

# The Decline of the Independent Inventor: A Schumpeterian Story?

by

Naomi R. Lamoreaux

University of California, Los Angeles and NBER

and

Kenneth L. Sokoloff

University of California, Los Angeles and NBER

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The perfectly bureaucratized giant industrial unit not only ousts the small or medium-sized firm and “expropriates” its owners, but in the end it also ousts the entrepreneur and expropriates the bourgeoisie as a class which in the process stands to lose not only its income but also what is infinitely more important, its function. The true pacemakers of socialism were not the intellectuals or agitators who preached it but the Vanderbilts, Carnegies and Rockefellers.

Joseph A. Schumpeter<sup>1</sup>

Thus Schumpeter foretold the end of capitalism. As Schumpeter saw it, the heart of the capitalist system was the entrepreneur, an extraordinary individual with the vision to see profit in new products or production processes and the tenacity to overcome all obstacles to making the vision a reality. Schumpeter believed that the rise of large firms in the early twentieth century was making the entrepreneur obsolete. By investing in in-house R&D laboratories staffed by teams of engineers and scientists, large firms had routinized the process of innovation, “depersonalized and automatized” economic change so that innovation occurred “as a matter of course.” In such an environment, not only did “personality and will power,” and thus the entrepreneur, “count for less,” but large firms’ superior efficiency made it difficult for the small- and medium-size enterprises that were the natural home of the entrepreneur to survive. The disappearance of these enterprises eliminated as well the primary political supports for “private property and free contracting,” paving the way for socialist revolution.<sup>2</sup>

From the standpoint of the early twenty-first century, this vision of the decline of capitalism is hard to take seriously. But when Schumpeter was writing the book on the eve of

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<sup>1</sup> Joseph A. Schumpeter, *Capitalism, Socialism and Democracy* (3<sup>rd</sup> edn.; New York: Harper & Row, 1950), p. 134.

<sup>2</sup> Schumpeter, *Capitalism, Socialism and Democracy*, pp. 131-63.

World War II, it was much more compelling. Capitalism had given way to National Socialism in Germany and to Communism the Soviet Union. Moreover, both these systems had growing numbers of adherents throughout the Western World, where the experience of prolonged deep depression was undermining support for unfettered capitalism. Even in the United States there was a massive increase in the role of the state in economic affairs.

More important for our purposes, there is evidence that the dynamics of technological change shifted during the early twentieth century in ways that at least superficially fit with Schumpeter's analysis. As Figure 1 shows, patenting rates per capita increased dramatically across the nineteenth century, peaked in the 1890s, and then began a long period of decline that has only recently been reversed. In other words, rates of patenting appear to have been inversely correlated with the growth of in-house R&D, declining in the twentieth century as more and more firms created their own research laboratories and then rising again in the last couple of decades as firms began to curtail their investments in R&D.

Of course, we recognize that Schumpeter explicitly distinguished his concept of entrepreneurial innovation from that of invention. What entrepreneurs did when they innovated, according to Schumpeter, was to take a new idea (an invention) and make it work—that is, embody the idea in a productive enterprise and generate profits. We realize that Schumpeter was much more interested in the process of making new ideas work than in the generation of the ideas themselves. We also recognize that patenting is an imperfect measure of invention. On the one hand, some valuable inventions are never patented; on the other, some patents represent inventions that are of little or no economic significance. Nonetheless, we contend that data on trends in patenting are useful for testing Schumpeter's argument about the diminishing role of the entrepreneur in technological change and, more generally, in capitalism. The essence of a

patent was the grant of an exclusive property right to a technological idea. By transforming an intangible idea into a tangible piece of property that could, like all property, be exploited by the owner or sold or leased to someone else, the patent system created the foundation of property rights on which entrepreneurial innovation flourished. The fate of the independent entrepreneur, we argue, can be read from the trends in the patent data—particularly what kinds of inventors obtained patents, and what they did with the patents they obtained.

Before plunging into the analysis, it is useful to provide a brief description of our data. The starting point for our analysis is three random cross-sectional samples (totaling about 6,600 patents) drawn from the *Annual Reports of the Commissioner of Patents* for the years 1870-71, 1890-91, and 1910-11. These documents report for all patents issued during the year a brief description of the invention, the name and location of the patentee(s), and the names and locations of any assignees who were granted rights to the inventions before the date the patent was issued. We also linked the data on patents to other information, such as characteristics of the counties in which the patentee resided or the kinds of firms to which the patentee assigned patent rights. Our second major data set is longitudinal and was obtained by selecting from the three cross-sectional samples all (561) inventors whose last names began with the letter “B.” We then collected information from *Patent Gazettes* and the *Annual Reports of the Commissioner of Patents* for all (6057) patents obtained by these patentees for the twenty-five years before and after they appeared in one of our samples, again linking this data to the same kinds of sources we used for the original cross-sections. Third, we collected similar information on patents issued to “great inventors” born between 1820 and 1885. We defined great inventors as those whose contributions were notable enough to earn them inclusion in the *Dictionary of American Biography*. In addition to the biographical information contained in their entries, we collected all

of the patents they obtained in every fifth year from 1840 to 1930 (3285 patents in all). Finally, we drew three cross-sectional samples of assignees by recording all the (11,188) patent assignments listed on every other page of the *Annual Reports of the Commissioner of Patents* for the years 1870, 1891, and 1911.<sup>3</sup>

In the analysis that follows we first describe the details of the patent system that we believe were most important for supporting entrepreneurial innovation. After legislation in 1836 put the final elements of this system in place, both patenting and trade in patent rights boomed, fostering the emergence by the last third of the century of a broad group of specialized, highly productive inventors. It was the thinning ranks of these productive inventors that, we argue, accounts for much of the decline in patenting rates in the early twentieth century. The bulk of this paper is devoted to examining the sources of this attrition. Contrary to Schumpeter, big business does not seem to have been the primary culprit. Rather, the evidence suggests that, in an important sense, independent inventors were victims of their own success. As technological advances raised the cost of invention (in terms both of physical and human capital), they outpaced the ability of the financial system to support inventive activity. In conclusion, we suggest that the late twentieth century resurgence in patenting rates owed less to the decline in in-house R&D than to the development of new kinds of venture capital markets that allowed creative people once again to specialize in the development of new technological ideas.

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<sup>3</sup> We will also refer in this article to earlier work based on samples taken from the manuscript records of patent assignments. In order to be legally binding, a contract for the sale or transfer of a patent right had to be recorded with the Patent Office. These records are now stored in the National Archives.

## **The Patent System and the Rise of Institutions Supporting a Market for Technology**

The institutional foundation for the rise of the independent inventor 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 individual men or women; firms could not receive patents directly for ideas developed in their shops. The individuals who received patent grants then had the option of exploiting their property rights themselves, or they could sell (assign) or lease (license) them to other individuals or to firms. These provisions not only extended the protection of property rights to a much broader range of inventions than obtained in Britain or elsewhere in Europe but, 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.

Although the main purpose of the patent system was to stimulate invention by granting creative individuals secure rights to their intellectual property, another important goal was to promote the diffusion of technological knowledge. The law required patentees to provide the Patent Office with detailed specifications of their inventions (including, where appropriate, working models), and the result was a central storehouse of information that was open to all. Anyone could journey to Washington and research others’ inventions in the Patent Office files. In addition, more convenient means of tapping this rich source of information soon developed. The Patent Office itself began to publish on a regular basis lists of the patents it granted. By the middle of the century, moreover, a number of private journals had emerged to improve upon this

official service. One of the most important was *Scientific American*, published by Munn and Company, the largest patent agency of the nineteenth century. Others included the *American Artisan*, published by the patent agency Brown, Coombs & Company; the *American Inventor*, by the American Patent Agency; and the *Patent Right Gazette*, by the United States Patent Right Association (which, despite its name, functioned as a general patent agency). Covering the full spectrum of technologies, these journals featured articles about important new inventions, 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. They also sought to drum up business for the patent agencies that published them.

