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Inventing in the Shadow of the Patent System: Evidence from 19th-Century Patents and Prizes for Technological Innovations

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ABSTRACT

Such institutions as patent systems cannot be well understood without an assessment of technological creativity in other contexts. Some have argued that prizes might offer superior alternatives to the award of property rights in inventions. Accordingly, this paper offers an empirical comparison of patents in relation to the award of prizes for technological innovation. The data set comprises a sample of patents, as well as exhibits and prizes at annual industrial fairs in Massachusetts over the course of the nineteenth century. The patterns shed light on the factors that influenced how specific inventions and inventors attempted to appropriate returns. Prizes in general provided valuable prospects for advertisements and commercialization, rather than inventive activity per se. Prize winners typically belonged to more privileged classes than the general population of patentees, as gauged by their wealth and occupational status. Moreover, the award of prizes tended to largely unpredictable, and was unrelated to such proxies for the productivity of the innovation as inventive capital or the commercial success of the invention. Prize-oriented institutions thus appear to be less systematic and not as market-oriented as patent systems. If inventors respond to expected returns, prizes may be less effective at inducing technological creativity.

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"The further consideration of whether prizes are wisely given or not is one we prefer to leave to our successors."

-- *MMA Exhibition Report (1874)*

During the past two centuries technological change has made a significant contribution to advances in human welfare. However, the nature of inventive activity and the processes through which individual creativity are transmuted into outward shifts in the production possibility frontier are still not well understood. Part of the reason lies in the difficulty of obtaining objective measures of inventive activity and innovation that are comparable across time and region. To date, the most extensive empirical studies of the economic history of technological change have relied on patents to gauge progress in the 'useful arts'.

The evidence from examination of the nineteenth-century patent system in the United States suggest that the specific design of this institution played a substantial role in influencing the rate and direction of inventive activity.[1] It may well be that the nineteenth century comprised the age of patented invention in the United States: contemporary Swiss observers noted that in the United States "every good thing deserving a patent was patented."[2] Moreover, the ability to protect their ideas through strongly-enforced property rights induced relatively ordinary individuals to reorient their efforts to exploiting market opportunities.[3] An extensive network of assignments and licenses characterized a flourishing market in inventive property rights and inventions, and this enabled

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[1] Contemporaries thought the logic was self-evident: "It is in this country, where patents are numerous and easily obtained, that improved machines and processes are most rapidly introduced, as in textile manufactures, in watch-making, and shoe-making; and not in Switzerland, where until recently no patents have been granted, or in England and Germany, where patents have been hard to get." James Richardson, Our Patent System and What We Owe to It, SCRIBNER'S MONTHLY, Nov. 1878, at 99, 104.

[2] EDWARD BALLY, INDUSTRY AND MANUFACTURES IN THE UNITED STATES: LOOK OUT FOR YOURSELVES! 33 (1878) (quoting Sir William Thompson, President of the Mathematical and Physical Section of the British Association). Prominent Swiss manufacturers like Bally, a Swiss Commissioner to the Philadelphia Exhibition, studied the state of technological innovation across countries and recommended "the institution of patents as the first and indispensable measure" for becoming competitive with American industry (p. 23).

[3] Kenneth Sokoloff's pioneering research (1988) showed that improvements in market access led to a greater proportionate patenting response among rural residents who were new to invention. Khan and Sokoloff (1990) traced the occupations of such patentees and identified an increasing tendency for inventive activity to originate among creative individuals who did not possess much in the way of human capital or financial resources.

financially disadvantaged inventors to specialize at invention, and garner benefits from their creative efforts through the market (Lamoreaux and Sokoloff 2001, Khan and Sokoloff 2004). The vast majority of great inventors in the United States, who were responsible for technologically and significant inventions such as the telegraph and telephone, were prompt to obtain patent protection for their inventions (Khan 2005).[4]

Nevertheless, patents have well-known problems as measures of inventive activity (Griliches 1990). Most significantly, some inventions are not patentable, not all inventors apply for patents and not all patent applications are granted, the propensity to patent differs across industries and individuals, and patented inventions vary in terms of value. Moser's innovative 2005 study examined the exhibits at the international Crystal Palace Exhibition of 1851 as a way of assessing invention outside the patent system. She found that only a small fraction of these inventions were covered by patents at the time they were exhibited and was pessimistic about the overall effectiveness of patent institutions. This result is interesting and important, but it is difficult to extrapolate from such data to make general statements about the propensity to patent, or even about the relative degree of inventiveness in any specific country. International exhibitions may not be representative of the inventive capital in individual countries, since the selection of items likely introduced biases that are uncorrelated with technological capability. For instance, the size and content of the exhibition for any country may be determined by distance and political expedience rather than by random draws from the underlying population of inventions in the nation. Moreover, without a time-limited test of novelty, exhibits in many instances comprise a stock rather than a flow measure, which increases the difficulty of comparisons across institutions.[5] A further consideration

[4] Their contributions exhibited similar patterns to those of less eminent inventors, refuting the notion that patents merely represented 'microinventions' or incremental and minor discoveries (Mokyr 2000).

[5] Thus, at the 1851 Crystal Palace event, Britain and its dependents accounted for 7,381 exhibitors (53 percent) but there were only twelve delegates from the entire continent of South America. At the Paris Universal Exhibition of 1855, by

is that exhibitions might conceivably represent efforts at advertisement and commercialization rather than inventive activity.[6]

Despite these flaws, data on prizes offer a valuable addition to the stock of information about technological creativity. For instance, Brunt et al. (2008) conducted an empirical analysis of prizes at the Royal Agricultural Society of England, and concluded that these mechanisms proved to be effective in inducing competitive entry into targeted areas, and in encouraging innovation. Such studies are timely because scepticism has increased of late about whether state grants of property rights in patents and in copyright protection comprise the most effective incentives for increasing creativity. A growing number of economists have been persuaded by theoretical models of prizes and subsidies and have begun to lobby for these nonmarket-oriented policies as complements or superior alternatives to intellectual property rights.[7] In a reprise of debates from the nineteenth century, extremists today refer to patent systems as "an unnecessary evil," creating "costly and

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way of contrast, France and its dependents comprised 50.1 percent of all 21,779 exhibitors, whereas Britain and its colonies were now a mere 15 percent. Even if the "home court advantage" is accounted for, there were significant differences in participation within and across countries that were uncorrelated with technological capability. The rules and fees differed in each of the international fairs in ways that affected participation and outcomes. The funding for the exhibitions, as well as for travel and other expenses influenced the number and composition of the displays, because financing of some exhibitions derived from private initiative and others were funded by state and national governments. For instance, the United States was in the middle of a war at the time of the Paris Universal Exhibition of 1862, and Congress did not allot the funds requested, so only 128 Americans participated among the total of 26,348 exhibitors.

[6] According to the 1874 Report of the Massachusetts Charitable Mechanic Association: "there is no doubt that they [awards at the exhibitions] are an incentive and stimulus to the best effort, and that they are of incalculable advertising advantage to those who receive them."

[7] In the absence of asymmetries in information regarding costs and benefits, theoretical models suggest that prizes, public funding or payment on delivery might be preferable to the temporary monopoly associated with intellectual property rights (Maurer and Scotchmer 2004). Wright (1983) found that prizes are optimal if the success probability is moderately high, if the supply elasticity of inventions is low, and where awards can be adjusted ex post. Shavell and van Ypersele (1998) argued that subsidies were likely the most effective means of calibrating rewards for innovations according to social value. Some versions of this subsidy mechanism center on discounting the price to consumers who value the patented product above its marginal cost. Kremer (1998) suggested an ingenious hybrid that transforms the patent into a prize that is auctioned to the highest bidder in a process that reveals the underlying value of the invention; the government could then engage in patent buyouts of high-valued discoveries and turn them over to the public domain. Taylor (1995) offered a model where contestants compete for a pre-specified prize, by creating an invention that offers the highest value to the sponsor of the tournament. The theoretical and practical problems with prizes are well recognized, however, and they include challenges in assessing the value of the invention (such as those that arise from asymmetric information, delays in the determination of value, and the difficulty of aggregating benefits which might accrue from sequential innovations). Even if these potentially intractable issues were resolved, the credibility or efficiency of bureaucrats in holding to contracted promises might be questioned, leading to a diminution in the expected return from a prize.

dangerous" intellectual monopolies that should be eliminated (Boldrin and Levine 2008). Such theoretical arguments cannot be fairly evaluated in light of the limited amount of actual evidence regarding the functioning and consequences of prize systems.

