (=1)					Number of patents					Years patents renewed				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Father's economic and social class															
Father top-10% (=1)	0.024	0.016	0.014	0.017	-0.002	1.751**	1.737	1.681	1.740	1.109	0.210	0.165	0.137	0.004	-0.135
	(0.018)	(0.022)	(0.023)	(0.029)	(0.027)	(0.722)	(1.138)	(1.177)	(1.150)	(1.120)	(0.252)	(0.282)	(0.286)	(0.328)	(0.314)
Father elite (=1)		0.023	-0.008	-0.009	-0.025		0.042	-1.137	-1.133	-1.670		0.140	-0.008	0.015	-0.090
		(0.033)	(0.029)	(0.029)	(0.028)		(1.837)	(1.612)	(1.590)	(1.548)		(0.290)	(0.317)	(0.316)	(0.327)
Family exposure to innovation															
Father higher technical education (=1)			0.208	0.208	0.183			8.161	8.169	7.221			0.748	0.735	0.429
			(0.136)	(0.135)	(0.144)			(5.450)	(5.447)	(5.430)			(0.810)	(0.812)	(0.850)
Father inventor (=1)			-0.016	-0.015	-0.021			-1.289	-1.319	-1.590			0.870	0.836	0.710
			(0.051)	(0.051)	(0.043)			(1.473)	(1.498)	(1.317)			(0.598)	(0.603)	(0.573)
Share inventors with surname, 1865-1880			0.006**	0.006**	0.005**			0.215	0.214	0.197			0.019	0.019	0.016
			(0.003)	(0.003)	(0.002)			(0.135)	(0.134)	(0.127)			(0.014)	(0.014)	(0.013)
Local exposure to innovation															
Born in urban area (=1)				-0.009	-0.007				-0.277	-0.195				0.322	0.357
				(0.025)	(0.025)				(0.696)	(0.691)				(0.250)	(0.252)
Share inventors in municipality, 1820-1880				0.002	0.001				0.183***	0.112**				-0.008	-0.031
				(0.002)	(0.002)				(0.053)	(0.053)				(0.031)	(0.027)
Son's education and location															
Son higher technical education (=1)					0.118***					4.129***					1.145***
					(0.027)					(0.946)					(0.260)
Migrant, 1880-1910 (=1)					0.017					0.254					-0.218
					(0.012)					(0.620)					(0.258)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Childhood county FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1055	1055	1055	1055	1055	1055	1055	1055	1055	1055	1048	1048	1048	1048	1048
Mean dep. var.	0.051	0.051	0.051	0.051	0.051	3.365	3.365	3.365	3.365	3.365	4.481	4.481	4.481	4.481	4.481

Notes: The table reports individual-level OLS regressions using the *linked father-son sample* between the 1880 and 1910 census. Individual controls include age in 1910. All regressions include a full set of fixed effects for county of birth. Standard errors are given in parentheses and are clustered at the county of birth level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

TABLE A.4: INVENTION AND INTERGENERATIONAL INCOME MOBILITY

Dependent variable:	Son's ln income, 1910			
	(1)	(2)	(3)	(4)
Inventor (=1)	0.380***	0.077***		
	(0.019)	(0.021)		
Inventor: pre-1910 (=1)			0.114***	
			(0.028)	
Inventor: post-1910 (=1)			0.027	
			(0.031)	
Inventor: 1 patent (=1)				0.053*
				(0.028)
Inventor: 2-9 patents (=1)				0.099***
				(0.033)
Inventor: 10+ patents (=1)				0.156**
				(0.066)
Individual controls	Yes	Yes	Yes	Yes
Father FE	No	Yes	Yes	Yes
Observations	140448	140448	140448	140448
Mean dep. var.	6.64	6.64	6.64	6.64

Notes: Individual-level OLS regressions using the *linked father-son sample* between 1880 and 1910. The dependent variable is a son's ln occupational income score in 1910. Individual controls correspond to a cubic in sons' age in 1910. We restrict all samples to sons where we observe at least one brother. Standard errors are given in parentheses and are clustered at the father level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

TABLE A.5: INVENTION AND INTERGENERATIONAL INCOME MOBILITY

Dependent variable:	Upward mobility (=1)			
	(1)	(2)	(3)	(4)
Inventor (=1)	0.089***	0.080***		
	(0.022)	(0.022)		
Inventor: pre-1910 (=1)			0.115***	
			(0.028)	
Inventor: post-1910 (=1)			0.034	
			(0.033)	
Inventor: 1 patent (=1)				0.048*
				(0.029)
Inventor: 2-9 patents (=1)				0.103***
				(0.033)
Inventor: 10+ patents (=1)				0.230***
				(0.073)
Individual controls	Yes	Yes	Yes	Yes
Father FE	No	Yes	Yes	Yes
Observations	140448	140448	140448	140448
Mean dep. var.	0.37	0.37	0.37	0.37

