5-1-2004

Institutions and democratic invention in 19th-century America: Evidence from "great inventors," 1790-1930

B. Zorina Khan
Bowdoin College

Kenneth L. Sokoloff
National Bureau of Economic Research

Institutions and Democratic Invention in 19th-Century America: Evidence from "Great Inventors," 1790–1930

By B. Zorina Khan and Kenneth L. Sokoloff*

In recent years there has been a revival of concern with the impact of patent institutions on the rate and direction of inventive activity, and of technological change more generally. Much of the analysis has focused on what seem to be the most direct effects of granting an exclusive property right in technological knowledge: the enhanced returns that inventors can extract by enjoying a state-mandated monopoly on discoveries they make, and the higher costs that those who might choose to employ the new technologies have to bear as a result of a society recognizing property rights in information. In this paper, however, we highlight another feature whose significance has received little attention. We argue that defining and enforcing a tradable asset in new technological knowledge is also important because it encourages the evolution of a market in technology, and because it extends and increases incentives for investment in inventive activity to segments of the population that would otherwise find it difficult to directly extract returns from their technological creativity.

The framers of the U.S. patent institutions quite self-consciously made major changes to the structures employed in Europe, and nearly all of their alterations can be viewed as extending effective property rights in technological discoveries to classes of the population that would not have enjoyed them under traditional intellectual property institutions. Not only did the United States break from Old World precedent in reserving the right to a patent to "the first and true" inventor anywhere in the world, as opposed to his employer or to the first to import the technology into the respective country, but from the very beginning the U.S. laws required that the specifications of patented inventions be made public immediately, and set the fee for obtaining a patent at a level far lower than anywhere else (less than 5 percent of the level in Britain).[1] Another consequential innovation, albeit one that was not permanent until 1836, was the introduction of an examination system, whereby applications were to be examined for novelty and appropriateness before a patent was granted. This provision was of fundamental significance, because approval from technical experts reduced uncertainty about the validity of the patent and meant that the inventor could more easily use the grant either to mobilize capital to commercially develop the patented technology or to sell or license off the rights to an individual or firm better positioned to directly exploit it. Private parties could always expend the resources needed to make the same determination as the examiners, as they did under the registration systems prevailing in Europe, but there was a distributional impact, as well as scale economies and positive externalities, associated with the government absorbing the cost of certifying a patent grant as legitimate and making the information public. Trade in patented technologies was, as a result, much more extensive, even on a per-patent basis, in

* Khan: Department of Economics, Bowdoin College; Brunswick, ME 04011, and NBER; Sokoloff: Department of Economics, University of California–Los Angeles, Los Angeles, CA 90095-1477, and NBER. We gratefully acknowledge valuable discussions with Naomi Lamoreaux and Gavin Wright.

[1] Telling examples of how seriously the patent law was enforced come from how disadvantaged groups such as slaves and married women were treated. Antebellum laws in many states regarded slaves and their output as the property of their owners; similarly, the property of married women belonged to their husbands. However, according to federal patent laws, a slaveholder could not obtain a patent in his own name for a device that his slave had created, and neither could a husband obtain a patent for his wife's invention. In 1857, a slaveholder from Mississippi, Oscar J. E. Stuart, wished to be given a patent in his own name for a cotton scraper plough invented by one of his slaves. Both the Patent Office and the Attorney General on appeal rejected Stuart's claim because, according to the patent laws, only the true inventor could be given a patent. Congress also failed to approve Stuart's plea "praying that the patent laws may be so amended as that a patent may issue to the master for a useful invention by his slave" (see Khan, 1995, 2004).

