Inventors among the "Impoverished Sophisticate"

THOR BERGER AND ERIK PRAWITZ

This paper examines the identity and origins of Swedish inventors prior to WWI, 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 inventors, we show that inventors were disproportionately drawn from privileged family backgrounds. However, innovation was a path to upward mobility for the middle- and working-class children that managed to overcome the barriers to entry.

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. In contrast, recent literature emphasizes the role of "upper-tail" human capital in generating growth and innovation during European industrialization (Mokyr 2005; Squicciarini and Voigtländer 2015; Hanlon 2022).

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This paper turns to the case of Sweden, which underwent a rapid industrial take-off driven by a "technological revolution" prior to WWI (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). In 1884, it moreover introduced a patent system 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 hand, Frans Wilhelm Lindqvist (1862–1931) was the son of a soldier. Working as a metal worker, he invented a pressurized-burner kerosene stove and went on to found 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 WWI, 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 records contain limited information about inventors beyond basic information such as their name, occupation, and place of residence. Therefore, we link patent records to the Swedish population censuses 1880–1910, which allows us to examine a rich set of inventor characteristics and to track (potential) inventors from birth into adulthood to shed light on the determinants of who becomes an inventor.

We first document that invention predominately originated from a small elite group, as inferred from the social status and income associated with

[1] For example, Jonas Wenström's (1855–1893) three-phase electricity system (ASEA), Gustaf de Laval's (1845–1913) cream separator (Separator), 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 differs between industries (Griliches 1990; Moser 2005). We explore how the availability of alternative forms of intellectual property protection may influence our main results.

inventors' occupations.[3] About 40 percent of all inventors in our patent data belong to the elite group, which constitute just about 2 percent of the population. During industrialization, an industrial elite mainly consisting of factory owners and engineers grew to prominence, while administrative and military elites lost ground. Inventors belonging to elite groups further produced more patented inventions than their middle- or working-class counterparts, accounting for more than half of all patents granted prior to WWI. They did not only develop more inventions, but also more valuable inventions, as reflected in patent renewal data. The productivity advantage of elite inventors is in part due to 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—such as Lindqvist—could enter elite groups and pursue a career in invention, as sometimes suggested both by contemporaries and historians.[4] A pessimistic explanation is that the dominance of elite groups reflects the fact that entry into invention was possible only for the children of 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. We first show that many Swedish inventors hailed from middle- or working-class backgrounds. However, the prevalence of inventors from more humble origins mainly reflects the large size of these social groups. In fact, children born to families at the absolute top of the income or social status distribution had substantially better opportunities to become inventors. For example, a child from an elite family was about 15 times more likely to become an inventor than a child born to an unskilled father. We also find a sharp non-linear relationship between parental income and the probability of becoming an inventor that is strikingly similar to evidence from twentieth-century Finland and the United States (Bell et al. 2019; Aghion et al. 2017; Akcigit, Grigsby, and Nicholas 2017b). Exploring underlying mechanisms, we show that children born to families belonging to the economic and social elite were more likely to attain

[3] 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, we refer to HISCLASS groups 1 (Higher managers) and 2 (Higher professionals) as "elite."

[4] Contemporaries such as Tisell (1910, p. 110) noted 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, pp. 173–74) argues that such rags-to-riches stories were not uncommon by the last decades of the nineteenth century.

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).

A simple counterfactual exercise suggests that the number of Swedish inventors before WWI would be about eight times as large if children born to middle- and working-class families had become inventors at the same rate as children born to elite families. 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, the high barriers to pursuing innovation—for example, due to limited access to educational opportunities and low exposure to innovation—not only meant that Sweden lost out on inventors, but potentially also lost out on high-impact innovation.

We lastly examine whether innovation was a way to climb the economic and social ladder for those middle- and working-class children that managed to overcome the hurdles in becoming inventors. 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 more mobile individuals into innovation. Thus, for children from more humble backgrounds that managed to become inventors, it 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, Grigsby, and Nicholas 2017b; Sarada, Andrews, and Ziebarth 2019; Billington 2021; Hanlon 2022).[5] 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). The findings of our paper contrast evidence from the United States where broadly dispersed human capital and an inclusive patent system have been argued to have democratized invention (Sokoloff and Khan 1990; Khan 2005).[6] Sweden had a similar patent system after

[5] A recent literature similarly sheds light on the identity and origins of inventors in the twenty-first 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).

[6] While this literature has primarily focused on early American industrialization, Sarada, Andrews, and Ziebarth (2019) show that white-collar occupations were underrepresented among American inventors relative to the population as late as 1900.

1884 and comparatively high levels of human capital (Sandberg 1979) and social mobility (Berger et al. 2023). Yet relatively few individuals at the lower rungs of the economic and social ladder pursued inventive activity. Instead, Sweden's accelerated pace of innovation prior to WWI 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 industrialization (Mokyr 2005; Squicciarini and Voigtländer 2015; Hanlon 2022; Maloney and Valencia Caicedo 2022).

CONTEXT: PATENT SYSTEMS AND INDEPENDENT INVENTION

A patent system was widely seen as crucial to promote national economic and technological progress among nineteenth-century observers. But there existed considerable differences in how patent systems were designed. European nations—for example, 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 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). In contrast, American lawmakers designed a patent system characterized by novelty examinations and low patent fees to enable also less advantaged individuals to pursue invention (Khan 2005).[7] Consequently, American inventors tended to be drawn from a much broader cross-section of the population (Sokoloff and Khan 1990; Sarada, Andrews, and Ziebarth 2019).