My project contributes to this ongoing debate by analyzing the record of patenting and prizes for technological innovation in the United States from an historical perspective. I have assembled an extensive panel data set of innovations that competed for annual prizes in the same location within the United States during the course of the nineteenth century. These entries were submitted for prizes in the fairs of the Massachusetts Charitable Mechanic Association of Boston, the San Francisco Mechanics' Institute, the American Institute of New York, the Ohio Mechanics' Institute, as well as the Franklin Institute of Philadelphia. By controlling for location, the analysis avoids the biases introduced by variation in distances. The samples of approximately 17,000 innovations have been matched in the manuscript censuses to obtain information on characteristics of the inventors, including age, wealth and occupations. The inventions and inventors were further traced in patent records, so it is possible to identify key features of inventors and inventions within and beyond the patent system, and to gauge the extent to which patent institutions overlapped with other incentive mechanisms.

The current paper presents an assessment of the industrial fairs of the Massachusetts Charitable Mechanic Association, from the first exhibition in 1837 through the twelfth in 1874. The first section discusses the summary statistics, and the characteristics of the exhibitors and innovations, including the patterns of inventive activity across industrial and sectoral categories. The results from these exhibitions are compared to the patterns for patenting activity. The second section examines data on the wealth and occupation of inventors at the exhibition in order to shed further light on the relationship between patent systems and "the democratization of invention,"

relative to the alternative institution of prizes. The final section estimates the factors that influenced the award of premiums for specific inventions, and compares these findings to the determinants of patented inventions and those that were patentable. I conclude that premiums provide a useful way of tracing innovation and commercialization that occurred outside the patent system. However, the process through which they are awarded is more idiosyncratic than is true of patent institutions, which has implications for their efficacy. This analysis of the design of prize mechanisms and their effects suggests the need for caution before adopting policy recommendations to employ prizes to promote the useful arts.

I. THE EXHIBITIONS OF THE MASSACHUSETTS CHARITABLE MECHANIC ASSOCIATION

The innovations that were displayed at the triennial exhibitions of the Massachusetts Charitable Mechanic Association (MMA) allow us to assess the patterns of technological innovation that occurred outside the patent system during early industrialization. The MMA was founded in 1795 under the auspices of Paul Revere, to "promote the mechanic arts" and "encourage the ingenious" as well as to offer charitable aid, pensions and death benefits to its members. Early on, in addition to forming a "Committee of patentees and proprietors of patents," the association received private donations for the dedicated purpose of offering cash premiums for specific innovations, such as improvements in barrel-making. Several of the members of the association strongly lobbied to replace these ad hoc efforts with more extensive rewards for individual enterprise. They proposed an annual exhibition where deserving inventors would be honoured, information about discoveries would be diffused, and the public would be educated as well as entertained. Encouraged by success of the exhibitions organized by the Franklin Institute in Philadelphia, and the American Institute of New York, the MMA held its first major exhibition in the fall of 1837.

According to its organizers, the exhibits at the MMA industrial fairs were noted for offering "the best specimens of American ingenuity and skill, in every branch of mechanics, rare and valuable productions natural and artificial, labor-saving machines, implements of husbandry, and models of machinery in all their variety, and for superior workmanship in all useful and ornamental branches of the arts, including the beautiful and delicate handiwork of females in every department of industry."[8] Gold medals were granted "only for very valuable and meritorious inventions or improvements" and silver medals for "articles of superior workmanship, new applications of material, and improvements in construction."[9] In addition, bronze medals were awarded for "articles of superior workmanship, but of less importance or utility," while diplomas were bestowed on "all other articles deserving a favorable-mention testimonial."[10] Although the primary objective was to showcase domestic enterprise and technological innovation, as in the case of most expositions, it was also expected that the Association would recoup its outlays on the exhibition from the admission fees that the public paid to view the convention. This dual objective necessarily had implications for the selection of exhibits and their evaluation by the admission committees and juries.

The 1837 exhibition proved to be enormously popular and, what is more, profitable, encouraging the organizers to hold them on a regular – roughly triennial -- basis.[11] Figure 1 itemizes

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[8] Massachusetts Charitable Mechanic Association, p. 6, *The Exhibition and Fair in the City of Boston, September 18, 1837*. Boston: Dutton and Wentworth, 1837.

[9] This emphasis on the quality of workmanship rather than novelty was also a feature of international expositions such as the Crystal Palace Exhibition of 1851 and the Paris Exhibition of 1867. Robert Palmieri (ed) Piano, an Encyclopedia (p. 131) notes that at the Paris Exhibition "jury members and visitors alike seem to have been more interested in the quality of construction than novelty of invention."

[10] Massachusetts Charitable Mechanic Association, p. 6, *The Exhibition and Fair in the City of Boson, September 18, 1837*. Boston: Dutton and Wentworth, 1837. Judges comprised "gentlemen of character and standing, and as far as is practicable of thorough technical knowledge of their respective subjects … who will in no case be competitors for premiums."

[11] Sample size in each exhibition year with percentage of total sample:

Year	#Obs	Percent
1837	259	5.02
1839	283	5.49

the total receipts, expenditures and profits for each exhibition through 1890. The early exhibitions were held in Faneuil and Quincy Halls in Boston, but by the end of the century the MMA had its own dedicated hall on Huntington Avenue, conveniently close to major transportation arteries. At the second exhibition in 1839, the two-week event attracted some 70,000 visitors, at a time when the population of Boston was approximately 93,000 residents. This fair included 1196 exhibits, which were awarded 25 gold medals, 133 silver medals, and 254 diplomas. By 1890, the halls displayed the efforts of 1300 exhibitors, and the medals included 55 of gold, 175 of silver, and 144 of bronze, along with 235 diplomas.[12] The 1890 fair ran for two months, and total attendance was estimated at 500,000, about the same as the population of the town. At the conclusion of each fair, some of the exhibits were sold to the public, but the organizers discouraged itinerant traders who specialized in selling their wares through conventions like these, and attempted to ensure that the exhibition represented the "latest and best in our industrial life, and not a bazaar for the sale of merchandise."[13]

Table 1 presents the descriptive statistics from the first twelve exhibitions for the sample of 5158 exhibits that could be regarded as potentially possessing a minimal degree of technological innovation. That is, the data exclude such entries as fine art paintings, busts, botanical specimens, displays of published books, artistic or decorative designs, confectionery and simple baked goods. Even with such filtering, the catalogued submissions were characterized by enormous variance in

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1841	287	5.56
1844	315	6.11
1847	386	7.48
1850	376	7.29
1853	367	7.11
1856	546	10.58
1860	524	10.16
1865	561	10.87
1869	558	10.82
1874	697	13.5

[12] "Who has been ? or mayhap the question may be more properly put, Who has not been ? during the past month, to the Exhibition of the Massachusetts Charitable Mechanic Association. When the number of visitors has grown to near a score of thousand in a day, it may well leave us wondering who of the multitudes have been omitted." *The Repository*, vol 51, 1874, p.396.

[13] *Annual Report, MMA*, 1892, p. 11.

subject matter, substance, and technological input. One way of ensuring at least a modicum of consistency in these dimensions is to limit the universe of items using a minimal criterion of inventiveness or innovative input. Bronze medals and diplomas were cheap and plentiful, given for exhibits that were relatively undistinguished, and rarely mentioned in subsequent records when itemizing accolades that an inventor or invention had earned. Accordingly, the data set comprises all exhibits for which medals were awarded, and a random sample of the items that were accorded diplomas; amounting to 298 gold medals, 1739 silver medals, 1200 bronze medals, and 1916 diplomas.[14] Although some of the participants traveled from New York, Philadelphia, and as far away as Michigan and Ohio, the exhibition was primarily a display of technologies that were created in Massachusetts and, to a lesser extent, New England. Thus, the population of goods exhibited at these localized fairs is largely unaffected by the bias that would be created from disparate transportation costs if variable distances were traveled.[15]

The design features of this exposition were common to those of most industrial fairs, whether national or international. MMA's stated objective was to showcase the newest products and mechanisms, and exhibitors were required to highlight improvements that they had made to former goods, but it was still possible to be credited for inventions that had been created several years before.[16] In many respects, the MMA and other exhibitions were more analogous to European patent systems based on registration, rather than the American system based on examination for

[14] The percent of items awarded any recognition varied from 34 percent to 50 percent, and increased over time. However, the assessment of what this implies is not straightforward, because the organizers became more selective and rejected more items over this period. Such undocumented variation is another reason for being more careful about the conclusions that can be drawn from exhibition data.