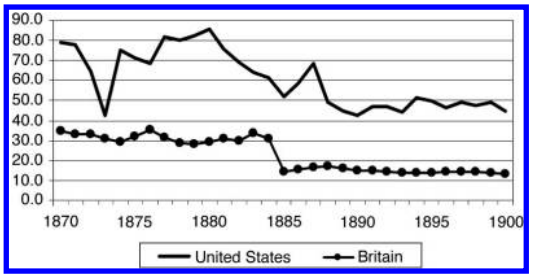

FIGURE 1. THE RATIO OF ALL ASSIGNMENTS TO PATENTS IN THE UNITED STATES, AS COMPARED TO THE RATIO OF ALL ASSIGNMENTS AND LICENSES TO PATENTS IN BRITAIN, 1870–1900

Sources: U.S. Patent Office, *Annual Report of the Commissioner of Patents;* Great Britain Patent Office, *Annual Report of the Commissioners of Patents* (after 1883: *Annual Report of the Comptroller-General of Patents, Designs and Trade Marks*).

the United States than elsewhere (see Fig. 1).[2] Technologically creative people without the capital to go into business and directly exploit the fruits of their ingenuity were major beneficiaries.

One would expect this system to have led to a more socially diverse composition of inventors and, in previous work, based on general samples of patentees, we showed how individuals from elite backgrounds accounted for a much smaller proportion of patentees in the United States than in countries such as Britain during the early 19th century (Khan and Sokoloff, 1998). Because many patents are of little or no value, however, this evidence may not conclusively demonstrate that providing broader and stronger incentives for inventive activity was of much technological significance (Sokoloff, 1988; Sokoloff and Khan, 1990; Khan and Sokoloff, 1993). Indeed, many observers, including those who were influential in maintaining the more socially restrictive patent systems that predominated in Europe until late in the 19th century, thought that little in the way of new technology that was novel or important could be expected from individuals who lacked sufficient capital to obtain patents and fund their commercial application:

> ... even with the present expense there are so many trifling patents taken out. If the fee was much higher, parties that are now taking out patents for little speculative things ... would not take them out. They are something like the dog in the manger; they prevent the public from benefiting by the invention or improvements on it for fourteen years, and yet do not benefit themselves.[3]

It is for this reason that we illustrate the significance of offering broad access to opportunities for deriving income from investment in inventive activity through an examination of the backgrounds and careers of a sample of so-called "great inventors" active in the United States during the 19th and early 20th centuries. Our sample encompasses all of the 409 individuals recognized as important inventors in the *Dictionary of American Biography* who were born before 1886 and active in the United States. For each person (408 men and one woman), we collected biographical information as well as the records of a substantial proportion of the patents (roughly 4,500 out of 16,900) they were awarded over their respective careers. The focus on those inventors who achieved renown for their contributions to the advance of technology seems fully appropriate for assessing whether the democratic orientation of the U.S. system supported important advances in technology.

I. The "Great Inventors"

The education and training of the "great inventors" suggest that initially most came from unassuming backgrounds. Table 1 presents the distributions of patents across classes of "great inventors" distinguished by the amount and type of formal schooling they received, and arrayed by birth cohort. It reveals that from the very earliest group (those born between 1739 and 1794) through the birth cohort of 1820–1845,

[2] The markedly higher ratio of assignments to patents in the United States is all the more significant, both because the British figures are biased upward by the inclusion of licenses and because the higher costs of obtaining a patent in Britain should have led to patents of higher average quality, at least in principle (if screening by cost was a good substitute for screening by examination).

[3] So testified Charles Few to the Select Committee on the Law Relative to Patents for Invention, on 15 May 1829. See British Parliamentary Papers (1968 [Vol. 1] p. 48).

TABLE 1—DISTRIBUTION OF "GREAT INVENTOR" PATENTS BY LEVEL OF EDUCATION AND THE MAJOR WAY IN WHICH THE INVENTORS EXTRACTED RETURNS OVER THEIR CAREERS, BY BIRTH COHORTS, 1739–1885