Over the course of the nineteenth century, Sweden transitioned from a "European" registration system to an "American" examination system. Because no novelty search was performed in the Swedish examination system established in 1834, it was characterized by litigation rates of granted patents that in some years 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 starting in the

[7] Technological novelty examinations reduce the uncertainty both regarding the validity and the value of a patent, which may facilitate trade in technology (Khan and Sokoloff 2004). Andersson, Berger, and Prawitz (2023) show that a patent market emerged in Sweden in the latter half of the nineteenth century as the railroad network connected agents, inventors, and firms across the country.

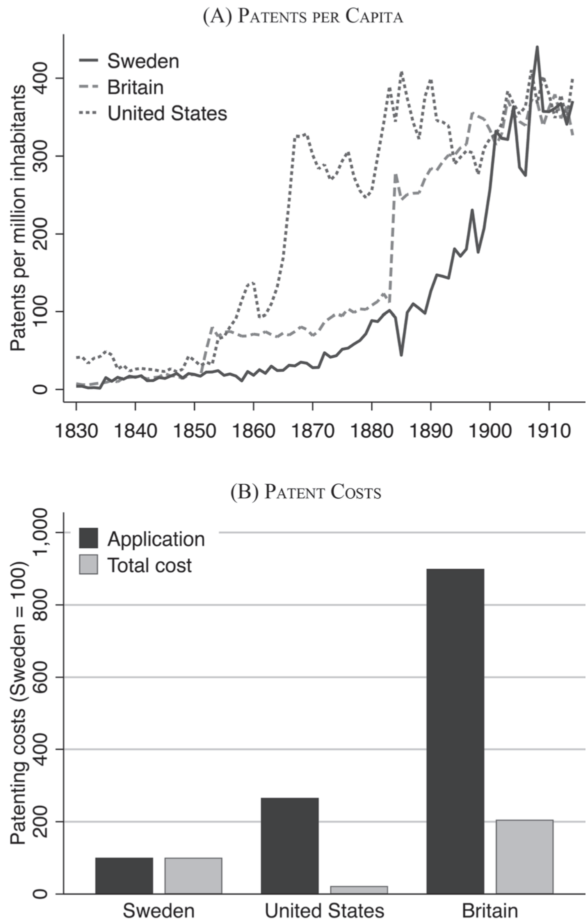


FIGURE 1

PATENTING ACTIVITY IN BRITAIN, SWEDEN, AND THE UNITED STATES

Sources: A: The number of granted patents per million inhabitants in Sweden, the United Kingdom, and the United States is based on WIPO historical IP statistics (Sáiz 1999). B: Patent application costs in Sweden (1885), Britain (before the 1883 Patents Act), and the United States (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).

mid-nineteenth century. As the system came under increasing criticism, the patent system was fundamentally reformed with the introduction of Sweden's 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 Germany and the United States. The system also introduced low application fees and allowed patent holders to renew their patents up to 15 years following an increasing fee structure. After the 1884 reform, the patent application fee was 50 *kronor* (approximately $360 in 2015 USD), which was further lowered in 1893 by some 60 percent to 20 *kronor*.[8] Application costs in Sweden were considerably lower than in Britain and the United States (see Figure 1B). However, the American system stands out in terms of its low cost for carrying a patent for the full length, while the total patenting costs are still much cheaper in Sweden compared to Britain. Together, these comparisons suggest that patenting in Sweden was comparatively cheap after the reforms in the late nineteenth century.

Against the backdrop of these reforms, Sweden experienced rapid growth in patenting output in the late nineteenth century. By the outbreak of WWI, it had caught up with Britain and the United States in terms of patents per capita (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.[9] Moreover, the similarities—rigorous examinations and relatively low costs—between the American and Swedish patent systems by the late nineteenth century give rise to the question of whether Swedish inventors also increasingly were drawn from the lower rungs of the economic and social ladder.

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 sample of all inventors that were granted a PRV patent before 1914 and that patented at least once after the 1884 reform (we denote this as 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 as 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 and later on observed in adulthood in the 1910 census (we denote this as the *linked father-son sample*). Defining inventors using links between the 1910 census and our patent data, we can

[8] Application costs prior to the 1884 reform were about 69 *kronor,* and each year of patent protection cost an additional 5 *kronor,* all of which had to be paid in advance (Andersson and Tell 2019). After the 1884 reform, the newly introduced increasing fee structure stipulated an annual cost of renewing a patent of 25 *kronor* during years 2–5, 50 *kronor* during years 6–10, and 75 *kronor* during years 11–15.

[9] 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 twentieth century (Nicholas 2010, 2011).

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.

Patents

Our patent data consists of the universe of all patents granted to Swedish inventors between 1840 and 1914 by the PRV. It was compiled and digitized from the PRV archives and various sources at the National Archives of Sweden (*Riksarkivet*) and includes detailed information, such as patent duration, application and grant date, and patent class according to the German patent classification, *Deutsche Patentklassifikation* (DPK).[10] 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.[11] In total, the patent data includes information on about 10,000 Swedish inventors. We code the occupation of each individual inventor and patentee using the Historical International Standard Classification of Occupations (HISCO) (Van Leeuwen, Maas, and Miles 2002).[12] We then allocate inventors into the HISCLASS social class scheme (Van Leeuwen and Maas 2011), which we aggregate into six broader groups: 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 patents granted to Swedish inventors by the United States Patent and Trademark Office (USPTO) 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 United States. 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.