[15] In later work, I will control for heterogeneity across regions by analyzing samples from the fairs of New York, Ohio and San Francisco, as well as the records of the Franklin Institute of Philadelphia.

[16] These features are common to all exhibitions, including the Crystal Palace: "It has not been made a condition in the admission of Articles to the Exhibition that they should be new . . . . It appears to the Commissioners that . . . fourteen to fifteen years . . . would form a limit, beyond which the claims should not be admitted." REPORTS BY THE JURIES, OFFICIAL CATALOGUE OF THE GREAT EXHIBITION OF THE WORKS OF INDUSTRY OF ALL NATIONS (2d corrected & improved ed. 1851, at xxv

novelty and patentable subject matter. First, in the absence of an examination for novelty, it is difficult to ascertain whether an item comprises an invention (a new creation) or an innovation (first commercial application). Second, patents were granted only to the "first and true inventor," whereas (as in all exhibitions, both national and international) exhibitors were not necessarily the inventors but, according to the rules, agents and other noninventors were still eligible to receive the credit for the innovation.[17] Third, it is unclear whether annual records consisted of stocks drawn from former inventions created several years prior to the date, or flows of the latest discoveries. The way in which patent registration systems and exhibitions blur the line between invention and innovation is illustrated by the prevalence of business enterprises at the fairs. Approximately one third of the sample consisted of firms, whose primary objectives clearly included commercialization and advertisement of merchandise that might have little to do with original or novel inventive activity. If firms had the intention of showcasing their best new inventions, it might be expected that they would tend to win a disproportionate amount of the prizes awarded. However, their share of each category of medal was roughly proportionate to their share of all exhibits.

It seems plausible that individual exhibitors had more mixed objectives than those of firms, that likely ranged from the pursuit of financial gain to personal gratification. However, the average age of the exhibitors (40.5) are a close match to the average age of patentees (38.5) and seem to suggest the pursuit of more systematic goals than glory. Although the average number of appearances in the roster of medals and diplomas typically comprised two exhibitions, for most attendees recognition at the fair was a unique event, since two thirds of these exhibits were entered by owners who only won a single award. By contrast, an average of 6.3 patents per person were

[17] At the Crystal Palace, "Juries will reward an important Machine without undertaking to pronounce whether the novelties exhibited in its construction have been originated by the Exhibitor, or have been borrowed or adapted by him from some one else." REPORTS BY THE JURIES, OFFICIAL CATALOGUE OF THE GREAT EXHIBITION OF THE WORKS OF INDUSTRY OF ALL NATIONS 309-14 (2d corrected & improved ed. 1851.

granted to patentees nationwide (sampled in 1860 and 1870) over the course of their career. This suggests at least in part that the average inventor who patented his discoveries possessed a greater degree of commitment to technological innovation than those who participated in exhibitions. This is consistent with the finding that only a few of the exhibitors (such as Jordan Mott, Moses Farmer, Jonas Chickering, Timothy and Lemuel Gilbert, and sewing machine entrepreneurs Wheeler and Wilson) possessed technological "brand name recognition," in comparison to the much larger roster of relative unknowns.

These data also bear on the question of whether biases in patent institutions explain the low participation rates of women in the rosters of patented inventions.[18] The organizers of the exhibition actively encouraged women to submit entries, expecting that their "taste and delicacy" would conduce to more visually appealing displays. Towards the end of the century special gallery space was set aside for a "Woman's Department," with the intention of encouraging "only those lines of woman's industries of intrinsic value and practicable as a means of obtaining a livelihood. The manufacture of certain classes of fancy articles – notably crazy quilts and elaborate trifles – was not encouraged."[19] Still, for the most part, women tended only to exhibit unique works of craft, clothing, household and domestic enterprise. The category of "needle work, millinery goods, artificial flowers" was dominated by women participants (including precocious children such as 11-year old Miss Caroline Harris of Boston). Women accounted for approximately 10 percent of the sample, a significantly higher proportion than the approximately 1 percent of patentees that were female (Khan, 2000). The fraction that earned medals, however, was closer to the patenting rates:

[18] For a study of women who participated in the National Industrial Expositions of France, see Khan (2014), "Invisible Women: Entrepreneurship, Innovation and Family Firms in 19th Century France."

[19] See the Report of the Exhibition, 1887, p. 16. "Another notable feature of the Exposition were the inventions of women. It has been so often reiterated that women are not inventors, that many have fallen into the trap of believing the statement. To all such, the eye evidence which they received at the Fair, that the inventive genius of women is rapidly developing, will be a beneficial correction of their misapprehension" (*The Repository*, vol 51, 1874, p. 396).

only 25 (0.5 percent of the full sample) obtained a gold medal, 157 (3.1 percent) silver medals, and 86 (1.7 percent) received bronze medals. The gold medals to women exhibitors were awarded for creations with low technological or market value, such as embroidery, wax flowers, decorative chairs, bonnet trimmings, and shellwork.[20] None of the women participants in the sample ever obtained a patent, and few created items that were patentable. For instance, Mr and Mrs A. Brooks of South Scituate, Massachusetts presented samples of silk from cocoons that she raised (not patentable), spun into thread using a machine that he invented (patentable subject matter). Hence, the sources of the gender-bias of technological innovation seem to have been more broadly-based and likely did not owe to specific biases in the patent and prize systems.

II. PATENTS AND PATENTABILITY AT THE EXHIBITIONS

Samuel Sidney posed the question in 1862, "Whether . . . manufacturing inventions [can be] stimulated, by invitations to compete for substantial or honorary awards?"[21] A central question for empirical analyses of technological change is how to gauge the extent to which inventive activity and innovation occur outside the patent system. The American patent system was internationally recognized as the most favourable towards inventors, and harmonization of patent laws converged towards the American model. After 1836, technically trained employees of the Patent Office conducted an examination of patent applications to ensure that inventions were novel. Patents were granted only to the first and true inventor, and even employers could not obtain property rights for

[20] The Maryland Institute for the Promotion of Mechanic Arts organized an exhibition in 1850 which rewarded creativity by gender: they presented men with gold and silver medals, whereas women received butter knives, ladles, teaspoons, pencils and thimbles.

[21] Samuel Sidney, *On the Effect of Prizes on Manufacturers*, 10 J. SOC'Y ARTS 374, 374, (1862). Sidney was trained as a lawyer, and was also an Assistant Commissioner of the Crystal Palace Exhibition in London in 1851. His careful empirical investigations over ten years led to his concluding that prizes generally tended to be inefficient, and improvements in market demand and competition offered the most effective inducements for inventive activity. The prize system merely encouraged "a long list of machines which, for practical purposes, are no better than toys."

the work that their workers created except through assignment. Patentees were required to fully disclose their contribution to the art, and to distinguish between their own efforts and those of prior inventors. Undue delay in applying for a patent could result in the decision that the idea had been ceded to the public domain. Patentees were not only prompt in applying for protection for ideas they had reduced to practical use, they even filed caveats notifying the Patent Office of the progress of their invention. As a result of such doctrines, it was unlikely that an intended patentee would exhibit his invention at a public exhibition prior to filing the patent; instead, patent applications certainly would have been submitted beforehand.[22]

The matching of exhibits to patents is straightforward for individual inventors whose names were traceable, but the rule that firms could not obtain patent rights makes it impossible to estimate their patent portfolios except in cases where the patent was assigned at the time of issue. Thus, although 845 or 16.4 percent of the exhibits were traced in the patent records, the denominator should be adjusted to take into account the number of exhibits attributed to firms. When firms are omitted from the base, a conservative estimate is that at least 24 percent of the exhibits were patented, and this figure increased over time.[23] The 'exhibitor is patentee' variable in Table 1 reports the number of exhibits whose exhibitors obtained at least one patent at some point in their career, even if the specific item at the fair was not patented. Again, the representation of patentees is higher in the second period, and at least 29.5 percent of the exhibits were credited to patentees (43.4 percent if adjustments are made for firms). These data suggest that a considerable amount of

[22] In the matching of patents and exhibits, exact wording of exhibits and patent descriptions were deemed to be for the same invention only if the patent had been awarded in the same 12-month period as the exhibition. As a result of delays between the period of filing and grant, which ranged from a few months to a little over a year, it was possible for an object for which a patent application had already been filed to be exhibited prior to the official date recorded in the patent grant.