	Level of education				
Birth cohort	Primary	Secondary	College	Eng./ nat. sci.	Total
1739–1794	69.5	6.8	12.5	11.3	*400*
(Average career patents)	(5.6)	(3.8)	(6.5)	(5.2)	*75*
Income method					
Sell/license	54.9	11.1	84.0	17.7	51.4
Proprietor	36.5	74.1	2.0	44.7	35.6
Employee	6.2	7.4	—	—	4.8
1795–1819	59.1	19.3	5.4	16.2	*709*
(Average career patents)	(20.0)	(14.4)	(17.3)	(12.1)	*80*
Income method					
Sell/license	58.2	81.0	42.1	60.4	62.1
Proprietor	33.2	10.2	47.4	24.3	28.1
Employee	8.4	8.8	—	13.5	8.8
1820–1845	39.2	34.7	16.3	9.7	*1,221*
(Average career patents)	(41.8)	(44.0)	(29.4)	(23.7)	*145*
Income method					
Sell/license	50.7	31.8	37.4	72.8	44.0
Proprietor	42.3	55.2	47.7	19.3	45.5
Employee	7.7	13.0	14.9	7.0	10.2
1846–1865	22.2	24.5	20.9	32.4	*1,438*
(Average career patents)	(158.3)	(73.6)	(78.6)	(55.3)	*80*
Income method					
Sell/license	94.5	68.5	46.2	57.1	66.0
Proprietor	5.5	18.6	52.8	16.9	22.6
Employee	—	12.9	—	23.6	10.4
1866–1885	0.2	17.9	21.4	60.5	*574*
(Average career patents)	(—)	(144.5)	(53.6)	(155.7)	*26*
Sell/license	—	1.0	46.3	40.1	34.3
Proprietor	100.0	98.1	49.6	18.7	39.7
Employee	—	1.0	4.1	41.2	26.0

Notes: The table reports the distribution of "great inventor" patents across the schooling class of the patentee, by the birth cohort of the inventor (as percentages, in the first row for each cohort); the average number of patents received by each inventor, by birth cohort and schooling class (in parentheses); and the distribution of patents across the principal method of the inventor extracting income, by birth cohort and schooling class (as three percentages within each column for the cohort). The numbers of patents and great inventors are reported in italics in the last column for each birth cohort. The classification of the way income was extracted was arrived at through a close reading of the biographies and refers to the overall career of the inventor (all of his or her patents). The categories include: inventors who frequently sold or licensed the rights to the technologies they patented; those who sought to directly extract the returns by being a principal in a firm that used the technology in production or produced a patented product ("proprietor"); and those who were employees of such a firm. We have omitted a category for those inventors who seem to have made no effort to extract income from their inventions. Our overall sample of "great inventors" was constructed in two waves. In the first (160 inventors) wave, consisting primarily of those born before 1821, we collected the information for all of the patents they received through 1865 and retrieved the information on the number they received after 1865 for our estimates of the total career patents. In the second wave (249 inventors), we collected patents from every fifth year through 1930; thus we are missing the patents received late in the careers of inventors who were born in the 1870's and 1880's.

roughly 75–80 percent of patents went to those with only primary or secondary schooling.[4] So modest were the educational backgrounds of these first generations of great American inventors, that 70 percent of those born during 1739–1794 had at best a primary education, with the proportion dropping to only just above 59 percent among those who entered the world between 1795 and 1819. Given that these birth cohorts were active, and indeed, dominant until the very last decades of the 19th century, these figures unambiguously indicate that people of rather humble backgrounds were capable of making important contributions to technological knowledge. Those who had received some schooling at institutions of higher learning are admittedly overrepresented (as they accounted for less than 1 percent of the overall population), but what is most striking is how individuals who had not enjoyed the advantages associated with a more advanced education accounted for such a large share of major inventions, and that those trained in engineering and/or the natural sciences (in college or beyond) did not play a major role until the birth cohort of 1846–1865. Moreover, in all of the birth cohorts, the great inventors who had only primary or secondary education received as many (and often more) patents over their careers as did their peers with more extensive formal schooling.[5] The technologically creative seem to have been able to accumulate the skills and knowledge necessary to operate at the frontier largely on their own, or through their work experience as apprentices or younger employees, up until the Second Industrial Revolution.

[4] Those classified as receiving only a primary education encompass a range from those who spent no time in school to those who attended school until about age 12. Those who were identified as spending any years in an academy or who attended school after the age of 12 (but did not attend a college or seminary) were placed in the secondary-schooled category. Those who spent any time at all in college were either counted in the college category, or (if they had attended a school with an engineering orientation or followed a course of study in medicine or a natural science) in the engineering/natural-science group.

[5] The less-educated inventors also seem to have produced as valuable or technically significant inventions. Their patents were just as likely to be assigned and just as likely to be referred to in applications for patents from later inventors.

