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Abstract

This paper explores the representation of women inventors in historical records and uncovers potential biases that influence our current understanding of history. By examining a comprehensive database of nineteenth-century French patents as a case study, we discover that women filed more patents than contemporary biographical records suggest. Further, we illustrate that women's inventive endeavors spanned all industries, challenging the perception that their contributions were confined to specific sectors. Beyond enhancing our awareness of women's patenting endeavors, our findings underscore the need to confront systematic biases and exclusionary practices in historical documentation. Such efforts are necessary for fostering a more inclusive and accurate comprehension of women's contributions to technological development and economic processes.

Keywords: Patent • Innovation • Gender • Women • Nineteenth Century • France

JEL Classification: J16, N33, O30

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> "*Il n'est pas étonnant qu'en tout pays l'homme se soit rendu le maître de la femme, tout étant fondé sur la force. Il a d'ordinaire beaucoup de supériorité par celle du corps et même de l'esprit. On a vu des femmes très savantes comme il en fut de guerrières; mais il n'y en a jamais eu d'inventrices*" [Our translation: It is not surprising that in every country the man has made himself the master of the woman, everything being based on force. He usually has a great deal of superiority in body and even in mind. We have seen very learned women as there were warriors; but there have never been female inventors] – Voltaire (Dictionnaire Philosophique, édition Lequien, 1829, tome 4, article « Femme », p. 354)

1. Introduction

The role of technical and scientific knowledge in the emergence and adoption of innovative industrial technology fostering industrialization is well documented. Scholars argue that a sustained acceleration in innovation lies at the core of the Industrial Revolution (Mokyr, 2010; Mokyr et al., 2019), and highlight the importance of human capital as a key element for the long-run development process (Diebolt and Hippe, 2019), including women's human capital (Diebolt and Perrin, 2013, 2019; Baten and de Pleijt, 2018).[1] Inventors are found to be critical actors within this process (e.g. Squicciarini and Voigtländer, 2015; Cinnirella and Streb, 2017; Diebolt and Pellier, 2020; Juhász et al., 2020; Hanlon, 2022; Maloney and Valencia, 2022), particularly through the industrialization channel (see MacLeod and Nuvolari, 2010). Scholars often rely on registries and biographies of inventors, and their creations, as empirical evidence to understand who was patenting, what type of inventions, and when new innovations were developed. However, a closer examination of these data reveals a striking pattern: women are severely under-represented when not wholly absent. This under-representation is not limited to specific regions or periods but is a global phenomenon.

In this paper, we delve into the French case to investigate the extent of women's under-representation and shed light on this frequently neglected aspect of innovation history. As per widely available biographical data, notable women inventors in France seem to have only surfaced once or twice during the 19th century (e.g. de Graffigny, 1928). This is exemplified by the book '*Brevets d'Invention Français 1791-1902*', a collaborative work with the National Institute of Industrial Property,[2] published in 1958. The book presents a thorough summary of

[1] See Merouani and Perrin (2022) for an exhaustive review of the literature on gender and the development process.
[2] In French: *Institut National de la Propriété Industrielle (INPI)*

patenting activity in France throughout the nineteenth century, but citing only two women. One woman is marginalized as a beneficiary of the previous system of *Privilèges*, while the other is portrayed solely as representing her husband (Plaisant et al., 1958). Some scholars have argued that stereotypical assumptions on women's historical (lack of) involvement in the development of technology is due to how history has been written – not as it has been experienced (Lerman et al., 1997). These observations raise an important question: Does the under-representation of women inventors in biographies accurately reflect their contributions to technological and economic advancements, or could it reflect systematic biases and exclusionary practices distorting our perception of women's contributions to past innovation processes?

Drawing upon Merouani and Perrin (2022), we argue that large scale datasets with detailed individual-level information are necessary to address these questions. In this paper, we compile a comprehensive database of nineteenth-century French patents from the National Institute of Intellectual Property. We find that while women were patenting less than men, their patenting activity significantly surpassed what was suggested by contemporary biographical data. Our data unveil that thousands of women inventors patented their inventions during the nineteenth century. Moreover, these women inventors were patenting across all industries, not only those typically associated with women's work. These findings challenge the notion that women's contributions to technological innovation were limited to certain sectors, providing evidence of their widespread involvement across all industries. Our results underscore the necessity of addressing systematic biases and exclusionary practices in the historical records to accurately grasp women's contributions to the development process.

2. The French Patent System and its Evolutions

2.1. Establishment of a Modern Patent System

Patent systems have been developed to promote and incentivize innovation activity. They offer inventors returns on their inventive and innovative efforts by protecting their inventions and publicizing them. Patent laws influence not only the quantity but also the direction of innovation by encouraging diversified innovation across various industries (Moser, 2005).

The current patent systems originate from the revolutionary period when, prior to implementing a modern patent system, arbitrary privileges and monopolies prevailed. The first laws protecting inventions through patents, in their modern sense, date back to 1790 for the United States and 1791 for France. The evolution of modern property rights regulation in France

transpired gradually. The recognition of inventors' rights began to slowly take shape in the latter half of the eighteenth century, and this was reinforced during the nineteenth century with the establishment of national legislation for obtaining and exploiting industrial property rights on drawings and models (1806), patents (1844), and brands (1857). Prior to 1789, authors of industrial inventions were not recognized by the law, but they could obtain an exclusive privilege for exploiting their innovations (Isoré, 1937).

The first laws related to valuable discoveries were enacted in France on January 7, 1791, and May 25, 1791. Consequently, all discoveries or new inventions became the property of their author, to whom the law guaranteed full enjoyment. The patent was envisaged as a contract of a limited duration: 5, 10, or 15 years, with progressive fees of 300, 800, or 1500 *livres tournois*. Half of the fees had to be paid when requesting the patent, with the remainder due six months later. The cost of patenting was prohibitive, potentially making French patents inaccessible to many inventors (Galvez-Behar, 2019). The contract was made between the '*Société des Inventions et Découvertes*' and the inventor. According to the law, the inventor benefited from property rights, granting them an exclusive monopoly to exploit the patent. The patent was issued without prior examination of the novelty, the value, or the very existence of the invention (Marchal, 2009). The 1791 laws differentiated between three types of patents: patents for invention (*brevet d'invention*) – protecting all discoveries or new inventions; patents for improvement (*brevet de perfectionnement*), protecting every method to elevate any kind of production to a new level of perfection; and patents for importation (*brevet d'importation*) – protecting anyone who would first introduce an invention to France from foreign discovery (see Emptoz and Marchal, 2002).[3]

After several attempted reforms between 1791 and 1844 (see Galvez-Behar, 2019), a new patent law was adopted in 1844. The law specified various aspects of the 1791 laws. Among the primary changes, the 1844 law narrowed down the definition of property rights as an exclusive right for the author to exploit to his benefit a discovery or a new invention (Art. 1).[4] The law recognized as new inventions or discoveries: the invention of new industrial products; the invention of new processes or the novel application of known processes to achieve a result or an industrial product (Art. 2). The creation of a '*certificat d'addition*' enabled

[3] Patent holders enjoy the freedom to make unlimited modifications and additions to their original patent by submitting new applications, adhering to the same procedural guidelines as for the *Brevet d'invention*, while incurring a nominal fee of 24 *livres tournois*.

[4] Art.1: Any new discovery or invention in all types of industry confers on its author, under the conditions and for the time determined below, the exclusive right to exploit for his benefit said discovery or invention.

patentees (or beneficiaries of the patent) to make changes, improvements, or additions to the invention during the term of the patent. Each request to obtain a certificate of addition required the payment of a fee of five hundred francs. The validity of patents' duration, which could be extended, remained unchanged with a single annuity of one hundred francs (previously *livres tournois*, until 1793) to be paid by the applicant, regardless of the chosen duration of the protection.[5]

Significant changes in the 1844 law concerned the cost of patenting and the patents for importation. The patent tax increased to 500 francs for five-year patents and to 1,000 francs for ten-year patents, payable by an annuity of 100 francs – under penalty of forfeiture if the patentee failed to make a payment (Art. 4). Galvez-Behar (2019) argues that this new possibility to spread the payment of the tax promoted a democratization of patenting by enabling artisans or small entrepreneurs to patent by decreasing its actual cost. The 1844 law abolished the patents of importation ('*brevet d'importation*'), i.e. the importation of inventions from foreign patentees to be registered in France by people who were not the inventors permitted by the 1791 law. However, the law allowed foreigners to obtain patents in France. According to Art. 29 relating to the rights of foreigners, the author of an invention or discovery already patented abroad may acquire a patent in France. However, the patent duration could not exceed that of patents previously obtained abroad.

2.2. Women's Property rights and the Patent System

Khan (1996) demonstrated in the context of the United States that women were historically barred from obtaining patents. For the majority of the nineteenth century, married women were subject to the "disability of coverture", which precluded them from owning property in their own name. They were also prohibited from rights to their own income, encompassing income from any invention they conceived (Khan, 2005). A shift in the legal status of women began in the individual States of the United States in 1839. However, the movement faced significant opposition and it took several decades for the Married Women Property Acts to be implemented across States. The Act aimed to alleviate some of the challenges women faced under coverture. Similarly, in the UK, the Married Women Property Act was established in 1882, aiming to rectify some of the difficulties women faced under coverture (McMillen, 2009).

[5] The 1844 law complemented the 1792 law prohibiting financial institutions to file patents (September 20, 1792) by removing the possibility to patent pharmaceutical compositions and remedies of all kinds (July 5, 1844).