[23] Firms were more likely to own larger amounts of patents than individual exhibitors, so the omission of firms from the calculations of the propensity to patent biases estimates downward.

creativity at invention of various sorts was indeed occurring outside the patent system, and it is interesting to speculate why such items were not patented.

Rather than indicating a rejection of the patent option, a straightforward explanation is that many exhibits were not eligible to be considered for a patent, either because the degree of novelty or improvement was minimal or because the innovation fell outside the subject matter that could be patented. Although such innovations could have been commercially valuable, and did indeed garner medals, it is useful to distinguish between exhibits that were eligible for patents and those that were not. It is impossible to determine the amount of novel inventive capital vested in unpatented exhibits; but the patentability of each item in terms of subject matter can be identified. For instance, improvements in rag rugs were not patentable, neither were items that just featured higher quality workmanship, nor mere changes in appearance or form (decorative flourishes, abnormal size, or silver plating used in place of wood). A total of 47.2 percent of the sample comprised patentable subject matter, which indicates that at least 34.7 percent (845 patents out of 2436 patentable exhibits) of eligible items were covered by patent protection. A closer assessment of the unpatentable items reveals that a large fraction comprised final or consumer goods, a finding that supports the conventional view that patents may be a better measure of inputs than of output.

The exhibits were categorized by sector and industry according to the final use of the innovation. In the period between 1790 and 1850, 22.3 percent of national patents were in agriculture, 16.7 percent in construction, 40.1 percent in manufacturing, 12.8 percent in transportation, and 8 percent in the miscellaneous category.[24] The majority of the entries at the MMA fairs fall into the manufacturing category, unlike the relatively more even sectoral dispersion of patents. Thus, although the exhibition data reveal higher rates of innovation in the manufacturing sector than the patent records show, patent protection extended to a wider range of creative activities

[24] Khan (2005), p. 63.

than those at the MMA. However, previous studies of patenting have found that the propensity to patent and other dimensions of inventive activity vary according to narrower classifications, so the exhibits were also allocated to twelve more detailed industrial categories.

Table 2 presents the industrial distribution of the exhibits, their patentability, and those that were actually patented. The table also includes the distribution by industry of the medals and diplomas awarded. Heat and power-related innovations (ranges, furnaces, lamps, electrical goods and the like) accounted for 9.7 percent of the entire sample, but 19.1 percent of the patentable and 18.6 percent of patented entries. By way of contrast, apparel comprised 6.2 percent of all innovations, but only 1.4 percent of those that were patentable, and still less of those that were patented. Chi-square tests confirm that the patentable exhibits, as well as those that were patented, varied significantly across industrial category. However, the shares of the total number of prizes awarded comprised 5.8 percent of gold medals, 33.8 percent of silver, and 23.3 percent of all bronze medals, and there is little variation in these allocations across industries. Transportation accounted for 6 percent of all exhibits, and garnered an equivalent proportion of each category of award. In other words, the medals in each industry were proportional across all the different industrial lines, a conclusion that is supported by the finding that statistical tests of independence are not significant.[25] This lack of variation across such disparate technologies raises the possibility that the award of medals was largely unrelated to the quality of inventive input, and may simply have been apportioned on a quota basis to each class on display.

III. OCCUPATIONS AND WEALTH OF EXHIBITORS

Prior research supports the notion that patent institutions in the United States promoted a process of market-oriented democratization (Khan and Sokoloff 1990, Khan 2005). In many instances, new

[25] This finding is common to the results for all other expositions that I have examined.

discoveries are difficult to finance because of asymmetries in information and other capital market imperfections, giving an advantage to wealthier or more well-connected inventors, who might be better able to fund marketing and production of their discoveries and innovations themselves. However, talented but impecunious nineteenth-century inventors could specialize in their area of expertise, and use the market for patents to sell their property and appropriate the benefits from their endeavours through these means. A system that offers greater accolades to elites has different implications for economic prospects than one that promises rewards will accrue to the most productive, so it is worth investigating the extent to which such patterns characterized technological advances throughout the United States, irrespective of institutional context.

An assessment of the occupations of patentees was consistent with the notion of open access and a broad distribution in the population of those who made significant contributions to productivity growth. During the antebellum period, the majority of patentees comprised artisans (approximately one third) and manufacturers (21 percent), whereas the elite social class of merchants, professionals and white collar workers decreased over time. The significance of more technically-qualified machinists and engineers grew substantially over this period, but such skills were hardly necessary for even important discoveries, as the work on the great inventors reveals. The majority of early patentees were quite unspecialized, and the increase in inventive activity that Sokoloff (1988) identified was generated by an influx of individuals with little prior experience at technological innovation in the form of patents. The most significant inventions of the time, such as Thomas Blanchard's lathe or Cyrus McCormick's reaper, were typically based on commonly available information applied to a bottleneck or specific practical problem.

Although the mandate of the Massachusetts Charitable Mechanic Association was to further the standing of innovative workers, Figure 2 shows that participants in the fairs were drawn from

more prominent occupations than the general population of patentees.[26] Indeed, even when the estimates for the MMA data exclude the category of firms from the analysis, exhibitors were significantly less likely to be artisans and ordinary labourers (in the 'other' category) than were patentees,. The representation of artisans at the exhibitions also declined over time: among those who participated at the fairs before 1855, 24.1 percent were artisans, compared to 18.5 percent after this period. It was, of course, possible that the innovations firms displayed were created by artisans in their employment. However, the point is that, when appropriating returns on their own account, inventors without social backing were more likely to turn to the patent system. At the same time, it is true that occupational class does not directly translate into economic or social status or influence, as witnessed by the MMA's founder, Paul Revere. For this, despite the flaws in the census surveys, we turn to the records on wealth-holding in the federal population censuses of 1850, 1860 and 1870.

The information on wealth allows us to more directly assess the economic status of exhibitors relative to patentee in general.[27] Lee Soltow estimated that the white male population owned an average of $2231 and $2141 in real estate in 1860 and 1870 respectively, and an average of $1549 and $966 in personal property over the same period. He found it to be "rather shocking" that 57 percent of white men in 1860 possessed no real estate wealth, and 43 percent owned no personal estate, a pattern that was maintained in 1870.[28] My own estimates indicate that, on the eve of the outbreak of war, poor patentees were on average rather like the general population. Over a half of all such inventors held no real estate, and over a third recorded no personal wealth. Poor inventors

[26] The diplomas of the exhibition included "a procession of artisans" who were presenting their inventions as candidates for prizes (see appendix).

[27] The 1850 census measures real estate wealth, whereas the 1860 and 1870 censuses included information on real estate wealth, exclusive of "liens or encumbrances," as well as personal estates comprising all personal property "consist of what it may." These entries are not entirely accurate, because of missing values, left-censoring of observations around values of $100, and "clumping" around popular figures such as round hundreds. However, they do suffice to give a general sense of the material standing of the two groups.

[28] See Soltow, Lee, *Men and Wealth in the United States, 1850-1870*, New Haven: Yale University Press, 1975, p. 60. "Patterns [between 1860 and 1870]… were remarkably stable. The most striking finding was that this country harbored vast proportions of populations with no wealth" (p. 61).

were somewhat more likely to assign their inventions so it is not surprising that, unlike those with lower human capital in the general population, many of these inventors had acquired assets within the following decade. Thus, patentees in general experienced greater economic mobility than the general population between 1860 and 1870. The gains over this period in terms of both personal and real wealth were especially evident for patentees at the higher end of the wealth distribution.