[10] 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.

[11] 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 percent of patents formally list the only individual on the patent as a patent holder. We explore the importance of this data limitation for our main results in Online Appendix Figure A.5.

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

With the patent data, we construct our *full inventor sample*, which includes all inventors that were granted a patent before 1914 and that patented at least once after the 1884 reform. 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.

Censuses and Record Linkage

Using data from the 1910 Swedish population census (Swedish National Archives 2016; IPUMS 2019), we link all individuals in the patent data to the census to obtain our *census sample*. The data includes population-wide data on demographic variables such as family structure, civil status, and occupation. The full linkage procedure is described in Online 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 least 15 years old at the time of the inventor's first patent application. We then use a stepwise procedure to establish links using information on names. In the 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 the 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 an average string similarity above 0.9, on a scale between 0 (no similarity) and 1 (identical), for first names and last names, as well as an average distance of at least 0.1 to the second-best candidate. In the 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). Considering inventors that are active in the period 1885–1914, we link 32.3 percent to the 1910 census.

To construct the *linked father-son sample*, we then use linked census data from Berger et al. (2023) 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). We here focus on a sample of sons, due to the small number of female inventors linked across censuses. These individuals were born 1860–1880 and resided in their family home in 1880, giving us information on their parents as well as other characteristics during their childhood. In the next step, we make use of inventor-census links from our *full inventor sample* as well as links between inventors and individuals in the 1880 census following the same procedure as described earlier. This provides us with information on which individuals in the *linked father-son sample* are inventors, as well as who had a father who was an inventor.

Other Sources

To get a measure of individuals' higher technical education, we link individuals observed in the 1880 and 1910 censuses to a list of all members of the Swedish Association of Engineers and Architects—*Svenska Teknologföreningen, STF*. The association was initiated in the 1850s and founded more formally in 1861. 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 only evaluate candidate links where both individuals are born in the same year, improving the linkage rate as compared to when linking the patent data to the censuses. 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, Molinder, and Prado (2021). As described in Berger et al. (2023), 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, HISCO major group, urbanity, and county of residence.

ANALYSIS

Our analysis in this section focuses on the identity and origins of Swedish inventors prior to WWI.[13] In the first part of the analysis, we draw on patent and census data to uncover descriptive facts about inventors. 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

[13] The estimates underlying our analysis are available through our published replication files, Berger and Prawitz (2024b).

(potential) inventors from 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 economic and social ladder.

INVENTORS AMONG THE "IMPOVERISHED SOPHISTICATE": DESCRIPTIVE FACTS

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 (with more than 10 patents) as well as the adult population in the 1910 census are presented in Table 1.

The most striking demographic fact about Swedish inventors prior to WWI is the vast overrepresentation of men. Women made up about 1 percent of inventors. But the share increases over time, with women constituting about 2 percent of active inventors in the early twentieth century (see Online Appendix Figure A.1A). However, from modern data, we know that the gender gap in innovation is closing at a glacial pace. By the early twenty-first century, the share of female inventors still lingered below 10 percent (see Online Appendix Figure A.1B).

Turning to the age of inventors, the average Swedish inventor was 42.6 years old and thus slightly older than the rest of the adult population. The probability to be an inventor increases from the late 20s, reaching a peak in the early 40s (Online Appendix Figure A.2). The average age of inventors prior to WWI is similar to today: in the early twenty-first century, Swedish inventors were on average 43.5 years old (Jung and Ejermo 2014). Lastly, Table 1 shows that inventors had a higher marriage rate, which could partly be ascribed to their higher age or greater value in the marriage market.

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 classes: elite, upper middle class, skilled, farmers, lower

TABLE 1
INVENTORS: DESCRIPTIVE FACTS

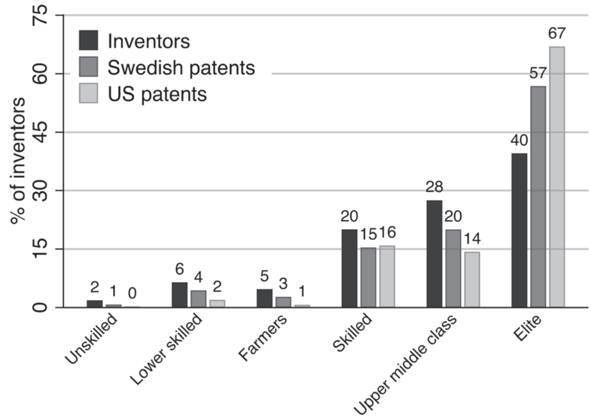
	(1) Population	(2) Inventors	(3) Star Inventors
Demographics:			
Age	37.64	42.58	41.92
% aged 18–25	24.31	4.30	3.43
% aged 26–35	25.17	25.87	29.18
% aged 36–45	19.54	30.10	31.33
% aged 46–55	17.64	25.28	21.03
% aged 56–65	13.34	14.46	15.02
% female	51.40	0.83	0.00
% married	52.79	73.21	75.54
% urban	26.06	48.86	60.52
% in Stockholm	12.17	31.92	51.07
Income, social class, and education:			
Income percentile rank	50.49	78.08	90.85
% elite	2.13	28.18	64.81
% upper middle class	12.76	29.24	18.52
% skilled	14.79	20.35	8.33
% farmers	18.90	6.71	4.17
% lower skilled	19.89	9.12	2.78
% unskilled	31.53	6.40	1.39
% higher technical education	0.23	19.13	57.51
Migration:			
% intercounty migrant	23.11	55.63	62.50
% international migrant	1.17	3.89	2.58
% born in Denmark	0.20	0.74	0.86
% born in Germany	0.18	1.17	1.29
% born in Norway	0.23	0.65	0.00
% born in United Kingdom	0.03	0.28	0.00
Observations	3,077,725	3,236	233

Notes: The table provides descriptive characteristics from the 1910 census. Column (1) displays means in the total adult population, Column (2) displays means for the linked inventor population in the *census sample*, 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 are given for all individuals in the three groups.
Sources: Census data from IPUMS. See main text for description of patent data.

