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"Not for Ornament": Patenting Activity by Nineteenth-Century Women Inventors

We obtain patents for protection, not for ornament.
advertisement in *Inventive Age* (1892)

Feminists have criticized neoclassical economists for not giving sufficient prominence to such gender issues as the sexual division of labor and the significant contributions to social product of the non-market household sector. Since the United States industrial transformation in the nineteenth century, the activities of the family have largely been omitted from economic models and national income accounts. Compared with the (measurable and measured) technologically progressive market economy, (unmeasured) non-market household activity was viewed as relatively unproductive, unresponsive to market incentives and unaffected by technical progress. As a result, "one is left with a strong sense that the industrial revolution is primarily a men's story."[1]

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1 Economic analysis has only recently attempted to gauge the validity of the 1851 view that "the economy of the household is generally as much the source of family wealth as the labor and enterprise of man" (*Proceedings of the Women's Rights Convention* [New York, 1852], 18). Studies of the value of household production in a number of countries and time periods find estimates ranging from 28 to 39% of GNP. For historical estimates of adjusted output in the United States, see Lee Craig, "The Value of Household Labor in Antebellum Northern Agriculture," *Journal of Economic History,* LI (1991), 67–81; Nancy Folbre and Barnet Wagman, "Counting Housework: New Estimates of Real Product in the United States, 1800–1860," *Journal of Economic History,* LIII (1993), 275–288. The "New Home Economics" that was

Until recently, economic historians who addressed the relationship between women and technology limited their attention to the impact of technical changes on the labor-market participation of single women during industrialization. However, the role of women as producers and consumers of technology is still not well understood, for at least two reasons. First, scholars tend to pay little systematic attention to contributions that women themselves made to technological progress. Second, some historians use material from diaries, catalogs, and letters to argue that inventions made only a nominal impact on the lives of the vast majority of women who married and exited the labor market to become full-time housewives; "woman's work" was insulated from the widespread technological progress that increased productivity in the market economy. The proponents of this thesis contend that the diffusion of household inventions was slow or nonexistent, especially in rural areas. Strasser, for one, suggests that "American manufacturers offered little to ease the work of most households before 1900" and that "mechanical cooking utensils existed in the second half of the nineteenth century, but few houses had them. Eggbeaters, cherry stoners, apple parers and corers, butter churns, meat choppers—all these and more were patented in large numbers. But mechanical devices rarely appear in lists of necessary equipment for nineteenth-century kitchens."[2]

Cowan and others argue that women did not benefit from technological change because even when innovations were

initiated by Gary Becker, *A Treatise on the Family* (Cambridge, Mass., 1981), posits the existence of a Household Production Function, which is based on the view that households are not simply consumers but also producers of commodities. This literature is surveyed in Robert A. Pollak, "A Transaction Cost Approach to Families and Households," *Journal of Economic Literature,* XXIII (1985), 581–608. However, the reaction of feminists has been less than approving; see, for example, Barbara R. Bergmann, "Becker's Theory of the Family: Preposterous Conclusions," *Feminist Economics,* I (1995), 141–150. Thomas Dublin, *Transforming Women's Work* (Ithaca, 1994), examines contributions of women to industrialization.

2 The literature on technological change and the labor-market participation of women is enormous. See, for example, Claudia Goldin and Kenneth L. Sokoloff, "Women, Children and Industrialization in the Early Republic: Evidence from Manufacturing Censuses," *Journal of Economic History,* XLII (1982), 741–774; Elizabeth Faulkner Baker, *Technology and Woman's Work* (New York, 1964). Donald Cardwell, *History of Technology* (London, 1994), 506, devoted two paragraphs to women inventors out of more than 500 total pages, in which he asserts that "female technologists of any distinction are hard to find." Susan Strasser, *Never Done: A History of American Housework* (New York, 1982), alleges that manufacturers refused to produce household items because they were unprofitable. She also maintains that their prices were

adopted, they did not change amount of time spent on housework. However, this argument shows a fundamental misunderstanding of economic analysis; the ultimate objective of individuals and households is not necessarily to save time, but to consume more higher-quality commodities. Household innovations led to two separate effects: time reduction and lower prices for household goods at the margin. This lower marginal price serves to induce a substitution effect toward the innovation that may outweigh the importance of labor saving. Even if the duration of housework was unchanged, Cowan's housewives undoubtedly would reveal preference for the adoption of the innovation, implying higher welfare. More systematic evidence concerning the influence of household inventions on the market would contribute greatly to our understanding of the welfare of women who worked at household tasks.[3]

Although qualitative evidence about the technology of household production and consumption patterns can provide valuable insights, they may suffer from unexpected male gender biases. For instance, unlike supporters of women's rights during the antebellum period, leaders of the women's movement after the Civil War deprecated household labor, regarding "traditionally 'male' activities as socially privileged—and encourag[ing] women to repudiate traditionally 'female' activities as socially subordinate." Nineteenth-century advocates of women's rights who wanted to publicize women who patented technically advanced industrial machines were often disappointed to find female invention and innovation heavily directed toward such household products as kitchen tools and apparel. Accordingly, the organizers of the

beyond the budget of the average household. According to her view, in the twentieth century, demand conditions changed because homemakers were enticed to enter the mass market through persuasive advertising that preyed on their feelings of guilt. See also Strasser, "An Enlarged Existence? Technology and Household Work in Nineteenth-Century America," in Sarah F. Berk (ed), *Women and Household Labor* (Beverly Hills, 1980), 29–52.

3 Ruth Schwartz Cowan, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave* (New York, 1983). For a survey of the plethora of studies addressing this question, see Ronald R. Kline, "Ideology and Social Surveys: Reinterpreting the Effects of 'Laborsaving' Technologies on American Farm Women," *Technology and Culture,* XXXVIII (1997), 355–385. He points out that earlier researchers felt that "household technology made work easier and enabled a higher standard of living" (379), but the majority of modern studies have chosen to emphasize the supposed "paradox" that time spent on housework did not change.

Women's Pavilion for the World's Columbian Exposition of 1893 preferred "to make no note of the inventions of women unless it [was] something quite distinguished and brilliant. We must not call attention to anything that would cause us to lose ground." Spokeswomen of the suffragist movement, predominantly from a middle class background, may have had interests, experiences, and affinities significantly different from those of women from other backgrounds, especially those from rural or frontier areas. By denigrating household work and the inventions of household articles, the women's movement likely contributed to the notion that women were not technologically adept. Even the Women's Bureau Bulletin documenting women's inventions from 1905 to 1921 opined, "[I]f the steady increase in the numbers of patents granted women is accounted for merely by the increase in the number of patented hairpins, hair curlers, and such trifles in feminine equipment, it is without large significance either to civilization or as an indication of women's inventive abilities."[4]

4 Glenna Matthews, *'Just a Housewife': The Rise and Fall of Domesticity in America* (New York, 1987), assesses how such work in the home as cooking, sewing, washing, and preserving foods was affected by technological change. Jeanne Boydston, *Home and Work: Housework, Wages and the Ideology of Labor in the Early Republic* (New York, 1990), points out that new household technologies were not labor saving but did increase labor productivity. Jeanne M. Weimann, *The Fair Women* (Chicago, 1981), 429. According to Reva B. Siegel, "Home as Work: The First Woman's Rights Claims Concerning Wives' Household Labor, 1850–1880," *Yale Law Journal,* CIII (1994), 1080, "the strategies the postwar movement employed to reduce the division of labor in the family reflected disparaging judgments about 'women's work' of the sort the antebellum movement originally contested. Paradoxically, the movement's new understanding of autonomy and dependence was as entangled in the gender discourse of its culture as the older vision it repudiated, and tacitly class-biased as well: to achieve this new form of autonomy, women were to delegate the work of household maintenance to other women." In the words of Judith A. McGaw, "Inventors and Other Great Women: Toward a Feminist History of Technological Luminaries," *Technology and Culture,* XXXVIII (1997), 219, "emphasizing woman's capacity to invent outside the domestic sphere, an approach characteristic of earlier feminist efforts and one that shapes Macdonald's and also Stanley's work, evidently left popular conceptions of inventors and invention virtually unaltered." U.S. Department of Labor, Women's Bureau, *Women's Contributions in the Field of Invention* (Washington, D.C., 1923), 13 (see note 8 for work by Macdonald and Stanley). The Women's Bureau authors took heart from the finding that "there is not an important sphere of industry, commerce, or the sciences unrepresented in these classifications." For, "the invention of a new hook and eye, a new garment appurtenance, a new kitchen appliance or other household device, finds no place among these grants. Excluding all such articles, although they unquestionably stimulate productive activity, and confining the list strictly to the operating methods and materials of manufacturing industries, gives peculiar significance to this group of inventions patented by women."