During the early years of the century, patent rights were awarded automatically to all inventors who registered their inventions and paid the necessary fees. This procedure effectively delegated to the courts responsibility for resolving disputes about the originality, novelty, and appropriate scope of patent rights. The obvious problems that resulted from such procedures were resolved in 1836 by new legislation creating an examination system in which technically trained examiners scrutinized each application to ensure that the invention constituted an original advance in the state of the art and otherwise conformed to the law. Uncertainty about the value of patent rights decreased dramatically after the passage of this law, and trade in patents boomed, attaining very quickly a volume of three to six times the number of patents issued.<sup>4</sup>

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<sup>4</sup> B. Zorina Khan, "Property Rights and Patent Litigation in Early Nineteenth-Century America," *Journal of Economic History*, 55 (March 1995), pp. 58-97; and Khan and Kenneth L. Sokoloff, "Two Paths to Industrial Development and Technological Change," in *Technological Revolutions in Europe, 1760-1860*, eds. Maxine Berg and Kristine Bruland (Cheltenham: Elgar, 1998), pp. 292-313.

The bulk of this early commerce in patents (80 to 90 percent of transactions during the 1840s) involved efforts by inventors to make multiple partial assignments of their patents for geographically restricted areas. Because markets were primarily local or regional, inventors with valuable intellectual property could exploit their ideas themselves and also earn additional profits by assigning rights to the invention to producers in other parts of the country. Thomas Blanchard, inventor of the gunstocking lathe, a woodbending machine, and a variety of other devices, exploited these possibilities to the hilt. Located in Boston, he used his lathe himself to make gunstocks for the local market and for export. At the same time, he leased the right to use the invention both to gun producers operating in other segments of the market and to producers making other goods (for example, shoe lasts, tool handles, and wheel spokes) in locations across the country.<sup>5</sup>

Once improvements in transportation led to the emergence of national product markets, however, producers lost interest in purchasing geographically segmented shares of patents and instead sought full national rights to new technological ideas. In a legal environment where many, if not most, inventions were protected by patents and where this kind of property right was vigorously enforced, maintaining one's competitive position often meant securing exclusive rights to new technology. As a result, already by 1870 the proportion of assignments that were geographically specific had dropped to 23 percent of the total, and it would fall to 5 percent by 1890. At the same time, as firms eagerly snapped up new technological ideas, more and more patents were being assigned even before they were issued (up from 18 percent in 1870-71 to 29 percent by 1890-91).<sup>6</sup>

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<sup>5</sup> Carolyn C. Cooper, *Shaping Invention: Thomas Blanchard's Machinery and Patent Management in Nineteenth-Century America* (New York: Columbia University Press, 1991).

<sup>6</sup> Naomi R. Lamoreaux and Kenneth L. Sokoloff, "Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries," in *Learning by Doing in Firms, Markets, and Nations*, ed. Lamoreaux,



As a consequence of the growth of national markets, the ways in which inventors exploited their patent rights necessarily changed. Whereas Blanchard could both use his invention himself and sell off partial rights to others, patentees now typically had to choose either to exploit their inventions themselves by founding enterprises capable of operating in national or even international markets or to transfer their rights to others better situated to develop and commercialize the technology on a large scale. Either way, they could greatly benefit from the assistance of intermediaries in securing the much more substantial financial backing they now needed to found their own enterprises or to find buyers for the national rights to their patents. Although the role of intermediary could be filled by almost any kind of businessman, patent agents and lawyers were particularly well suited for this function, and indeed inventors who used their services were able to sell their patents more quickly than anyone else (by the early 1870s, 47 percent of the assignments handled by patent agents or lawyers registered with the Patent Office occurred before issue, as opposed to 18 percent handled by other intermediaries, and 9 percent handled by the parties themselves). Not only did patent agents and lawyers typically have considerable technical training, but in the course of their ordinary business they serviced both sides of market for technology, helping inventors file patent applications and also assisting buyers in evaluating inventions' technical merits. They were thus especially well placed to obtain information about new technologies coming on the market, as well as the about the kinds of technologies that buyers would be interested in purchasing. Located in urban centers, these agents were often linked with colleagues in other cities—sometimes formally through partnerships, sometimes informally through family ties or through

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Daniel M. G. Raff, and Peter Temin (Chicago: University of Chicago Press, 1999), p. 26. These figures are based on a sample of assignment contracts taken from the manuscript records in the National Archives.

links established by repeat business. In this manner, the dense local networks of information that patent agents created could be tapped by other intermediaries operating elsewhere.<sup>7</sup>

As is evident from 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 in the nation since the beginning of the nineteenth 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 exactly what one would expect to observe. On the one hand, intermediaries should, all other things being equal, concentrate in areas where rates of invention were already high. On the other, the presence of firms and institutions conducive to trading inventions should stimulate greater specialization and productivity at invention in the area, first, by increasing the net returns inventors could expect from a given discovery (accordingly encouraging individuals with a comparative advantage in invention to make appropriate investments in physical and human capital) and, second, 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 in invention to move there.

The decline in patenting rates per capita is also apparent in Table 1, which shows that the trend was most pronounced in regions that were early leaders in patenting and in the sale of

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<sup>7</sup> Naomi R. Lamoreaux and Kenneth L. Sokoloff, "Intermediaries in the U.S. Market for Technology, 1870-1920," in *Finance, Intermediaries, and Economic Development*, eds. Stanley Engerman, Philip Hoffman, Jean-Laurent Rosenthal, and Kenneth L. Sokoloff (New York: Cambridge University Press, forthcoming), currently available as NBER Working Paper 9017.

patented technology. Although the decline coincided with, and may have been associated with, the beginnings of the development of in-house R&D, the geographic pattern suggests possible alternative explanations. The most obvious is that changes in the location of industry associated with the migration of production to the Midwest (and, in the case of textiles, to the South) may have disproportionately impacted regions, like New England, that were losing production to other areas. Another possibility is that changes in technology associated with the growth of new (second industrial revolution) industries during the late nineteenth and early twentieth centuries meant the institutions that had emerged to support patenting in the middle of the nineteenth century were not well adapted to continue that role in the next period and that regions with disproportionate investments in these institutions suffered a corresponding decline.

### **The Rise of the Independent Inventor**

As we have seen, by the middle of the nineteenth century the economic environment had changed in ways that forced inventors to pursue new strategies for exploiting their technological ideas. Both the 1836 reforms to the patent system, which strengthened the property rights embodied in a patent, and the development of patent agencies and other institutions conducive to trade in intellectual property encouraged creative individuals to treat new technology like any other output that was traded in the marketplace. Manufacturing firms during this era were competing fiercely to stay on the technological cutting edge, and this too was a powerful stimulus to investment in inventive activity. Although the increasing complexity of technology tended over time to raise the levels of technical skills and knowledge required if one was to be effective at invention, the opportunities were great for those with the appropriate human capital. These conditions not only supported an explosion of patenting rates from the late 1840s through

the 1870s, but also stimulated the rise of a class of professional inventors who specialized in the generation of new technologies. As is evident from Table 2, the relative importance of such specialized inventors jumped between the first and last third of the century. The proportion of patents that were awarded to individuals who received ten or more patents over their careers increased from below 5 percent in during the early 1800s to 28.9 and 35.9 percent respectively in 1870-71 and 1890-91.