Per the Roman legal tradition, most parts of southern Europe, as well as the French written law of the *Ancien Régime*, limited the legal status of women (Gerhard, 2016). With the French Revolution, the lawful guardianship of men over women became gradually challenged, and the implementation of several laws put women on a more equal footing with men (see Perrin, 2022). The Legislative Assembly notably introduced civil marriage (with equal rights between spouses), matrimonial majority and emancipation from paternal authority at 21 years, freedom of divorce by mutual consent, and equality in inheritance between sons and daughters.

The implementation of the French Code Civil in 1804 marked the patriarchal reaction to the rights of freedom and equality that women had acquired during the Revolution (Gerhard, 2016). The Napoleonic Code is infamously known for its rigid and misogynistic regulations that reinforced male dominance over women. According to the Code, women were subject to marital power in all respects. Women were not deemed independent legal persons and were required to obtain their husband's authorization for every legal act and business, whether managing their household or engaging in independent commercial activity. Women could not sue or contract. They could own property but not acquire or dispose of it or benefit from income from its activity. Even when the spouses lived under the regime of separate property, the wife could not dispose of the landed property, which belonged to her, without her husband's consent.

Despite the strict regulations introduced by the Civil Code, women were able to register patents in their own names. As described in the law, the patent system reflects the system's openness regarding the inventor's status. Article 5 of the 1844 law, which indicates the formalities of the patent application, declares the formalities applicable to "whoever wishes to take out a patent." This article is complemented by the reference that "the law also does not authorize the administration to inquire about the civil capacity of the petitioner. If the request comes from a married woman, a minor, or a prohibited person, the administration must issue the patent" (see Pelletier, 1893).

3. A Database of Nineteenth Century French Patents

3.1. Sources and Construction of the Database

Chanteux (2009) and Khan (2016) have improved our understanding of women inventors in nineteenth century France using samples of women inventors. Chanteux (2009) paints the portrait of the French woman inventor as relatively autonomous, technically knowledgeable, and socially active. Focusing on women's patents for the 1791-1855 period, Khan (2016)

further demonstrates that entrepreneurship and innovation were not limited to societal elites but also pursued by middle-class women. However, comprehensive databases covering the entirety of the century remain unavailable. In this paper, we complement these seminal works by gathering information about women (as well as men) who held patents throughout the entire nineteenth century.

Our database encompasses patents issued in France between 1791 and 1900, and covers about 390 thousand patents. To achieve this, we use information about patents from the National Institute of Industrial Property (INPI). Patent entries provide valuable and essential information on individual patents, including the registration date, duration, and description, as well as the names of depositors, the marital status of female depositors, and information on the city or commune from which the depositor hails. Some of these records contain additional relevant details, such as legal issues (INPI, 2011). Second, we transform these data from text into structured form for analysis. Third, we standardize and correct, when necessary, as the accuracy of patent-level information is crucial to conduct a reliable exploration of patenting activities. Additionally, we constructed variables such as the gender of the depositors, by exploiting the use of honorific titles, kinship terms describing the relations between depositors, linguistic gender marking, and first names when applicable.

3.2. Challenges – An Example

Emphasizing the existence of a number of inconsistencies and errors in the patent data, such as frequent misspellings of names, incomplete occupational records, and inconsistent addresses, is crucial. These limitations curtail the precision of statistical analysis, including that of micro-level geographic analysis. Nonetheless, it provides an excellent foundation for accurately analyzing women's patenting activities from a dynamic and macroeconomic perspective, while highlighting the discrepancies that conceal their contributions.

The patent granted to inventor Jeanne-Geneviève Labrosse (1775-1847) serves as a notable example that underscores the challenges of researching women's contribution to innovation. The existence of heightened uncertainty and occasional confusion in historical records related to patents awarded to women compared to men can mask the contributions of women inventors.

Jeanne-Geneviève was a witness to the first successful, albeit nearly fatal, parachute descent by André-Jacques Garnerin on October 22 1797 – an invention he had designed a few years earlier. She became his student, and by 1799 she executed her first descent (Millet, 2022), becoming the first woman to do so. "A woman has just demonstrated that her gender, too, is

capable of executing daring and astonishing feats. Rising into the air to a height of 1200 meters, then detaching oneself from the aerostat and descending by parachute - I bet more than one spectator would not have dared to attempt it. Yesterday, around four-thirty, citizen Labrosse, a student of citizen Garnerin, entered the area that separated the public from the aerostat. […] The citizen Labrosse, after graciously greeting the spectators, rose to a prodigious height from where her parachute gently brought her back down to earth" (Tivoli, 1799, p.3).

During their time together, the original design of the parachute became measurably better. Not only did the height of their descent significantly increase compared to the initial descent of André-Jacques, but also the safety was vastly improved (Millet, 2022). In 1802, Jeanne-Geneviève, now Garnerin, was granted a patent for the frameless parachute. The INPI provides documents associated with her application under the code "1BA185". The patent entries from INPI serve as condensed overviews of already summarized patent information.[6] The contained summaries within these books are derived from already summarized information presented on the front page of patent applications. The digitized entry provided by INPI describes Jeanne-Geneviève Labrosse as a widow (see Figure A in the Appendix). It additionally includes an observation stating that the "applicant is the wife of André-Jacques Garnerin, physicist aeronaut". Together, these two pieces of information imply Jeanne-Geneviève merely representing her husband in the application of his invention.

The original patent documents, however, do not designate Jeanne-Geneviève as a widow (see Figure B in Appendix). Indeed, André-Jacques died in 1823, hence, Jeanne-Geneviève was not a widow when she received the patent. Further, on the same page of the patent documents, the administrators write that "Jeanne-Geneviève's husband gave her the power to petition for a patent for his invention." However, the patent office allowed depositors to have official representatives. There is a clear distinction in the records between being a depositor and being a representative of a depositor. There are also virtually no limits on the number of depositors. Despite this regulation, the sole official depositor in this case is Jeanne-Geneviève.

The content of the application's documentation and attached letters provide compelling supplementary evidence that the invention behind the patent was a joint effort of the Garnerin couple. Apart from leading the application process, Jeanne-Geneviève signed the documents

[6] These entries are brief summaries digitized from the *Catalogues des Brevets d'Invention* book series. The inaugural volume of this series was released 34 years (1825) after the inception of the patent system, with yearly publications following until 1883. At this point, the patent office administration replaced these volumes with the *Bulletin Officiel de la Propriété Industrielle*.

describing the invented parachute and explicitly referred to "this invention, of which I am the author" (see Figure C in Appendix). The documentation includes several pages signed by a notary describing the extensive and virtually unlimited powers held by Jeanne-Geneviève, suggestive of the necessary authorities to run a family business. Such documentation is unusual in patent applications, and we could not find similar examples attached to women's patent applications for the corresponding period.

When considering solely the biography, Jeanne-Geneviève's contribution to developing the invention and the application process is omitted. In his reflections on the 1797-1837 parachute designs, Jackson (1964) makes a detailed analysis of the invention but never mentions the close collaboration of the couple Garnerin, mentioning only the husband. Soreau (1959, p. 243) mistakenly describes Jeanne-Geneviève as the first female patent holder[7] and insinuates that she merely represented her husband. However, upon closer examination, it becomes clear that this was not be the case. While it is well-documented that the original design of the parachute was her husband's work, there is no direct evidence from the Garnerin couple asserting that Jeanne-Geneviève had no involvement in the final design. In fact, historical records indicate that she played a significant role in their collaborative work. Prior to their marriage, she was both his student and collaborator. Their remarkable collaboration has been documented through the account of some of their adventures published in newspapers (see La Chronique Universelle, 15 juin 1798; La Chronique Universelle, 17 novembre 1798; L'Ami des lois, ou Mémorial politique et littéraire, 14 octobre 1799). Given this evidence, it is difficult to conceive that she played only a minor role in the development of the patented parachute design.

We chose the case of Jeanne-Geneviève to highlight the difficulties with researching women's role in innovation. Her case could arguably be a situation of uncertainty, as could be present in other patent applications. However, even in cases where there should be no doubt, prevailing assumptions about women's capabilities and systematic biases in secondary sources render women inventors largely more likely to be overshadowed than men. Even in the most clear-cut cases, history seems to have overlooked women's contributions to innovation processes. The construction of a database gathering information about women patentees will hopefully set the stage for a better understanding of women's role in these processes.

[7] By the time Garnerin applied for her patent, three patents had already been granted to women. The first women to acquire such patent was Françoise Guyonne Le Roi De Jaucourt.

3.3. Content of the Database

Our final database encompassed information about 390 thousand patents, of which over 6,800 linked to women.[8] This data provides a valuable window into the contributions of both women and men in patenting activities. Besides detailing the invention itself (through specifications such as description, type of patent, submission year, and length), the database contains information about the patentee(s). As mentioned earlier, we can identify the gender of the patentee(s) and determine whether the patent was granted to a single inventor or as part of a collaborative effort.

Table 1 illustrates the distribution of patents by type: *brevet d'importation* (patent of importation)[9], *brevet d'invention* (patent of invention), or *certificat d'addition* (certificate of addition). Most patents registered between 1791 and 1900 were awarded for a duration of 15 years. Upon examining the overall distribution of patents, we discover that 74% are '*brevets d'invention*' valid for 15 years, 20% are certificates of addition, 3% are patents of importation, and the remaining 3% are divided between the '*brevets d'invention*' granted for five and ten years. This distribution, based on the type of patent, remains consistent irrespective of whether one examines women's inventions, men's inventions, or inventions developed by mixed-gender teams.