Ironically, the views of nineteenth-century suffragists are reflected in current economic models of productivity and technological change, which emphasize the role of manufacturing processes and intermediate capital goods in promoting growth. Empirical work mirrors this bias, because of well-known problems that lead to the understatement of improvements due to changes in quality and the introduction of new goods. Inventors tend to be judged in similar terms, celebrated for "macroinventions" and large-scale capital inputs in major industries such as iron and steel. Yet, much technological change is incremental, based on the accumulated effects of numerous improvements, and a significant part of economic welfare is related to small changes in the quality or nature of final goods. A full understanding of the remarkable transformation in the daily experience of both men and women during the past 200 years is impossible without an appreciation for the gradual improvements in their dress, the shelf life of processed foods, kitchen utensils and other aids to housework, and a host of other supposedly minor "microinventions."[5]

As Mohun points out, "despite more than twenty years of scholarship on domestic technology . . . rigorous quantitative analysis, in particular, remains to be done." This lapse is partly due to the paucity of relevant data in an era when women were rendered "invisible" by legal and social conventions. Patent records are inherently useful in this regard because they provide a continuous source of information about market-related activities of women. Time series and cross-sectional analyses of women's patenting allow us to trace variation in female market participation across regions and sectors. Comparison of the record for female patentees to that of male patentees affords insights into the sources of inventive activity. Patents also provide information about creativity, entrepreneurial activity, and the pursuit of profit. The very attempt to obtain a patent signaled a commercial orientation, but some women also obtained returns from their discoveries by selling the patent rights to them, by licensing others to use them, or by developing enterprises to promote them. These market activities yield direct information about the users of inventions,

5 For a discussion of "microinventions" and "macroinventions," see Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York, 1990); Khan and Sokoloff, "'Schemes of Practical Utility': Entrepreneurship and Innovation Among 'Great Inventors' in the United States, 1790–1865," *Journal of Economic History,* LIII (1993), 289–307.

as well as indirect evidence about the transformations in the home that accompanied the diffusion of domestic innovations.[6]

This article addresses the relationship between women and technology, both as producers and as consumers, by analyzing patterns of patenting and commercialization. The data set comprises a sample of 4,196 patents filed in the United States by approximately 3,300 women inventors between 1790 and 1895. Patents measure inventive activity imperfectly, because not all inventions are patented or patentable, and because institutions change. The propensity to patent may also vary in an unpredictable manner. According to Charlotte Smith, a nineteenth-century lobbyist for women's rights, women patentees tended to use only initials, making it difficult accurately to trace their inventions. Patent records undoubtedly undercount the number of inventions by women, in part because some might have allowed male relatives to file the invention. Some researchers have speculated about women who might have been responsible for discoveries formally attributed to men, such as Caroline Greene/Eli Whitney and Mrs. Elias Howe/Elias Howe. However, because the patent law explicitly voids a patent that is not filed by the true and original inventor, it is far more likely that an undeserving male was listed as a co-inventor on the patent, rather than as the sole inventor. In any event, though imperfect, researchers find that these data provide an adequate index of the resources committed to technical change. The patent data are supplemented with information from city directories and assignment records.

WHO WERE THE WOMEN PATENTEES? The framers of the American Constitution recognized the importance of secure property rights in order to stimulate invention, and, in 1790, Congress passed the first statute to protect intellectual property. A substantial revision in 1836 created the modern patent system, which remained essentially unchanged for the rest of the century. The United States places no restrictions on the race, gender, or citizenship of inventors eligible to apply for patents. Nineteenth-century patentees paid a fee of $30 to $35 to the Patent Office. Skilled examiners checked the patent applications to ensure that

6 See Arwen Mohun, *Steam Laundries: Gender, Technology and Work in the U.S and Britain, 1880–1940* (Baltimore, 1999), 29.

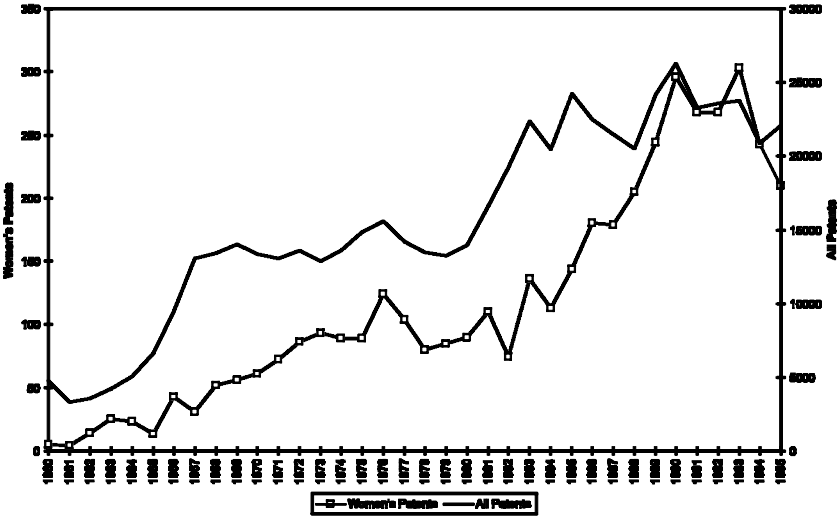
they conformed to the patent laws and represented a significant advance in the state of the art. A patent was valid only if issued to the "first and true inventor," and the rights to a patented invention could be assigned, transferred, or bequeathed. Information about patenting was readily available throughout the country, and the application procedures were so straightforward that some women chose to file the papers themselves; others retained the services of a patent agency.[7]

The first female patentee in America was possibly Sybilla Masters, a native of Pennsylvania, whose husband obtained two English patents on her behalf in 1717. Hazel Irwin, a Boston resident, obtained a United States patent for a cheese press in 1808, and the following year Mary Kies of Connecticut obtained a patent for weaving straw. Only 77 patents were credited to women inventors from 1790 through 1860; 4,773 patents were issued to male patentees in 1860 alone. This discrepancy in patent grants persisted throughout the period. Figure 1 shows that the post–Civil War contribution of women inventors amounted to less than 1 percent of all patents granted by the United States Patent Office. However, the decadal growth rate of women's patents exceeded that for men's. In 1876, the cumulative patents for women amounted to just over 1,000, whereas by the 1890s, the number of patents issued to women was double that of the preceding decade. The decadal rate of increase for patents by women at this point was more that three times that of the corresponding rate for men.[8]

7 U.S. Const. Art. I, § 8, cl. 8 ("Congress shall have Power . . . To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries"). The first intellectual property statute in the United States was the Act of May 31, 1790, ch. 15, 1 Stat. 124. The first U.S. Patent Act of 1790 reads, "That upon the petition of any person or persons that he, she, or they, hath invented of discovered any useful art, . . . it shall be lawful . . . to cause letters patent to be made out in the name of the United States." The patent application fee was increased from $30 to $35 in 1861. For notes on the rules and standards of the patent system, see Khan and Sokoloff, "Two Paths to Industrial Development and Technological Change," in Maxine Berg and Kristine Bruland (eds.), *Technological Revolutions in Europe, 1760–1860* (London, 1997); Khan, "Property Rights and Patent Litigation in Early-Nineteenth Century America," *Journal of Economic History,* LV (1995), 58–97.

8 According to Bruce Bugbee, *The Genesis of American Patent and Copyright Law* (Washington, D.C., 1967), 72, one of Masters' patents dealt with a method for curing corn; the other was an invention for weaving straw into bonnets. General studies of women inventors include

Fig. 1 Patents Granted, 1790–1895



Several factors were likely responsible for this rapid growth, including women's higher labor-market participation, their greater access to education, and legal reforms that improved married women's property and economic rights. Moreover, information about the prospects for patenting and marketing inventions was reaching a wider audience. Journals such as *Scientific American, Inventive Age,* and *The Patent Record* described and analyzed current patent practices, both in the United States and abroad, occasionally including articles that advised women inventors about correct procedures. *Scientific American,* in particular, issued editorials that highlighted the commercial profitability of "small inventions" that might seem technically undemanding. Exhibitions such as the Philadelphia Centennial Exposition and the World's Columbian Exposition in 1892/3 reserved special pavilions for women inventors and alerted other women about opportunities. In the early 1870s, the Patent Office hired its first female patent examiner,

Anne L. Macdonald, *Feminine Ingenuity: Women and Invention in America* (New York, 1992); Autumn Stanley, *Mothers and Daughters of Invention* (New Brunswick, 1995); Joseph Rossman, "Women Inventors," *Journal of the Patent Office Society,* X (1927), 18–30.

possibly encouraging women to submit inventions that they might have feared would be viewed with less sympathy by men.[9]

As Figure 1 shows, the rate of change was not constant over time. Since patenting for both men and women was responsive to major economic cycles, it fell in the business downturns of 1873, 1883, and 1893. Like other patentees, women inventors appear to have varied their efforts in this regard to follow changes in market demand and expected profitability. Women who were already involved in commerce or a profession—like Margaret Knight, a machine operator who came up with an invention to manufacture "satchel-bottomed" paper bags—might have had a comparative advantage in perceiving existing demand, in gaining the required skills, and in pursuing the patent application process. But most female patentees appear to have been introduced to commercial activity after patenting their inventions.

Table 1 presents descriptive statistics for the sample, based on patent records and city directories. Although city directories provide information about the occupations and marital status of a number of women patentees, these data are not totally reliable because of sampling differences across cities covered. They are also likely to over-represent heads of household, widows, single women, wives whose jobs were separate from husband or family, and urban patentees. However, the individuals who were traced through the city directories accounted for approximately 900 patents, or a little over one-fifth of the entire sample. One-third of the patents linked to city-directory entries were granted to women with no listed occupations. Another 10.7 percent of these

9 Khan, "Married Women's Property Laws and Female Commercial Activity: Evidence from United States Patent Records, 1790–1895," *Journal of Economic History,* LVI (1996), 356–388. For a discussion of the impact of the Civil War and the importance of commercial networks and other forms of business acumen, see Lisa Marovich, "'Let her have brains too': Commercial Networks, Public Relations, and the Business of Invention," *Business and Economic History,* XXVII (1998), 140–161. According to the *Patent Record and Monthly Review,* "Few inventions are more profitable than little matters of feminine utility" (cited in MacDonald, *Feminine Ingenuity,* 248). See Deborah Warner, "Women Inventors at the Centennial," in Martha Moore Trescott (ed.), *Dynamos and Virgins Revisited: Women and Technological Change in History: An Anthology* (Metuchen, N.J., 1979), 102–119; Weimann, *Fair Women.* For contemporary sources, see Otis Mason, "Woman as an Inventor and Manufacturer," *Popular Science Monthly* (May 1895), 92–103; "Household Inventions," *Scientific American,* LXXIV (1896), 99; "Female Inventive Talent," *Scientific American,* XLVIII (1870), 184. Sarah J. Noyes, a specialist in chronological devices, entered the Patent Office in 1873, and was appointed First Assistant Examiner of the Electrical Division.