Some skeptics might suggest that the great inventors who had to make do with little or no formal schooling were not so disadvantaged. That is perhaps the point, at least as regards the sources of technological creativity, but this should not be interpreted as meaning that this class of great inventors was as well off in material terms as those who went to college. Matthias Baldwin, James Eads, George Eastman, Thomas Edison, and Elias Howe are among the many great inventors who were compelled to go to work at an early age to support themselves or their families, and thus to forgo much in the way of formal schooling. A perhaps more fundamental question is whether this class of inventors was especially advantaged by the structure of the U.S. patent system, where the cost of obtaining a property right in the new technological knowledge one had discovered was low, the State supported strict enforcement of those rights, and where (between 1790 and 1793, and from 1836 onward) the patent office invested substantial resources in determining the validity of patents before they were granted. The biographies suggest that inventors with only primary or secondary schooling had more limited financial resources than those who were able to attend college. Given the financial institutions of that era, inventors lacking in wealth would surely have found it much more difficult to extract a return from their inventions if they had to mobilize the capital to start or conduct a business on their own to exploit their idea directly without patent protection. The lower cost of obtaining a patent, and the certification that stemmed from having successfully passed an examination screening, should have made it much easier for inventors to market the new technology and either extract returns by selling off or licensing the rights to a firm better positioned for commercial exploitation or to attract investment (by offering shares in a firm whose assets consisted largely of the patent rights to the new technology or commitments by the inventor) to support the continued efforts of the inventor.

Our evidence does indeed suggest that these features of the U.S. patent system were highly beneficial to inventors, and especially to those whose wealth would not have allowed them to directly exploit their inventions through manufacturing or other business activity. The ability to obtain patents provided a means for individuals whose chief asset was technological creativity, or accumulated human capital that was conducive to inventive activity, to extract a return from their talents by focusing on invention. Table 1 shows that a remarkably high proportion of the great inventors, generally near or above half, extracted much of the income from their inventions by selling or licensing off the rights to them. Moreover, it was just those groups that one would expect to be most concerned to trade their intellectual property that were indeed the most actively engaged in marketing their inventions. The great inventors with only a primary school education were most likely to realize the income from their inventions through sale or licensing, whereas those with a college education in a nontechnical field were generally among the least likely to follow that strategy. With the exception of the birth cohort of 1739–1794, the college-educated inventors were much more likely than others to extract the returns to their technological creativity by being a proprietor or principal in a firm that directly exploited the technology in production.[6] Inventors who chose to realize the fruits of their technological creativity in this way might not seem to have been so affected by the patent system, but in fact even this group benefited. They were obviously helped by holding a monopoly on the use of the respective technology, but many of them were also aided in mobilizing capital for their firms by being able to report patents (or contracts committing patents granted in the future) as assets. Patent portfolios were especially useful as a signal for those who wished to attract venture capital for exceptionally innovative projects that might otherwise have seemed overly risky.

What stands out from an examination of the figures in Table 1 on the principal approaches used by the great inventors to derive income from their inventions is that the reliance on sales and licensing was quite high among the first birth

[6] It is interesting to note that many of the college-educated inventors of the 1739–1794 birth cohort were evidently not so concerned with realizing a return from their inventions. Fourteen percent of the college-educated inventors and more than one-third of those who studied engineering or natural science chose not to pursue returns to their inventions. This attitude, however admirable, was not shared by inventors who came from less privileged backgrounds.

cohort (51.4 percent on average), and remained high (62.1, 44.0, and 66.0 percent in the next three cohorts), until a marked decline among the last birth cohort, those born between 1866 and 1885. The proportion of great inventors who relied extensively on sales or licensing of patented technologies fell sharply from the levels of preceding cohorts, and there was a rise in the proportion that realized their returns through long-term associations (as either principals or employees) with a firm that directly exploited the technologies. This finding parallels that of Naomi R. Lamoreaux and Sokoloff (1999), whose analysis of different data indicated that there was a substantial increase in the likelihood of the most productive inventors forming long-term attachments with a particular assignee over the late-19th and early-20th centuries.