Once one accepts the notion that inventions were a tradable good which, like other tradable goods, could be a source of profit, then it is not difficult to see that the specialized inventors of the second half of the nineteenth century strongly resembled Schumpeterian entrepreneurs. In the first place, invention was not incidental to their careers, but rather a long-term commitment, and this combination of dedication and talent paid off. The major share of such inventors in all patents is evident from Table 2, but both logic and other evidence suggest that this group of men played an even more disproportionate role in generating the most important patented inventions of the era. Those who were most successful at invention were also those who would be the most inclined toward, and best able to, mobilize resources for continuing along that career path. On average, therefore, one would expect the value of a patent received by individuals who obtained many patents over their careers to be greater than that for patentees who stopped after receiving one or two patents. This view is consistent with the finding that the career patent totals for “great inventors” were far higher among than they were for representative patentees, and that, for both groups of inventors, patent totals were higher for inventors who assigned away their inventions than for those who did not (see Table 3). Further support comes from the observation that rates of assignment across our “B” inventors were strongly associated with career patent totals.<sup>8</sup>

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<sup>8</sup> On this latter point, see “Intermediaries in the U.S. Market for Technology.” For a study of “great inventors” during the early nineteenth century, see B. Zorina Khan and Kenneth L. Sokoloff, “‘Schemes of Practical Utility’:

The entrepreneurial bent of these specialized inventors was manifested in a variety of ways. Perhaps most significant was the extensive use they made of the “market for technology”—extracting the returns from their patented inventions by selling off the rights to other individuals or firms. The resulting division of labor gave inventors the freedom to concentrate on what they did best—invent. It also allowed them to take advantage of the fact that firms might differ in their ability to exploit the commercial potential of particular inventions. Although some skeptics might object that the high assignment rates of specialized inventors reflected not their independence, but rather their status as employees of their assignees, our analysis indicates that this was generally not the case until well into the twentieth century. During the middle of the nineteenth century, as we have already seen, most assignments involved patentees selling geographically delimited rights to firms or individuals in different jurisdictions; such geographic assignments were virtually always arms-length transactions. Moreover, even as the prevalence of geographic assignments declined over time with the emergence of national product markets, it remained quite unusual for highly productive inventors to be employees of the firms that obtained their patent rights.<sup>9</sup> On the contrary, the great majority of these patentees generally either had no long-term attachment with their assignees or, as was increasingly the case by the early twentieth century, were principals in the firms to which they assigned their patents.

The greater scope for action that these specialized inventors gained by selling off their patent rights was not merely potential. The most productive inventors seem to have assigned their patents to multiple firms and individuals. This pattern is evident from Table 4, which examines the careers of the 545 patentees from our “B” sample who were residents of the United States. 168 of

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Entrepreneurship and Innovation Among ‘Great Inventors’ in the United States, 1790-1865,” *Journal of Economic History*, 53 (June. 1993), pp. 289-307.

<sup>9</sup>In earlier work, for a subset of the “B” sample, we examined the relationships between the patentees their assignees, drawing on information retrieved from city directories about their places of work and job titles. See Lamoreaux and Sokoloff, “Inventors, Firms, and the Market for Technology in the Late Nineteenth and Early Twentieth Centuries.”

these 545 patentees (or 30.8 percent) received ten or more patents over the fifty years we followed them (accounting for 80.6 percent of the total 5794 patents awarded to the 545 inventors), and 51 of these 168 (or just over thirty percent of the inventors with ten or more career patents) sold their patent rights to four or more different assignees over their careers. These 51 patentees (9.4 percent of the total number of patentees) received 2034 patents (or more than 35 percent of the total patents). These figures can be compared to the record of patentees with ten or more career patents who sold their patents to only one assignee over their careers: 36 patentees (6.6 percent of all patentees) received 727 (12.5 percent of total patents).<sup>10</sup> This way of describing the patterns in the data slightly overstates the strength of the relationship we want to highlight, because the possibility of having more assignees increases with the number of patents, but the qualitative result is robust to other approaches. The most productive inventors, as gauged by their number of career patents, were highly entrepreneurial in the sense of exhibiting substantial contractual mobility.

The career of Elmer Sperry offers an excellent example.<sup>11</sup> Sperry was born into an upstate New York family of modest means. He attended public schools and then Cortland Normal School, where he decided that he wanted to be an inventor and tried to learn as much about electricity as possible from courses and also from technical journals in school's library. He also attended lectures at nearby Cornell University. Acting on the suggestion of one of the professors he sought out at Cornell, he designed an automatically regulated generator capable of supplying a constant current even though the load on its circuits varied, and then immediately scoured the local business community in search of a financial backer. The Cortland Wagon Company, whose executives included both inventors and investors interested in supporting new

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<sup>10</sup> The contrast is even more striking for those inventors with ten or more career patents who never assigned any of their patents at issue.

<sup>11</sup> The following discussion is based on Thomas Parke Hughes, *Elmer Sperry: Inventor and Engineer* (Baltimore: Johns Hopkins Press, 1971).

technological developments, took Sperry in, providing him with the advice and services of a patent lawyer, as well as money to live on and a shop in which to work. The year was 1880, and in this sheltered environment, Sperry not only perfected his dynamo, but over the next two years developed a complete system of arc lighting to go with it. The company had a branch in Chicago, and there the company's officers, with additional backing from local Chicago investors, organized The Sperry Electric Light, Motor, and Car Brake Company in 1883, with Sperry (who owned a big chunk of the company's stock) serving as "electrician, inventor, and superintendent of the mechanical department."

Although the company was never a financial success, it launched Sperry's career. He would go on to secure more than 350 patents and found nearly a dozen companies. More than anything else, Sperry sought time and resources to pursue his creative work, and hence some of the firms he founded were essentially research and development facilities whose output was patented technology. For example, the Elmer A. Sperry Company of Chicago, which Sperry formed in 1888 as a vehicle for his inventive activities, also advertised its business as helping inventors "develop, patent and render commercially valuable their inventions." At the same time as Sperry was intent on devoting his energies to research and development, however, he was also deeply concerned that his inventions be commercially exploited. To this end, he sold many of his inventions to companies well placed to put them to productive use, but he commercialized others himself, founding with the help of a wide assortment of financial backers new companies that bore his name, such as the Sperry Electric Mining Machine Company, the Sperry Streetcar Electric Railway Company, and the Sperry Gyroscope Company. Although Sperry often played an active role in these companies in their early stages, once they were reasonably well established he typically downgraded his role to the position of technical consultant and went on

to something new. He was also willing, when the technical challenges and financial rewards were sufficiently alluring, to work as an employee or under contract for major companies such as American Can and National Battery.

### **Geographic Patterns as Clues to the Sources of Decline**

The entrepreneurial inclination of productive patentees like Sperry is also apparent in their extraordinary geographic mobility. Sperry, for example, moved from upstate New York to Chicago in order to commercialize his arc lighting systems. The promise of financial backing for his inventions later lured him to Cleveland and ultimately back East to Brooklyn, New York. More generally, the great inventor sample allows us to compare patentees' residence at the time they received any of their patents with their place of birth and with their location at the time they obtained their first patent. As Table 5 shows, the extent of their geographic mobility is striking. From 1845 to 1930, seventy-one percent of the patents awarded to great inventors went to patentees who resided outside the state of their birth, and forty-seven percent went to patentees who had moved out of the state of their first patent.<sup>12</sup> Again, the most productive patentees were the most mobile and hence seemingly the most entrepreneurial. Even after adjusting for the duration of their careers, the great inventors with relatively more career patents were also relatively more likely to have moved.

Also suggestive of the entrepreneurial inclinations of great inventors was their increasing concentration, especially after 1905, in the Northeast.<sup>13</sup> This pattern is in stark contrast to the contemporaneous trend toward regional convergence in overall patenting rates. Given that the

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<sup>12</sup> In part, the high rate of geographic mobility resulted from the disproportionate number of great inventors who were foreign born (24 percent), but the substantial rates of migration after the first patent indicate that much more was involved.

