Market Trade in Patents and the Rise of a Class of Specialized Inventors in the 19th-Century United States

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It has long been recognized that one of the original aims of the U.S. patent system was to stimulate technological development by granting inventors temporary monopoly rights to their discoveries. This paper argues that the U.S. system fostered inventive activity in another important way as well, by providing the institutional infrastructure necessary for the growth of a market for technology. Early 19th-century inventors often had to play a direct role in the commercial development of their ideas, a situation that constrained their ability to focus on the generation of new technologies (B. Zorina Khan and Sokoloff, 1993). The growth of a market in patents not only made invention a more attractive activity by raising returns, but also enabled creative individuals to extract income from their ideas by selling them off, making it possible for them to specialize in the inventive activities for which they had a comparative advantage.

Ever since Adam Smith, economists have understood that one of the most fundamental processes at work in economic development is the specialization in the use of resources that the growth of market trade makes possible. Given the importance of the generation of new technologies to economic growth, as well as the long-standing recognition that investment in invention, like other types of investment activity, is responsive to material returns, the lack of research on the dynamics of these processes for the case of technology is somewhat puzzling. The answer may simply be that this topic did not seem very relevant in a world dominated by large-scale businesses that integrated both the generation and commercialization of new technologies. In recent years, however, venture capital has flowed to firms that focus on inventive activity and sell off or license the resulting intellectual property to enterprises better positioned to exploit its commercial advantages. In other words, it now seems that, whatever the coordination benefits of conducting these various activities within a single large firm, investors are realizing that there are also potential gains to be derived from a division of labor across organizations. This specialization of function is not, however, a modern innovation in organization. On the contrary, as we will show, such a division of labor was commonplace by the late 19th century, a period which, like the present age, was characterized by rapid technological change.

The institutional foundation for market trade in technology was the U.S. patent system, created in accordance with the Commerce Clause of the Constitution. Although influenced by British law, the framers of the U.S. system self-consciously made a number of important innovations. Among them were dramatically lower fees, impersonal administrative procedures for handling applications, and the requirement that a patentee be the "first and true" inventor anywhere in the world (patentees also had to be humans not firms). These provisions extended the protection of property rights to a much broader range of inventions than obtained in Britain or elsewhere in Europe and, when coupled with effective enforcement, meant that inventors could advantageously reveal information about their ideas to prospective buyers even before they received a patent grant. Moreover, uncertainty about the value of the patents decreased dramatically after the law was reformed in 1836, replacing a registration system (which left to civil litigation the resolution of questions of originality, novelty, and appropriate scope) by an examination system in which technically

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trained examiners scrutinized each application to ensure that the invention conformed to the law and constituted an original advance in the state of the art. Within just a few years of the 1836 legislation, trade in patents boomed, attaining a volume of from three to six times the number of patents issued (Khan, 1995; Khan and Sokoloff, 1998).

The patent system also encouraged trade in technology by requiring immediate public disclosure of the specifications of patents and by helping to disseminate this information broadly. Early in the 19th century the Patent Office began regularly to publish descriptions of patents granted, and it maintained offices throughout the country where models of recently patented inventions could be displayed and examined. Public knowledge of new patents and developments in technology was further spread by the growing legions of patent agents or lawyers who materialized soon after the 1836 law, especially in major cities and other localities where rates of patenting were high. Although these agents focused initially on helping inventors obtain patents under the new system, it was not long before they assumed a major role in the marketing of inventions. By the mid-1840's, for example, a number of national patent agencies had begun to publish periodicals (such as *Scientific American*) that printed complete lists of patents issued, provided news about the latest technological developments, featured articles about how inventors could profit from their ideas, and provided extensive space for classified advertisements placed by patent agents and lawyers soliciting clients, inventors seeking partners with capital to invest, and patentees hoping to sell or lease rights to their technologies.

The bulk of the early commerce in patents (80–90 percent of transactions during the 1840's) involved inventors making multiple partial assignments (sales) of the rights to their patents for geographically restricted areas. During this period, inventors frequently turned to small-town attorneys, plugged into local networks of businessmen, to handle sales of their patents in distant regions of the country. Once improvements in transportation led to the emergence of national product markets, there was a corresponding movement toward national assignments, and new techniques for marketing patents had to be developed. Patentees now needed intermediaries who could tap into the very different kinds of networks of businessmen operating in national and even international markets. This role was most commonly filled by patent agents or lawyers, often with considerable technical training, who in the course of their ordinary affairs serviced both sides of the market for technology, helping inventors file patent applications but also assisting buyers in evaluating the technical merits of inventions. Located in urban centers, these agents were often linked (sometimes formally, sometimes informally) with colleagues in other cities who served as sources of information both about new inventions coming on the market and about potential buyers for patents the agent was handling (Lamoreaux and Sokoloff, 1999b, 2000).