Table 1 Characteristics of Patenting by Women Inventors, 1790–1895

OCCUPATION OF PATENTEE	PATENTS	PERCENT
Professional	81	10.7
Education	57	7.5
Owner of firm	184	24.2
Apparel makers	74	9.7
Factory employees	12	1.6
Clerical	24	3.2
Boarding, petty traders	52	6.8
None	275	36.3
NUMBER OF PATENTS FILED BY PATENTEE	PATENTS	PERCENT
One	2683	66.6
Two or Three	874	21.7
Four to Nine	324	8.0
Ten or More	149	3.7
MARITAL STATUS OF PATENTEE	PATENTS	PERCENT
Single	127	14.3
Married	207	23.4
Widowed	233	26.3
Married or widowed	52	5.9
Unknown	267	30.1
CO-INVENTORS OF PATENTEE	PATENTS	PERCENT
Female, related	19	6.0
Male, related	115	36.3
Female, unrelated	35	11.0
Male, unrelated	148	46.7
ASSIGNMENTS MADE WHEN PATENT ISSUED	PATENTS	PERCENT
Clothing	96	29.6
Household machines	19	5.9
Household (non-machine)	77	23.8
Industrial machines	59	18.2
Tools	10	3.1
Transportation	20	6.2
Health	19	5.9
Miscellaneous	24	7.4

SOURCES See text for details about data set.

NOTES Patentee occupations and marital status were obtained from city directories. Co-inventor status is based on whether individuals have the same surname, which tends to result in an underestimate. Patent assignment made after the patent was granted are not included here.

patents belonged to professional women—doctors, school principals, and painters. Almost one-quarter of all patents filed (21.3 percent) were issued to working-class women—dressmakers, milliners, and factory workers. The predominance of middle-class women may be an artifact of city-directory listings, especially since rural residents are excluded, but the reasons for their representation among patentees might have been their ability to obtain funds for the patent application and their greater opportunities for patent management.[10]

City directories also contain information about the marital status of these patentees, a variable that might contribute to our understanding variation in patenting by women. Of the linked patents, 127 patents (14.3 percent) were filed by single women, 207 (23.4 percent) by married women, and 233 (26.3 percent) by widows; 52 (5.9 percent) were filed by women whose marital status was either married or previously married. The remaining 267 patents were issued to women whose status was unknown. The sample size is too limited to sustain any strong conclusions, but interesting patterns emerge nonetheless. First, half of all patents to single women were filed in New England, and almost two-thirds of all widows filed in the Mid-Atlantic region. Unmarried women accounted for almost one-half (47.4 percent) of patenting in the New England states, compared to only 3.9 percent of patents in the Mid-Atlantic, 7.6 percent in the South, 14.6 percent in the West, and 15.5 in the Midwest. On the other hand, married women filed 35.1 percent of Midwestern patents, and 31.7 percent of Western patents, compared to 19.7 percent in the South, 16.8 percent in the Mid-Atlantic, and 22.6 percent in New England.

New England's population might have featured a higher fraction of single women, and women might have been more likely to marry in the West and Midwest. The figures seem sufficiently distinct, however, to warrant speculation that location-specific factors—such as the laws relating to the property rights of married women—might account for some of the differences. Legal reforms, for instance, encouraged women to increase their investments in patenting. Average per capita patenting increased when states passed laws that protected the earnings and property of married women. Similarly, the passage of sole-trader laws that

10 See Appendix for cities included.

enabled married women to conduct business on their own account was associated with increases in their patenting rates. These results were bolstered by evidence that community-property states, which effectively functioned in the same way as legal systems based on marital disability, did not demonstrate any particular advantage in promoting patenting activity.[11]

REGIONAL PATENTING AND MARKET DEMAND

> *With all their zeal for woman, did they ever ask why one woman . . . should give of her head and hand labor, without fair compensation?*
>
> Susan Converse (1875)

Previous research documents a correlation between expansion in market demand and inventive activity at both the regional and county levels. Schmookler pioneered investigations that systematically related patenting to changes in net expected benefits, and showed that the rate and direction of patenting responded to changes in market demand. Sokoloff likewise found that patenting varied pro-cyclically with phases of economic activity during early industrialization, and that areas with recent access to developing markets experienced a surge in patenting. Sokoloff and Khan argued that the increase in inventive activity during the early industrial period was mainly due to the influx of new entrants, attracted by the potential profits that larger markets promised. The overall conclusion from these systematic patterns was that patenting responded to economic incentives and that the individuals who applied were seeking to maximize expected returns. Furthermore, the results highlighted the contribution of technically un-

11 Matilda Jocelyn Gage, "Woman as an Inventor," *North American Review,* CXXXVI (1883), 478–489. Gage, a prominent suffragist, wrote that "it is scarcely thirty years since the first State protected a married woman in the use of her own brain property. Under these conditions, legally incapable of holding property, and trained, as she has been, to seclusion, dependence, and abeyance of thought, that woman has not been an inventor to an equal extent with man is not so much a subject of surprise as that she should have invented at all" (488–489). Several lawsuits illustrate how female inventors were protected by these laws. For instance, in *Fetter v. Newhall,* 17 F. Cas. 841 (1883), the defendant infringed a patent for drive screws, and tried to overturn the case by arguing that Mary Fetter, a married woman, had no right to assign the patent property to the Fetter Drive Screw Company nor to sue for infringement, since "at common law a patent-right granted or assigned to a married woman would be such personal property that her husband could, by virtue of his marital right, reduce it to possession and make it his own." The judge rejected this argument because the state of New York had long since revoked marital disability. See Khan, "Married Women's Property."

demanding, incremental improvements to economic growth in early industrial America, even in the case of supposed "great inventions."[12]

Was the inventive activity initiated by women also systematic and related to market demand? If so, (1) the regional pattern of female patenting would tend to vary with that of male patentees; (2) industrial patterns of patenting would show systematic variation; and (3) patentees would attempt to commercialize and profit from their investments in inventive activity. Goldin points out, however, that women's work "cannot be understood as an isolated market responding to economic factors" because of persistent links with the family and life-cycle factors. Presumably, those factors would influence both the demand and supply of inventive activity by women. Female inventors were confronted by problems specific to women, such as coping with voluminous, impractical clothing and managing household tasks in rural areas without access to hired help. Theoretically, they could try to benefit from their comparative advantage in household-related skills to satisfy the demand for innovations that would ease the burden of domestic chores. As a case in point, Sarah M. Clark was a servant who obtained four patents for a cake-stirrer, a dough maker, an invention for adjusting mirrors, and an improved cooking stove. Despite their formal occupations, however, all women tended to have a measure of domestic expertise; artists, physicians, and milliners all added to the roster of household inventions.[13]

The regional distribution of patterns of inventive activity by all patentees appears to have varied with the extent of the market. Table 2 indicates that women patentees were located in the same regions as other patentees. Almost one-quarter of all women

12 Jacob Schmookler, *Invention and Economic Growth* (Cambridge, Mass., 1966). Sokoloff, "Inventive Activity in Early Industrial America: Evidence from Patent Records, 1790–1846," *Journal of Economic History,* XLVIII (1988), 813–850, provides extensive and careful tests that support the hypothesis that patenting activity varied with market demand in the antebellum United States. Sokoloff and Khan, "The Democratization of Invention during Early Industrialization: Evidence from the United States, 1790–1846," *Journal of Economic History,* L (1990), 363–378.

13 Goldin, *Understanding the Gender Gap: An Economic History of American Women* (New York, 1990). Annie F. Craig, servant, obtained patent no. 215,725 for an "improvement in pictures," in May 1879. Mary Evard, a milliner, invented a broiler and toaster; Lucinda Warren, a dressmaker, patented a dishwasher; Adelia Covell, an artist, devised a dough-making machine; Mary Ross, a physician obtained patents both for a salve and for an invention related to dressmaking.

Table 2 Female Patenting, Total Patenting, and Population Percentage Distribution, 1800–1895

	PRE-1860	1860S	1870S	1880S	1890S
New England					
Female patents	26.0	19.2	19.0	11.7	9.9
Female population	10.2	9.8	9.1	8.5	8.2
Total patents	28.0	22.8	19.8	17.8	15.8
Total population	10.0	9.5	8.8	8.2	7.9
Middle Atlantic					
Female patents	62.0	43.6	39.3	34.4	32.2
Female population	24.0	23.8	22.8	22.1	21.7
Total patents	45.9	40.1	38.9	35.7	33.3
Total population	23.7	23.4	22.3	21.6	21.3
East North Central					
Female patents	4.0	20.3	20.8	24.2	23.0
Female population	21.4	22.4	22.5	22.2	21.9
Total patents	12.0	24.1	22.5	24.7	25.8
Total population	22.0	22.9	22.8	22.5	22.1
West North Central					
Female patents	0.0	4.5	6.5	11.1	14.0
Female population	6.6	7.9	9.4	11.0	12.0
Total patents	1.2	4.2	6.2	8.4	9.5
Total population	6.9	8.3	9.8	11.4	12.3
West					
Female patents	0.0	3.0	5.2	5.8	9.0
Female population	1.3	1.5	2.0	2.7	3.3
Total patents	0.3	1.9	3.0	4.1	5.6
Total population	2.0	2.2	2.6	3.3	3.9
South					
Female patents	8.0	9.4	9.1	12.8	12.0
Female population	36.6	34.6	34.2	33.5	33.0
Total patents	12.7	7.0	9.5	9.3	10.0
Total population	35.4	33.7	33.6	32.9	32.5

NOTES The female patent figures exclude 196 patents granted to foreigners, and 40 patents for which no information was available. The decadal figures for 1890 were obtained by inflating the patents granted up to March 1895 by 1.9355.