<sup>13</sup> Foreign born great inventors tended to gravitate toward New England, whereas native born concentrated increasingly in the Middle Atlantic.



Northeast had the highest per capita patenting and assignment rates, the highest concentration of patent agents, as well as the highest career patenting totals by individual inventors, this result seems to imply that productive inventors were especially likely to gravitate toward areas where the institutions supporting the market for technology and other conditions conducive to inventive activity were most developed. A similar interpretation might be offered of the concentration of patenting within large cities, even within regions.

Regional differences in the degree of specialization by inventors are also evident in our “B” sample. In Table 6, we present the distribution of both patents and patentees broken down by the total number of career patents received by the patentee and the location of the patentee for three cohorts: patentees drawn originally from the 1870-71 cross-section; the 1890-91 cross-section; and 1910-11. As the table shows, specialized inventors generally accounted for larger shares of patented inventions in New England than they did in other regions. In the 1870-71 cohort, for example, 76.1 percent of the patents awarded to patentees residing in New England went to inventors who ultimately received 10 or more patents over their careers, whereas only 5.0 percent went to inventors who had only 1 or 2 career patents. This distribution compares with respective shares of 65.2 and 6.2 among Middle Atlantic inventors, and 68.4 and 9.2 for those in the East North Central states. The regional differences are even more dramatic for the distribution of patentees. 43.9 percent of the New Englanders in the 1870-71 received 10 or more patents over their career, as opposed to 18.5 and 26.3 percent respectively of their counterparts in the Middle Atlantic and the East North Central.

The relative share of patentees with more than ten patents did not change very much over time in the East North Central, but in 1890-91 the Middle Atlantic looked much more like New

England.<sup>14</sup> This convergence, which was driven by a sharp rise in the prominence of specialized inventors in the Middle Atlantic, did not last long, however. Between the 1890-91 and 1910-11 cohorts, the composition of patentees in the Middle Atlantic and New England again diverged radically, with relative contributions of specialized inventor in the former region decreased sharply. Although in 1910-11 the two regions had similar rates of patenting per capita—the gap between them (approximately 10 percent) was narrower than it had been for more than three-quarters of a century—their populations of inventors appear to have been quite different. On average, inventors in New England received considerably more patents over their careers and thus might be considered more specialized at inventive activity.

In order to make sense of these patterns, it is important to remember that patenting rates were declining during the last decades of the nineteenth and the early-twentieth centuries most rapidly in areas that had attained high levels of patenting early on: the New England and Middle Atlantic regions and also urban counties more generally (including cities in the East North Central region). Whatever developments accounted for this decline seem to have had differential impacts on specialized inventors in the respective regions. In New England and the urban counties of the East North Central, the decrease in patenting was more pronounced among the less specialized (or low-patent career total) inventors. Hence the relative contributions of the specialized inventors increased somewhat over the period. In the Middle Atlantic, however, invention by specialized (high-patent career total) patentees appears to have been the activity that was relatively more depressed. Indeed, the decline in the national share of patents accounted for

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<sup>14</sup> If one controls for urbanization (whether the county in which the patentee is located has a city of 100,000 or not) as well as region, the difference between the East North Central and other regions appears to be due primarily to regional differences in the composition of inventors in rural counties. In other words, the relative importance of specialized inventors varies relatively little within New England or the Middle Atlantic, and it is roughly the same in the urban counties of the East North Central states. However, specialized inventors account for a markedly smaller share of all patents in the rural areas (essentially outside of big cities) of the latter region.

by specialized inventors that can be seen in Table 2 seems to have been largely accounted for by drop in the Middle Atlantic.

Thus far, the evidence might be considered consistent with Schumpeter's suggestion that the rise of large bureaucratic organizations diminished the scope for entrepreneurial innovation. Although conditions during the second half of the nineteenth century appear to have provided great latitude for creative individuals to specialize in, and extract income from their, inventive activity, important changes are evident by the 1910-11 cohort. Especially in the Middle Atlantic (the region from which more than 30 percent of domestic patented inventions emanated), the share of patents awarded to specialized inventors fell substantially, while the share going to individuals with only one or two patents over their career rose significantly. Given that the Middle Atlantic region was home to many of the nation's largest industrial corporations, such as General Electric and AT & T, there might certainly be reason to believe that Schumpeter had it right.

More support for this view comes from examination of trends over time in contractual mobility. As shown in Table 7, after rising between the cohorts of 1870-71 and 1890-91, the contractual mobility of inventors declined significantly between the 1890-91 and 1910-11 cohorts. The proportions of the patentees who assigned their patents at issue to 2-3 different assignees and 4 or more assignees increased respectively from 7.5 to 21.1 percent and 7.5 to 12.5 percent between the first and second cohorts. They then fell to 16.9 and 9.4 percent in the third cohort. Moreover, the decline in contractual mobility in the latter period was virtually all a result of developments in the Middle Atlantic region. Contractual mobility changed little, or even increased slightly, in New England and the East North Central between the 1890-91 and 1910-11 cohorts and was much greater in both of these regions than in the Middle Atlantic.

In the spirit of Schumpeter, one possible explanation for why the Middle Atlantic diverged in its patterns of inventive activity is that it had a different industrial or sectoral composition than other regions. Schumpeter argued that large bureaucratic firms were less congenial to great innovators, who tended to be entrepreneurial as well as creative, and these sorts of organizations may have come earlier to dominate the Middle Atlantic than they did other regions. We can explore this idea by classifying by type the assignees that obtained patent rights from the inventors in our samples and then examining how these types varied over time and by region and patentee characteristics. The analysis is complicated by the difficulty of classifying the large number of assignees in our samples by degree of bureaucratization or some other quality that captures the characteristics of large firms that Schumpeter had in mind. At this stage of our research, we characterize assignments according to the following typology: (0) the inventor did not assign the patent at issue; (1) the inventor made a partial assignment to an individual (often a partner); (2) a full assignment to an individual; (3) an assignment to a company with the same name as the patentee (indicating that the inventor likely was a principal in the firm); (4) an assignment to a company for which financial information was reported in the *Commercial and Financial Chronicle* or in *Poor's* or *Moody's Manual of Industrial Securities* (indicating that the company was important enough to tap the national capital markets) or, alternatively, that was listed in an early-1920s National Research Council directory of companies with research laboratories; (5) an assignment to a not-already classified company that was located in the same city as the patentee; (6) an assignment to a not-already classified U.S. company (thus a company located in another city from that of the patentee); and (7) an assignment to a company located in another country. We think of category (4) as being closest to the sort of bureaucratic enterprise to which Schumpeter attributed the decline of the

independent entrepreneur, and assume that patentees were more likely to be employees than principal of such firms. Category (3), by contrast, consists of enterprises likely run by inventors, their relatives or other close personal associates. The firms in this category most resemble Schumpeter's concept of an entrepreneurial enterprise—that is, a company set up to exploit the profit-potential of a particular innovation.

In Table 8, we present cross-tabulations, for each cohort in the “B” sample, of patents by the total number of career patents the patentee received (our gauge for the degree of specialization at invention) and the type of assignment. Major differences in assignment behavior across patentees by the degree of their specialization at invention are evident, as are changes over time. First, in all three cohorts, patentees who are specialized at invention have markedly higher assignment rates. This pattern has been discussed above, as a reflection of the likely higher value of the inventions generated by such individuals; there is more of a market for valuable inventions, and inventors are only likely to have continued their inventive activity if they were producing something of value. Second, although all classes of inventors assigned some of their patents to individuals, especially in the early cohorts, those that were more specialized or productive over their careers were much more likely to assign their patents to companies – both as a share of their assigned patents as well as of all patents. Another perspective on this strong association between specialized inventors and assignments to companies is suggested from noting that a disproportionately high proportion of the patents being assigned to companies came from the specialized inventors, and virtually all of those assigned to companies classified in (3) or (4) (companies with the same name as the inventor or firms that were highly-capitalized or had early R & D labs) came from such inventors. This association became much stronger over time, with the implication that by the 1910-11 cohort,

inventors needed to have relationships with such firms in order to remain specialized and productive at invention or such companies only purchased the patents of well-established inventors.