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.[14] While the vast majority of inventors were male, female inventors also typically belonged to privileged

[14] Online Appendix Figure A.3 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 to selection in the linkage process, but also due to differences in reported occupations in the 1910 census as compared to those in the patent records during our entire study period.

(A) Social Class of Inventors



(B) Share Inventors in Population

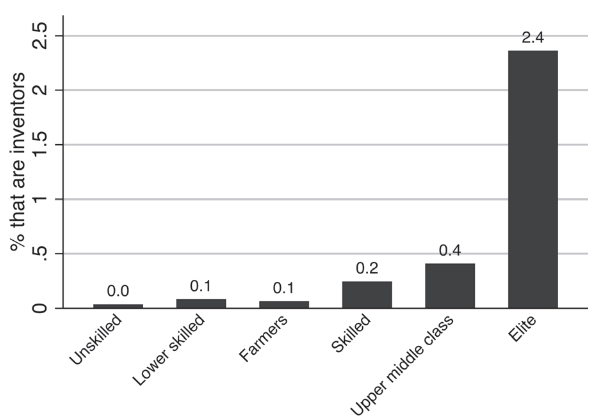


Figure 2
SOCIAL CLASS OF INVENTORS

Notes: A: Distribution of social class among Swedish inventors (using the *full inventor sample*). Swedish and U.S. patents denote distribution when weighted by the number of patents granted to each inventor by the PRV and the USPTO, respectively. B: The share of inventors in the adult population in 1910 across social classes (using the *census sample*). The different status categories are based on the HISCLASS social class scheme, as described in the main text.
Sources: Census data from IPUMS. See main text for description of patent data.

groups.[15] Figure 2A also shows the social status of inventors when weighted by the number of patents granted to each inventor, which makes the dominance of the elite 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

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

the elite group only constitutes about 2 percent of the adult population (see Table 1). At the same time, farmers and lower-skilled or unskilled workers—constituting about 70 percent of the population—were heavily underrepresented among inventors, accounting for about 8 percent of all patents before WWI.[16]

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 inventors compared to those belonging to the lower classes. A similar picture emerges if one instead considers the position of inventors in the income distribution, where there is a sharp overrepresentation among the top income groups (Online Appendix Figure A.6).

Inventors belonging to the top of the economic and status distribution can most aptly be described as an emerging industrial elite. Almost 50 percent of inventors belonging to the elite group were engineers, while an additional 31 percent were factory owners or general managers (see Online Appendix Table A.1).[17] About one in five inventors and more than half of the star inventors had obtained a higher technical education (see Table 1).

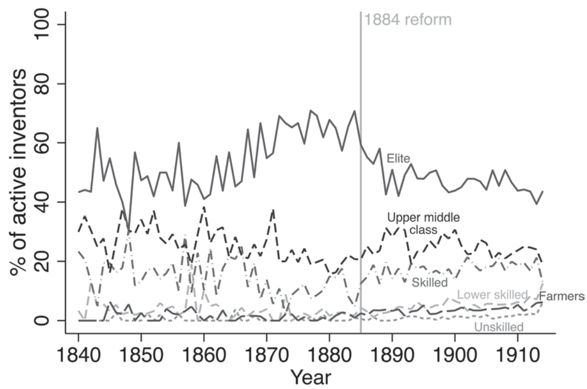
Inventors belonging to elite groups played an outsized role in innovation both before and after the 1884 patent reform. Figure 3A shows that the share of active inventors that belonged to the elite remained relatively stable from 1840 through 1914. The figure displays the social class distribution among all inventors that patent 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.[18] 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

[16] 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 are relatively more effective. We explore this issue in Online Appendix Figure A.4, where we examine the role of secrecy in explaining our results.

[17] 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 supervisors (see Online Appendix Table A.1). Similarly, within the skilled group we find several occupations—carpenters, mechanics, and watchmakers—that embodied crucial knowledge and skill for the development of increasingly sophisticated technologies during industrialization (Kelly, Mokyr, and Ó Gráda 2023; Mokyr, Sarid, and van der Beek 2022).

[18] Although the elite share declined after the 1884 reform to levels observed in the 1860s, a direct comparison should be made with care because occupational information was more accurately collected after the reform. Indeed, Online Appendix Figure A.7 shows that the share of active inventors that belonged to the elite remained broadly constant when including inventors with missing occupations.