SOURCES Data for total patents at the regional level are computed from the *Annual Report* of the Commissioner of Patents for 1891. For women's patents, see text and Appendix. Population data are from *Historical Statistics,* computed at the decadal midpoint by exponential interpolation.

patentees during the entire period resided in New York state, followed by Illinois (8 percent), and Massachusetts (7.5 percent). These states were dominant in patenting by both women and men since the Civil War, but they lost ground in subsequent years, when patentees from areas such as Kansas, Michigan, Minnesota, Texas, and Wisconsin increased in relative and absolute numbers. New York, for instance, accounted for 35 percent of all women patentees before the Civil War, but only 18 percent by the 1890s. Nevertheless, in the latter period, women inventors in the Mid-Atlantic still produced 32 percent of all patents, implying that these women were more prolific patentees than the new entrants from the western and midwestern states.[14]

The dramatic decline in the percentage of patents from the New England area, and the less marked fall in the Mid-Atlantic, reveal a striking congruence between the general and female patterns of patenting. Conversely, midwestern states increased their share of patenting to 32 percent (women) and 35 percent (all patentees) by the 1890s. Lamoreaux and Sokoloff first noted this phenomenon in their study of a sample of all patentees in the late nineteenth and early twentieth centuries. They related the change to regional variation in relative per capita income, arguing that patenting rates were associated with economic development. Patenting activity possibly responded to a fall in the per capita incomes of the New England states relative to the increases of the eastern North Central region. Whatever the underlying reasons, the parallels between the results for females and all patentees suggest that women's motivation for patenting was hardly unique.[15]

Adjusting the numbers of patents filed in a particular region for population size highlights an intriguing exception to the idea that women's patenting followed the general trends. The patenting rate, reported per million women, reveals a rapid increase in patents relative to population in the western states after the 1860s. Table 3 shows that patents per capita increased in all regions throughout the century, even in the lagging South, but the rate of increase, as well as the absolute rates, were highest in the West.

14 For evidence relating to patterns for all patentees, see Sokoloff, "Inventive Activity"; Naomi Lamoreaux and Sokoloff, "The Location of Invention and Technical Change in Late Nineteenth and Early Twentieth Century America," unpub. ms. (Los Angeles, 1993).

15 Lamoreaux and Sokoloff, "Location of Invention."

Table 3 Female and Total Patenting per Capita, 1800–1895 (Per Million Residents)

	PRE-1860	1860S	1870S	1880S	1890S
New England					
Female	0.8	30.3	96.0	79.6	102.9
Total	102.1	484.4	725.3	820.2	698.4
Ratio (%)	0.8	0.2	13.2	9.7	14.7
Middle Atlantic					
Female	0.8	28.5	79.3	90.6	126.3
Total	70.4	346.7	561.3	626.4	547.0
Ratio (%)	1.1	8.2	14.1	14.5	23.1
East North Central					
Female	0.0	14.1	42.7	63.1	89.3
Total	19.9	212.7	317.0	417.3	409.4
Ratio (%)	0.0	6.6	13.5	15.1	21.8
West North Central					
Female	0.0	8.9	31.9	58.6	99.4
Total	6.1	102.6	204.0	277.9	269.2
Ratio (%)	0.0	8.7	15.6	21.1	36.9
West					
Female	0.0	30.1	120.5	126.7	231.5
Total	5.0	175.8	367.7	464.2	504.6
Ratio (%)	0.0	17.1	32.8	27.3	45.9
South					
Female	0.0	4.2	12.2	22.1	31.0
Total	13.0	41.9	91.5	107.0	107.6
Ratio (%)	0.0	10.0	13.3	20.7	28.8
United States					
Female	0.3	15.5	46.0	58.0	85.1
Total	36.4	202.4	322.1	379.1	349.8
Ratio (%)	0.8	7.6	14.3	15.3	24.3

SOURCES See Appendix. Figures for male patentees were obtained by subtracting the total for women from the annual data in the *Report of the Commissioner of Patents* for various years.
NOTES The total number of patents for women in the 1890–1894 period includes patents issued during January and February, 1895. A small number of patents attributed to women included male co-inventors. The ratio comprises female patents per capita as a percentage of total patents per capita within each region. The data include patent grants alone, because separate information is not available for patent applications by women.

Such was not the case for the general population of patentees; the absolute number of patents per capita filed in the West still lagged behind that of the more technologically experienced Mid-Atlantic and New England regions.

In short, western women (in per capita terms) held a greater absolute and comparative advantage over nonwestern women than western men held over nonwestern men. These results are in accord with the "Turner thesis," which claims that the frontier was associated with "a special American character of fierce individualism, pragmatism, and egalitarianism"—especially in the case of women, who were relatively more disadvantaged in terms of the laws, norms, and practices of the settled regions. The fact that the frontier states were pioneers in protecting the rights of women might have stimulated greater efforts to secure their intellectual property in the form of patents. The frontier "feminist ethos," with its liberal laws, may well have beckoned more innovative and independent women migrants, thus boosting the rates of inventive activity in the West and Midwest.[16]

RURAL INVENTORS AND HOUSEHOLD PATENTS

> *It is a woman's right to be supplied with labor-saving appliances to assist her in the labor of the house*
>
> *New Northwest* (1873)

Women inventors, like their male counterparts, responded to expanding markets and increased their investments in inventive activity during economic upturns. Historians of technology, however, argue that this market was largely the province of wealthy middle-class women and urban households. In general, women in rural households tended to be "among the most underrepresented of all Americans in the standard histories," especially in terms of systematic studies. This section therefore considers variation in overall patterns relating to urbanization and the distribution of patents by industry. The results support the hypothesis that the market for household innovations was expanding, and, per-

16 Judith K. Cole, "A Wide Field for Usefulness," *American Journal of Legal History,* XXXIV (1990), 262–294; Mari Matsuda, "The West and the Legal Status of Women: Explanations of Frontier Feminism," *Journal of the West,* XXIV (1985), 47–56.

haps surprisingly, that women in rural areas were prominent participants in inventive activity.[17]

Research into the occupations and patenting of both the ordinary and the "great inventors" finds that the majority of patentees tended to produce job-related inventions. The industrial distribution of patents filed by women also yields evidence of responsiveness to market demand, and of job relatedness. As Table 4 indicates, less than one-quarter of women's patented inventions were in such untraditional fields as tools, industrial and agricultural machinery, transportation, construction, and chemicals. A noticeable feature of the patterns of invention by industrial category is that they are predominantly related to the role of women in the home and family. For instance, in 1872 Mrs. Sophronia Dodge of deSoto, Iowa, fashioned an appliance for raising dough that "does the work thoroughly and perfectly in the coldest weather." In 1873, Ella Haller patented a fruit jar that contained a gasket to expel air and increase the shelf life of preserved fruit. She also patented a self-lighting lamp in 1878. Women also created improvements in stoves, dishwashers, and laundering devices.[18]

If this focus had been due primarily to a lack of education or market experience, household patents would probably have declined over time. But clothing and related items—including hats, shoes, sewing, and textiles—absorbed a fairly constant share of patent efforts. The share of women's inventions related to household articles and furniture increased from 22.8 percent in the period 1800–1865 to 36.1 percent between 1890 and 1895. Initially, supply-side explanations of these patterns might seem to apply: Technological change required greater training and forced women who lacked it to focus on household gadgets; or the development of technology may have opened up the field for marginal contributions to household items. However, these arguments are not entirely convincing, given that the share of household patents was increasing at the same time as women's patenting was rising in absolute as well as relative terms to men's. The evidence is con-

17 For instance, Strasser, "Enlarged Existence," 30, contends that "the technological potential of the nineteenth-century house was fairly high; it could only be achieved, however, by wealthy people in urban areas." She concludes that "technology had little impact on most women's working life" (37). John Mack Faragher, "History from the Inside Out: Writing the History of Women in Rural America," *American Quarterly,* XXXIII (1981), 537–557.

18 Khan and Sokoloff, "Schemes;" Sokoloff and Khan, "Democratization."

Table 4 Types of Inventions Patented by Women, 1790–1895

TYPE	NUMBER	PERCENT
Teaching, music, or games	226	5.4
Food preparation	29	0.7
Textiles and sewing	244	5.8
Clothes, general	295	7.0
Hats	46	1.1
Shoes	27	0.6
Dresses	115	2.7
Corsets	241	5.8
Furniture and household	817	19.5
Kitchen utensils	410	9.8
Tools and instruments	140	3.3
Irons	30	0.7
General household machines	68	1.6
Stoves	182	4.3
Sewing machines	118	2.8
Laundry machines	123	2.9
Churns	29	0.7
Industrial machines	261	6.2
Agricultural inventions	61	1.5
Transportation	142	3.4
Medical and chemical	350	8.4
Construction/building	120	2.9
Miscellaneous	116	2.8

SOURCE See Appendix.
NOTE The inventions are categorized according to industry of final use.

sistent with the idea that female inventive activity was responding more to market demand than to trends in technical knowledge, education, or occupations.[19]

The regional decomposition of these patterns, as reported in Table 5, is informative. New England states dominated in the production of clothing and related items; the largest share of inventions in this industry by far occurred in the same region. For instance, Susan Taylor Converse, Clara Clark, and Emmeline Philbrook of Massachusetts all devised patented corsets that were manufactured by George Frost and Company of Boston. Foy,

19 The Women's Bureau, *Women's Contributions,* and the Office of Technology Assessment and Forecasting, *Buttons to Biotech: U.S. Patenting by Women, 1977 to 1988* (Washington, D.C., 1990), reveal that similar patterns (in terms of both the level and composition of women's patents relative to men) exist in the twentieth century, a period when women's labor-force participation increased dramatically.