Notes: Individual-level OLS regressions using the *linked father-son sample* between 1880 and 1910. The dependent variable is an indicator taking the value one if a son's occupational income rank in 1910 surpasses that of his father in 1880. Individual controls correspond to a cubic in sons' age in 1910. We restrict all samples to sons where we observe at least one brother. Standard errors are given in parentheses and are clustered at the father level. *** - $p < 0.01$, ** - $p < 0.05$, * - $p < 0.1$.

A.6 Occupational mobility

We here examine whether inventors also exhibit more occupational mobility asking whether inventors were more likely to transition out of their fathers social class. Here we focus on the same six broad social groups used throughout the paper: elite, upper middle class, skilled, farmers, lower skilled, and unskilled. Inventors were much more likely to transition out of their fathers social class: 67 percent of inventors are observed in a different occupational group than their fathers, which can be compared to 58 percent among non-inventors.[47] To paint a richer picture of the occupational origins and destinations of inventors, Appendix Table A.6 displays the occupational origins and destinations for sons based on their fathers occupation. Here we observe children's occupational groups in the 1910 census, while their fathers occupations are observed in 1880. We observe more persistence among inventors in the top of the distribution: 67 percent of inventor sons born to elite fathers remain in elite occupations as adults, which can be compared to 39 percent among non-inventors. At the same time, we observe more mobility in the bottom of the distribution. For example, only 13 percent of inventor sons born to fathers with an unskilled occupation remain in an unskilled occupation in adulthood.

To more formally measure rates of relative occupational mobility, we also estimate Altham statistics as common in the historical literature (Long and Ferrie, 2013; Pérez, 2019; Berger et al., 2021a). The Altham statistic summarizes all the odds ratios in a mobility table, which reflect the relative chances of reaching a given occupational standing for sons from different origins. We then compare the mobility table of inventors and non-inventors ($\mathbf{P}$) to a table ($\mathbf{I}$) where the occupational attainment of sons is independent of their fathers. The Altham $d(\mathbf{P}, \mathbf{I})$ statistic ranges between 0 and infinity, where a larger statistic corresponds to a greater departure from the case of full mobility (i.e., less mobility).[48] The Altham $d(\mathbf{P}, \mathbf{I})$ statistic is 58.5 ($p < 0.000$) and 42.6 ($p < 0.000$) for non-inventors and inventors respectively, which indicates a higher degree of intergenerational occupational mobility among inventors.

[47]The relatively higher mobility rates among inventors occurred against a backdrop of high rates of both absolute and relative occupational mobility among the Swedish population before World War I. Berger et al. (2021a) shows that late-19th century Sweden exhibits higher intergenerational occupational mobility than other European countries and that mobility rates are closer to those observed in the highly mobile Americas (Long and Ferrie, 2013; Pérez, 2019).

[48]Formally, the Altham $d(\mathbf{P}, \mathbf{I})$ statistic is estimated as:

$$d(\mathbf{P}, \mathbf{I}) = \sqrt{\sum_{i=1}^{r}\sum_{j=1}^{s}\sum_{i'=1}^{r}\sum_{j'=1}^{s}\left[\log\left(\frac{p_{ij}p_{i'j'}}{p_{ij'}p_{i'j}}\right)\right]^2}$$

where $\mathbf{P}$ corresponds to the mobility table for inventors and non-inventors respectively and $\mathbf{I}$ is a table where all odds-ratio comparisons are 1 (i.e., the case of full mobility).

TABLE A.6: OCCUPATIONAL FATHER-SON TRANSITIONS FOR (NON-)INVENTORS, 1880–1910

Panel A. Inventors

	Son's occupation						
Father's occupation	Elite %	Upper middle class %	Skilled %	Farmers %	Lower skilled %	Unskilled %	Total %
Elite	67	22	8	2	1	0	100
Upper middle class	40	40	11	3	4	2	100
Skilled	20	29	34	0	10	7	100
Farmers	15	29	24	19	11	3	100
Lower skilled	12	32	24	7	17	7	100
Unskilled	10	22	31	7	16	13	100
Total	29	30	21	7	9	4	100
N	306	317	226	70	90	46	1,055