The data for the three decades with census information for wealth show that the participants in the Massachusetts exhibitions were substantially wealthier than the general population. Recall that these data do not include information on corporations and companies whose owners could not be identified, which biases the estimates of property-holding downward. Forty six percent of the exhibitors owned no real estate, and 32 percent had no personal property. Nevertheless, Figure 3 illustrates how the assets of the exhibitors significantly exceeded the holdings of the sample of general patentees. In 1860 the MMA sample owned average personal property of almost twice that of patentees in general, and more than double their average real estate holdings. A number of these individuals were exceptionally wealthy. Edward H. Ashcroft, who possessed $150,000 in real estate and $20,000 in personal property in 1870, was the inventor of 12 technically and commercially notable steam engine patents, which are still cited in patents today.[29] Iron-founder Amos Chafee Barstow (1813-1894), whose 1860 portfolio included $288, 500 in real estate and $151, 500 in personal goods, employed four servants in his home. Barstow was a stove manufacturer and proprietor of the Barstow Stove Company on Point Street in Providence, Rhode Island, and he was appointed as mayor of the city in 1852 and Speaker of the House in 1870. A capable inventor who specialized in cooking appliances, he was the patentee of some eight inventions. The improvement

[29] For further details, see David, Barry Lee, *The Antique American Steam Gauge: A Collector's Guide*. Mendham, N.J.: Astragal Press, 2003.

in stoves that he patented in 1873 was awarded the Grand Medal of Merit at the 1873 Vienna World's fair, but at the MMA of 1874 this innovation only received a bronze medal.

IV. REGRESSIONS: DETERMINANTS OF INVENTION AND INNOVATION

What were the factors that influenced patenting and prizes? Khan (2011) compared the experience of great inventors in Britain and the United States between 1750 and 1930, in terms of patent grants and prizes for technological achievement. The award of prizes appeared more susceptible to misallocation, but the results varied by institutional context. As in the case of its patent institutions, the award of prizes to British great inventors primarily depended on their socioeconomic background rather than on their productivity, elite affiliations, and on their proximity to the capital city. The analysis indicated that the distribution of prizes tended to be less systematic and more random than that of patents. Thus, if inventors respond to expected benefits, the results for the great inventors imply that prizes may offer fewer incentives for investments in inventive activity. Nevertheless, more research is needed to ascertain whether such results owe to British institutions in general, or whether those features are typical of administered reward systems.

Table 3 presents regressions of the determinants of exhibits that were patentable and those that were patented, both of which increased over time as a proportion of total exhibits. The specifications that control for industry and occupation explain 35 percent of the variation in patentability, and 25 percent of the variation in the patenting of exhibits. Women's entries were significantly less likely to patentable or patented. Multiple exhibitors were responsible for more patentable exhibits, but there is no difference in their propensity to patent, relative to other innovators. However, multiple patentees (those with more than two patents over the course of their career) were more likely to obtain patent protection for their exhibits at the MMA fair. As the

simple statistics suggested, wealthier individuals did not possess any particular advantages in the realm of patenting. Machinists, who tended to be more technically qualified than other inventors, were associated with higher levels of patentability and patenting of their exhibits, but other classes of inventors were relatively similar in terms of their patenting behaviour. Significant differences existed across industries in terms of the probability that exhibits were patentable or patented, especially for the heat, power and communications inventions and for manufacturing machines. The overall conclusion from these results is that the profiles of patentee-exhibitors at the MMA were not identical to those of patentees in general but, at the same time, they differed even further from the findings for the population of exhibitors.

Table 4 examines the factors that influenced whether an exhibit received a gold or silver medal at the exhibitions of the Massachusetts Mechanic Association. Regressions of gold medals alone had zero explanatory power, and the regressions reported here indicate that most of the variation in the silver or gold awards also remains unexplained. Amidst this welter of null results, two findings stand out. The first is that women are less likely to receive the highest accolades at the exhibitions. The second is striking: regardless of the specification, exhibitors with greater personal wealth experience a greater probability of winning gold and silver medals. The size of the coefficient is rather small, but there is also a lot of noise in the wealth measure which makes it difficult to gauge the precise magnitude of the effect. Moreover, the regression is consistent with the simple statistics, and with the biographical information of the participants in the fairs. However, the mechanism through which wealthier exhibitors gained an edge over their competition is unclear. The finding could be due to greater expenditures on their presentation at the fairs, or owe to a noncausal correlation whereby more innovative and deserving entrepreneurs also tended to be richer.

Such variables as occupation and industrial classification have little influence on the award of the medals. We might expect that machinists would be responsible for more technologically advanced discoveries, but in fact they are less likely to receive medals (although the result is not significant) relative to manufacturers (the excluded occupation). Patent assignments are a close proxy for commercially successful inventions, but they are similarly unrelated to the likelihood of a medal. Urbanization is also associated with higher productivity at invention, but adding cities yields no additional explanatory power. As the summary statistics showed, medals were awarded uniformly across technology and industry classes. Controlling for industry adds virtually nothing to the explanatory power of the estimated equation. Since it is quite unlikely that the apparel and furniture industries were as technologically creative as areas such as heat, power and communications or transportation, it seems plausible that the award of medals reflected factors other than inventiveness, productivity or technological innovation.

Isaac W. Lamb, who obtained his first patent at age 19, contributed several important patented improvements which are still incorporated in modern knitting machines. At the Paris World's Fair of 1867 his invention was awarded the silver medal, and he later established knitting factories in Europe that employed his internationally patented technology. However, at the 1869 exhibition of the MMA, his knitting machine only received a bronze medal. On the other hand, John O' Neil of Xenia Ohio applied for patented protection for a churn in 1852, but the application was rejected.[30] Nevertheless, a diploma was given for the churn he exhibited at the MMA in 1853. The judges' report on the New York Safety Steam Power Co.'s vertical engines states "we know of no distinctive feature in this engine that calls for particular mention," but they nevertheless awarded the

[30] See the disclaimer in John K. Mickey's patent grant of February 1861: "I am aware that the paddles in the case have been arranged obliquely in combination with vertical paddles on theshaft and also that in the case of John O'Neil's rejection of June 24, 1852 the stationary and rotating paddles are both made tapering in two directions, and are solid, or without any perforations and I disclaim any such mode of construction."

engine a diploma in the 1874 exhibition.[31] The lack of systematic patterns in the regressions, in tandem with numerous such examples, raises questions about how, and by whom, prizes were awarded.

Judges of the exhibits included "gentlemen of character and standing, and as far as is practicable of thorough technical knowledge of their respective subjects … who will in no case be competitors for premiums."[32] Although they did not compete in the particular exhibition for which they were appointed as judges, many of the judges and trustees of the MMA did participate in exhibitions in other years, so there was a repeated-game element that had the potential for unconscious or explicit bias in the awards. But quite apart from such concerns, there is reason to doubt that medals were an effective measure of technological creativity, because of the heterogeneity in the criteria for their award. The managers of the 1874 exhibition pointed to "the necessity of an uniform standard of merit for rewards should prizes continue to be given… In the past, each set of Judges has fixed its own standard of awards, and as a consequence some have been rigidly exacting in the qualities of usefulness and originality, while others have been profuse and generous, touched by sympathy or good-fellowship; others, again, have asked the question whether their Department was receiving its full share of the higher awards, as though the bestowal, not the merit, was the consideration influencing them."[33] The regression results presented here are consistent with the notion that "the bestowal, not the merit," was indeed the consideration. The committee members also pointed out that, despite the longstanding practice of offering premiums, it was becoming more common elsewhere for exhibitions to incorporate "mechanical and inventive results without

[31] Diplomas also went to Charles Wardwell's Wood Planing Machines and Blind Slat Planer, although "there is nothing new or novel in their construction," and to George Cavanagh's machines which were "neatly made" but "we think it would be very liable to get out of order."
[32] Massachusetts Charitable Mechanic Association, p. 6, *The Exhibition and Fair in the City of Boson, September 18, 1837*. Boston: Dutton and Wentworth, 1837.
[33] Report of the MMA Exhibition, 1874, p. vii.

awards." Such criticisms were still being offered later on, in addition to repeated calls for "a methodical, systematic, and intelligent basis," for the awards.[34]

CONCLUSIONS

The question of the appropriate institutions to promote technological change and economic progress has always generated a great deal of controversy. In the nineteenth century, calls for the repeal of patent systems intensified, and its proponents influenced the Netherlands to abolish patents in 1869. The European leaders such as Britain and France employed prizes and alternative policies to induce and reward inventive activity, but such mechanisms were never popular in the United States at the national level. The United States was the universally-acknowledged global leader in setting rules and standards that favoured patentees, and in lobbying for other nations to increase their patent protection. U. S. patent rights were affordable, their scope of protection extended over the entire country, procedures for the application and grant of patents were so straight-forward that inventors had no need for the assistance of professional attorneys to navigate the process, and such property rights were well-enforced by the legal system. The American patent system was market-oriented, and offered all classes of inventors the opportunity to benefit from their technological creativity.