As is evident in Table 1, both the propensity to trade patent rights and the location of concentrations of patent agents were positively associated across regions with rates of patenting per capita. New England, which had exhibited the highest patenting rates since the beginning of the 19th century, had both the largest proportion of patents assigned at issue as well as the most disproportionate concentration of patent agents relative to population. The Middle Atlantic and the East North Central regions were next highest, respectively, and the South lowest, in patenting, assignments rates, and the clustering of agents. This robust regional correspondence between the extent of the market in technology and patenting rates is easy to explain. On one hand, one would expect investment in institutions of intermediation in patented technologies to concentrate in areas where rates of invention were already high. On the other, the presence of firms and institutions conducive to trading inventions would be expected to stimulate greater specialization and productivity at invention in the area by increasing the net returns inventors could expect from making a given discovery (accordingly encouraging individuals with a comparative advantage to make appropriate investments in invention, including human capital to augment their productivity at invention) and by making it easier for inventors to raise capital to support their inventive activity. More developed market institutions in a city or region would also attract individuals already inclined to specialize at invention to move to the respective location.

TABLE 1—PATENTS, ASSIGNMENTS AT ISSUE, AND PATENT ATTORNEYS, BY REGION

Variable	1870–1871	1890–1891	1910–1911
New England			
Patents/population	775.8	772.0	534.3
Percentage of patents assigned	26.5	40.8	50.0
Patent attorneys/population	—	2.7	2.0
Middle Atlantic			
Patents/population	563.4	607.0	488.6
Percentage of patents assigned	20.6	29.1	36.1
Patent attorneys/population	—	2.2	2.0
East North Central			
Patents/population	312.3	429.9	442.3
Percentage of patents assigned	14.7	27.9	32.3
Patent attorneys/population	—	1.1	1.1
West North Central			
Patents/population	146.5	248.7	272.0
Percentage of patents assigned	9.0	21.8	17.5
Patent attorneys/population	—	0.3	0.7
South			
Patents/population	85.8	103.1	114.4
Percentage of patents assigned	6.4	25.0	22.7
Patent attorneys/population	—	0.1	0.2
West			
Patents/population	366.7	381.6	458.4
Percentage of patents assigned	0.0	25.4	21.4
Patent attorneys/population	—	0.5	1.1
All patents, including foreign			
Patents/population	325.4	360.4	334.2
Percentage of patents assigned	18.5	29.1	30.5
Patent attorneys/population	—	—	—

Notes: The figures for patents/population are estimates of annual rates of patenting per million residents. The estimates of the percentage of patents assigned pertain to the proportion of patents that were assigned before the date of issue. Patent attorneys/population was computed as the ratio of the proportion of attorneys registered with the patent office who were located outside of the District of Columbia to the proportion of the U.S. population. For sources, see the notes to tables 4, 6, and 11 in Lamoreaux and Sokoloff (1999c).

TABLE 2—AVERAGE NUMBER OF "CAREER PATENTS" BY WHETHER OR NOT THE INVENTOR ASSIGNED A PATENT FULLY

Type of assignment	1865–1880	1885–1900	1905–1920
All patentees			
None	20.0	39.7	38.2
Full	31.4	65.3	64.5
"Great inventors"			
None	105.8	187.2	205.2
Full	115.2	250.7	260.9

Notes: The estimates are weighted averages of the number of "career" patents for two classes of patentees: those who assign away all of their patent rights to an unrelated assignee before the patent is issued and those who retain all of their rights. For the upper panel, the averages were computed over all of the patents awarded to patentees in the "B" sample (as sorted by the original cross-sections they were sampled from: 1870–1871, 1890–1891, and 1910–1911) who either made no assignment or a full assignment. See the note to table 8 in Lamoreaux and Sokoloff (1999b) for more information. In the lower panel, the averages were computed over all of the patents awarded to "great inventors" within the specified periods (1865–1880, 1885–1900, and 1905–1920) that were either assigned fully or not assigned. Each inventor's total number of career patents was computed as the sum of the number we collected in our every-fifth-year sample, and then multiplied by 5. Because we did not include those inventors (26 in number) for which our sample did not pick up any patents, the averages we report are biased upward. See the note to Table 3 for more information.