Table 5 Regional and Industrial Distribution of Patents, 1790–1895 (Percentages within Region)

	1800–59	1860–69	1870–79	1880–89	1890–94	1800–1894
Middle Atlantic	(31)	(116)	(368)	(492)	(424)	(1431)
Clothing	12.9	20.7	17.9	30.0	21.7	23.3
Health	22.6	15.5	7.3	8.5	6.6	8.5
Household	35.5	31.9	40.5	33.1	40.8	37.3
Industrial machines	22.6	23.4	19.6	15.2	14.6	17.0
Transport	0.0	1.7	8.2	2.9	3.8	4.3
Miscellaneous	6.5	6.9	6.5	10.4	12.5	9.6
New England	(13)	(51)	(179)	(167)	(131)	(541)
Clothing	30.8	47.1	38.6	37.7	34.5	37.9
Health	7.7	3.9	8.4	5.4	3.1	5.7
Household	23.1	37.3	33.0	33.5	34.4	33.6
Industrial machines	23.1	5.9	10.1	13.2	17.6	12.8
Transport	0.0	2.0	1.7	1.2	3.1	1.9
Miscellaneous	15.4	3.9	8.4	9.0	7.6	8.1
Midwest	(2)	(66)	(256)	(507)	(488)	(1319)
Clothing	50.0	25.8	18.8	23.3	20.0	21.3
Health	0.0	12.1	10.2	7.1	5.1	7.2
Household	50.0	36.4	49.7	46.0	52.9	48.8
Industrial machines	0.0	12.1	14.1	12.0	11.7	12.3
Transport	0.0	1.5	2.7	3.2	1.6	2.4
Miscellaneous	0.0	12.1	4.7	8.5	8.8	8.0
West	(0)	(8)	(49)	(83)	(119)	(259)
Clothing	0.0	37.5	12.2	15.7	13.5	14.7
Health	0.0	12.5	24.5	12.1	7.6	12.4
Household	0.0	25.0	38.8	43.4	50.4	45.2
Industrial machines	0.0	0.0	18.4	10.8	10.1	11.6
Transport	0.0	0.0	2.0	2.4	8.4	5.0
Miscellaneous	0.0	25.0	4.1	15.7	10.1	11.2
South	(5)	(25)	(85)	(183)	(162)	(460)
Clothing	0.0	8.0	15.3	21.3	13.6	16.5
Health	0.0	12.0	16.5	8.2	4.3	8.5
Household	80.0	56.0	45.9	47.0	47.5	47.8
Industrial machines	20.0	16.0	12.9	14.2	16.7	15.0
Transport	0.0	0.0	2.3	3.8	5.6	3.9
Miscellaneous	0.0	8.0	7.1	5.5	12.4	8.3
United States	(70)	(266)	(937)	(1433)	(1324)	(4030)
Clothing	20.0	26.3	21.6	26.5	20.5	23.3
Health	15.7	12.0	10.0	7.8	5.5	8.0
Household	35.7	36.1	41.9	40.1	46.3	42.2
Industrial machines	22.9	15.8	15.6	13.5	13.7	14.4
Transport	0.0	1.5	4.6	2.9	3.6	3.4
Miscellaneous	5.7	8.3	6.3	9.2	10.4	8.8

NOTES Total number of patents is in parentheses. The South includes the District of Columbia. Percentages may not total to one hundred due to rounding. This table excludes patents filed by foreign inventors.

Harmon, and Chadwick of New Haven employed several hundred female workers to make patented articles by inventors like Lavinia Foy of Massachusetts, whose seventeen corset inventions brought her a reputed annual income of $25,000. Catherine Griswold, a New York resident, produced some twenty clothing-related inventions for which she obtained patents, including garment supporters and corsets that were manufactured by the Worcester Corset Company. Lena Sittig, another New York inventor, was granted several patents for garments, at least one of which was commercialized. The advent of activities such as bicycling and the need for less restrictive clothing meant that the market for new forms of apparel was expanding and profitable.[20]

The direction of women's interests may also be related partially to the nature of the market for female inventions in the West relative to other areas. According to Katzman's study of the availability of domestic servants, southern white households were less inclined to use household innovations because of the surplus of low-wage black labor. Midwestern and western women, without the benefit of such readily available help, might have had a greater incentive to employ devices in their household tasks. This proposition may be tested by examining the industrial distribution of patents by region and by level of urbanization.[21]

Western patentees produced only thirty industrial (machine and tool) inventions during the entire nineteenth century. Their efforts, and to a lesser extent those of women in the Midwest, focused on household machines, furniture, and utensils. From 1790 to 1895, household inventions amounted to 47.8 percent of patents granted to women in the South, 45.2 percent in the West, and 48.8 percent in the Midwest. Moreover, the share of household patents increased in the 1890s to 50.4 percent in the West and 52.9 percent in the Midwest, compared to 34.4 percent in New England during the same period. Margaret Colvin of Michi-

20 See Macdonald, *Feminine Ingenuity,* 247. Sarah L. Naly and Mary Scott Jones of Philadelphia, Pennsylvania, explained in their 1893 patent (no. 499,244) specification that the conventional bicycle saddle "is excellently adapted to male riders, it is obviously not suited to female riders. Aside from being uncomfortable to a female rider, it has the important objection that the point or projection at the forward part catches upon the skirts of the rider when getting on or off the bicycle, often causing considerable mishap, to say nothing of mortification."

21 David M. Katzman, *Seven Days a Week: Women and Domestic Service in Industrializing America* (New York, 1978).

gan invented a successful washing machine; Hattie Adler of Colorado, Nella Balch of Wisconsin, Margaret Brass of Minnesota, and Ellen Dillon of Iowa patented clothes driers, washboards and boilers, dishwashing machines, iron-heaters, and other household improvements. The lack of access to household help possibly accounts for a significant fraction of western and midwestern patented inventions in this category, although, at first glance, southern women seem to have exhibited the same focus. However, the size of the female population in the South was approximately the same as the western and midwestern states combined, and in the latter states, the per capita rate of patenting in the household category was four times higher than the equivalent rate for southern patentees. Thus, the per capita data are consistent with the thesis that the industrial composition of female patenting activity in these two regions was at least partly due to labor-market conditions for domestics and household help. The urbanization patterns also support this hypothesis.

Table 6 indicates that the influence of urbanization differed significantly with regard to male and female per capita patenting. Patenting by male inventors occurred disproportionately in cities. Except for the Northeast, where Boston, Philadelphia, and New York City featured prolific inventive activity by both men and women, female patentees were located mainly in rural areas, within counties of fewer than 25,000 residents. Only in the Middle Atlantic region was per capita patenting higher in metropolitan areas during the nineteenth century. The strong relationship between urban centers and male invention might have been the result of better access to information flows, capital and externalities from clusters of innovations, and the presence of active markets. Since women were not able to benefit from those advantages to the same extent, the potential market for inventions that reduced housework was likely greatest in rural areas. However, the data for rural residents are also consistent with the influence of such supply factors as a relatively lower level of education or technical knowledge outside of cities.

Table 7, which examines the distribution of women's patents by industry and urbanization, indicates that most of the clothing-related patents were filed in metropolitan areas, as were industrial machines and transportation patents. Household articles and machines were prevalent in rural areas; 60.4 percent of household

Table 6 Urbanization and per Capita Patenting by Region: Male and Female Patentees

	1870s		1890s		1860–1895
	WOMEN	ALL	WOMEN	ALL	WOMEN
East North Central					
No city	25.9	237.8	36.2	240.2	26.9
25,000	5.0	889.8	12.3	703.8	7.0
100,000	1.9	724.2	4.8	763.0	3.8
250,000	7.9	—	32.1	1139.4	17.7
Total	10.2	312.2	21.4	429.9	13.8
West North Central					
No city	19.2	129.4	50.7	168.4	33.8
25,000	2.7	239.9	7.3	300.6	4.5
100,000	—	—	10.5	588.9	5.0
250,000	3.8	293.3	13.5	938.4	11.5
Total	6.4	146.5	20.5	248.7	13.7
New England					
No city	13.4	438.5	12.6	382.4	11.8
25,000	40.0	1039.2	57.1	989.9	39.8
100,000	—	—	1.7	870.2	2.6
250,000	69.7	1875.9	43.9	1250.1	37.1
Total	30.8	775.8	23.8	772.0	22.8
Middle Atlantic					
No city	17.8	295.6	27.4	280.6	19.0
25,000	4.5	603.9	13.1	681.9	7.1
100,000	4.6	1009.0	8.6	795.2	4.8
250,000	53.7	1137.4	73.2	943.5	52.8
Total	20.2	563.4	30.6	607.0	21.0
South					
No city	6.1	53.2	15.4	63.5	10.4
25,000	0.5	266.4	4.4	452.5	1.9
100,000	0.5	563.8	1.2	434.2	0.7
250,000	0.6	492.8	3.5	421.8	2.1
Total	1.9	85.8	6.1	103.1	3.8
West					
No city	50.0	236.3	54.7	265.3	54.2
25,000	—	—	52.8	452.5	35.9
100,000	81.6	876.4	10.1	—	24.3
250,000	—	—	68.1	1056.9	39.4
Total	32.9	366.7	46.7	381.6	38.4

SOURCES See text and Appendix for data on women. The data for all patentees are from Naomi Lamoreaux and Kenneth L. Sokoloff, "The Location of Invention and Technical Change in date Nineteenth and Early Twentieth Century America," unpub. ms. (Los Angeles, 1993).

NOTES The data for women refer to the entire decade of the 1870s and 1890s. The columns for females are computed by dividing the number of patents within each urbanization category by total state population. The columns for all patentees refer to the 1870–1871 and 1890–1891 periods, respectively.