The patterns of variation over educational class and time in the relative prevalence of different means employed by inventors in realizing the returns to their inventive activity, and in the relative productivity or prominence of different subgroups at invention, are both fascinating and complex. We have highlighted the role of a revolutionary, low-cost, examination-based patent system, which encouraged a broad range of creative individuals and firms to invest more in inventive activity, but which was especially crucial for those who began without much in the way of resources except for their technological creativity. A key feature of the story, however, is that much of the population possessed some familiarity with the basic elements of technology during this era. Moreover, apprenticeship or the widespread practice of leaving home during adolescence to pick up skills in a trade, a traditional social institution for the transmission and accumulation of more detailed technological knowledge, was both widely accessible and capable of adapting to many of the new developments and to the general quickening of the pace of advance over the 19th century. Technologically creative individuals without the resources to attend institutions of higher learning thus had avenues for acquiring the skills and knowledge necessary to be effective at invention and could later take advantage of the access to opportunities for inventive activity grounded in the patent system. Good things generally come to an end, eventually, and in this case circumstances changed over time with the evolution of technology. Formal knowledge of science became increasingly important for making significant contributions at the technological frontier, particularly with the so-called Second Industrial Revolution, and the cost of carrying out inventive activity rose. Both of these developments served to narrow the range of the population that could generate important inventions, at least to the extent that technologically creative individuals from humble origins found it difficult to gain access to the programs in engineering or natural sciences which proliferated with the expansion of land-grant state universities during the late-19th century. Given the much higher costs of conducting inventive activity, those who were supplying the capital to fund such endeavors may have reasonably desired more in the way of credentials, as well as long-term commitments, from those they were supporting. This interpretation is obviously somewhat speculative, but it does seem to be consistent with the major patterns in the data.

An alternative perspective is that many of the phenomena we have noted could be explained by changes in the sectoral composition of the economy. In this view, there were always some industries in which formal schooling in a technical field was nearly a prerequisite for significant invention, while in others inventors could make do with little or no formal schooling. The latter industries, such as agriculture or light manufacturing, may have featured prominently in the early industrial economy and, thus, created opportunities at invention for the under-schooled, but over time the more capital-intensive and science-based industries grew in importance. The sectoral shifts then led to the dominance among great inventors of those trained in engineering or the natural sciences, as well as to the rise of R&D laboratories in large integrated companies. Although some aspects of this account ring true, the estimates presented in Table 2 of variation in the educational backgrounds of the great inventors across sectors (and over time) suggest that changes in the sectoral composition of the economy offer little explanatory power. Although inventors in the electrical/communications sector (i.e., electrical machinery and equipment, telegraph, telephone, radio, etc.) were always slightly more likely to have studied engineering or a natural science, in general the differences across sectors seem very

TABLE 2—DISTRIBUTION OF "GREAT INVENTOR" PATENTS ACROSS SECTOR AND EDUCATION OF INVENTOR, BY BIRTH COHORT, 1739–1885

Cohort and sector	Patents		Level of education		
	Number	Sector share (percent)	Primary	College	Eng./ nat. sci.
1739–1794					
Agriculture	33	8.3	60.6	9.1	15.2
Construction[a]	27	6.8	59.3	11.1	14.8
Electrical[b]	4	1.0	—	100.0	—
Manufacturing	209	52.6	69.4	12.4	13.4
Transportation	99	24.9	73.7	13.1	7.1
Miscellaneous	25	6.3	84.0	4.0	4.0
1795–1819					
Agriculture	61	8.7	68.9	21.3	4.9
Construction[a]	37	5.3	70.3	5.4	24.3
Electrical[b]	6	0.9	66.7	—	33.3
Manufacturing	316	44.8	56.7	5.4	14.6
Transportation	218	30.9	52.3	—	21.6
Miscellaneous	67	9.5	76.1	9.0	11.9
1820–1845					
Agriculture	98	8.2	24.5	23.5	2.0
Construction[a]	110	9.2	41.8	6.4	20.9
Electrical[b]	73	6.1	11.0	23.3	17.8
Manufacturing	659	54.8	44.8	10.8	9.0
Transportation	118	9.8	49.2	17.8	7.6
Miscellaneous	144	12.8	27.1	38.2	6.9
1846–1865					
Agriculture	40	2.8	5.0	7.5	42.5
Construction[a]	154	10.8	31.2	19.5	35.1
Electrical[b]	413	29.0	28.8	7.8	37.5
Manufacturing	430	30.2	27.9	13.3	23.0
Transportation	261	18.3	6.5	35.3	33.3
Miscellaneous	128	9.0	6.3	66.4	6.3
1866–1885					
Agriculture	7	1.2	—	28.6	71.4
Construction[a]	44	7.8	—	6.8	75.0
Electrical[b]	133	23.5	—	49.6	50.4
Manufacturing	213	37.6	—	23.0	67.6
Transportation	87	15.3	—	—	90.8
Miscellaneous	83	14.6	—	2.4	18.1