It is remarkable that inventors with 10 or more career patents in this last cohort assigned at issue nearly two-thirds of all the patents they were awarded, and of those assigned patents, over sixty percent went to firms in categories (3) or (4), a bit over thirty percent to other companies, and less than ten percent to individuals. In stark contrast, inventors with only 1 or 2 career patents assigned at issue only fifteen percent of their patents, with nearly two-thirds of those going to individuals and none to firms in categories (3) or (4). This differentiation in experience across classes of inventors developed over time, but the most dramatic changes occurred between the 1890-91 and 1910-11 cohorts. It was during this interval that rates of assignment continued to increase for the more specialized inventors with 10 or more career patents (from 54.4 to 62.4 percent), while actually falling for inventors in the 1-2 and 3-5 total career patent classes. It was also during this period that the firms in categories (3) and (4) became dominant in the market for patented inventions; more than thirty-one percent of all of the patents ever awarded to the inventors in the 1910-11 cohort were assigned to them at issue.

In order to shed more light on the reasons why the specialized or highly productive inventors increasingly chose to assign their patents to the sorts of firms that they would have longer-term attachments with, in Table 9 we present for each cohort the distribution of patents awarded to inventors with 10 or more career patents by the stage of the inventor's career and the type of assignment. The early, intermediate, and late stages of the career refer to the periods: up to five years from first patent; from 5 to 15 years since first patent; and more than 15 years since first patent. The logic to this approach is that identifying when inventors began to assign to the

firms they were more likely to have long-term attachments with helps one determine whether inventors were very productive in generating patents over time because they came to be supported early in their careers, or whether they had to distinguish themselves from other inventors before attracting such support. The figures suggest that in all three cohorts, even high-patent-total inventors had much more difficulty finding assignees for their patents, and relied more on assignments to individuals, during the early stage of their careers than during the later phase. This pattern suggests that inventors had, in some sense, to prove themselves before they could mobilize the capital to organize their own firms, or to develop relationships with the large integrated firms. Although the speed at which these highly productive inventors made the transition to assigning high proportions of their patents at issue, and to making these assignments to firms in category (3) or (4), seems to have increased over the cohorts, dramatic differences in assignment behavior by stage of career remain evident in the 1910-11 cohort. For example, among the patents awarded to inventors in that cohort with 10 or more career patents, 54.4 percent of those received during the first five years of the career were assigned at issue and 13.4 percent were assigned to firms in categories (3) or (4). The respective numbers for those received by the patentee more than fifteen years after his first patent, were 70.3 percent assigned, and 50.4 percent assigned to firms in categories (3) or (4).<sup>15</sup>

Firms in categories (3) and (4) share the feature that they were more likely to have ongoing relationships or attachments with the inventors who assigned their patents to them than the other classes of assignees were. Thus, we think it reasonable to interpret the finding that specialized inventors tended increasingly over time to assign to these classes of firms late in their

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<sup>15</sup> Although the pattern suggested by aggregation over the experiences of a number of different inventors may not conform to the record of any specific inventor, the qualitative results seem to be robust. We have tried to aggregate over relatively homogenous inventors by basing the table on inventors with 10 or more career patents. We have also examined the records of individual patentees. Overall, we are confident that the generalizations offer hold as a characterization of central tendencies.

career than they were earlier as further evidence that the inventors were becoming more inclined to develop long-term associations with their assignees.<sup>16</sup> If one considers such attachments as necessarily constraints on entrepreneurial innovators, then this might constitute support for Schumpeter's notions. It may be the case, however, that the voluntary association between the inventor and the assignee firm was conducive to invention, as well as presumably being in the interests of both private parties. Indeed, it is difficult to view the association of an inventor with a firm of the same name as his (category (3)) as being anything but positive for an entrepreneurial inventor. It is notable, for example, that the specialized inventors who ultimately began to assign to companies with the same name generally did so late in their careers and after exhibiting substantial contractual mobility.<sup>17</sup> These patterns, supported by the histories we have constructed for a subset of such individuals, seem to suggest that inventors who distinguished themselves early actively sought to mobilize financial backing sufficient to organize or expand their own firm.

Why did specialized inventors wait until the late-nineteenth and early-twentieth centuries to increasingly develop long-term associations with the firms to which they assigned their patents? The observation that in many cases the specialized inventors were principals in the respective firms raises the possibility that changes in financial institutions, may have lowered the cost of what was essentially venture capital to creative entrepreneurs. Such advances likely play some role, but the parallel recruitment of specialized inventors to large integrated firms -- where the inventors were surely not principals -- implies that there may have been other contributing

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<sup>16</sup> Using other information available for a subset of the B sample, we have previously come to the same conclusion. See Lamoreaux and Sokoloff, "Inventors, Firms...".

<sup>17</sup> This claim about the high levels of contractual mobility among those inventors who ultimately assign patents to firms with the same name is based upon an analysis of the information contained in the B sample. The patentees who assign to large firms (category (4)) do seem to have had exhibited significantly less contractual mobility however.



factors as well. Specifically, as technology became more complex over time, it is likely that inventive activity became much more costly to finance, and inventors with the skills and knowledge that suited them for specialization at inventive activity may have required more capital than traditional sources – such as local partners – were able to provide. The marked decrease by the early twentieth century in the numbers of productive inventors who managed their careers without such associations, together with the decline in national patenting rates (concentrated in areas where patenting rates had been very high during the age of much more independent inventors), suggests that the need to mobilize substantial amounts of capital may have operated as a screen on who could have careers focusing on inventive activity.<sup>18</sup> That patents in the manufacturing and energy/communications sectors, which were presumably the most capital-intensive on average, were especially likely to be assigned to firms in categories (3) or (4) is consistent with this view.<sup>19</sup>

As has already been discussed, the patterns of patenting and assignment in the Middle Atlantic seem to have diverged from the other leading industrial areas, New England and the East North Central states, between the 1890-91 and 1910-11 cohorts. The regional difference was manifest, as indicated in Table 10, in rather low rates of assignment to firms that had the same name as the patentee, and relatively higher rates of assignment to other enterprises. The implication would seem to be that specialized inventors in the Middle Atlantic were less inclined

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<sup>18</sup> Elsewhere we have suggested that the increasing educational requirement for being an effective inventor may also have operated as a screen. See Naomi R. Lamoreaux and Kenneth L. Sokoloff, “Market Trade in Patents and the Rise of A Class of Specialized Inventors in the 19<sup>th</sup>-Century United States,” *American Economic Review*, 91 (May 2001), pp. 39-44.

<sup>19</sup> We classified each of the patents in the cross-sectional samples, from 1870-71, 1890-91, and 1910-11, into one of six sectors: agriculture/food processing; construction; energy and communications; manufacturing; transportation; and miscellaneous. Although the differences across sectors in 1870-71 were small and insignificant, patents in energy and communications or in manufacturing were much more likely to be assigned at issue than patents in other sectors in the latter two cross-sections. Given that they were assigned, they were much more likely to be assigned to companies than to individuals. They were, moreover, much more likely (energy and communications patents especially) to be assigned to large companies with integrated research facilities, and somewhat more likely to be assigned to companies with the same name as the inventor.

or able to organize their own firms than their counterparts in New England and especially the East North Central region. Although we are cautious about drawing strong conclusions from estimates based on the experience of a modest number of inventors, it is interesting to note that this feature seems to fit well with our previous observation that the relative numbers of highly productive inventors fell sharply in the Middle Atlantic 1910-11 cohort. More work needs to be done, but it would seem as if the Middle Atlantic was the one region of the country where Schumpeter's notions were most likely to be relevant. The disparate patterns across regions are puzzling, however, and it is not yet clear why the Middle Atlantic would be different.