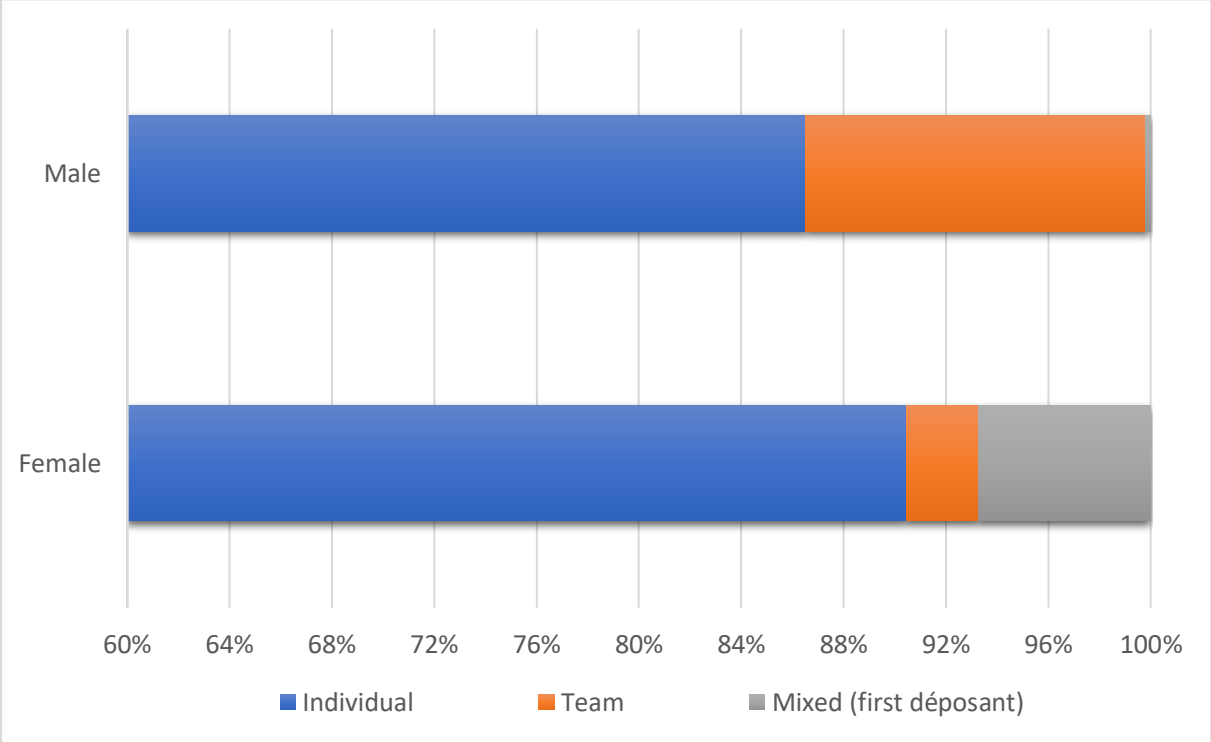
Table 1: Distribution of Patents by Type and Gender

	Women (%)	Men (%)	Mixed (%)	Total (%)
Brevet d'importation 5 ans	0.10	0.12	0.18	0.12
Brevet d'importation 10 ans	0.03	0.25	0.18	0.25
Brevet d'importation 15 ans	1.17	2.85	1.26	2.82
Brevet d'invention 5 ans	2.25	1.97	2.33	1.97
Brevet d'invention 10 ans	0.99	1.39	1.35	1.38
Brevet d'invention 15 ans	74.36	73.65	75.31	73.67
Certificat d'addition	21.09	19.77	19.39	19.79
Total	100	100	100	100

[8] 5734 patents are only by women, without any men linked to them.
[9] See Nuvolari et al. (2020) for a discussion on the patterns of technology transfer from Britain to France during the 1791-1844 period.

Figure 1 highlights the proportion of patents associated with individual inventors, teams, and mixed-gender groups. Both men and women inventors were more likely to patent individually than in teams: 91% of women's patents are individual patents compared to 86% for men's patents. Women were somewhat less likely than men to patent in teams, with 14% for men against 9% for women. Notably, in teams, the probability is relatively higher of finding inventors from both genders (i.e. mixed-gender teams) when the first depositor is a woman.

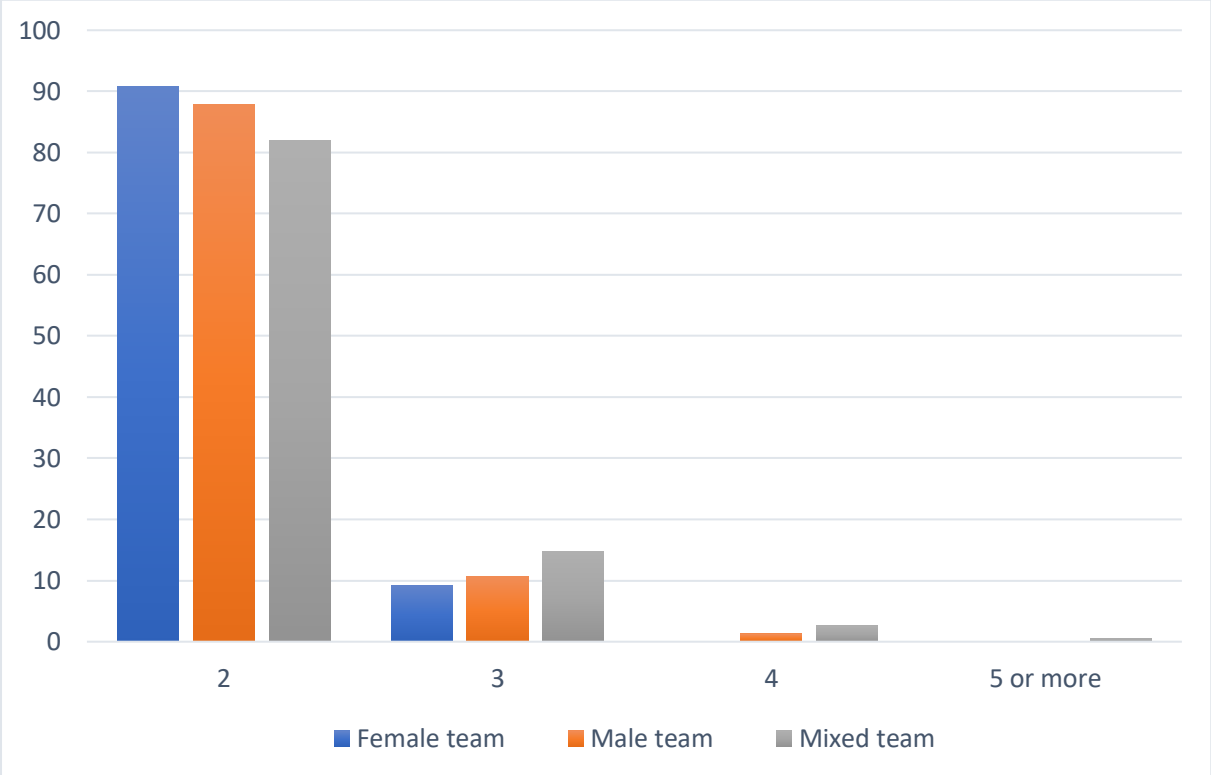
Figure 1: Inventor Constituency by Gender, 1791-1900



Certain women patentees stand out due to the substantial number of patents registered in their name. One such example is Marie Joséphine Herminie Michelle. Born in Besançon (Doubs, France) in 1830, Marie holds over 30 patents, placing her among the most prolific women in our database. During her patent applications, she resided in Paris. Her list includes 13 patents of invention, each lasting 15 years, and 17 patents of addition. In 1853, she married Joseph Antoine Jean Redier, known for his "*Comparateur Chronométrique*", which addressed the challenge of precise synchronizations for timepieces in the nineteenth century (Arnott, 2014). Although her husband also held many patents, their areas of expertise diverged. While

Marie focused on barometers and certain aspects of pendulums in larger timekeeping instruments, her husband showed some interest in pendulums but primarily concentrated on other facets of time precision instruments. Marie Joséphine Herminie Michelle's exceptional patent portfolio sets her apart from most women inventors recorded in the database. However, much like most women inventors, she is – to the best of our knowledge – never acknowledged in biographies of inventors as anything beyond being her husband's wife.

Figure 2: Distribution of the Number of Inventors on Teams, 1791-1900



When we scrutinize the number of inventors on teams—whether all-female, all-male, or mixed-gender (Figure 2)—we find that most teams consisted of two patentees: 91% for female teams, 88% for male teams, and 82% for mixed-gender teams. Overall, female teams were smaller than their male and mixed counterparts. Interestingly, several of the largest teams in our database comprise inventors of both genders. Teams with female members, particularly the larger ones, are typically tied to family businesses. For instance, we encountered a certificate of certificate of addition registered by a mixed-gender team of 12 individuals (five women and seven men) which included Marie Foudegoire (a widow), as the first depositor, along with other members of the Fougedoire family. We also came across a 15-year patent of invention awarded

to the widow Frezon and her son, two daughters, and two sons-in-law for enhancements to the process known as *frézonnage*.[10]

3.4. Geographic Distribution

Figures 3a and 3b delineate the geographic distribution of patenting activities for women and men, respectively, determined by the address furnished by the first depositor on the patent. The geographic distributions of women's and men's patents bear striking resemblances. Both maps underscore the pronounced dominance of large industrial cities in determining patent density.