Notes: The distributions of patents across sectors of intended use are reported (as percentages within each column) for each birth cohort of inventors. Within each sector and birth cohort, the table reports the distribution of patents across the educational level of the great inventor (as percentages within rows). The omitted schooling class is secondary schooling.

[a] Construction and civil engineering.

[b] Electrical and communications.

small. Instead, the most striking pattern is that the educational backgrounds of inventors tended to move together over time, with each sector characterized by a marked increase in reliance on inventors educated in engineering or natural sciences during the last two birth cohorts. Although our classification of patents by sector is more aggregated than we would like, the data appear to indicate that the change in the composition of inventors overall was likely driven more by developments that extended across all sectors, rather than by movements in the relative importance of different sectors.

II. Concluding Remarks

Invention was a remarkably democratic activity in the United States throughout the 19th century. Although individuals who had been able to study at institutions of higher learning were overrepresented among great inventors, those with little in the way of formal schooling were major contributors to the progress of technology. As we have argued before, this era of democratic invention owed much to the broad access to economic opportunities available in an environment where enterprises operated on a small scale, markets were rapidly expanding, and there were relatively modest barriers to entry. In this paper, however, we call attention to a crucial institution whose role has not been fully appreciated. The U.S. patent system was revolutionary in its extension of property rights in technology to an extremely wide spectrum of the population. Moreover, it was exceptional in recognizing that it was in the public interest that patent rights, like other property rights, should be clearly defined and well enforced, with low transaction costs. These were radical notions in a world accustomed to technology being a free good to all who had the capital to exploit it, except as limited by the authority of the government to arbitrarily grant a monopoly. It is hardly surprising that these ideas encountered fierce resistance in Old World Europe.

We have demonstrated that those 19th-century skeptics who contended that only an elite segment was capable of truly important invention, and therefore that an extension of property rights in technology to the general population would have no beneficial effect on the pace of technical progress, were wrong. Although few of the celebrated inventors in Britain were of humble origins, by design such individuals were well represented among the great inventors of the United States. In the United States, this group was more likely to invest in inventive activity, not only because of the relatively lower cost of obtaining a patent, but also because the examination system facilitated the use of a patent as a general asset that could be sold,

licensed, or offered as collateral for finance. This latter feature was of profound importance for technologically creative individuals who lacked the financial resources to exploit inventions directly. In short, the patent system was a key institution in the progress of technology, but it also stands out as a conduit for creativity and achievement among otherwise disadvantaged groups.

REFERENCES

British Parliamentary Papers. *Reports from select committees on the Law Relative to Patents for Inventions, 1829–72*. Shannon: Irish University Press, 1968.

Dictionary of American Biography. New York: Scribner's, 1928–1936.

Great Britain Patent Office. *Annual report of the Commissioners of Patents* (after 1883: *Annual report of the Comptroller-General of Patents, Designs and Trade Marks*). London, U.K.: Her Majesty's Stationer's Office, various years.

Khan, B. Zorina. "Property Rights and Patent Litigation in Early Nineteenth-Century America," *Journal of Economic History*, March 1995, *55*(1), pp. 58–97.

_____. "The Democratization of Invention: Patents and Copyrights in American Economic Development." Unpublished manuscript, Bowdoin College, 2004.