### **Some Preliminary Conclusions**

There was clearly much truth in Schumpeter's observations about how the advance of technology was changing the organization of innovation. Our analysis thus far suggests that he was largely correct in his view that individuals with the potential for significant invention would increasingly have to develop long-term attachments with enterprises if they were to realize their potential. He recognized that the increased complexity of technology was associated with greater costs of conducting R & D, and believed that the best way for innovators to procure the necessary funds was to associate themselves with large companies that had relatively easy access to finance and that could accommodate investing in risky projects. In order to obtain the necessary capital, however, great innovators would have to give up some of their independence. These constraints, in Schumpeter's view, served as screens and reduced the numbers and effectiveness of creative people engaged in inventive activity.

Our results are generally consistent with these aspects of Schumpeter's perspective. We find a substantial increase about the turn of the 20th century in the inclinations of specialized

inventors to assign their patents to enterprises that they had long-term associations with, and a corresponding decrease in the relative numbers of inventors who maintained both their productivity at patenting and their independence from assignees. Together with the ever-growing educational or technical requirements for effective invention in many fields, the difficulty of obtaining ongoing support may have limited the range of the population that was specialized at invention – and in so doing contributed to a fall in the rates of patenting per capita.

Not all aspects of Schumpeter's vision are corroborated by our examination of the records of patenting activity however. First, and most importantly, he appears to have underestimated the degree to which the flexibility of financial and intellectual property institutions would evolve to allow entrepreneurial innovators with good ideas to mobilize sufficient funds to organize their own firms. We find evidence that many specialized inventors, if not so many in the Middle Atlantic, were indeed able to accomplish this. Obtaining funds from others does always involve accepting some constraints on freedom of action, but the constraints here were very different from the sort afflicting bureaucratic organizations that Schumpeter focused on. Second, his forecasts may also have suffered from overestimating the returns to scale. His faith in the (at least) static efficiency of large bureaucratic organizations may reflect a full appreciation of how trade in technological information could come to be carried out at sufficiently low cost to permit a division of labor between the production of new knowledge and the application of that knowledge to the production of final products.

Figure 1

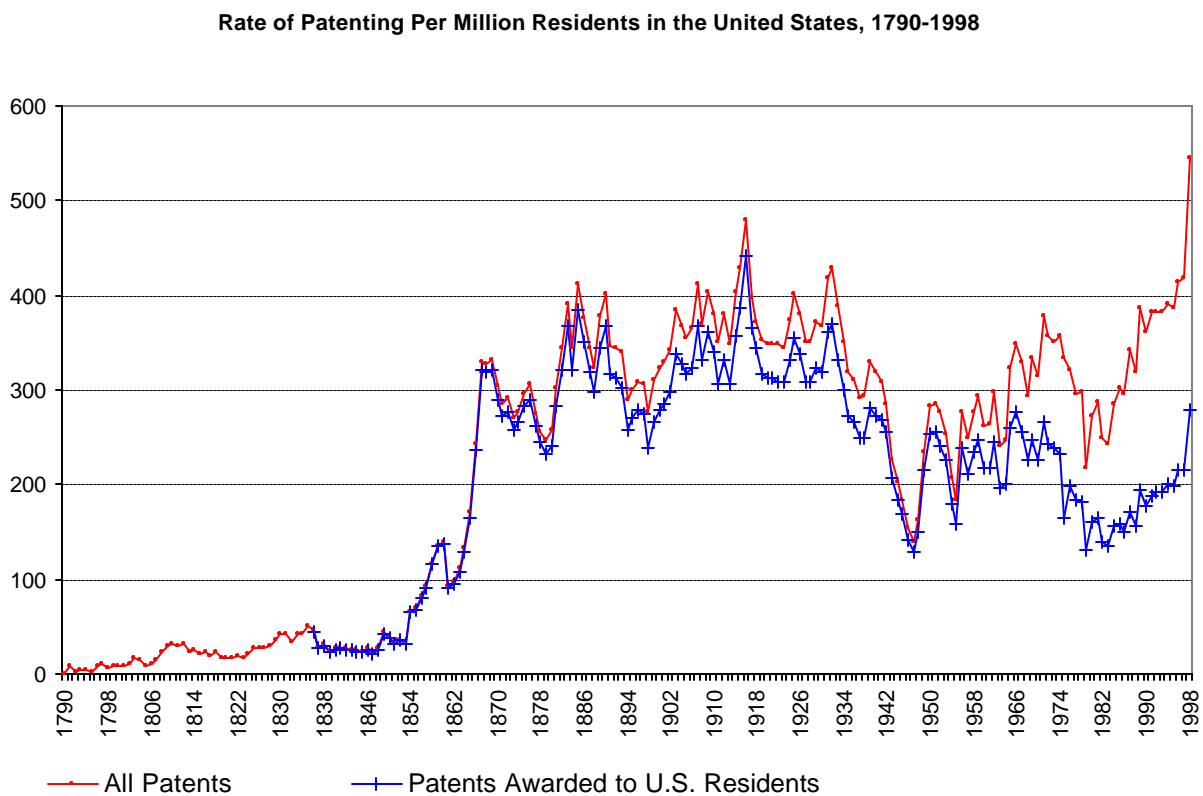


TABLE 1

## PATENTS, ASSIGNMENTS AT ISSUE, AND PATENT ATTORNEYS, BY REGION

	1870- 1871	1890- 1891	1910- 1911
<i>New England</i>			
Patents/Population	775.8	772.0	534.3
% of Patents Assigned	26.5	40.8	50.0
Patent Attorneys/Population	-----	2.7	2.0
<i>Middle Atlantic</i>			
Patents/Population	563.4	607.0	488.6
% of Patents Assigned	20.6	29.1	36.1
Patent Attorneys/Population	-----	2.2	2.0
<i>East North Central</i>			
Patents/Population	312.3	429.9	442.3
% of Patents Assigned	14.7	27.9	32.3
Patent Attorneys/Population	-----	1.1	1.1
<i>West North Central</i>			
Patents/Population	146.5	248.7	272.0
% of Patents Assigned	9.0	21.8	17.5
Patent Attorneys/Population	-----	0.3	0.7
<i>South</i>			
Patents/Population	85.8	103.1	114.4
% of Patents Assigned	6.4	25.0	22.7
Patent Attorneys/Population	-----	0.1	0.2
<i>West</i>			
Patents/Population	366.7	381.6	458.4
% of Patents Assigned	0.0	25.4	21.4
Patent Attorneys/Population	-----	0.5	1.1
<i>All Patents, Including Foreign</i>			
Patents/Population	325.4	360.4	334.2
% of Patents Assigned	18.5	29.1	30.5
Patent Attorneys/Population	-----	-----	-----

*Notes and Sources:* The figures for Patents/Population are estimates of annual rates of patenting per million residents. The estimates of the % 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.

TABLE 2  
 DISTRIBUTION OF PATENTS BY PATENTEE COMMITMENT TO  
 PATENTING, 1790-1911

	Number of "Career" Patents by Patentee					
	1 Patent %	2 Patents %	3 Patents %	4-5 Patents %	6-9 Patents %	10+ Patents %
1790-1811	51.0	19.0	12.0	7.6	7.0	3.5
1812-1829	57.5	17.4	7.1	7.6	5.5	4.9
1830-1842	57.4	16.5	8.1	8.0	5.6	4.4
1870-1871	21.1	12.5	9.9	15.8	11.8	28.9
1890-1891	19.5	10.3	10.3	10.3	13.8	35.9
1910-1911	33.2	14.3	8.2	9.8	9.4	25.0

*Notes and Sources:* The figures from 1790 to 1842 are drawn from Kenneth L. Sokoloff and B. Zorina Khan, "The Democratization of Invention During Early Industrialization: Evidence from the United States, 1790-1846," *Journal of Economic History*, 50 (June 1990), pp. 363-78. The figures for the latter years were computed from the longitudinal "B" data set constructed.