As we have shown in previous work (Lamoreaux and Sokoloff, 1996), the boom in market trade in technology, especially from the 1840's to the early 1870's, was associated with a rise in the proportion of patents awarded to individuals who received ten or more patents over their careers, from below 5 percent in the first half of the century to 25 percent or more during the period between 1870 and 1911. That the rise of a class of professional inventors was related to the growth of the market for patents is further suggested by two data sets we constructed to trace inventors' careers. For one, we drew 561 inventors whose family names began with the letter "B" from random cross-sectional samples of patentees from 1870–1871, 1890–1891, and 1910–1911, and collected information on all of the (6,057) patents they received for the 25 years before and after the year they were sampled (Lamoreaux and Sokoloff, 1999a). For the other data set, we compiled a list of 267 "great inventors" born between 1820 and 1885 from the *Dictionary of American Biography,* and collected data on the patents they obtained in every fifth year from 1840 through 1930. Although patents for inventors in the later birth cohorts may have been undersampled, the procedure picked up roughly 20 percent of the patents (3,285 in all) granted to the 251 inventors for which we found this information.

The upper panel of Table 2 reports the average number of career patents received by "B" patentees, classified by the period in which the

patentee was originally sampled and by whether the inventor had sold off all rights to the patent, or had made no assignment at all, by the date it was issued. The lower panel reports the estimated average number of career patents of "great inventors" who received at least one patent in the respective time period, again classified by whether the patent was fully assigned or not assigned at all by issue. For both groups of patentees there was a substantial rise over time in the average number of career patents received. Moreover, consistent with the hypothesis that the growth of trade in patents was associated with an increase in specialization in invention, in both groups patentees who made full assignments of their patents had markedly higher career totals than did those who retained the rights to their inventions. It is also evident from the table that patentees who made especially important contributions to technological advance were the ones most oriented toward extracting the returns to their efforts by selling off patent rights; "great inventors" assigned away a considerably higher proportion of their patents than did patentees overall.

The difference in career productivity at patenting between inventors who assigned their rights away and those who did not is robust to multivariate analysis in which controls for region, degree of local urbanization, and a number of other relevant variables are included. It is also robust to whether the comparison is conducted using weighted (as in Table 2) or unweighted means. Moreover, a similar contrast is apparent in the length of inventors' careers, gauged by the number of years between the first and last patent. Overall, therefore, our results suggest that two rather distinct classes of inventors had emerged by the late 19th century. The first consisted primarily of individuals who tended to retain control of the relatively few patents they received over relatively short careers at invention. These occasional inventors had little involvement with the market for technology, perhaps because they focused on exploiting their discoveries directly, or perhaps because their inventions failed to attract interest from buyers. The other class of inventors, by contrast, had careers that were largely shaped by the market. They assigned away a high proportion of their inventions and were quite focused on generating patented inventions, receiving many patents over careers that extended over several decades. Most of the prolific patentees fell into this second category, and it would seem reasonable to argue on the basis of these findings that the market for technology played a significant role in allowing them to be so specialized.[1]

It is likely that the growing complexity of technology over the course of the 19th century was an important factor behind this association between career productivity at patenting and the assignment of patents. As the investment in human capital required to be an effective inventor increased, so did the return to specialization in invention. As Table 3 shows, this trend was reflected in changes in the educational backgrounds of "great inventors" from successive birth cohorts. Although well-educated inventors were highly over-represented relative to the general population throughout the 19th century, there was a marked rise in their share over time, especially among the groups born after the 1850's. By the 1870's birth cohort, more than 95 percent of patents were awarded to "great inventors" with at least some years of college (the great majority studied engineering or another technical field); fewer than 1 percent of the general population had similar levels of educational attainment. The results are all the more striking given that our data likely understate the magnitude of the change in the educational background of productive inventors. We were unable to obtain this information for 53 of

[1] Skeptics might object that many of the prolific patentees who assigned their patents at issue were likely to have been employees of the companies to which they assigned, and that their greater specialization at invention reflected a division of labor within, rather than across, firms. Although this objection undoubtedly has merit for some inventors, in other work we carried out a rather extensive investigation of the relationships between the patentees in the "B" sample and their assignees, drawing on information retrieved from city directories about their places of work and job titles, and found that the most highly productive inventors of the late 19th century were generally not employees of the companies to which they assigned their patent rights (Lamoreaux and Sokoloff, 1999a). Instead, they generally behaved entrepreneurially, selling their patents to different assignees, and to firms other than their employers. It was not until the early 20th century that there was a decrease in the proportion of arms-length transactions, resulting first from a rise in assignments by patentees to companies in which they were officers or other principals and only later by employees to employers (Lamoreaux and Sokoloff, 1999a, b, c).