Khan, B. Zorina and Sokoloff, Kenneth L. "Schemes of Practical Utility." *Journal of Economic History*, June 1993, *53*(2), pp. 289–307.

_____. "Two Paths to Industrial Development and Technological Change," in Maxine Berg and Kristine Bruland, eds., *Technological revolutions in Europe, 1760–1860*. Cheltenham, U.K.: Elgar, 1998, pp. 292–313.

Lamoreaux, Naomi R. and Sokoloff, Kenneth L. "Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries," in Naomi R. Lamoreaux, Daniel M. G. Raff, and Peter Temin, eds., *Learning by doing in markets, firms, and countries*. Chicago: University of Chicago Press, 1999, pp. 19–60.

Sokoloff, Kenneth L. "Inventive Activity in Early Industrial America: Evidence from Patent Records, 1790–1846." *Journal of Economic History*, December 1988, *48*(4), pp. 813–50.

Sokoloff, Kenneth L. and Khan, B. Zorina. "The Democratization of Invention During Early Industrialization: Evidence from the United States, 1790–1846." *Journal of Economic History*, June 1990, *50*(2), pp. 363–78.

U.S. Patent Office. *Annual report of the Commissioner of Patents*. Washington, DC: U.S. Government Printing Office, various years.

This article has been cited by:

1. Francesco Campo, Mariapia Mendola, Andrea Morrison, Gianmarco Ottaviano. 2022. Talents and Cultures: Immigrant Inventors and Ethnic Diversity in the Age of Mass Migration. *Journal of the European Economic Association* **20**:5, 1971-2012. [Crossref]
2. Xunan Feng, Zhi Jin, Anders C. Johansson. 2021. How beliefs influence behaviour: Confucianism and innovation in China. *Economics of Transition and Institutional Change* **29**:3, 501-525. [Crossref]
3. Nicolás Figueroa, Carlos J. Serrano. 2019. Patent trading flows of small and large firms. *Research Policy* **48**:7, 1601-1616. [Crossref]
4. Ufuk Akcigit, Tom Nicholas. 2019. History, Microdata, and Endogenous Growth. *Annual Review of Economics* **11**:1, 615-633. [Crossref]
5. Patricio Sáiz, Rubén Amengual. 2018. Do patents enable disclosure? Strategic innovation management of the four-stroke engine. *Industrial and Corporate Change* **27**:6, 975-997. [Crossref]
6. B. Zorina Khan. 2018. Human capital, knowledge and economic development: evidence from the British Industrial Revolution, 1750–1930. *Cliometrica* **12**:2, 313-341. [Crossref]
7. Deli Yang, Mahmut (Maho) Sonmez. 2018. Global norm of national treatment for patent uncertainties: A longitudinal comparison between the US and China. *Journal of World Business* **53**:2, 164-176. [Crossref]
8. Zorina Khan. Intellectual Property, History of 6634-6639. [Crossref]
9. Alexander Donges, Felix Selgert. 2018. Do Legal Differences Matter? A Comparison of German Patent Law Regimes Before 1877. *SSRN Electronic Journal* . [Crossref]
10. Mike W Peng, David Ahlstrom, Shawn M Carraher, Weilei Shi. 2017. An institution-based view of global IPR history. *Journal of International Business Studies* **48**:7, 893-907. [Crossref]
11. Mike W. Peng, David Ahlstrom, Shawn M. Carraher, Weilei (Stone) Shi. 2017. History and the Debate Over Intellectual Property. *Management and Organization Review* **13**:1, 15-38. [Crossref]
12. Christian Le Bas. 2016. Les inventeurs prolifiques comme déterminants des performances technologiques des firmes. *Innovations* **n° 50**:2, 119-141. [Crossref]
13. B. Zorina Khan. 2016. Invisible Women: Entrepreneurship, Innovation, and Family Firms in Nineteenth-Century France. *The Journal of Economic History* **76**:1, 163-195. [Crossref]
14. Patricio Sáiz, Ruben Amengual. 2016. Knowledge Disclosure, Patent Management, and the Four-Stroke Engine Business. *SSRN Electronic Journal* **32**. . [Crossref]
15. B. Zorina Khan. 2015. Inventing Prizes: A Historical Perspective on Innovation Awards and Technology Policy. *Business History Review* **89**:4, 631-660. [Crossref]
16. Patricio Sáiz. 2014. Did patents of introduction encourage technology transfer? Long-term evidence from the Spanish innovation system. *Cliometrica* **8**:1, 49-78. [Crossref]
17. John Howells, Ron D. Katznelson. 2014. The Coordination of Independently-Owned Vacuum Tube Patents in the Early Radio Alleged Patent Thickett. *SSRN Electronic Journal* . [Crossref]
18. B. Zorina Khan. 2013. Selling Ideas: An International Perspective on Patenting and Markets for Technological Innovations, 1790–1930. *Business History Review* **87**:1, 39-68. [Crossref]
19. B. Zorina Khan. 2013. Going for Gold. *Revue économique* **Vol. 64**:1, 89-113. [Crossref]
20. Carsten Burhop, Thorsten Lübbers. 2012. The design of licensing contracts: Chemicals, pharmaceuticals, and electrical engineering in imperial Germany. *Business History* **54**:4, 574-593. [Crossref]
21. Patricio Sáiz. 2012. Social Networks of Innovation in the European Periphery. Exploring Independent versus Corporate Patents in Spain circa 1820-1939. *SSRN Electronic Journal* . [Crossref]