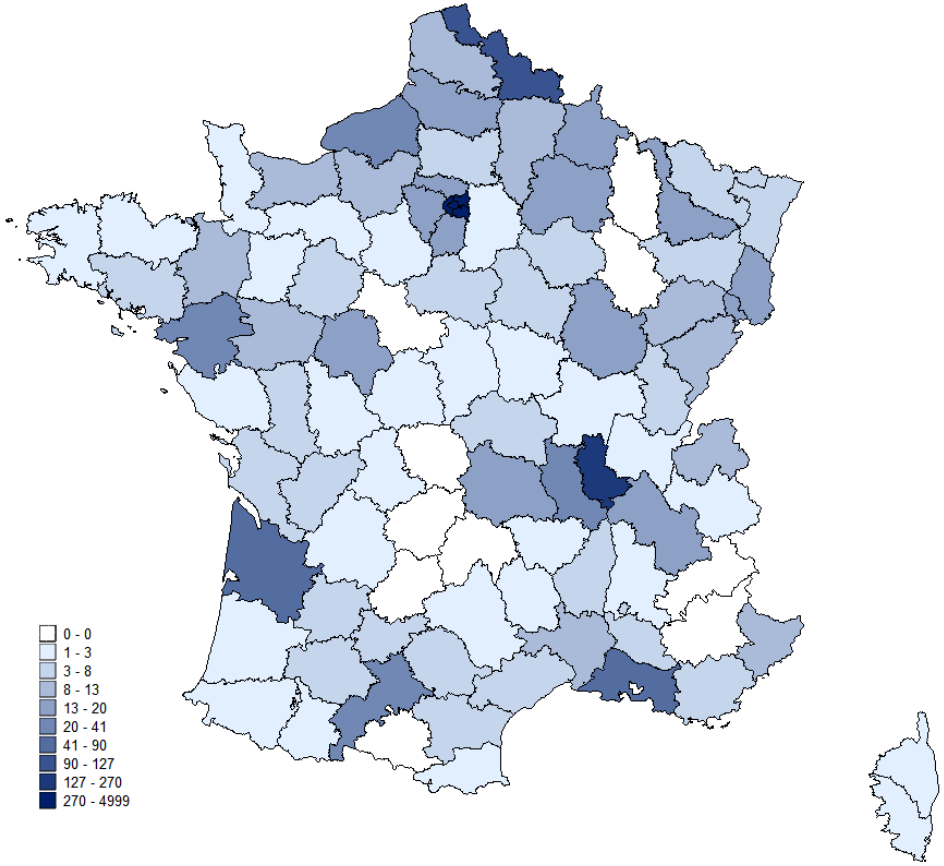
Paris is the most prominently represented city in our overall sample. When zeroing in on women's patenting activities, Paris amasses a significant 4,845 patents on its own. It is followed by Lyon (240 patents), Marseille (89 patents), Bordeaux (65 patents), Lille (65 patents), and Toulouse (34 patents). Nonetheless, for Paris, we have compelling reasons to speculate that a non-negligible share of the patents associated with the city were filed by depositors residing outside of Paris. These individuals likely provided either the address of the address of their temporary residence during the patenting process, the address of family members or acquaintances, or the address of their representative residing in the city.[11]

[10] See Igersheim and Le Chapelain (2022) for an interesting article tracing the history of Amélie de Dietrich in her role as head of one of the oldest family-owned businesses in Europe.

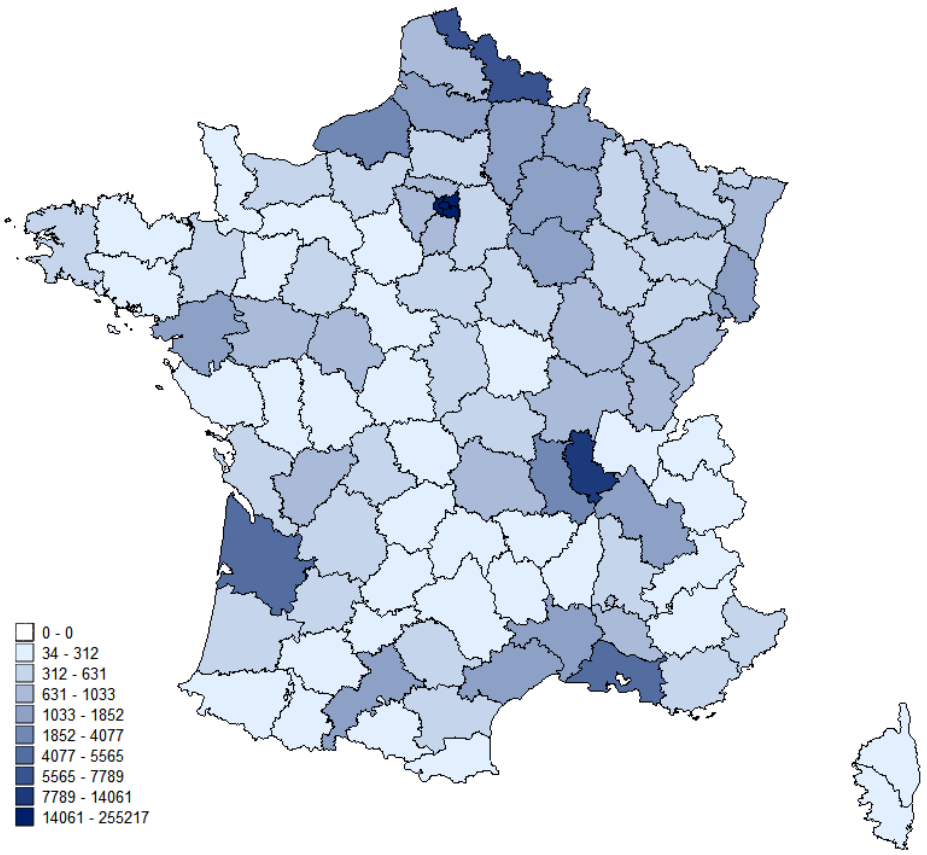
[11] This over-representation of Paris could partly be explained by the law of May 1791 (article 2 of the First Title decreed on March 29) itself, which stated that the patent "will be established, in Paris, in accordance with the article, under the supervision and the authority of the Minister of the Interior, as well as by the centralization of patent administration in the capital city. This is an issue that we are solving by linking the individuals to census and other data available at the individual level.

Figure 3: Geographic Location of Patents' Registration, 1791-1900

(a) Women Patents



(b) Men Patents



4. Longitudinal Evolution of Patenting Activities

4.1. Trends in Patenting Activities by Gender

The inaugural *brevet d'invention* awarded to a woman in France was received by Madame Françoise-Guyonne Le Roi de Jaucourt in 1791 for her novel metallic varnish capable of preserving copper, iron, firearms, and other metallic instruments from rust.[14] From the inception of the modern patenting system in France in 1791 to the modification of the law in 1844, 272 patents were assigned to women. Following 1844, the number of patents granted to women rose considerably.

Figure 4 outlines the evolution and extent of patenting in France between 1791 and 1900. The left axis depicts the annual number of patents granted to women and mixed-gender teams, while the right axis corresponds to the number of patents granted to men. The graph indicates that patenting activity by women in France took off by the end of the 1830s. Although women were actively patenting throughout the majority of the nineteenth century, with over 6,800 patents registered in their name, they did not patent to the same degree as men. However, the correlation between the two series is remarkable. Notably, two distinct sudden declines are visible, impacting both genders: the first right before 1840s concluded and the second at the commencement of the 1870s. The former corresponds to the *Révolution de Février*, the French Revolution of 1848, while the latter aligns with the *Guerre de 1870*, the Franco-Prussian War.

Interestingly, during the larger part of the nineteenth century, women in France patented to a relatively larger degree than their counterparts in the US and the UK. In 1814, France reached a peak of 5.6%, an unprecedented share of patents awarded to women. This figure significantly outstrips those from the two most advanced countries in patenting at the time – the US and the UK (see Khan, 2016, 2020). The same proportion of female inventors associated with patent applications was only reached again in the 1980s.

[14] Before the establishment of the modern patent system, the king had granted several 'privilèges' to reward women for their inventions. Among them, we find Marie de Baillon who received a *privilège* in 1611 for "three inventions of the most convenient and useful to the public and very necessary for her designs and companies to know the industry to make and manufacture a clock with the help of an element which will make the monster work; an infinite roll; a grater"; or Magdelaine Bel who received a *privilège* in 1624 for the "establishment and continuation of satins from Bruges and Damas in Troyes".