TABLE 3—LEVEL OF EDUCATION OF GREAT INVENTORS BY BIRTH COHORT

Birth cohort	Education level (percentage)				Total number
	Primary	Secondary	Some college	College/ postgraduate	
1820's					
Patents	17.4	41.6	23.6	17.4	305
Inventors	29.5	27.3	20.5	22.7	44
1830's					
Patents	15.2	25.6	23.0	32.0	387
Inventors	17.0	21.3	29.8	31.9	47
1840's					
Patents	11.6	41.6	28.2	18.6	510
Inventors	17.5	25.0	22.5	35.0	40
1850's					
Patents	4.8	38.3	14.9	41.9	582
Inventors	13.5	18.9	21.6	45.9	37
1860's					
Patents	—	27.5	44.7	27.8	600
Inventors	—	20.0	36.0	44.0	25
1870's					
Patents	—	—	8.9	91.1	292
Inventors	—	—	28.6	71.4	14
1880's					
Patents	—	2.4	7.3	90.2	41
Inventors	—	14.3	42.9	42.9	7

Notes: The distributions were computed over all of the observations in our sample of "great inventors" for which we had information on the educational background of the inventor. This data set was based on an exhaustive list of all of the prominent inventors included in the *Dictionary of American Biography* and born after 1819. The biographical information, including educational background, was collected from that source. The data also contain a sample of each inventor's patents, which were assembled by searching every fifth year of the U.S. Patent Office's *Annual Report of the Commissioner of Patents* from 1840 through 1930.

the 267 "great inventors," and we suspect that the difficulty we had in retrieving information on these men owed to their low levels of schooling. Because these cases were concentrated among the early birth cohorts, Table 3 almost certainly underestimates the extent of the increase in the educational background of the most productive inventors over the 19th century.

Over the course of the 19th century, rates of patenting increased dramatically, and there was substantial growth as well in the relative importance of highly specialized inventors as generators of new technological knowledge. Although it is difficult to demonstrate causality in any conclusive way, there is much evidence to support our argument that the growth of an active market for technology over the same period enabled creative individuals to specialize in invention, and that rising human-capital requirements for effective invention increased the returns to this specialization. After changes in the patent law in 1836 strengthened the property rights of both patentees and their assignees, rates of patenting per capita boomed, and patent agents, periodicals devoted to inventions, and other institutions conducive to trade in technology proliferated. Moreover, patenting rates were highest in regions like New England and the Middle Atlantic, where the market for technology (as measured by rates of assignment and the number of patent agents relative to population) was most developed. Evidence on "great" as well as ordinary inventors indicates that the most productive patentees (in terms of number of career patents) were those who took advantage of the improving market for technology to assign away full rights to their patents and specialize in the generation of patentable inventions. That this career strategy required greater investments in human capital over time is suggested by the significant rise in the educational levels of "great inventors" over the course of the century.

The patent system is often celebrated for the stimulus its grants of limited monopoly rights provide to invention. Although this effect is undoubtedly substantial, the specification of tradable assets in technology was another fundamentally important way in which the patent system stimulated inventive activity. In establishing a basis for extensive trade in the rights to new technological knowledge, the patent system not only enhanced the potential returns to particular inventions, but also facilitated the realization of economies to specialization at invention by independent inventors or small enterprises. Although some scholars have been skeptical of the feasibility or extent of arms-length transactions of this sort, it is clear that they were very common throughout the 19th century and that access to, or involvement in, a market for technology had a profound impact on the patterns of inventive activity.

The independence of the most productive inventors appears to have declined during the 20th century (at least until recently) for reasons that are not yet well understood. Evidence that we have examined elsewhere suggests that this change in the organization of inventive activity was unlikely to have resulted from high costs in transacting over technology (Lamoreaux and

Sokoloff, 1999a). Other possible explanations, such as advantages large enterprises may have had in raising capital or improvements in personnel management that facilitated the coordination of in-house inventors, deserve serious investigation. It is intriguing to note, however, that the change roughly coincided with the beginning of a secular decrease in rates of patenting per capita.

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