By contrast, the regular award of prizes occurred at the local level, as private associations mobilized inventors and innovators in industrial fairs in different cities. The major annual exhibitions in the Northeast were those organized by the American Institute of New York City, the Franklin Institute of Philadelphia, and the Massachusetts Charitable Mechanic Association of

[34] Massachusetts Charitable Mechanic Association, *Annals of the Massachusetts Charitable Mechanic Association, 1795-1892*, Boston: Rockwell and Churchill, 1892, p. 327: "If any radical change is needed in connection with our exhibitions, I think it should be in the method of bestowing the medals. Each committee is now almost the sole judges of awards. They establish their own standard of excellence for goods, and bestow medals accordingly. Some are conservative in their estimate of merit, while others are found to be generous. The result is a great disparity in the significance of the award."

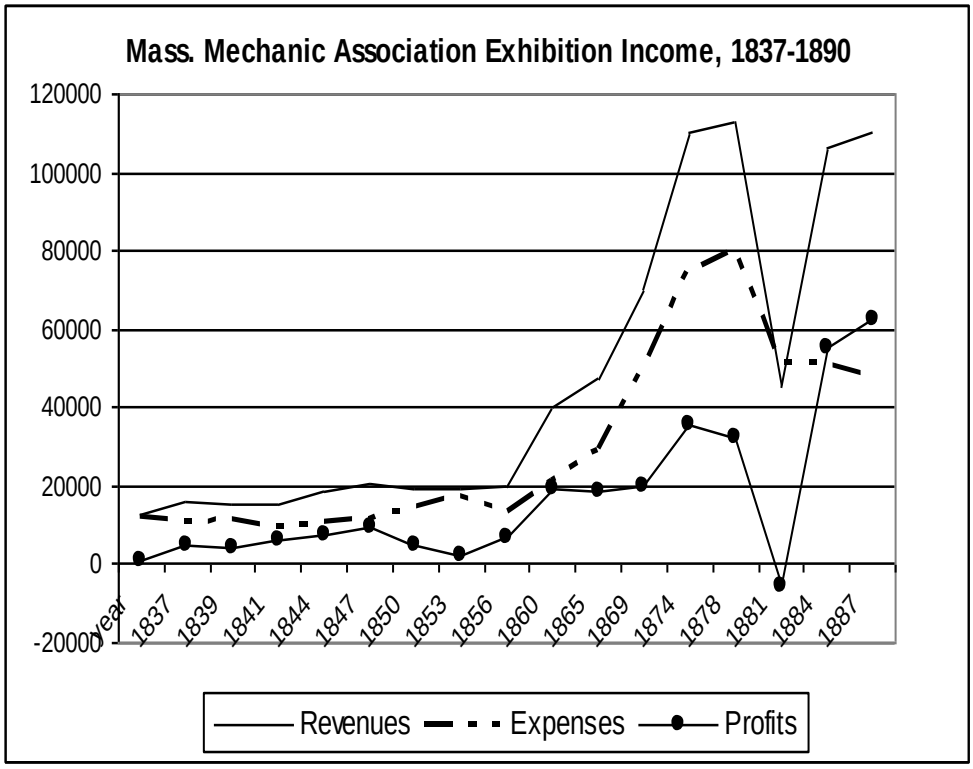
Boston. The organizers and participants at these conventions would have been appalled at the claim that the patent system should be abolished, and they proudly advertised patented items. However, the MMA exhibits illustrate that some degree of invention was indeed occurring outside the patent system, and these industrial fairs were certainly significant for the commercialization of new technologies, both patented and unpatented.

The executives at all industrial fairs argued that their endeavours provided incentives for ingenious individuals to turn their attention to invention. Whether the prizes that such institutions awarded were indeed effective in encouraging future creativity and inventive activity is difficult, if not impossible, to determine. Many of the items were entered into competition at multiple exhibitions, both here and abroad, so the effect of any one event is debatable. More important, procedures through which the prizes were determined seem to have been idiosyncratic and difficult to predict. The random nature of judging is a theme that recurs in numerous contexts both within and beyond the MMA expositions.[35] Competitors who were financially better off may have had an advantage in gaining the attention of the judges, regardless of the technological merits of their contributions. Decentralized judging encouraged a lack of uniformity in standards, and also led to the award of premiums that did not necessarily reflect the same degree of inventive capital across technology classes. By contrast, the centralization and consistency of patent grants in the United States were derived from their administration at the federal level, and from an examination system that was based on predetermined standards that were applied by technically trained professional examiners. If potential inventors responded rationally to net expected benefits, then prize systems

[35] For a contemporary assessment, see "Awards at Exhibitions" in the *Electrical Review* of August 22, 1885, p. 172: "The cynic will say that medals, like kissing, go pretty much by favour…. Gold medals are limited in number; and while two hundred firms may deserve them, two hundred cannot receive them. .. while a gold medal indicates the reputation of a firm, the lack of a gold medal does not necessarily indicate an inferior reputation… The majority of gold medals call for no comment, but when we come to the silver medals the process of selection seems more invidious. It is very difficult to see why certain names should be selected as being more worthy than some of those in the "bronze" class."

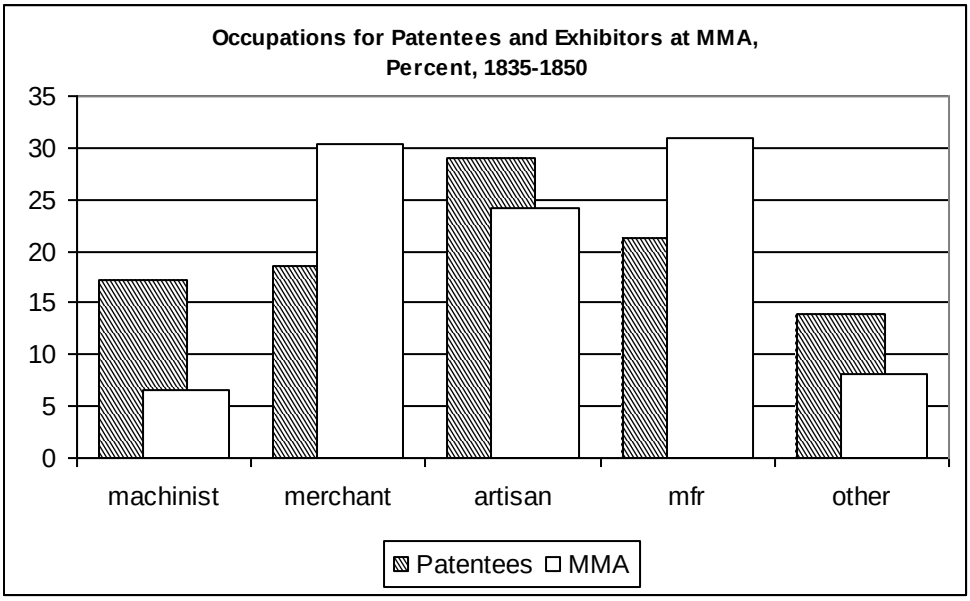
such as the MMA's were arguably less successful in achieving the Constitution's mandate to "promote the progress of science and useful arts."

Figure 1



Massachusetts Charitable Mechanic Association, *Annals of the Massachusetts Charitable Mechanics Association, 1795-1892*, Boston: Rockwell and Churchill, 1892.