(A) SOCIAL CLASS OF INVENTORS



(B) INDUSTRIAL AND OTHER ELITES

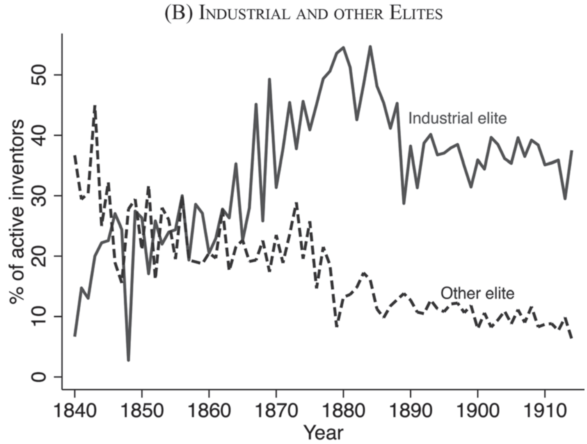


FIGURE 3
SOCIAL CLASS OF INVENTORS, 1840–1914

Notes: A: The distribution of social class among Swedish inventors between 1840 and 1914 among all active inventors that apply for a patent in each year. The different status categories are based on the HISCLASS social class scheme, as described in the main text. B: The share of inventors that belong to the "industrial" and "other" elite each year. We define these groups based on occupations reported by inventors on the patent records. The following occupational strings are categorized as the "industrial" elite: **ingenjör,* direktör*, *disponent*, *fabriksdirektör*, *fabriksdisponent*, *fabriksidkare*. Remaining occupations are categorized as "other."
Sources: See main text for description of patent data.

displays the share of inventors that belonged to the elite disaggregated into an industrial elite, 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.

Migration and the Geography of Inventors

Swedish inventors prior to WWI predominately clustered in urban areas, especially 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, which disproportionately was home to inventors belonging to elite groups (Online Appendix Figure A.8). The concentration in the capital likely reflects agglomeration benefits due to 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 about one in four among the adult population (Table 1). Inventors were more mobile already at young ages, which persisted over the life cycle (Online Appendix Figure A.9A). In particular, they disproportionately migrated to Stockholm (Online Appendix Figure A.9B).

Inventors were also more mobile across countries. Almost 4 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. These findings are consistent with a large body of work emphasizing the historical overrepresentation of immigrants among inventors (Akcigit, Grigsby, and Nicholas 2017a; Sarada, Andrews, and Ziebarth 2019).

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 working-class inventors obtained around two patents.

To gauge the 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). Table 2

TABLE 2
INVENTOR OUTPUT AND QUALITY: DESCRIPTIVE FACTS

	(1) All	(2) Elite	(3) Upper Middle Class	(4) Skilled	(5) Farmers	(6) Lower Skilled	(7) Unskilled
Patent output:							
Number of PRV patents	3.59	6.70	2.76	2.33	2.54	2.05	1.96
Number of USPTO patents	0.25	0.61	0.12	0.14	0.16	0.05	0.05
% with 1 PRV patent	52.84	35.63	57.63	59.87	60.91	64.18	64.36
% with >10 PRV patents	6.33	15.10	4.07	2.68	4.57	1.87	1.06
Patent characteristics:							
Years patents renewed	4.15	4.98	4.16	3.74	3.56	3.28	3.63
% renewed for 15 years	3.08	4.93	2.54	2.51	1.50	1.90	2.57
% firm patents	8.97	14.94	6.98	6.02	5.90	7.39	6.64
% collaborative patents	27.94	28.15	27.70	27.32	30.89	22.91	28.11
% transferred patents	15.14	14.93	15.87	14.65	15.80	10.77	14.50
Career:							
Age at first invention	35.54	34.63	36.13	35.49	37.21	34.78	34.15
Career length (years)	5.95	9.55	5.17	4.52	4.35	3.82	3.54
Observations	3,236	828	859	598	197	268	188

Notes: The table reports mean outcomes for Swedish inventors belonging to different social classes (using the *census sample*). The different status categories are based on the HISCLASS social class scheme, as described in the main text. Note that the first column also includes inventors with missing HISCLASS information.
Sources: Census data from IPUMS. See main text for description of patent data.

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 from the USPTO further suggests that they developed more novel and valuable technologies. Moreover, firm patents (that on average were of higher quality as measured by patent fees) were much more prevalent among elite inventors. In contrast, collaborative patents were not more common in the elite group.[19] While the role of the patent market has been emphasized as crucial for disadvantaged inventors (Khan and Sokoloff 2004), Table 2 shows that the share of patents that was transferred 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

[19] However, this is consistent with recent evidence from Berger and Prawitz (2024a) that collaboration was less related to complexity or quality of innovation during this era as compared to later periods.

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.[20] 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.

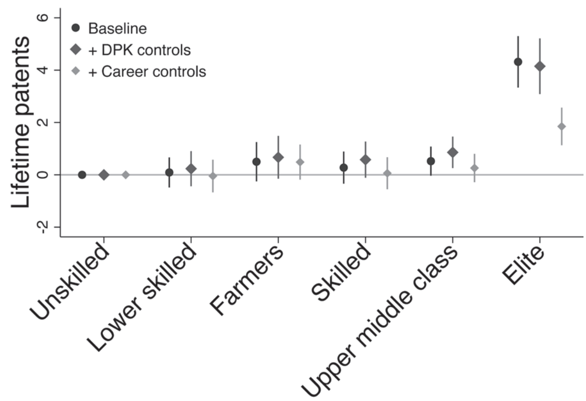
A potential explanation for differences in patenting output and quality across social groups is differences in career dynamics. As a matter of accounting, differences in patenting output can be due to an earlier entry into innovation, a longer career as an inventor, or productivity differences conditional 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 35.5 years old at the time of their first (subsequently granted) patent application.[21] 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.[22] The average inventor had a career that lasted less than six years. Inventors belonging to elite groups, however, had considerably longer careers (9.6 years) compared to middle- or working-class inventors. Additional evidence that elite inventors were more specialized in innovation can

[20] We provide additional evidence that inventors belonging to the elite group produced more and higher-quality inventions in Online Appendix Figure A.10, 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.11.