TABLE 3

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

Type of Assignment	1865- 1880	1885- 1900	1905- 1920
<i>All Patentees</i>			
None	20.0	39.7	38.2
Full	31.4	65.3	64.5
<i>Great Inventors</i>			
None	105.8	187.2	205.2
Full	115.2	250.7	260.9

*Notes and Sources:* 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 full 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: 1870-71, 1890-91, and 1910-11) who either made full assignments or no assignments. 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.

TABLE 4

CONTRACTUAL MOBILITY AND CAREER PRODUCTIVITY OF PATENTEES:  
DISTRIBUTIONS OF PATENTS AND PATENTEES

		Career Patent Total for Patentee				
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats	
		(%)	(%)	(%)	(%)	n
<u>Panel A: Distributions of Patents</u>						
No Assignees	row%	23.8	25.3	15.2	35.8	875
	col%	76.8	52.1	30.9	6.7	15.1%
1 Assignee	row%	6.1	15.0	9.2	69.8	1042
	col%	23.3	36.8	22.3	15.6	18.0%
2-3 Different Assignees	row%	-	2.4	8.1	89.6	1781
	col%	-	9.9	33.5	34.2	15.8%
4+ Different Assignees	row%	-	0.2	2.7	97.0	2096
	col%	-	1.2	13.3	43.6	36.2%
<i>n</i>		271	424	430	4669	5794
		4.7%	7.3%	7.4%	80.6%	



Career Patent Total for Patentee						
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats	
		(%)	(%)	(%)	(%)	n
<u>Panel B: Distributions of Patentees</u>						
No Assignees	row%	59.9	22.5	7.5	10.1	267
	col%	78.8	53.6	32.3	16.1	49.9%
1 Assignee	row%	32.3	30.1	10.5	27.1	133
	col%	21.2	35.7	22.6	21.4	24.4%
2-3 Different Assignees	row%	-	12.8	24.4	62.8	86
	col%	-	9.8	33.9	32.1	15.8%
4+ Different Assignees	row%	-	1.7	11.9	86.4	59
	col%	-	0.9	11.3	30.4	10.8%
<i>n</i>		203	112	62	168	545
		37.3%	20.6%	11.4%	20.6%	

Notes and Sources: These estimates were computed from the patentees in the ‘B’ sample that were residing in the U.S.. The sample consists of all patents ever awarded to a randomly drawn group of 561 patentees (whose surnames began with the letter ‘B’) from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). Panel A presents the distribution of patents for U.S. residents and Panel B presents the distribution for one patent per patentee, where the patent is selected randomly from the patentee’s record. We estimated the total number of career patents for each patentee in the sample by searching the annual reports 25 years before their cohort and 25 years afterward. We were quite conservative in estimating the number of different assignees, and thus we believe our figures underestimate the extent of contractual mobility.

TABLE 5  
GEOGRAPHIC MOBILITY OF GREAT INVENTORS:  
PROPORTION OF PATENTS AWARDED TO MIGRANTS

Region	Year of Patent			Total
	1845-1879	1880-1900	1905-1930	
New England				25.4%
% Migrant	0.53	0.78	0.82	0.74
% Foreign	0.08	0.43	0.32	0.32
n	170	402	263	835
Mid. Atlantic				48.6%
% Migrant	0.59	0.81	0.67	0.71
% Foreign	0.18	0.21	0.21	0.21
n	186	624	786	1,596
E. North Cent.				14.8%
% Migrant	0.90	0.63	0.61	0.65
% Foreign	0.31	0.17	0.11	0.16
n	48	263	174	485
W. North Cent.				2.3%
% Migrant	1.00	0.92	0.93	0.94
% Foreign	0.25	0.38	0.34	0.35
n	8	40	29	77
South				4.6%
% Migrant	0.52	0.74	0.69	0.68
% Foreign	0.00	0.43	0.21	0.25
n	21	46	84	151
West				2.3%
% Migrant	1.00	0.46	0.13	0.47
% Foreign	0.60	0.30	0.04	0.28
n	15	37	23	75
TOTAL				
% Migrant	0.62	0.77	0.69	0.71
% Foreign	0.16	0.28	0.22	0.24
n	453	1,441	1,365	3,285

*Notes and Sources:* The estimates were computed as the proportions of patents awarded to great inventors who were born in a state other than the one they resided in at the time of the award. Of the 267 inventors in that sample, we obtained at least one patent record for 241 of them. It is this latter group that the estimates pertain to. See text for further information.

TABLE 6  
 DISTRIBUTIONS OF PATENTS AND PATENTEES BY REGION AND CAREER  
 PATENTING ACTIVITY:  
 FOR THREE COHORTS OF INVENTORS, 1870-71, 1890-91, AND 1910-11

		Career Patent Total for Patentee				
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats	
		row (%)	row (%)	row (%)	row (%)	n
<u>Panel A: Distributions of Patents</u>						
New England	c1	5.0	6.5	12.4	76.1	322
	c2	1.8	4.7	6.0	87.6	555
	c3	2.6	2.9	2.6	91.9	383
Middle Atlantic	c1	6.2	16.1	12.4	65.2	434
	c2	2.2	4.3	5.3	88.2	947
	c3	5.8	9.8	3.7	80.7	601
E. North Central	c1	9.2	15.6	6.9	68.4	218
	c2	3.8	6.9	10.9	78.4	707
	c3	4.6	4.4	6.2	84.9	1050
Other U.S.	c1	4.8	14.3	12.4	68.6	105
	c2	5.0	5.5	11.8	77.7	238
	c3	17.1	16.7	9.8	56.4	234
TOTAL	c1	6.3	13.0	11.3	69.4	1079
	c2	2.9	5.3	7.7	84.2	2447
	c3	5.9	6.8	5.3	82.0	2268

TABLE 6 con't

		Career Patent Total for Patentee				
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats	
		(%)	(%)	(%)	(%)	<i>n</i>
<u>Panel B: Distributions of Patentees</u>						
New England	c1	29.3	12.2	14.6	43.9	41
	c2	22.9	20.0	11.4	45.7	35
	c3	26.1	17.4	8.7	47.8	23
Middle Atlantic	c1	35.2	33.3	13.0	18.5	54
	c2	21.2	18.2	13.6	47.0	66
	c3	45.2	24.2	4.8	25.8	62
E. North Central	c1	39.5	26.3	7.9	26.3	38
	c2	35.0	20.0	18.3	26.7	60
	c3	48.8	24.2	4.8	26.3	80
Other U.S.	c1	21.4	28.6	14.3	35.7	14
	c2	37.5	16.7	12.5	33.3	24
	c3	60.4	18.8	8.3	12.5	48
TOTAL	c1	33.3	25.2	12.2	29.3	147
	c2	28.1	18.9	14.6	38.4	185
	c3	47.9	18.8	8.0	25.4	213

*Notes and Sources:* These estimates were computed from the patentees in the “B” sample that were residing in the U.S. The sample consists of all patents ever awarded to a randomly drawn group of 561 patentees (whose surnames began with the letter “B”) from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). Panel A presents the distribution of patents for U.S. residents by their region of residence and the total number of career patents we estimated for them by searching the annual reports 25 years before their cohort and 25 years afterward. Panel B presents the distribution for one patent per patentee, where the patent is selected randomly from the patentee’s record.