Figure 4: Men and Women Patents, 1791-1900

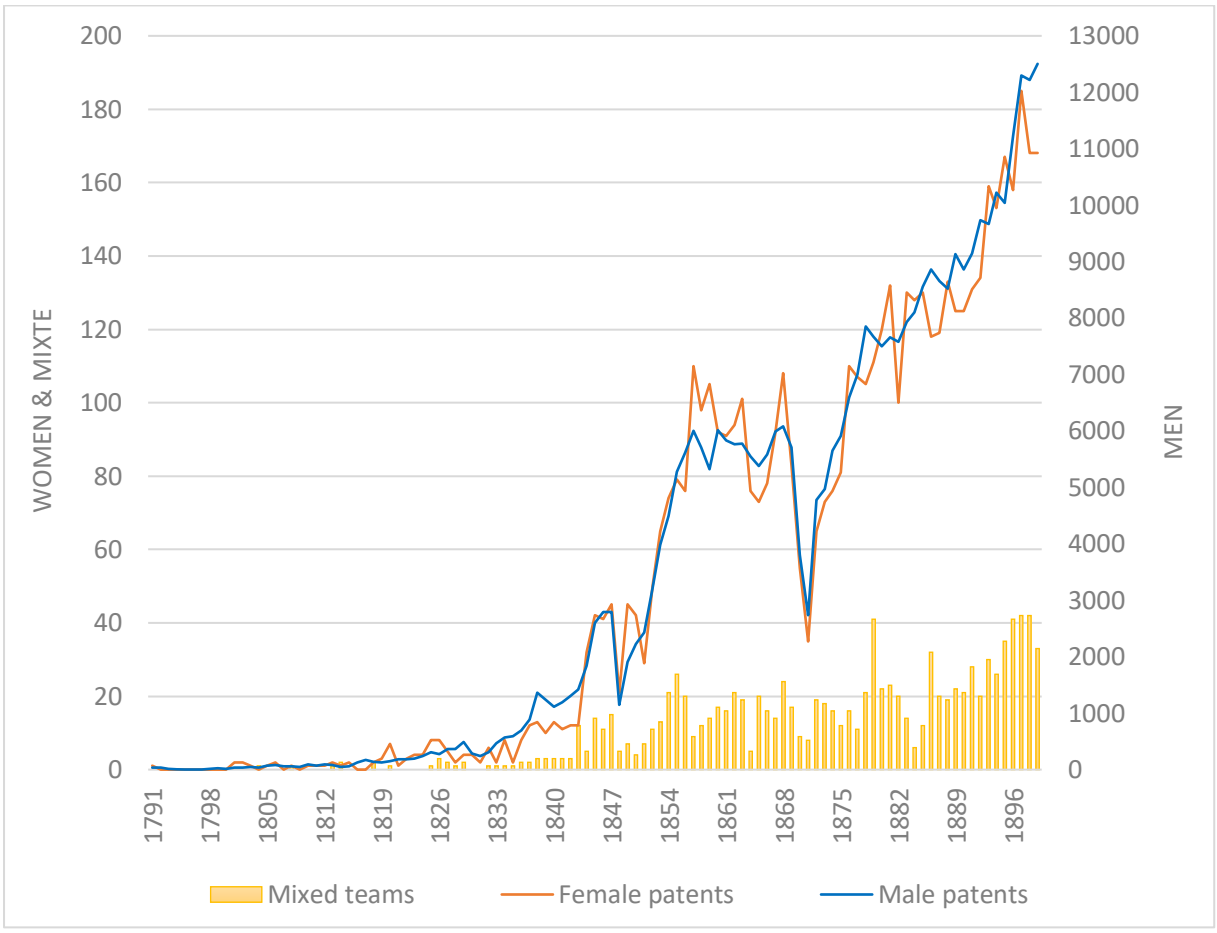
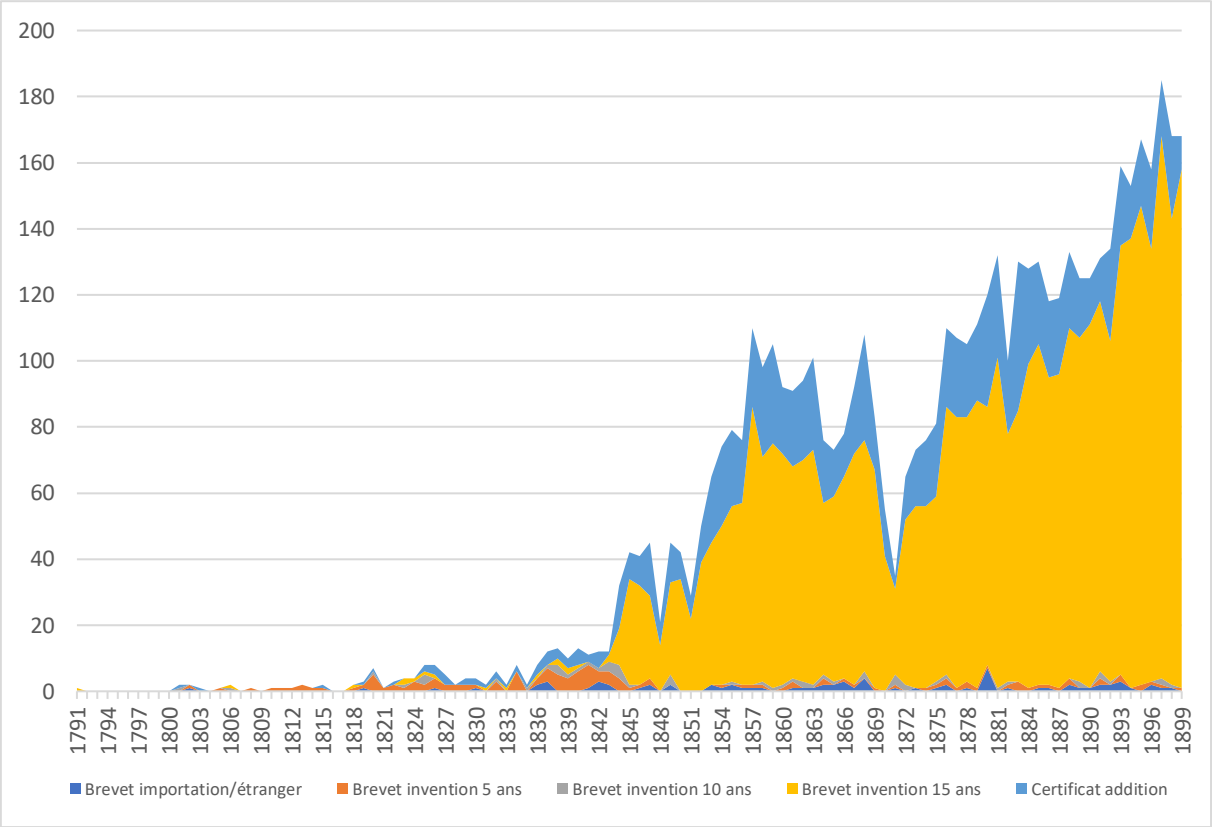


Figure 4 highlights that men and women also collaborated to obtain patents during this period. Patenting by mixed-gender teams did not become frequent until the 1840s. While the share of mixed-gender teams remained relatively low, their presence increased during the second half of the nineteenth century. Women patented both alone and as part of a team, either in all-female teams or together with men. A higher share of men's patents resulted from cooperation than women's. Men's teams were, on average, larger than women's teams (as discussed previously in subsection 3.2.).

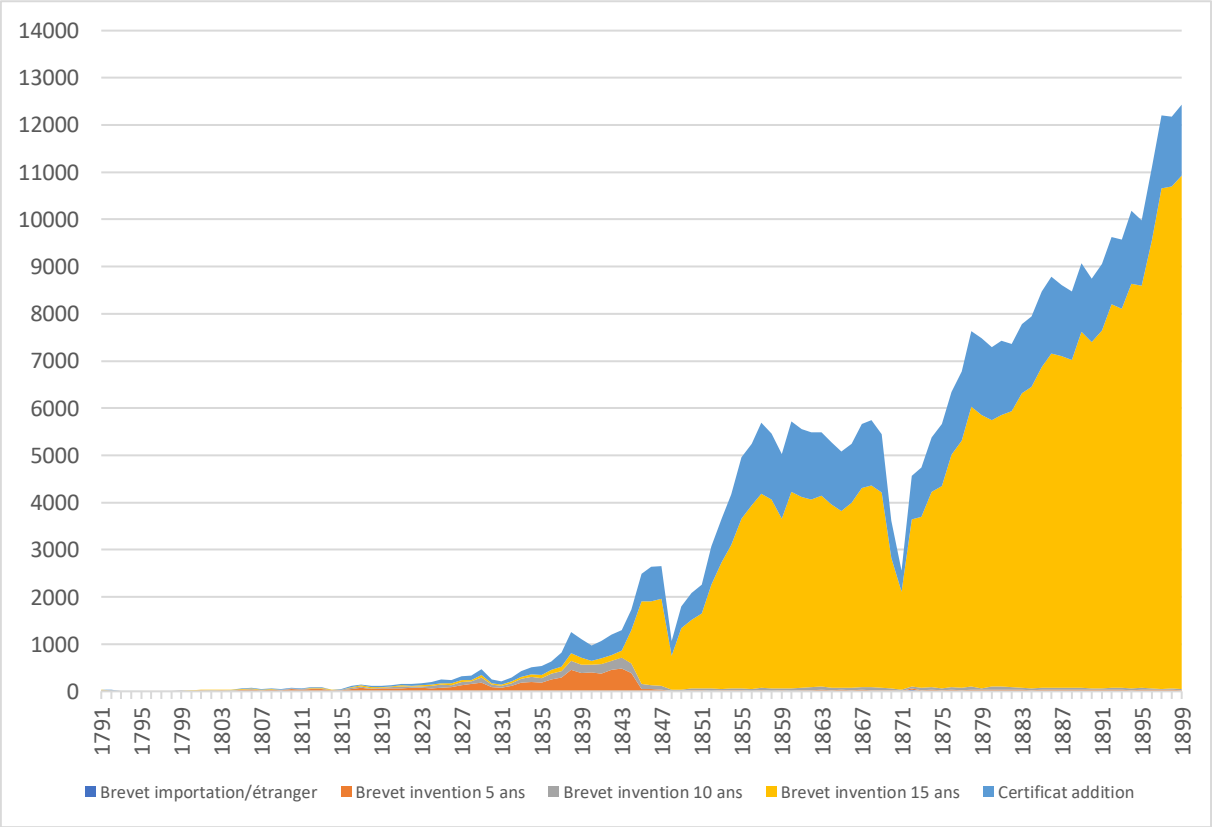
While we observe a substantial penalty for being a woman (women patented considerably less than men throughout the century), it is intriguing to see a robust correlation in the trends followed by men's and women's patents (with more volatility observed in the trend of women patents due to the smaller number of patents). It appears that men's and women's patenting activities were similarly impacted by the various shocks affecting France during the century.