22. Lisa D. Cook. 2011. Inventing social capital: Evidence from African American inventors, 1843–1930. *Explorations in Economic History* **48**:4, 507-518. [Crossref]
23. Carsten Burhop, Thorsten Luebbers. 2011. The Design of Licensing Contracts: Chemicals, Pharmaceuticals, and Electrical Engineering in Imperial Germany. *SSRN Electronic Journal* . [Crossref]
24. Carsten Burhop. 2010. The Transfer of Patents in Imperial Germany. *The Journal of Economic History* **70**:4, 921-939. [Crossref]
25. Tom Nicholas. 2010. The Role of Independent Invention in U.S. Technological Development, 1880–1930. *The Journal of Economic History* **70**:1, 57-82. [Crossref]
26. Ashish Arora, Alfonso Gambardella. The Market for Technology 641-678. [Crossref]
27. Carsten Burhop, Thorsten Lübbers. 2010. Incentives and innovation? R&D management in Germany's chemical and electrical engineering industries around 1900. *Explorations in Economic History* **47**:1, 100-111. [Crossref]
28. Michael Edelstein. The Production of Engineers in New York Colleges and Universities, 1800–1950: Some New Data 179-218. [Crossref]
29. Jeremy C. Short, Todd W. Moss, G. T. Lumpkin. 2009. Research in social entrepreneurship: past contributions and future opportunities. *Strategic Entrepreneurship Journal* **3**:2, 161-194. [Crossref]
30. Carsten Burhop, Thorsten Luebbers. 2009. The Historical Market for Technology Licenses: Chemicals, Pharmaceuticals, and Electrical Engineering in Imperial Germany. *SSRN Electronic Journal* . [Crossref]
31. Carsten Burhop. 2009. The Transfer of Patents in Imperial Germany. *SSRN Electronic Journal* . [Crossref]
32. Qiang Chen. 2008. The effect of patent laws on invention rates: Evidence from cross-country panels. *Journal of Comparative Economics* **36**:4, 694-704. [Crossref]
33. T. Nicholas. 2008. Spatial diversity in invention: evidence from the early R&D labs. *Journal of Economic Geography* **9**:1, 1-31. [Crossref]
34. Zorina Khan. Intellectual Property, History of 1-6. [Crossref]
35. R. Duane Ireland, Justin W. Webb. 2007. A Cross-Disciplinary Exploration of Entrepreneurship Research. *Journal of Management* **33**:6, 891-927. [Crossref]
36. Sandra E. Black, Kenneth L. Sokoloff. Chapter 2 Long-Term Trends in Schooling: The Rise and Decline (?) of Public Education in the United States 69-105. [Crossref]
37. 2004. Recent Scholarship. *Journal of American History* **91**:3, 1161-1214. [Crossref]