Table 7 Distribution of Women's Patents by Industry and Urbanization, 1790–1895

	1790–1879				1880–1895			
	RURAL	URBAN	METRO	TOTAL	RURAL	URBAN	METRO	TOTAL
Clothes								
Number	82	59	145	286	200	101	351	652
Row percentage	28.7	20.6	50.7		30.7	15.5	53.8	
Column percentage	15.1	31.7	26.7	22.5	18.2	24.5	28.2	23.6
Household machines								
Number	90	16	43	149	135	35	76	246
Row percentage	60.4	10.7	28.9		54.9	14.2	30.9	
Column percentage	16.5	8.6	7.9	11.7	12.3	8.5	6.1	8.9
Household (non-machine)								
Number	165	59	141	365	437	130	374	941
Row percentage	45.2	16.2	38.6		46.4	13.8	39.7	
Column percentage	30.3	31.7	26.0	28.7	39.8	31.5	30.0	34.1
Industrial machines								
Number	56	12	82	150	107	46	114	267
Row percentage	37.3	8.0	54.7		40.1	17.2	42.7	
Column percentage	10.3	6.5	15.1	11.8	9.7	11.1	9.1	9.7
Tools								
Number	26	7	21	54	39	20	49	108
Row percentage	48.2	13.0	38.9		36.1	18.5	45.4	
Column percentage	4.8	3.8	3.9	4.2	3.6	4.8	3.9	3.9
Transport								
Number	15	4	28	47	34	12	42	88
Row percentage	31.9	8.5	59.6		38.6	13.6	47.7	
Column percentage	2.8	2.2	5.2	3.7	3.1	2.9	3.4	3.2
Health								
Number	79	13	45	137	60	31	94	185
Row percentage	57.7	9.5	32.8		32.4	16.8	50.8	
Column percentage	14.5	7.0	8.3	10.8	5.5	7.5	7.5	6.7
Miscellaneous								
Number	31	16	38	85	86	38	147	271
Row percentage	36.5	18.8	44.7		31.7	14.0	54.2	
Column percentage	5.7	8.6	7.0	6.7	7.8	9.2	11.8	9.8
Total								
Number	544	186	543	1273	1098	413	1247	2758
Percentage	42.7	14.6	42.7	100	39.8	15.0	45.2	100

SOURCES See Appendix.

machines and 45.2 percent of household non-machine inventions were patented by rural residents between 1790 and 1879. Both categories of household patents accounted for more than half of rural patenting between 1880 and 1895, compared to 36 percent for metropolitan patentees. Sara Sewell, of Defiance, Ohio, whose invention of a "combination washing-apparatus and see-saw" enabled her to "provide . . . amusement and recreation for children

and young persons, while at the same time . . . utilize their exertions, when desired, in washing the family or other clothes," is not unrepresentative.[22]

Several studies have attested to the prevalence of innovations in specific tasks such as cheesemaking and other forms of household production. Technological change influenced women's lives by increasing the availability of goods and services in the market place. Despite the view that women were not the major purchasers of products for the home—and thus not likely to buy items that would relieve household burdens—until the 1890s, professional laundry women apparently had begun to "apply mechanical means" to the treatment of clothes as early as 1861. The decadal census of the United States suggests that mechanical aids may also have extended to homes in areas where housewives did not have access to professional laundry women. By 1860, establishments to produce washing machines had opened in small counties in such frontier regions as Iowa, Kansas, and Indiana. Four factories located in Iowa were producing washing machines valued at $11,890 at a time where there were no more than 132,000 dwellings in the state. By contrast, Pennsylvania had four establishments producing goods valued at $14,000 for a population of 515,319 dwellings. The 1880 census also shows that four firms in Wisconsin were producing refrigerators.

Although questions can be raised about the interpretation of these data, the provision of household goods clearly accounted for a disproportionate fraction of manufacturing in the more rural states relative to the urbanized East. A recent study of business gazetteers contends that "most manufactures of washing machines took place in small rural communities" by transient firms that were not sufficiently long-lived to appear in the decadal census. Thus, rural women patentees were addressing their efforts in arenas that seemed most likely to provide rewards for investments in inventive activity, as well as contributing to a ready market for products that would improve frontier life.[23]

22 The specification of Sewell's 1885 patent, no. 330,626.

23 Joan Jensen, *Loosening the Bonds: Mid-Atlantic Farm Women, 1750–1850* (New Haven, 1986), examines changes in the technology of the dairy industry. Sally McMurry, *Transforming Rural Life: Dairying Families and Agricultural Change, 1820–1885* (Baltimore, 1995), traces improvements in cheese-making technology that affected rural women. Carolyn M. Gold-

PROFESSIONAL INVENTORS, COMMERCIALIZATION, AND ENTREPRENEURSHIP

"Should such a woman be successful in getting a patent, what then?"
Matilda Gage, *Woman as an Inventor* (1883)

Many inventors undoubtedly never applied for patents either because their creation was not patentable or because they were unable, or unwilling, to do so. Those who did apply for patents most likely intended to profit from their efforts. Even if *The Patent Record*'s claim that 75 percent of all women's patents were profitable is an exaggeration, at least a subset of women inventors were active entrepreneurs and succeeded in their pursuit of profit. A professional approach to invention is often linked with multiple patenting, as well as the attempt to derive income from it. Although only 15 percent of women patentees qualify as multiple inventors, the record includes Eliza Murfey, who filed twenty-three patents; Catherine Griswold, who filed twenty; Anna Dormitzer and Helen Blanchard, who filed sixteen; and Harriet Tracy, Margaret Knight, and Maria Beasley, who filed fourteen. Patentees of clothing and related items, household machines (such as dishwashers and clothes driers), and industrial machines all tended to have higher numbers of patents. Since inventors would hardly persist in patenting inventions that were worthless, the implication is that multiple patenting supports the idea that the market for household machines was extensive and profitable.

The regressions with the log of the total number of patents awarded to each inventor as the dependent variable (Table 8) indicate that multiple patenting was most prevalent in the Mid-Atlantic and New England areas, and increased in metropolitan

stein, "From Service to Sales: Home Economics in Light and Power, 1920–1940," *Technology and Culture,* XXXVIII (1997), 130, states that "commonplace wisdom held that women purchased about 85 percent of American household products overall." In Canada, a region that historically lagged behind the United States in technological progress, new household goods had "profoundly" improved the standard of living of women by the first decade of the twentieth century. (See Suzanne Marchand, "L'impacte des Innovations Technologiques sur la vie Quotidienne des Québécoises du Début du XXe Siècle [1910–1940])," *Material History Bulletin,* XXVIII [1988], 1–14, who finds that "L'apparition de nouveaux biens d'équipement ménager, au cours de la période 1910–1940, a contribué a altérer profondément les conditions de vie quotidienne des femmes québécoises.") Mohun, *Steam Laundries,* 29; Orville Butler, "The Changing Gender of Authority in American Home Appliance Technology: Dishwasher and Washing Machine Patents from 1860–1950," in Santimay Chatterjee et al. (eds.) *Studies in History of Sciences* (Calcutta, 1997), 163–184.

Table 8 Regressions of Total Patents by Individual Inventors—Dependent Variable, Log of Number of Patents per Person

	(1)	(2)
CONSTANT	0.27	0.30
	(5.34)	(4.69)
Regional Dummies		
New England	0.29	0.25
	(6.47)	(5.67)
Mid-Atlantic	0.25	0.16
	(6.65)	(4.25)
West North Central	0.05	0.04
	(1.04)	(0.96)
East North Central	0.02	0.09
	(0.58)	(1.95)
West	−0.05	−0.02
	(0.90)	(0.34)
Time trend		
1870s	−0.01	0.01
	(0.29)	(0.21)
1880s	−0.14	−0.14
	(2.94)	(2.99)
1890s	−0.20	−0.19
	(4.11)	(4.05)
Log per capita patents	0.03	0.02
	(5.40)	(3.28)
Industry		
Industrial machines		0.28
		(8.77)
Household machines		0.11
		(3.01)
Apparel and textiles		0.12
		(4.57)
Urbanization		
Urb25		0.09
		(2.57)
Urb100		0.21
		(6.31)
	N=4001	N=4001
	R^2=0.06	R^2=0.11

SOURCES See text and footnotes.

NOTES "Rural" refers to a location with fewer than 25,000 inhabitants (the excluded variable); "Urb25" indicates an urban population between 25,000 and 100,000; "Urb100" represents metropolitan districts of 100,000 and more residents. Population in the per capita patents variable is computed by exponential interpolation between census years. T-statistics are in parentheses.

areas as well as in regions with greater per capita patenting rates. It is not coincidental that the Midwestern and Western states recorded the least number of multiple patentees, the time trend showing a fall in such activity. The inventors from these states entered the market in larger numbers over time, but they tended to file only single patents. As Sokoloff and Khan indicated, a similar process of "democratization" had transformed the patenting process in the antebellum period, when patenting also increased because of new entrants rather than multiple patenting by individuals.[24]

Inventors tend to file for patents if the expected benefit exceeds the cost. In efficient capital markets, the creator of a useful invention can borrow to finance the patent and its development. Women inventors, however, undoubtedly faced greater obstacles in obtaining funding for their inventions, and might not have been able to afford the patent fee and application process, which could amount to as much as $100 (about one-quarter of average annual non-farm wages in the late nineteenth century). Some patentees bypassed capital markets and attempted to promote their inventions through their own enterprises. Other women were able to obtain technical, and possibly financial, assistance from co-inventors, or individuals who accepted payment in the form of partial assignments of the patent right. Over 300 patents were attributed to co-inventors, the majority of whom were unrelated males, typically from the same city and state (see Table 1). Co-inventors included machinists, engineers, pattern makers, toolmakers, manufacturers, and artisans, who, according to patent law, needed to have made a significant contribution to the invention to warrant joint billing.