Panel B. Non-inventors

	Son's occupation						
Father's occupation	Elite %	Upper middle class %	Skilled %	Farmers %	Lower skilled %	Unskilled %	Total %
Elite	39	37	10	7	4	4	100
Upper middle class	11	41	13	10	12	13	100
Skilled	3	14	39	8	18	18	100
Farmers	1	8	12	49	13	18	100
Lower skilled	1	12	19	13	34	22	100
Unskilled	1	10	19	12	26	33	100
Total	2	12	17	30	18	21	100
N	6,800	34,091	48,248	85,410	50,583	58,457	283,589

Notes: This table displays occupational transitions for sons relative to their fathers using the *linked father-son sample*. Each row corresponds to the occupational group of fathers observed in the 1880 census. Each column corresponds to the occupation of sons observed in the 1910 census.

B Data appendix

B.1 Patent data

The patent data draws on a large database covering the whole population of granted Swedish patents 1746–1945.[49] It has been compiled using the following sources:

- *Kommerskollegium, Ingående diarier över patent, 1820-1884* (Swedish National Archive)
- *Bidrag till Sveriges officiella statistik (BiSOS) D: Fabriker och manufakturer, 1860-1884* (Statistics Sweden)
- *Förteckning över patenter beviljade i Sverige och Norge 1866–1875* (L. A. Groth & Co Patent Agency, Stockholm: 1876)
- *Patent- och registreringsverkets registratur, 1885-1914* (Swedish Intellectual Property Office)

The registers were stored in large hand-written ledgers. To minimize data entry errors and for more effective and systematic storage, a relational database structure was created and data entry performed through a structured and standardized template using a database software. Each patentee and inventor were given a unique identifier. To identify individuals across multiple patents, trained research assistants have created hand links using the full information in the hand-written ledgers, including name, occupation, address, patent agents, co-patentees and co-inventors, as well as patent type.

B.2 Linking inventors to the census

We here describe how we link the inventors from our patent data (A) to the 1910 census (B). To link inventors across time we compare first and last names for individuals of the same sex in the two data sets. Since spelling variations occur in the two data sets and since the inventor data sometimes do not provide a full list of first names, we link individuals using string distance metrics common in the literature. In particular, we make use of the Jaro-Winkler string distance metric, which measures name similarity on a scale between 0 (no similarity) and 1 (full similarity).

[49] The database has been produced by a group of researchers at the Department of Business Administration at Uppsala University in collaboration with the Patent and Registration Office (PRV) during the period 2017–2021. See https://svenskahistoriskapatent.se for additional information.

Moreover, while we do not know the birthyear of our inventors, we assume that inventors are at least 15 years of age when filing for a patent. Below we describe the used record linkage algorithm in detail.

1. We consider two records, an inventor (X) and a census individual (Y) as a match if they are the only pair with the same sex and the exact same names among candidates with a birth year in the census that is at least 15 years before the patent application.

2. If there is no single candidate above, we proceed by comparing names that has undergone a limited cleaning in terms nobiliary particles, suffixes, and a few common Swedish language spelling variations.[50]

3. If there is no single candidate above, we proceed by establishing links using name similarity. We consider a pair of individuals of the same sex as a match if the last names have a similarity of at least 0.9, the mean similarity of first names is at least 0.9, and there is no closely competing candidate. For the latter, we impose that the pair has the highest mean of the last name and first name JW scores, and it is at least 0.1 JW score units higher than the candidate with the second highest mean. To compute the similarity between first names without imposing any order of first names, we calculate the mean for the n number of first name pairs with the highest JW score, where n is equal to the number of first names in the record with the least number of first names in the pair.[51]

4. As a last step, we perform step 3 again after discarding candidates that are residing in a different county in 1910 than in their modal patent application (or first application if a modal is not applicable).

In total, we link about 33 percent of inventors to the 1910 census. After discarding a few duplicates in terms of census individuals, we find ourselves with 3,147 inventors. Roughly 57 percent are established in step 1 above, 13 percent in step 2, 26 percent in step 3, and 4 percent in step 4. For these established links, the mean JW score is 0.97 for first names and 0.99 for last names.

[50]We make the following corrections: (i) V for W, (ii) K for C if C is followed by the vocals A or O, by T, or if C is the terminal character, (iii) V for F if preceded by A or O, (iv) S for double SS, (v) L for HL, and (vi) K for Q if followed by V.

[51]To exemplify, a census individual with the first names CARL GUSTAF PATRIK and an inventor with the single first name GUSTAF is given a JW score of 1, since the inventor has only one (1) first name (i.e. n=1), and since GUSTAF—GUSTAF is the pair with the highest JW score.