Figure 5: Patents by Types, 1791-1900

(a) Women



(b) Men



4.2. Effects of the 1844 Law

As discussed in section 2, a new law specifying various points of the 1791 laws was adopted in 1844 (see Galvez-Behar, 2019). Among the principal amendments, the 1844 law constricted the definition of property rights as an exclusive entitlement for the author to exploit a discovery or a new invention for their benefit and reformulated the cost of patenting. The patent tax increased to 500 francs for five-year patents and to 1,000 francs for ten-year patents.

Figures 5a and 5b trace the evolution of patents by type for women and men, respectively. The effect of the 1844 law is clearly observable on both figures. The '*brevets d'invention de 5 ans*' and '*brevet d'invention de 10 ans*' saw a significant decrease, while the '*brevets d'invention de 15 ans*', which became relatively less expensive due to the modifications brought by the law, saw a rise in popularity. Post 1844 law, the occurrence of five-year patents almost dropped to zero while the popularity of 15-year patents continued to increase.

The new law allowed the payment of the patent tax to be spread out (payable by an annuity of 100 francs), promoting a democratization of patenting (Galvez-Behar, 2019). As depicted by Figure 5, both women and men benefited from the expanded accessibility to patenting enabled by the law.

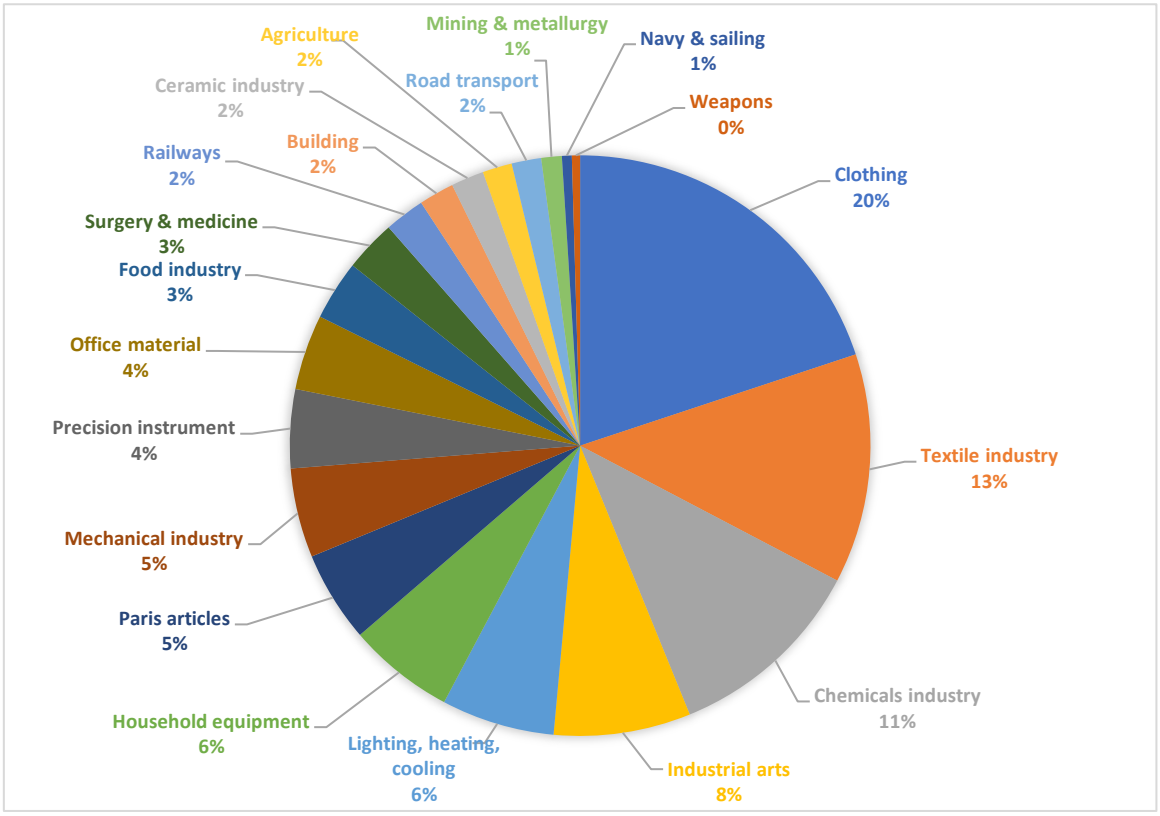
5. Specialization and Characteristics of Women Inventors

5.1. Sector Specialization

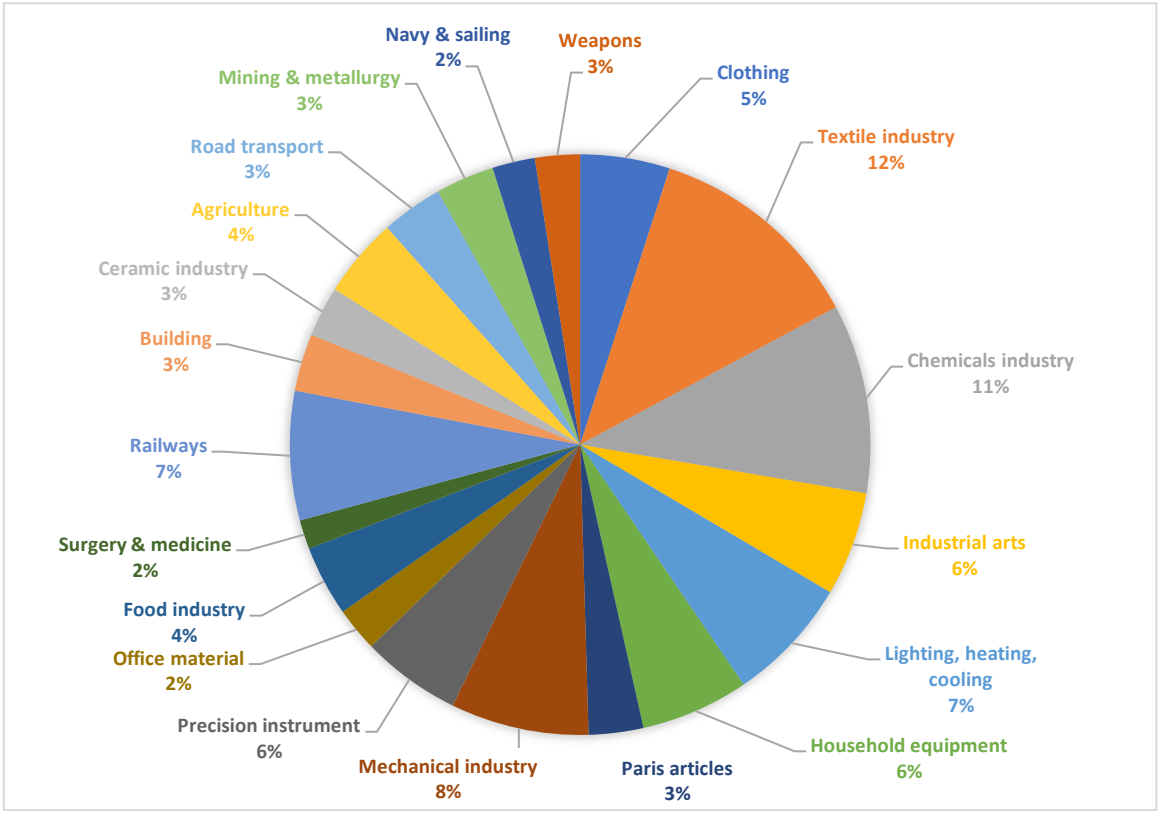
Were women inventing for themselves, i.e. developing products and tools based on personal needs or interests? Did their inventions relate to their roles within the home and family? Did they invent in correlation to their work or areas of expertise, suggesting a "learning by doing" process? Did they invent incremental technologies that everyone found useful? Were they driven by market demand, i.e. inventing where the market pulled them?

Figure 6: Patents by Sectors, 1791-1871

(a) Women



(b) Men



An examination of patents distribution across various industry types helps us better understand the sectors where women and men patented in the past. Figures 6a and 6b depict the patent distribution across sectors, based on a sample of roughly 2,190 patents for women and about 119,000 patents for men between 1791 and 1871. Interestingly, women patented in many sectors, not very dissimilar to men. As Khan (2016) demonstrated for the 1791-1855 period, the textile industry attracted a similar proportion of patents from women and men. Additionally, both women and men patented to a similar extent in the chemical industry. Four sectors predominantly attracted 50% of women patents: clothing, textile industry, chemical industry, and industrial arts.

A captivating example of women inventors is the case of Anne Joseph Soyez. Known exclusively as "veuve Leroy-Soyez" in historical patent-related documents, Anne was born in Ligny-en-Cambrésis (Nord, France) in 1778. She took ownership of a glass factory that her husband, Jean-Louis Leroy, purchased a few months before his death in 1847 (Archives Nord, 1804). Anne managed the factory, employing around a hundred workers, with the assistance of her son. She left a remarkable legacy through her three patents obtained in glassmaking. At the age of 75, Soyez acquired her first patent for glass bottle molds. Her subsequent patents, granted in 1855 and 1856, were for developing glass blowing techniques in special molds. Soyez's inventive quality didn't go unnoticed, as her bottles were recognized at the 1855 Universal Exhibition of Paris for their technical quality and aesthetic appeal. The jury members noted that her products "stand out for their excellent craftsmanship" (Robin, 1855). Despite her inventions being referenced in technical books and magazines of the time,[15] the woman behind these innovations remained obscure, her first name not even mentioned – until now.