[21] 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 twenty-first century were on average 40.7 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 twentieth century (Jones 2009, 2010).

[22] We define career length as the number of years between an inventor's first and last patent application.

(A) Patent Output



(B) Patent Quality

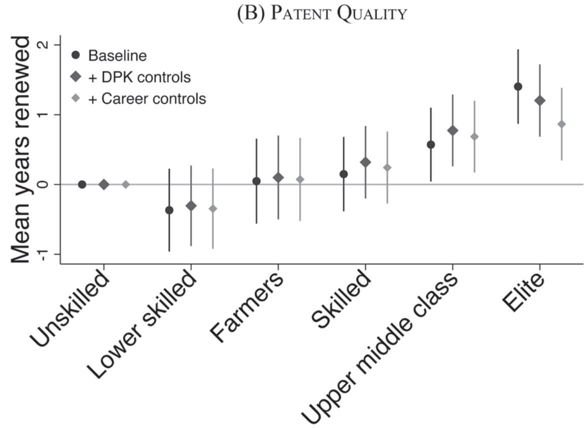


Figure 4
INVENTOR OUTPUT AND QUALITY BY SOCIAL CLASS

Notes: The figure displays point estimates and 95 percent confidence intervals from inventor-level OLS regressions with robust standard errors. The outcome is the total number of granted patents over an inventor's lifetime (A) and the average number of years patent fees were paid per patent (B) for inventors belonging to different social classes relative to inventors belonging to the unskilled class (using the *census sample*). The different status categories are based on the HISCLASS social class scheme, as described in the main text. 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).
Sources: Census data from IPUMS. See main text for description of patent data.

be gleaned from Table 2, showing that about 15 percent obtained more than 10 patents over their lifetime. Notably, controlling for career length in Figures 4A and 4B reduces differences in patent output and quality. Thus, the productivity advantages of elite inventors can partly be ascribed to the fact that they specialized in invention and had longer inventive careers.

ECONOMIC AND SOCIAL ORIGINS OF SWEDISH INVENTORS

Our findings in the previous section showed that Swedish inventors before WWI were heavily overrepresented among the elite, which raises questions about their economic and social background. Did inventors mainly hail from 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?

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 majority of Swedish inventors were born to fathers from the upper middle, skilled, and farmer classes (see Online Appendix Figure A.12). However, the relatively large number of inventors hailing from middle- and working-class families mainly reflects the fact that these social groups were vastly overrepresented in the population (see Table 1). Indeed, Figure 5A displays the *share* of sons born to fathers across the status distribution that become inventors as adults. For example, a son born to a father belonging to the elite group was about 15 times (3.94/0.26) more likely to become an inventor than a son born to an unskilled father. Thus, while many inventors hailed from more modest 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 90th 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-twentieth-century United States (Akcigit, Grigsby, and Nicholas 2017b; Bell et al. 2019), as well as present-day Finland (Aghion et al. 2017).

Together, these results show that children to parents at the top of the economic and social ladder were substantially more likely to become inventors as adults. To gauge the potential importance for aggregate innovation, one can construct a simple counterfactual by assuming that sons

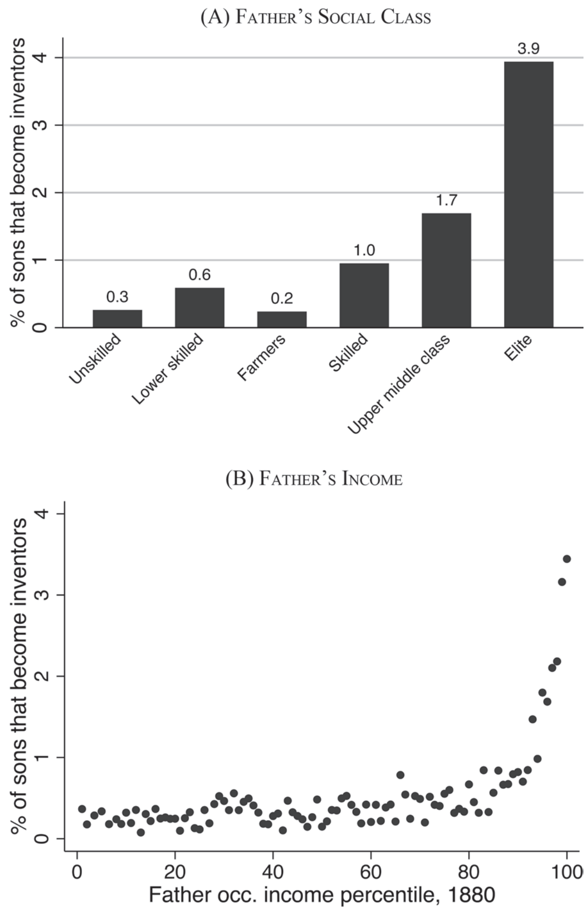


FIGURE 5
SOCIAL AND ECONOMIC ORIGINS OF INVENTORS

Notes: The figure displays the probability that a son becomes an inventor based on his father's social class and income (using the *linked father-son sample*). A: The share of sons that become inventors by the social class of their father. The different status categories are based on the HISCLASS social class scheme, as described in the main text. B: Binned scatter plot of the probability for a son to become an inventor by the 1880 occupational income score of their father. 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.
Sources: Dataset described in main text.

of non-elite fathers would have gone on to invent at the same rate as elite sons (as in Figure 5A). In that case, the number of Swedish inventors would have been about eight times higher. While suggestive, the fact that invention was reserved for children to the privileged few meant that Sweden potentially lost out on a large number of inventors. We next explore potential mechanisms that may explain the central role of family background in shaping who becomes an inventor.