Assignees purchased, or were granted, rights to an invention without any claim to its origin. Patent rights could be assigned any time during the patent's life, including at the time of granting; 323 patents were assigned when issued. The identity of assignees yields insights into the market for invention. Matching assignees with occupations from the city directories reveals that patent lawyers and agents comprised one-quarter of the assignees of a patent at the time that it was granted, suggesting that on occasion, women inventors may have traded part of their property rights as

24 Sokoloff and Khan, "Democratization."

payment for patent application fees and services. Manufacturers, who comprised one-third of assignees at time of issue, either purchased a share in an invention because of its value, or were granted the share in return for funding or for marketing and commercializing the invention. For instance, in 1881, Maria Beasley reached an agreement to transfer half of the rights to an uncompleted invention to James Henry of Philadelphia in return for an advance of funds to complete the machine. Leonia Mabee of Paris, Texas, similarly ceded half the rights in her bedstead patent in exchange for one-third ownership in a $100,000 company that was to make and promote the invention.[25]

Table 9 indicates that the likelihood of a patent being assigned at time of issue was higher for individuals with multiple patents, and for those with patents for industrial or household machines. Women who patented clothing improvements were especially successful in marketing their inventions. The assignment data suggest a reputation effect; that is, assignees were more inclined to purchase a patent at time of issue if the inventor had proven her ability by obtaining more than one patent. Assignments at time of issue happened less often in the West than in other areas. As may be expected, assignment at time of issue was positively related to urbanization. Although urban patentees may have an advantage in early patent assignments, these results do not imply that rural inventors were unable to benefit commercially from their patents, since the table does not include assignments that occurred during the life of the patent. In 1872, Sarah Dake, a resident of Eureka, Wisconsin, obtained a patent for corsets that was the subject of thirty-eight contracts for three years after it was issued. Valuable evidence on trade in inventions can also be gleaned from less systematic sources, such as advertisements, mail-order catalogs, and probate records.

25 Beasley, in her assignment of May 5, 1881, promised to finish her invention within three months. In the contract, she reserved the rights for foreign patents to herself. Beasley showed a shrewd business sense in her numerous assignments. On the same day, she filed an agreement for the boot-pasting machine with another set of assignees, who paid $500 for 10% of the future patent. Despite the existence of married women's property laws, her husband explicitly signed codicils to her contracts stating that he repudiated any claim that he might have in the transactions, thus making absolutely certain that the agreements could not be overturned based on coverture. Beasley sold the U.S. rights in her footwarmer patent to Osborn Conrad of Philadelphia on December 14, 1878, a few months after the application was approved. In this case, she did not retain all of the foreign rights, selling the Canadian rights for $100.

Table 9 Logistic Regressions of Patent Assignments—Dependent Variable, Probability of a Patent Being Assigned at Issue

	(1)	(2)	(3)
CONSTANT	−2.57***	−2.82***	−2.91***
	(89.3)	(107.9)	(111.29)
Regional dummies			
New England	0.27	0.12	0.05
	(1.57)	(0.29)	(0.04)
Mid-Atlantic	0.09	−0.02	−0.12
	(0.20)	(0.01)	(0.39)
West North Central	−0.26	−0.26	0.21
	(1.04)	(1.02)	(0.65)
East North Central	−0.33	−0.31	−0.30
	(2.31)	(2.00)	(1.94)
West	−1.07***	−1.02***	−1.05***
	(7.29)	(6.67)	(6.94)
Time Trend			
1870s decade	0.22	0.21	0.15
	(0.78)	(0.72)	(0.38)
1880s decade	0.30	0.31	0.25
	(1.59)	(1.72)	(1.01)
1890s decade	0.12	0.17	0.09
	(0.25)	(0.48)	(0.14)
Log (number of pats)		0.26***	0.22***
		(12.92)	(9.09)
Industry			
Machine inventions		0.53***	0.54***
		(11.16)	(11.43)
Household inventions		−0.31	−0.27
(non-machine)		(1.46)	(1.17)
Apparel and textiles		0.36***	0.34***
		(6.56)	(5.70)
Urbanization			
Urb25			0.27
			(1.99)
Urb100			0.35
			(5.72)***
	N=4030	N=4030	N=4030
	χ^2=26.67***	χ^2=64.27***	χ^2=69.45***

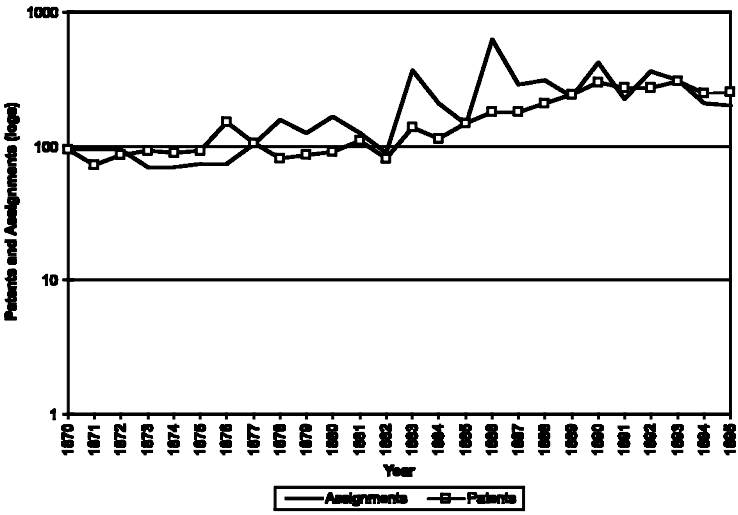
*** Significant at 1 percent level.

** Significant at 5 percent level.

SOURCE See text and Appendix.

NOTES The response profile includes 323 assignments at time of issue (N=1) and 3,707 patents that were not assigned (N=0) at time of issue. The data do not include assignments that took place after the patent was granted. The urbanization variables represent counties that included at least one town with 25,000 to 100,000 residents (Urb25), and over 100,000 residents (Urb100). Wald χ^2 statistics are in parentheses.

Fig. 2 Patents and Assignments by Women Inventors, 1870–1895



NOTES AND SOURCES The data for assignments were estimated from a sample drawn from the listing of inventors whose initial was "B" in the Index to Assignments of Patents held by the National Archives, Record Group 241. Further information was obtained from the Digest of Assignment of Property Rights in Patents, various years. Totals were obtained by creating an annual figure from the monthly average and multiplying by 26. Since "B" initials are probably more common than "Q" or "Z," these figures overstate the actual totals to some extent; however, the trend would not necessarily be affected by this feature of the calculations.

Figure 2 indicates that the growth rate of assignments (patents that were commercially successful) drawn up by women inventors after the patent was issued matched the rapid increase in patents granted. Ellene A. Bailey negotiated several assignments, including the entire rights to a powder puff for "$450 and other considerations" to William Smith and Co. of New York. She sold her patent for a corset protector to John Moore and Addison Tuttle of New York a year later. In 1879, Amelia Baglin chose to license the rights to her patent for hats to firms throughout the Northeast. Julia Banfield sold the exclusive rights to her 1879 improvement in corset busks to a Connecticut firm, with the proviso that the company sell her busks for her own manufacturing of corsets, "at a reasonable price." According to Strasser, patented inventions were unrelated to household production because few were ever

used. However, the assignment records do not support this view, since they highlight the commercialization of numerous household inventions, such as washboards, roasting pans, churns, ironing boards, pillowsham holders, improvements in ovens, and various ingenious furniture contrivances. Patent agencies and journals, such as *Scientific American,* undoubtedly inflated the expected gains from inventions, but their claim that such improvements could prove to be extremely profitable was true for a significant number of women inventors.[26]

Although the city directory sample is unrepresentative, it allows us to trace the activities of women who exercised entrepreneurial, as well as inventive, abilities, and attempted to profit from their inventions. Almost one-quarter of the linked patents (24.2 percent) were filed by women who established businesses, marketed their inventions, or manufactured innovations for sale as final products. For example, Emily Stears was listed in the 1885 New York directory as the "patentee and sole manager" of a Brooklyn enterprise that sold odorless, steamless cooking vessels. Sarah Drewry, another New York inventor included in the directory that same year, manufactured and sold surgical instruments. Some women inventors demonstrated an uncommon degree of independence. Elizabeth van Vleck, patentee of a corset improvement, listed her Chicago company as "Van Vleck and Daughter." The assignment records show that Carina Banning purchased patents from other inventors—such as a dustpan patent for $100—for her Boston firm, the Banning Stationary Dustpan and Manufacturing Company.