Women are, therefore, not merely found in 'female-oriented sectors'. They also appear in knowledge-intensive sectors like chemistry, the mechanical industry, precision instruments, surgery, and medicine. They developed products and tools they needed but also tools and machinery with broader applications and implications. The diversity of women's patents reflects the variety and incremental role played by women in the production process and, more generally, their significant role in French society.

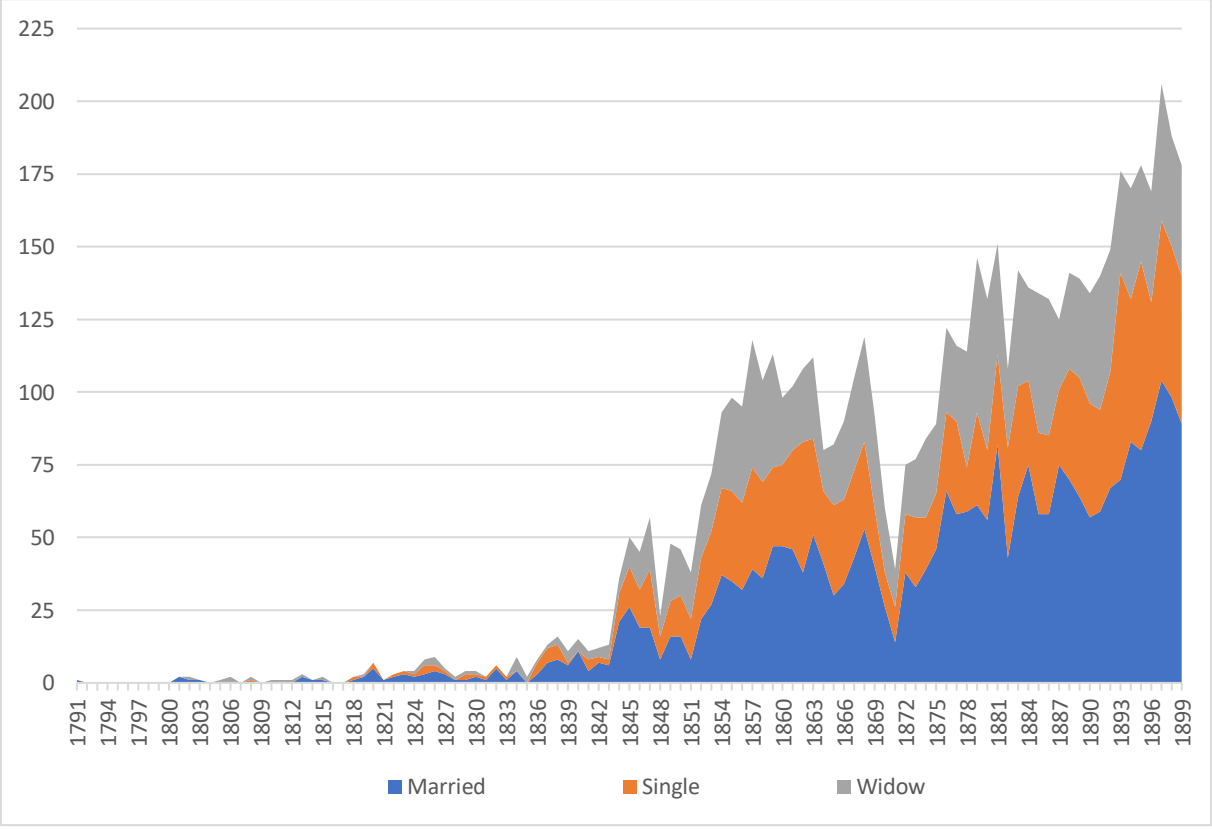
[15] Such as Catalogue des brevets d'invention.

5.2. Marital Status and Occupation of Women Inventors

Who were these women? Our database identifies women who were patenting by their marital status. Despite women in France having legal status more equal to men than in most other European countries, married women faced more restrictions than widows or unmarried women (Hart, 1997; Lewis, 1980). Hence, one might expect a significantly higher proportion of widows and single women among female patentees.

Figure 7 portrays the distribution of women's patents by marital status throughout the nineteenth century. Despite the Code Civil's discrimination, married women were patenting to a similar extent as widows and single women. Widows are slightly overrepresented compared to this group's proportion in the total female population. However, by the end of the study period, the distribution of women patentees by marital status aligns closely with the division of the female population by marital status.

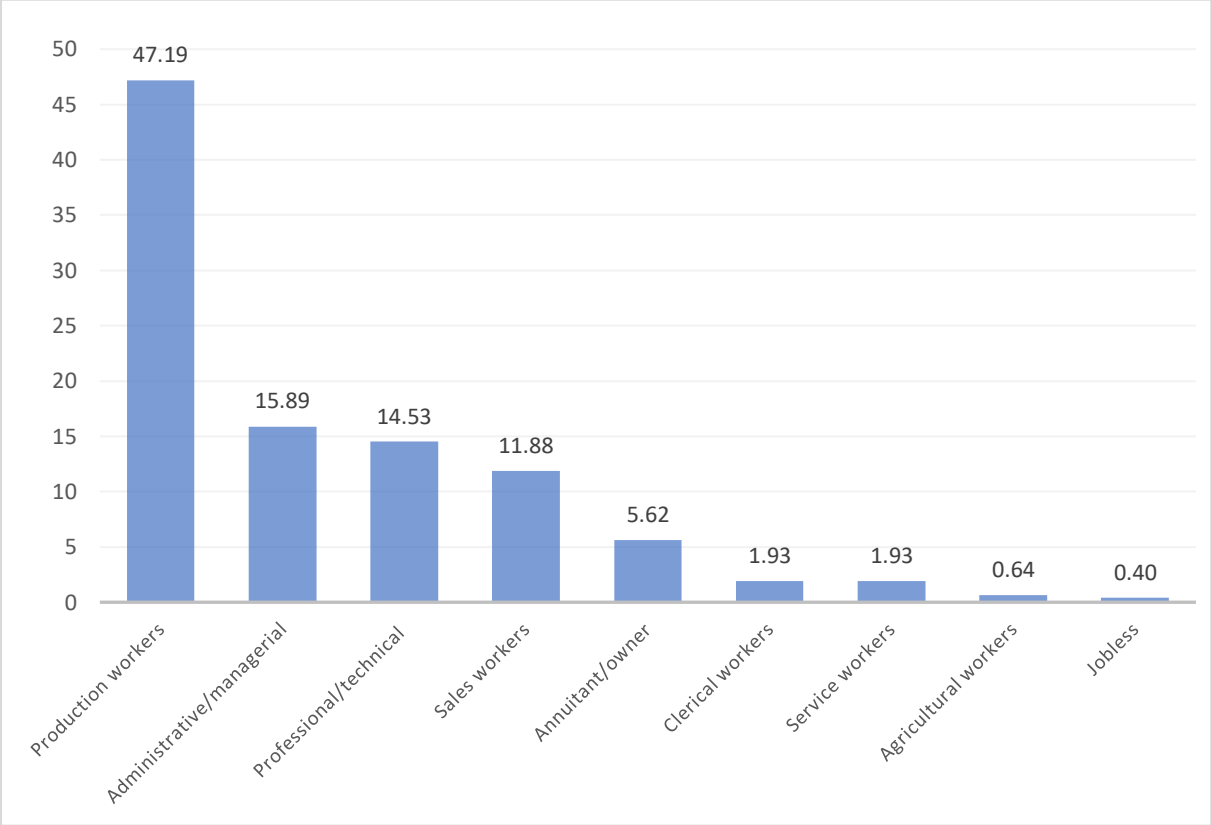
Figure 7: Women Inventors by Marital Status, 1791-1900



Khan (2016), using a sample drawn from patent and exhibition records for France during the first half of the nineteenth century, demonstrated that entrepreneurship and innovation were not exclusive to society's elites but also involved middle-class women. During this era, women

could not access formal schooling to the same degree as men. It was not until the latter half of the nineteenth century that changes in French legislation permitted a more inclusive state educational system for both sexes (Perrin, 2013). Despite limited technical education, married and unmarried women increased their patenting activity during the latter half of the nineteenth century.

Figure 8: Women patentees by HISCO occupational groups (in %), 1791-1900



Note: Based on 1249 observations available for women's occupations (women listed as first depositor).

We investigate the distribution of women patentees by HISCO occupational groups using information on the occupations of a subsample (18%) of women inventors. These groups are divided into nine major categories (Leeuwen et al., 2002). Figure 8 presents the percentage of women patentees belonging to each category. Almost half of these women were production workers, which we interpret as the "learning-by-doing" type of inventors. Notably, nearly 15%

of women patentees held jobs requiring a high level of education ('Professional/technical' category), while around 5% are annuitants or owners, often linked to family businesses.[16]

6. Conclusion

In this study, we examine the historical evolution of women's patenting activity, focusing on France as a case study. To the best of our knowledge, this constitutes the first exhaustive investigation of women's patenting activity throughout the entirety of the nineteenth century. Specifically, we seek to understand the under-representation of women inventors and the presence of biases and exclusionary practices that may have distorted our perception of women's contributions to historical innovation processes. To accomplish this objective, we utilize information about women's and men's patents from the National Institute of Industrial Property, which we then structure, and standardize for better analysis.