Potential Mechanisms

A large set of mechanisms may explain the fact that children of 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 greater investment in their children's human capital (Akcigit, Grigsby, and Nicholas 2017b; Aghion et al. 2017; Celik 2023). Second, parents at the top of the status distribution are more likely to be inventors themselves, which 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, Grigsby, and Nicholas 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 (Online Appendix Figures A.13A and A.13B). 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 (Online Appendix Figures A.13C and A.13D).[23] 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 (Online Appendix Figures A.13E and A.13F), as well as being more geographically mobile (Online Appendix Figure A.13G).

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 becomes an inventor in adulthood. We first document the statistical significance of the patterns depicted in Figure 5. 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 1.1–1.5 percentage points more likely to become an inventor in adulthood. This is a large difference, considering

[23] To measure exposure to innovation within the broader family, we calculate the number of inventors before 1880 by surname, which we then normalize by the number of adult men holding the same surname in the 1910 census. The resulting measure is standardized to have a mean of zero and a standard deviation of one.

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)	0.015***	0.011***	0.010***	0.009***	0.006***	0.005	0.481	0.015
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.013)	(0.491)	(0.319)
Father elite (=1)		0.026***	0.021***	0.021***	0.013***	–0.025	–1.199	–0.059
		(0.003)	(0.003)	(0.003)	(0.003)	(0.025)	(1.187)	(0.252)
Family exposure to innovation:								
Father higher technical education (=1)			0.088***	0.087***	0.050***	0.054	1.210	–0.008
			(0.015)	(0.015)	(0.016)	(0.075)	(3.016)	(0.649)
Father inventor (=1)			0.046***	0.045***	0.041***	0.028	2.796	0.377
			(0.007)	(0.007)	(0.007)	(0.043)	(2.376)	(0.485)
Inventors with same surname, pre-1880			0.001***	0.001***	0.001***	0.008**	0.197	0.038
			(0.000)	(0.000)	(0.000)	(0.003)	(0.121)	(0.031)
Local exposure to innovation:								
Lives in urban area, 1880 (=1)				0.003***	0.002**	–0.006	–0.064	0.130
				(0.001)	(0.001)	(0.016)	(0.544)	(0.305)
Inventors in municipality, pre-1880				0.001***	0.001***	0.004	0.168*	0.018
				(0.000)	(0.000)	(0.004)	(0.092)	(0.057)

TABLE 3 (CONTINUED)
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)
Son's education and location:								
Son higher technical education (=1)					0.135***	0.117***	4.313***	0.938***
					(0.010)	(0.028)	(1.456)	(0.288)
Migrant, 1880–1910 (=1)					0.005***	0.012	0.225	–0.270
					(0.000)	(0.010)	(0.537)	(0.292)
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Childhood county FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	284,644	284,644	284,644	284,644	284,644	1,456	1,456	1,448
Mean dep. var.	0.005	0.005	0.005	0.005	0.005	0.041	3.001	4.924

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 residence in 1880. 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 level. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Sources: Dataset described in main text.

that the probability of becoming an inventor is 0.5 percent in the sample. Similarly, having an elite father increases the probability of becoming an inventor by about 2.6 percentage points. Notably, both the economic and social 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 4.6 and 8.8 percentage points, respectively. Similarly, a higher number 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 number of inventors in the childhood municipality and an indicator for residing in an urban area in childhood.[24] 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 by 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.[25] 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 and facilitating geographic mobility. Notably, sons that attained a higher technical education were 13.5 percentage points more likely to become inventors. While the

[24] We calculate the former as the number of inventors that were active before 1880 in a municipality normalized by population in 1880. The resulting measure is standardized to have a mean of zero and a standard deviation of one.

[25] 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 Online Appendix Figure A.14.

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 a father's education is largely mediated through the educational choices 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, were inventors from advantaged family backgrounds more or less prolific than those that came from more humble origins?

Table 3, Panel B, examines the link between family background and inventor productivity and quality. Family background seemingly mattered little on the intensive margin once controlling for the son's educational attainment. Inventors born to fathers belonging to the top-10 percent, the elite, or to fathers with technical backgrounds were not significantly more or less 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.[26] Notably, these results contrast those in Figure 4, showing that inventors belonging to elite groups produced more and higher-quality patents.

We showed previously that family background was a key determinant of who becomes an inventor and that the aggregate number of inventors in Sweden would have been substantially higher had children from working-class backgrounds pursued innovation at the same rate as those from more privileged backgrounds. The fact that inventors from working-class backgrounds seemingly did not produce patents of lower quality further suggests that Sweden lost out on inventors that may have produced highly valuable ideas.

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 as a metal worker, Lindqvist

[26] Online Appendix Table A.2 provides additional specifications showing that inventors born to fathers belonging to the top-10 percent are somewhat more likely to patent more (but not of higher quality) when we do not control for the son's technical education.