Warner traced the activities of women who exhibited at the Centennial Exposition in Philadelphia, in hopes of turning a profit and achieving economic self-sufficiency. She estimated that 35 percent of the devices at the exhibition actually went into production, some for more than twenty years. Similarly, in her study of women inventors at the World's Columbian Exposition in 1893, Weimann found that demand for displayed innovations was high, including 600 customers for Mary Harris' refrigerator and 60,000 orders for the Hambell egg and cake beater. Expositions undoubtedly were atypical, but evidence of these purchases illustrates the existence of a market that could be tapped through

26 Strasser, *Never Done.*

personal transactions, local newspapers, trade journals, and publications devoted to inventors' efforts.[27]

Women inventors who used the legal system to counter attempts to infringe their rights incidentally created records of their entrepreneurial activities. The competitive and rapidly expanding market for women's corsets provoked several instances of litigation. Lavinia Foy, patentee of several corset improvements that were produced by the Foy, Harmon and Chadwick company, was involved in a number of such lawsuits. Similarly, Catharine Judson, who obtained a patent for corset clasps in 1876, successfully defended her property against the Bradford enterprise of Massachusetts which was using her invention without authorization. *Mayer v. Hardy,* 127 NY 125, 1891, reveals that Judson licensed the patent to Saly Mayer and three others in 1879 for a royalty fee of 50¢ per gross, promising to protect the patent against infringers. Later in the same year, she sold the entire patent right to Garret Hardy, of New York. Helen M. Macdonald's 1874 improvement in dress protectors was the subject of a series of lawsuits in Massachusetts and New York in 1886, only two years before the patent was due to expire. Macdonald, acting as her own counsel in *Macdonald v. Sidenberg et al.,* 16 F. Cas. 48, 1879, was able to win an injunction against the defendants who claimed that their variant of the protector was both different and prior to hers.[28]

Studies in the history of technology exhibit many biases, but the two most significant are the tendency to mythologize supposed "heroes of invention," "macroinventions," and large discrete inventions, and the failure to pay systematic attention to the rela-

27 Warner, "Centennial"; Weimann, *Fair Women,* 432.

28 Bernard Smith, "Market Development, Industrial Development: The Case of the American Corset Trade, 1860–1920," *Business History Review,* LXV (1991), 91, discusses the market for corsets. Macdonald's invention protected "the dress from being cut or damaged by contact with earth or brick or concrete pavements and sidewalks, said invention being impervious to moisture . . . it also forms a very neat trimming and improves the hanging of the skirt" (patent application, May 6, 1873, cited in *Shepard v. Carrigan*). The patent application was rejected twice. The subsequent amended specification was the subject of an interference suit with M. Herbert Chase, over whom she finally prevailed and was granted the patent (*Macdonald v. Blackmer,* 16 F. Cas. 38, 1876). The patent was bequeathed to Carrigan, the appellee in the Supreme Court case, *Shepard v. Carrigan,* 116 U.S. 593, 1886. See also *Eastern Paper Bag Co. v. Standard Paper Bag Co.,* 29 F. 787, 1887. See Khan, "Married Women's Property."

tionship between women and technology. The common perception that inventive ability was rare among women is reflected in G. C. Baddeley's play "The End of the Tether, or, A Legend of the Patent Office: *An Original Drama in Two Acts for Male Characters Only.*" Well aware of such misconceptions, women's rights activists who organized the Women's Pavilion for the World's Columbian Exposition encouraged female inventors to submit improvements in the hope of proving that women's work extended to spheres far from the home. They were mortified to find that the inventions submitted were predominantly domestic. Similarly, a number of feminist scholars today who attempt to redress the second bias seem to share the first, reserving most of their admiration for the "heroines of invention" who produced machines or "masculine" inventions. In so doing, suffragists and historians may underestimate the extensive contributions of nineteenth-century women to technology and the existence of an expanding market for their inventive efforts. As McGaw usefully reminds us, the roster of important female technologists may be limited because we have inherited a limited vision of what constitutes important technology.[29]

Employing a number of sources—including patent records, assignment contracts, city directories, and the decadal census—to examine the relationship between women and inventions in the nineteenth century, this study finds that the patenting rate of women was significantly less than that of males and that their inventions were predominantly related to the household sector. Women inventors of household inventions, however, were not isolated from the market. The data suggest that patentees were motivated by market incentives. Almost 500 of them patented more than one discovery, and many succeeded in gaining income from their inventions. Women patented in the same regions as general patentees, and, overall, their efforts were greater in regions where markets (as shown by per capita income) were expanding. Inventive activity surged in the second half of the nineteenth century with the efforts of women to devise and promote patented inventions with the objective of obtaining "fair compensation."[30]

29 Baddeley's play was published in London in the nineteenth century, exact year unknown. Italics added. McGaw, "Inventors and Other Great Women."

30 Susan Taylor Converse posed the question, "With all their [feminists'] zeal for woman, did they ever ask why one woman like myself should give of her head and hand labor, without fair compensation?" (Macdonald, *Feminine Ingenuity,* 115).

Researchers have argued that "woman's work" was insulated from the widespread technological progress of the nineteenth century, remaining largely unchanged by innovation. Despite the evidence from such limited sources as diaries, catalogs, and letters, however, the diffusion of household inventions was hardly slow, let alone nonexistent. Although the existence of a patent does not indicate whether an invention ever became a commercial success, the systematic data in this study indicate that women inventors—like inventors in general—expected to benefit from their investments in inventive activity. Female patentees who specialized in household inventions were exercising a comparative advantage in responding to market demand, and many of their domestic improvements had commercial success. Sources such as assignment contracts and the decadal census show the existence of establishments devoted to producing similar articles. Although more research needs to be undertaken, a not unreasonable inference is that the changes in technology that transformed the world outside the home may have also been instrumental in transforming the household during the postbellum period.

The literature is ambivalent about the role of technological change in the lives of frontier and rural women in this arena. Some have argued that men who were prompt to purchase innovations for the farm were resistant to improvements in the home, and that women did not have sufficient power to counter their wishes. "Pessimists" also assert that technological change led to a "deskilling" of women's work and the devaluation of women's contributions to the household. Other studies, however, point to the importance of women's innovations in such key industries as dairy farming and food preservation, and to changes in the nature (if not the time-consuming aspect) of housework. Although the evidence at hand cannot directly address this complex issue, the results reported herein imply a more optimistic view about the role of rural women as creators and users of innovations. The distribution of women's patenting was far more concentrated in rural areas than it was for men, especially in frontier states. Moreover, there appears to have been a ready market for women's inventions.[31]

31 See Pamela Riney-Kehrberg, "Women, Technology and Rural Life: Some Recent Literature," *Technology and Culture,* XXXVIII (1997), 942–953, for a survey of studies about the role of technological change in women's lives.

Although this study offers conclusions from a systematic analysis of data that are amenable to quantitative analysis, supplementation by more broadly ranging sources is useful. For instance, technological change encompasses improvements in diet as well as techniques of food preparation, more efficient childrearing processes, and new furniture designs. Nevertheless, even within the narrow confines of patented inventions, women were by no means passive bystanders in an environment deprived of the innovations that were revolutionizing the workplace. They were applying their creative insights to the sphere of influence in which they had the greatest experience. In the process, many were introduced to the market in their attempt to pursue profit. Patentees may have been atypical of women in general, but their experience suggests that the spheres of household and market were closely linked for both men and women. Additional quantitative research, especially in the extensive archives of assignment contracts, would be valuable. Further evidence of an active market in domestic inventions may shed more light on the conclusion that, like the economy at large, the household economy was the locus of both invention and innovation. The answers hold important implications for our assessment of women's standard of living during the nineteenth century.[32]

APPENDIX: DATA SOURCES

Toward the end of the nineteenth century, the United States Patent Office published a list of women patentees—*Women Inventors to whom Patents Have Been Granted by the United States Government, 1790 to July 1, 1888 (WIP)*—and two appendixes that extended the coverage through March 1, 1895. The publication included 3,975 patents filed either by women alone or women with co-inventors (both male and female), omitting initials and androgynous names. *WIP* catalogues the patent number (available after 1836); the names of inventors, co-inventors, and assignees (if the patent right was transferred at time of issue); state and

32 A good example of literature that adopts a more inclusive definition of technology is Sarah McMahon's study of early New England households, "Laying Foods By", in McGaw (ed.), *Early American Technology: Making and Doing Things from the Colonial Era to 1850* (Chapel Hill, 1994). McMahon proposes that "the search for better methods may well have followed the growing impulse, in rural New England households, to adopt new methods and technologies that were being developed in agriculture and cooking in the first half of the nineteenth century" (177).

city of residence; a brief description of the invention; and the date that the patent was issued.

This list is incomplete, however; it should be regarded as a sample, rather than a complete census, of the population of female patents. The preconception that women invent few technically complex devices probably influenced the exclusion of androgynous names. However, in most cases, the omitted names are quite common, evidently female names, the result of careless tabulation on the part of the patent office clerks drawing up the list. *WIP* omitted roughly 56 percent of patents issued to women in 1870. The omission of patents granted to women subsequently decreased (at least in the years that I checked): 21.0 percent in 1876, 14.5 percent in 1888, 9.9 percent in 1889, 14.3 percent in 1890, and 9.8 percent in 1891. My sample, which totals 4,198, includes missing data drawn largely from 1888 to 1891. The basic patterns are not altered by the inclusion or exclusion of the missing data, suggesting that the omissions were not systematic. I categorized inventions according to sector of final use, and also obtained information on the numbers of patents per person and the length of inventive career (defined as the period between the first and last patent up to 1895).

The Patent Office records also normally included information about assignments that were made at the time that the patents were issued. The data regarding assignments of women's patents are unreliable for the earlier years, and are entirely missing from *WIP* between July 1, 1888, and October 1, 1892, but I retrieved them from the Patent Office Gazette. Additional information about assignments transacted after the patent's issue date was obtained from the records held at the National Archives. Since these records are voluminous, I constructed a random sample of assignments by selecting inventors whose name started with the letter "B." This is a standard procedure; individuals do not vary systematically depending on their initials.

City directories from 1875 to 1890 provided additional information about the marital status and occupations of the inventors holding 900 patents or so. Cities include Washington, D.C., Indianapolis, Oakland, San Francisco, Los Angeles, Brooklyn, New York, Buffalo, Syracuse, Toledo, Philadelphia, Pittsburgh, Providence, New Orleans, Kansas City, Topeka, Jersey City, Newark, Cambridge, Boston, Worcester, Springfield, Framingham, Milwaukee, Detroit, Grand Rapids, Minneapolis, St. Louis, Kansas City (Mo.), Cincinnati, Cleveland, Toledo, Denver, New Haven, Chicago, Baltimore, and Portland (Oreg.).