TABLE 7

DISTRIBUTION OF PATENTS BY ASSIGNEE TYPE AND CAREER PATENTS:  
BY COHORTS, 1870-71, 1890-91, AND 1910-11

		Categories of Patentees By Career Patents			
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats
		(%)	(%)	(%)	(%)
Not Assigned	c1	82.4	88.6	87.7	75.3
	c2	72.9	70.5	60.6	45.6
	c3	85.0	78.1	57.5	37.6
Individual – Share	c1	10.3	3.6	4.1	5.5
	c2	10.0	11.6	12.8	3.9
	c3	7.5	6.5	5.8	2.6
Individual – Full	c1	2.9	5.0	2.5	8.8
	c2	2.9	8.5	6.4	9.6
	c3	1.5	3.2	1.7	3.0
Family-Name Co.	c1	-	-	-	1.7
	c2	-	1.6	3.7	6.1
	c3	-	-	5.8	23.5
Large Integrated Co. (R & D labs)	c1	-	-	0.8	1.2
	c2	1.4	-	0.5	9.9
	c3	-	1.9	-	14.1
Other Local Co.	c1	1.5	0.7	2.5	4.5
	c2	10.0	3.9	5.3	15.9
	c3	1.5	3.9	15.8	8.0
Other Companies	c1	2.9	2.1	2.5	2.9
	c2	4.3	3.9	10.6	9.0
	c3	3.9	6.5	13.3	6.7
n		68	140	122	749
		70	129	188	2060
		133	155	120	1860

*Notes and Sources:* These estimates were computed over the records of patenting by the patentees from the “B” sample with 10 or more career patents that were residing in the U.S. The “B” sample consists of all patents awarded over a fifty-year period to a randomly drawn group of 561 patentees (whose surnames began with the letter “B”) from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). We assembled the list of patents by searching annual reports for 25 years before and 25 years after the cohort the patentee was drawn from. The figures for assignments to foreign companies are not reported in the table, but counted when computing the percentages.

TABLE 8

DISTRIBUTION OF PATENTS BY ASSIGNEE TYPE AND CAREER PATENTS:  
BY COHORTS, 1870-71, 1890-91, AND 1910-11

		Categories of Patentees By Career Patents			
		1-2 Pats	3-5 Pats	6-9 Pats	10+ Pats
		col. (%)	col. (%)	col. (%)	col. (%)
Not Assigned	c1	82.4	88.6	87.7	75.3
	c2	72.9	70.5	60.6	45.6
	c3	85.0	78.1	57.5	37.6
Individual – Share	c1	10.3	3.6	4.1	5.5
	c2	10.0	11.6	12.8	3.9
	c3	7.5	6.5	5.8	2.6
Individual – Full	c1	2.9	5.0	2.5	8.8
	c2	2.9	8.5	6.4	9.6
	c3	1.5	3.2	1.7	3.0
Family-Name Co.	c1	-	-	-	1.7
	c2	-	1.6	3.7	6.1
	c3	-	-	5.8	23.5
Large Integrated Co. (R & D labs)	c1	-	-	0.8	1.2
	c2	1.4	-	0.5	9.9
	c3	-	1.9	-	14.1
Other Local Co.	c1	1.5	0.7	2.5	4.5
	c2	10.0	3.9	5.3	15.9
	c3	1.5	3.9	15.8	8.0
Other Companies	c1	2.9	2.1	2.5	2.9
	c2	4.3	3.9	10.6	9.0
	c3	3.9	6.5	13.3	6.7
n		68	140	122	749
		70	129	188	2060
		133	155	120	1860



Notes and Sources: These estimates were computed over the records of patenting by the patentees from the "B" sample with 10 or more career patents that were residing in the U.S.. The "B" sample consists of all patents awarded over a fifty-year period to a randomly drawn group of 561 patentees (whose surnames began with the letter 'B') from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). We assembled the list of patents by searching annual reports for 25 years before and 25 years after the cohort the patentee was drawn from. The figures for assignments to foreign companies are not reported in the table, but counted when computing the percentages.

TABLE 9  
 THE ASSIGNMENT OF PATENTS AT ISSUE:  
 BY COHORT AND STAGE OF CAREER  
 OVER PATENTEES WITH 10 OR MORE CAREER PATENTS

		Stage of Career		
		≤5 years since 1 <sup>st</sup> pat	>5 and ≤15 yrs since 1 <sup>st</sup> pat	>15years since 1 <sup>st</sup> pat
		<b>col.</b> <b>(%)</b>	<b>col.</b> <b>(%)</b>	<b>col.</b> <b>(%)</b>
Not Assigned	c1	81.9	75.3	68.9
	c2	62.0	52.7	36.6
	c3	45.6	50.3	29.7
Individual – Share	c1	6.2	6.7	3.6
	c2	4.0	5.4	3.0
	c3	6.9	4.0	0.8
Individual – Full	c1	4.1	11.4	10.8
	c2	12.1	11.1	8.0
	c3	7.2	3.1	1.8
Family-Name Co.	c1	0.4	0.0	4.8
	c2	2.2	4.2	8.4
	c3	1.3	17.1	32.6
Large Integrated Co. (R & D labs)	c1	0.0	0.0	0.0
	c2	7.1	6.3	12.9
	c3	12.1	7.3	17.8
Other Local Co.	c1	6.6	3.1	7.6
	c2	8.4	15.1	18.6
	c3	17.1	11.7	3.8
Other Companies	c1	0.8	3.5	4.4
	c2	4.3	5.4	12.6
	c3	9.8	6.5	5.9
n		243	255	251
		323	651	1086
		305	479	1076

Notes and Sources: These estimates were computed over the records of patenting by the patentees from the “B” sample with 10 or more career patents that were residing in the U.S.. The “B” sample consists of all patents awarded over a fifty-year period to a randomly drawn group of 561 patentees (whose surnames began with the letter ‘B’) from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). We assembled the list of patents by searching annual reports for 25 years before and 25 years after the cohort the patentee was drawn from. The figures for assignments to foreign companies are not reported in the table, but were counted when computing the percentages.

TABLE 10  
ASSIGNEE TYPE BY COHORT AND REGION

		New England	Mid. Atlantic	E. No. Central
		col. (%)	col. (%)	col. (%)
Not Assigned	c1	76.1	75.6	83.0
	c2	24.7	58.1	51.3
	c3	35.0	38.1	44.6
Individual – Share	c1	3.7	5.5	8.3
	c2	3.8	5.3	4.8
	c3	3.7	2.0	3.1
Individual – Full	c1	10.6	8.3	2.3
	c2	7.8	4.5	18.3
	c3	5.2	3.2	2.1
Family-Name Co.	c1	0.6	2.3	0.5
	c2	3.4	5.0	6.8
	c3	23.0	2.7	31.4
Large Integrated Co.	c1	-	-	-
	c2	15.5	9.4	3.8
	c3	23.0	22.1	4.1
Other Local Co.	c1	7.5	3.9	1.0
	c2	30.8	9.5	10.6
	c3	3.7	8.2	8.4
Other Companies	c1	1.6	4.4	-
	c2	14.1	8.2	4.4
	c3	6.5	23.8	6.4
n		322	434	218
		555	947	707
		383	601	1050

Notes and Sources: These estimates were computed over the records of patenting by the patentees from the “B” sample with 10 or more career patents that were residing in the U.S.. The “B” sample consists of all patents awarded over a fifty-year period to a randomly drawn group of 561 patentees (whose surnames began with the letter ‘B’) from the total population of patentees in 1870-71 (cohort 1), 1890-91 (cohort 2), and 1910-11 (cohort 3). We assembled the list of patents by searching annual reports for 25 years before and 25 years after the cohort the patentee was drawn from. The figures for assignments to foreign companies are included in the category for “other companies”.