Figure 2: Occupational Distributions of Patentees and MMA Participants, 1835-1875



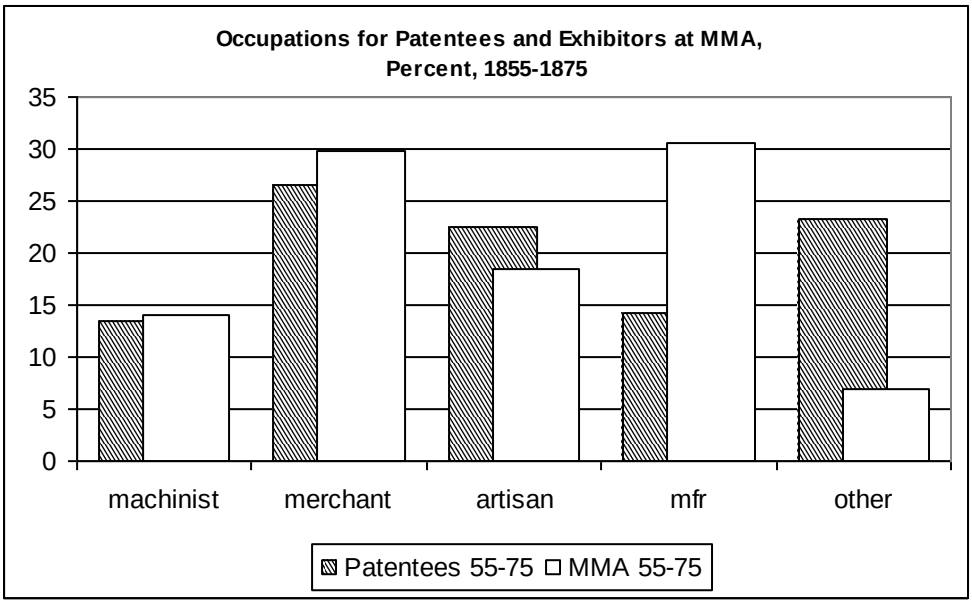
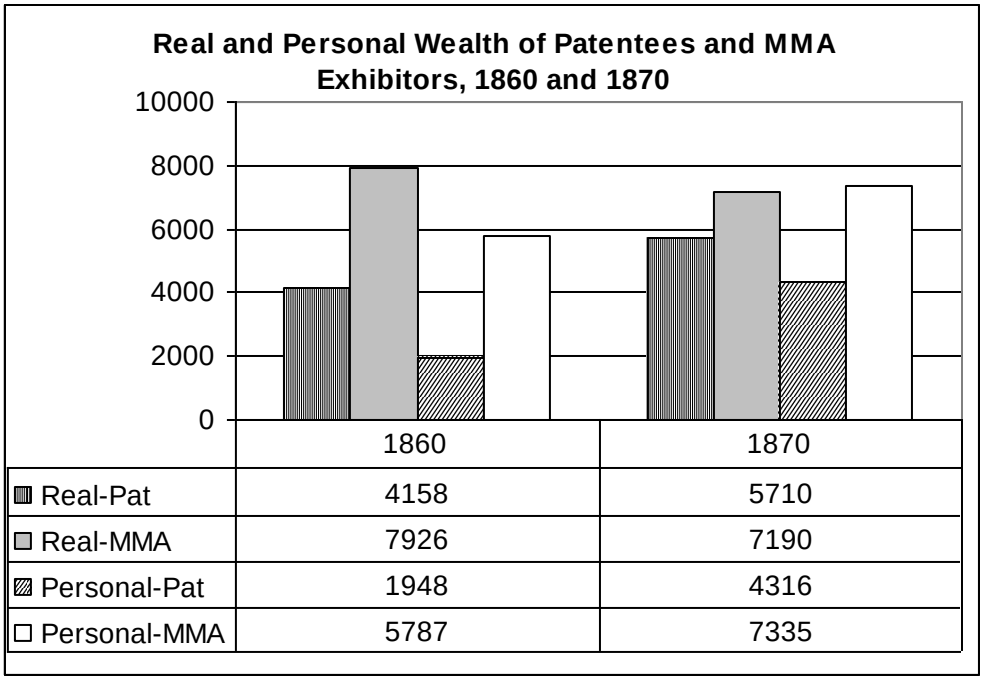


Figure 3



	1860	1870
Real-Pat	4158	5710
Real-MMA	7926	7190
Personal-Pat	1948	4316
Personal-MMA	5787	7335

Notes and Sources:

The MMA sample was matched with the manuscript census that was closest to the date of the exhibition. This resulted in 404 matches for 1860 and 329 matches for 1870, over which these averages for real estate and personal wealth were estimated. Missing values are treated as zero. Wealth is expressed in terms of real $1860 dollars. The sample of ordinary patentees in 1860 and 1870 is described in Khan, "Creative Destruction.:

TABLE 1: Summary Statistics for Sample of Exhibits at Massachusetts Mechanics Association Fair, 1837-1874

	BEFORE 1855		AFTER 1855		TOTAL	
	N	%	N	%	N	%
AWARDS						
Gold Medal	146	6.4	152	5.3	298	5.8
Silver Medal	940	41.4	799	27.7	1739	33.8
Bronze Medal	213	9.4	986	34.2	1200	23.3
Diplomas	973	42.8	943	32.7	1916	33.2
Total Awards	2273	100	2880	100	5153	100
LOCATION						
Massachusetts	1950	85.8	2592	89.8	4542	88.0
Other New England	157	6.9	154	5.3	311	6.0
Mid-Atlantic	150	6.6	124	4.3	274	5.3
Other	16	0.7	16	0.6	32	0.5
EXHIBITORS						
Women	281	12.4	214	7.4	495	9.6
Companies	572	25.1	1082	37.5	1654	32.1
Age, mean and (s.d.)	37.1	(10.3)	42.7	(11.3)	40.5	(11.3)
Participation in fairs, mean and (s.d.)	2.0	(2.1)	1.9	(2.2)	2.0	(2.1)
OCCUPATION of individual (nonfirm) exhibitors (1635 matches with ms. Census)						
Artisan	156	24.1	183	18.5	339	20.7
Machinist/ engineer/Inventor	42	6.5	139	14.1	181	11.1
Manufacturer	200	30.9	301	30.5	501	30.6
Merchant/professional/wh.collar	197	30.4	295	29.9	492	30.1
Other	53	8.2	69	7.0	122	7.5
PATENTING						
Patentable subject matter	801	35.3	1635	56.7	2436	47.2
Exhibitor is patentee	456	20.0	1065	36.9	1521	29.5
Patent obtained for exhibit	212	9.3	633	21.9	845	16.4
Career patents, mean and (s.d.)	1.4	(16.2)	3.1	(13.0)	2.4	(14.5)
SECTORS						
Agriculture	62	2.7	117	4.1	179	3.5
Construction	115	5.1	214	7.4	329	6.4
Manufacturing	1681	74.0	1948	67.5	3629	70.4
Transportation	187	8.2	404	14.0	591	11.5
Other	227	10.0	203	7.0	430	8.3

Notes and Sources: Reports of Exhibitions of MMA, 1837-1874; U.S. Patent Records 1790-2009; Manuscript censuses (federal), 1850-1880. Patentable subject matter: exhibits that fall into classes that could be patented, as gauged from a subject search of the patent records; it does not imply that the invention would have qualified for the grant of a patent, which would require additional scrutiny for novelty. Exhibitor is a patentee refers to those who had ever attained a patent. Career patents: total patents that the patentee obtained over his lifetime.

TABLE 2: Industry distribution of Exhibits at Massachusetts Mechanics Association Fair, 1837-1874

INDUSTRY	Total	Patentable	Patents	Gold Medal	Silver Medal	Bronze Medal
Agriculture (n)	358	200	73	20	129	81
Col %	6.9	8.2	8.6	6.7	7.4	6.8
Row %		55.6	20.4	5.6	36.1	22.7
Apparel (n)	319	33	6	18	95	66
Col %	6.2	1.4	0.7	6.0	5.5	7.3
Row %		10.3	1.9	5.7	29.9	20.8
Arts (n)	609	167	40	39	95	66
Col %	11.8	6.9	4.7	13.1	12.4	11.3
Row %		27.4	6.7	6.4	35.5	22.2
Construction (n)	329	185	79	19	113	79
Col %	6.4	7.6	9.4	6.4	6.5	6.6
Row %		56.2	23.9	5.8	34.2	23.9
Furniture (n)	305	75	38	11	95	73
Col %	5.9	3.1	4.5	3.7	5.5	6.1
Row %		24.6	12.5	3.6	31.2	23.9
Heat & Power (n)	499	464	157	33	150	143
Col %	9.7	19.1	18.6	11.1	8.6	11.9
Row %		93.0	31.5	6.6	30.1	28.7
Manf. Machines (n)	493	441	125	36	161	133
Col %	9.6	18.1	14.8	12.1	9.3	11.1
Row %		89.5	25.4	7.3	32.8	27.1
Manf. Goods (n)	898	350	144	52	307	179
Col %	17.4	14.4	17.0	17.5	17.7	14.9
Row %		39.0	16.0	5.8	34.2	19.9
Printing & Publish. (n)	295	71	22	12	100	69
Col %	5.7	2.9	2.6	4.0	5.8	5.8
Row %		24.1	7.5	4.1	33.9	23.4
Scientific (n)	132	51	17	9	41	26
Col %	2.6	2.1	2.0	3.0	2.4	2.2
Row %		38.6	12.9	6.9	31.3	19.9
Textiles (n)	620	185	71	31	226	140
Col %	12.0	7.6	8.4	10.4	13.0	11.7
Row %		29.8	11.5	5.0	36.5	22.6
Transportation (n)	300	214	73	18	106	76
Col %	5.8	8.8	8.6	6.0	6.1	6.3
Row %		71.3	24.3	6.0	35.3	25.3

Total	(n) 1200	5157	2436	1521	298	1739	
%		100	47.2	29.5	5.8	33.8	23.3

Notes and Sources: See Table 1. The percentages in the table include the undisplayed calculations for 1915 diplomas, given to 37 percent of the exhibits in the dataset.