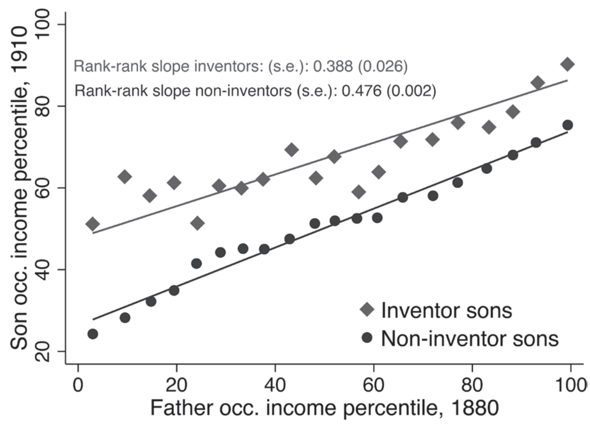


FIGURE 6
INTERGENERATIONAL INCOME MOBILITY AMONG (NON-)INVENTORS

Notes: The figure displays a binned scatter plot of sons' occupational income score in 1910 and their fathers' occupational income score 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 rank in each group. Linear regression lines based on the underlying (ungrouped) data where we include controls for cubic functions in the age of fathers in 1880 and sons in 1910 are also shown. We report the slope from these underlying rank-rank regressions in the figure with standard errors clustered at the father level.
Sources: Dataset described in main text.

became a business executive (*direktör*) after he invented 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. 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-inventors.[27] 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

[27] We present additional estimates of traditional IGEs where we regress sons' ln income on the ln income of fathers as well as our preferred rank-rank measures in Online Appendix Table A.3. The IGE estimates similarly show that the elasticity between the income of fathers and sons is lower among inventors than among non-inventors.

TABLE 4
INVENTION AND INTERGENERATIONAL INCOME MOBILITY

Dependent Variable:	Son's Occ. Income Percentile Rank, 1910					
Sample:	All (1)	All (2)	All (3)	All (4)	Bottom-75% (5)	Top-25% (6)
Inventor (=1)	24.257*** (1.021)	4.713*** (1.080)			7.713*** (1.758)	1.863 (1.251)
Inventor: pre-1910 (=1)			6.428*** (1.566)			
Inventor: post-1910 (=1)			2.953** (1.468)			
Inventor: 1 patent (=1)				3.734*** (1.439)		
Inventor: 2–9 patents (=1)				5.530*** (1.622)		
Inventor: 10+ patents (=1)				10.748*** (3.997)		
Individual controls	Yes	Yes	Yes	Yes	Yes	Yes
Father FE	No	Yes	Yes	Yes	Yes	Yes
Observations	140,448	140,448	140,448	140,448	103,704	36,744
Mean dep. var.	50.840	50.840	50.840	50.840	44.739	68.062

Notes: The table reports individual-level OLS regressions using the *linked father-son sample* between the 1880 and 1910 census. The outcome is a son's occupational income percentile 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.
Sources: Dataset described in main text.

that inventors on average placed 24 percentile ranks higher in the income distribution compared to non-inventors.[28] The higher mobility among inventors could reflect a selection of inherently more mobile individuals into innovation or a causal link between innovation and mobility. To discern between these explanations, we next compare brothers, where one becomes an inventor while the other(s) do 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 becomes an inventor. Table 4, Column (2), includes father-fixed effects and thus compares inventors

[28] We document in Online Appendix Tables A.4 and A.5 that inventors are similarly more mobile in terms of income in logarithms, 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 are transmitted across generations (e.g., Long and Ferrie 2013; Pérez 2019; Berger et al. 2023). Online Appendix A.6 presents an analysis of the intergenerational occupational mobility of inventors where we estimate so-called Altham statistics, which reveal that inventors also exhibit a higher rate of occupational mobility.

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 still placed substantially higher (about 5 percentile ranks) in the income distribution relative to their non-inventor brothers.

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. Inventors that were granted at least one patent prior to 1910 experienced high rates of upward mobility. Estimates for those that obtained their first patent later are smaller in magnitude, which suggests that the high mobility among inventors is not solely reflecting preexisting high levels of mobility. Additionally, Column (4) shows that the mobility gains are fairly small among one-time inventors, while star inventors (with more than 10 patents) experienced relatively high rates of mobility. Together, these results suggest that the higher mobility among inventors partly reflects a causal link between innovation and intergenerational mobility.

We lastly examine mobility gains among inventors that hail 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 hail from relatively disadvantaged backgrounds.

In sum, our findings earlier 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 show 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.

CONCLUDING DISCUSSION

Our paper studies the origins of inventors in Sweden—Europe's "impoverished sophisticate"—that had high levels of broadly dispersed human capital and a newly introduced inclusive patent system in the late nineteenth century. While these two features have been suggested as key determinants of the "democratization" of invention in America (Sokoloff and Khan 1990; Khan 2005), we find no similar development in Sweden.

Invention during Sweden's industrialization was predominately due to a small industrial elite, which remained dominant both before and after the transition to a patent system resembling the American one. Our findings thus resonate with an emerging literature emphasizing the key role of upper-tail human capital during European industrialization (Mokyr 2005; Squicciarini and Voigtländer 2015; Hanlon 2022).

What explains 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 broader access to the patent system.[29] Second, Sweden's transition to an examination system took place during the Second Industrial Revolution, when innovation was becoming increasingly 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.[30] Third, exposure to innovation may have been more diffused in the United States 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.

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[29] 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 origins often were granted patents for relatively simple technical inventions. For example, 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 had been developed by the workers involved in using or manufacturing a particular machine.

[30] 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 United States well into the twentieth century (Sarada, Andrews, and Ziebarth 2019).

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