Table 3
OLS Regressions: Determinants of Patenting of Exhibits at the MMA

	Pr that Exhibit is Patentable		Pr that Exhibit is Patented	
	(1)	(2)	(3)	(4)
Intercept	0.47	0.79	0.17	0.25
	(15.87)	(18.68)	(6.68)	(6.33)
TIME DUMMIES				
1850s	0.14	0.01	0.06	0.06
	(0.40)	(0.26)	(2.20)	(2.05)
1860s	0.25	0.15	0.15	0.12
	(7.99)	(5.31)	(5.77)	(4.34)
1870s	0.16	0.10	0.16	0.18
	(3.98)	(2.77)	(4.74)	(4.16)
GENDER	-0.53	-0.24	-0.23	-0.15
	(8.59)	(4.02)	(4.45)	(2.68)
BOSTON	-0.16	-0.09	-0.10	-0.07
	(6.84)	(4.08)	(5.02)	(3.64)
MULTIPLE EXHIBITOR	0.04	0.03	0.00	0.00
	(3.83)	(3.08)	(0.08)	(0.42)
REAL WEALTH	-0.00	-0.00	0.00	-0.00
	(0.09)	(0.50)	(1.55)	(0.97)
PERSONAL WEALTH	0.00	0.00	-0.002	-0.001
	(0.66)	(0.72)	(3.06)	(2.16)
CAREER PATENTS			0.03	0.02
			(16.33)	(13.77)
OCCUPATION				
Artisan		-0.01		-0.00
		(0.25)		(0.11)
Machinist		0.21		0.13
		(5.89)		(3.58)
Other		-0.03		0.01
		(0.61)		(0.23)
Merchant		-0.02		0.01
		(0.72)		(0.38)
INDUSTRY				
Agriculture		-0.21		-0.04
		(4.38)		(0.83)
Apparel		-0.60		-0.16
		(10.38)		(2.95)
Arts		-0.69		-0.00
		(14.55)		(0.11)
Construction		-0.21		-0.01
		(4.49)		(0.23)
Furniture		-0.48		-0.01
		(9.47)		(1.72)

Table 3 (Cont'd)
OLS Regressions: Determinants of Patenting of Exhibits at the MMA

	(1)	(2)	(3)	(4)
Heat, Power & Communicns		0.01 (0.25)		-0.03 (0.61)
Manuf. Products		-0.38 (9.61)		-0.11 (2.87)
Printing		-0.64 (12.34)		-0.25 (5.08)
Science & Medicine		-0.45 (7.25)		-0.22 (3.73)
Textiles		-0.44 (9.44)		-0.15 (3.41)
Transportation		-0.12 (2.34)		-0.01 (0.21)
Other		-0.10 (1.46)		-0.15 (2.17)
	N=1640 R^2=0.12 F=27.31	N=1640 R^2=0.35 F=36.74	N=1640 R^2=0.21 F=46.74	N=1640 R^2=0.25 F=21.4

Notes and Sources:

The excluded variables are the 1840s, manufacturers, and machinery in the manufacturing sector. All exhibits are allocated to industry of final use. The dummy variable for Boston represents city of residence, multiple exhibitors submitted in more than one exhibition, and gender has a value of 1 if female. Patents and assignments refer to the patenting of the specific invention at the exhibition, and the assignment at issue of the patent for that exhibit. Occupations and wealth were determined from the federal manuscript censuses.

Table 4
OLS Regressions: Determinants of probability of a gold or silver medal

	(1)	(2)	(3)	(4)
Intercept	0.52	0.52	0.52	0.50
	(41.0)	(16.88)	(14.35)	(9.83)
TIME DUMMIES				
1850s	-0.14	-0.19	-0.20	-0.20
	(7.54)	(5.74)	(5.75)	(5.77)
1860s	-0.20	-0.22	-0.22	-0.21
	(11.68)	(6.76)	(6.68)	(6.37)
1870s	-0.16	-0.19	-0.19	-0.18
	(7.34)	(4.62)	(4.57)	(4.45)
GENDER	-0.06	-0.10	-0.10	-0.06
	(2.43)	(1.63)	(1.46)	(0.81)
PATENT FOR EXHIBIT		0.01	0.02	0.02
		(0.39)	(0.18)	(0.64)
ASSIGNED PATENT		0.04	0.05	0.04
		(0.72)	(0.75)	(0.68)
BOSTON		0.02	0.02	0.03
		(0.90)	(0.80)	(1.07)
MULTIPLE EXHIBITOR		0.00	0.00	0.00
		(0.21)	(0.18)	(0.31)
REAL WEALTH		-0.00	-0.00	-0.00
		(1.21)	(1.19)	(1.41)
PERSONAL WEALTH		0.001	0.001	0.002
		(2.36)	(2.30)	(2.64)
OCCUPATION				
Artisan			0.01	0.01
			(0.19)	(0.15)
Machinist			-0.05	-0.04
			(1.07)	(0.87)
Other			-0.01	-0.02
			(0.26)	(0.35)
Merchant			0.01	0.01
			(0.22)	(0.35)
INDUSTRY				
Agriculture				0.07
				(1.19)
Apparel				-0.07
				(1.01)
Arts				0.02
				(0.41)
Construction				0.05
				(0.93)
Furniture				0.01
				(0.22)
Heat, Power				-0.10
& Communicns				(1.93)
Manuf. Products				0.07
				(1.41)

Table 4 (Cont'd)
OLS Regressions: Determinants of probability of a gold or silver medal

		(1)	(2)	(3)
Printing				-0.02
				(0.31)
Science & Medicine				0.03
				(0.33)
Textiles				0.04
				(0.66)
Transportation				0.06
				(1.10)
Other				0.00
				(0.00)
	N=1640	N=1640	N=1640	N=1640
	R^2=0.03	R^2=0.04	R^2=0.04	R^2=0.047
	F=37.11	F=5.95	F=4.38	F=3.08

Notes and Sources:

The excluded variables are the 1840s, manufacturers, and machinery in the manufacturing sector. All exhibits are allocated to industry of final use. The dummy variable for Boston represents city of residence, multiple exhibitors submitted in more than one exhibition, and gender has a value of 1 if female. Patents and assignments refer to the specific invention at the exhibition, and the assignment at issue of that exhibit. Occupations were determined from the manuscript census.

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Appendix: Awards of the MMA Exhibition

THE MEDALS AND DIPLOMA

GOLD MEDAL.

SILVER MEDAL.

BRONZE MEDAL.

DESCRIPTION OF THE DIPLOMA.

(DESIGNED BY THE LATE HAMMATT BILLINGS, AND ENGRAVED ON STEEL BY S. A. SCHOFF.)

In the centre, upon a high dais, stands Pallas (Minerva), holding in her right hand a wreath, and with her left resting upon a shield bearing the insignia of the State of Massachusetts; at her left hand is Justice, pointing out those worthy of the rewards of Skill and Industry; and on her right sits a Scribe recording their names. On the left of the principal group a procession of artisans approaches, with specimens of their handicraft, as candidates for the prizes; on the right, corresponding to these, are figures representative of the Fine Arts, Music, etc. The background is occupied by an Exhibition Hall, filled with various objects of manufacture, and a crowd of visitors. In the centre, below the principal figures, is the crest of the Association.