Close analysis of the data reveals that although women patented less than men, their patenting activity was much higher than previously suggested. We identify several thousands of women inventors who patented their innovations in France during the nineteenth century. Furthermore, these women inventors were active across all industries, not solely those traditionally associated with women's work. These findings challenge the notion that women's contributions to technological innovation were limited to specific sectors. Instead, we provide evidence of their wide-ranging involvement across all industries.

In spite of the absence of scientific and technical education for women, they patented significantly throughout the studied period, largely alone but also in all-female teams, and with men. The structural changes in human capital investment occurring in the second half of the nineteenth century might have bolstered women's capacity to innovate and invent. We find that women obtained patents in numerous sectors, even those demanding advanced technical know-how. Yet, half of the women inventors did not hold occupations requiring high levels of education. Instead, it appears that women inventors primarily developed new products and processes through their direct involvement with the production process. Consequently, we

[16] Among the most represented occupations for women in each category, we find the following occupations: Production workers & Administrative/Managerial: builders and manufacturers (among the various types of female manufacturers, we found many seamstresses, mechanics, corset makers, milliners); Professional/Technical: midwives, teachers, professors, mistresses, doctors of medicine, painters, chemists, engravers, accountants, as well as engineers; Sales workers: traders, merchants, florists; Service workers: linen seller, lemonade maker; Clerical workers: commissionaires, postmaster; Agricultural workers: farmers, winemakers.

believe that the concept of learning by doing played a significant role in fostering women's innovation skills. Paradoxically, we also find that despite the legal restrictions established by the Civil Code, married women appear almost as frequently in the patent data as widows and unmarried women.

Our findings highlight the need to address systematic biases and exclusionary practices in historical record. Addressing these issues could allow us to study and understand women's contributions to the development process in more accurate ways. While the prevalence of women patentees is more significant than initially expected, women remain underrepresented among patent holders. This underrepresentation could be attributed to cultural barriers (division professional sphere vs. family sphere), institutional and legal constraints, and unfavorable educational context, all of which may have hindered women from participating in patent-prone activities, obtaining patents, and benefitting from their inventions.

Women's under-representation may also be partly explained by internal bias within patent systems (Marcowitz-Bitton and Morris, 2020; Marcowitz-Bitton et al. 2020). Patenting was a lengthy, costly process with procedures that were often unclear. The procedures and practices associated with patenting activities may have been subject to gender bias. Further research is essential for a more comprehensive understanding of women's roles in historical economic processes. This requires a heightened effort to ensure the reliability and accuracy of our understanding of historical patenting and innovation activities, including their dynamics and implications. Despite the progress made, significant challenges remain to be addressed. Confronting the gendered assumptions and biases that have shaped our perception of the history of innovation and technology emerges as one of the pressing challenges requiring more attention.

References

Archives Nord (1804). *Registres d'état civil: CAMBRAI 1800-1804*.

Arnott, P. (2014). 'Antoine Redier's ingenious Comparateur Chronométrique for precise time comparisons', *Antiquarian Horology*, 35(4): 1077–1084.

Baten, J., de Pleijt, A. (2018). Female Autonomy generates Superstars in Long-term Development: Evidence from 16th to 19th century Europe, *CEPR Discussion Papers*, DP 13348.

Chanteux, A. (2009). Les inventives. Femmes, inventions et brevets en France à la fin du XIXe siècle, *Documents pour l'histoire des techniques*, 17(1) : 90–97.

Cinnirella, F., Streb, J. (2017). The Role of Human Capital and Innovation in Economic Development: Evidence from Post-Malthusian Prussia, *Journal of Economic Growth*, 22(2): 193–227.

De Graffigny, H. (1928). *Les grandes inventions et les grands inventeurs du XIX et XX siècle*. Available at: https://gallica.bnf.fr/ark:/12148/bpt6k9763575j (Accessed: 3 February 2023).

Diebolt, C., Hippe, R. (2019). The long-run impact of human capital on innovation and economic development in the regions of Europe, *Applied Economics*, 51(5): 542–563.

Diebolt, C., Pellier, K. (2020). Patents in the Long Run: Theory, History, and Statistics, *History & Mathematics*, 8: 80–119.

Diebolt, C., Perrin, F. (2013). From Stagnation to Sustained Growth: The Role of Female Empowerment, *American Economic Review*, Papers & Proceedings, 103(3): 54–549.

Diebolt, C., Perrin, F. (2019). A cliometric model of unified growth. Gender equality and family organization in the long run of history. In: C. Diebolt, S. Carmichael, S. Dilli, A. Rijpma and C. Störmer (eds), *Cliometrics of the Family* (Studies in Economic History). Berlin: Springer.

Emptoz, G., Marchal, V. (2002). Aux Sources de la Propriété Industrielle: Guide des Archives de L'INPI. Paris: Institut National de la Propriété Industrielle, 247 pages.

Galvez-Behar, G. (2019). The Patent System during the French Industrial Revolution: Institutional Change and Economic Effects, Jahrbuch für Wirtschaftsgeschichte / Economic History Yearbook, 60(1): 31–56.

Gerhard, U., (2016). Droit Civil et Genre en Europe au XIX^{e} siècle [translated by Valentine Meunier]. *Clio. Femmes, Genre, Histoire*, 43(1): 250–273.

Hanlon, W. W. (2022). The rise of the engineer: Inventing the professional inventor during the Industrial Revolution. *National Bureau of Economic Research*, No. w29751.

Hart, S. (1997). Women and Education in 19th-century France, *Modern & Contemporary France*, 5(1): 85–87.

Igersheim, H., Le Chapelain, C. (2022). Women leaders in industry in nineteenth-century France: The case of Amélie de Dietrich, *Business History*, E-print.

INPI (2011). *Les brevets français du 19ème siècle*.

Isoré, J. (1937). De l'existence des brevets d'invention en droit français avant 1791, *Revue historique de droit français et étranger*, 16: 94–130.

Jackson, S.B. (1964). Some Reflections on Parachute Design, 1797-1837, *The Aeronautical Journal*, 68(643): 464–466.

Juhász, R., Squicciarini, M. P., Voigtländer, N. (2020). Technology Adoption and Productivity Growth: Evidence from Industrialization in France, *NBER Working Papers*, No. 27503, National Bureau of Economic Research.

Khan, B. Z. (1996). Married women's property laws and female commercial activity: Evidence from United States patent records, 1790–1895, *Journal of Economic History*, 56(2): 356–388.

Khan, B. Z. (2005). *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920*. Cambridge University Press.

Khan, B. Z. (2016). Invisible Women: Entrepreneurship, Innovation, and Family Firms in Nineteenth-Century France, *Journal of Economic History*, 76(1): 163–195.

Khan, B. Z. (2020). *Inventing Ideas: Patents, Prizes, and the Knowledge Economy*. Oxford University Press, USA.

Leeuwen, M. V., Maas, I., Miles, A. (2002). *HISCO: Historical international standard classification of occupations*. Leuven UP.

Lerman, N. E., Mohun, A. P., Oldenziel, R. (1997). The shoulders we stand on and the view from here: Historiography and directions for research. *Technology and Culture*, 38(1): 9–30.

Lewis, H. D. (1980). The Legal Status of Women in Nineteenth-Century France, *Journal of European Studies*, 10(39): 178–188.

MacLeod, C., Nuvolari, A. (2010). Patents and industrialization: an historical overview of the British case, 1624-1907, *LEM Working Paper Series*, No. 2010/04.

Maloney, W. F., Valencia Caicedo, F. (2022). Engineering Growth, *Journal of the European Economic Association*, jvac014.

Marchal, V. (2009). Brevets, marques, dessins et modèles. Évolution des protections de propriété industrielle au XIXe siècle en France, *Documents pour l'histoire des techniques*, 17(1): 106-116.

Marcowitz-Bitton, M., Morris, E. (2020). Unregistered Patents. *Washington Law Review*, 95(4), p. 1835.

Marcowitz-Bitton, M., Kaplan, Y., Morris, E. M. (2020). Unregistered Patents & Gender Equality, *Harvard Journal of Law & Gender*, 43: 47–89.

McMillen, S. (2009). *Seneca Falls and the Origins of the Women's Rights Movement*. Oxford University Press.

Merouani, Y., Perrin, F. (2022). Gender and the long-run development process. A survey of the literature. *European Review of Economic History*, 26(4): 612–641.

Millet, C. (2022). Le ciel, une célébration de l'homme et de la femme. Le parachute d'André Jacques Garnerin (1797). *Romantisme*, 197(3): 24–36

Mokyr J. (2010). *The Enlightened Economy: An Economic History of Britain 1700–1850*, New Haven, CT: Yale University Press.

Mokyr J, Sarid, A., van der Beek, K. (2019). The Wheels of Change: Human Capital, Millwrights, and Industrialization in Eighteenth-Century England, *CEPR discussion paper*, DP 14138.

Moser, P. (2005). How Do Patent Laws Influence Innovation? Evidence from Nineteenth-Century World's Fairs. *The American Economic Review*, 95(4): 1214–1236.

Nuvolari, A., Tortorici, G., Vasta, M. (2020). British-French Technology Transfer from the Revolution to Louis Philippe (1791-1844): Evidence from Patent Data, *CEPR Discussion Papers*, DP 15620.

Pelletier, M. (1893). *Droit industriel, brevets d'invention, marques de fabrique, modèles et dessins, nom commercial, concurrence déloyale*. Librairie Polytechnique, Baudry et Compagnie, Paris, 428 pages.

Perrin, F. (2013). *Gender Equality and Economic Growth in the Long Run: A Cliometric Analysis*, Université de Strasbourg (France) and Scuola Superiore Sant'Anna di studi universitari e di perfezionamento (Pisa, Italy), Ph.D. thesis.

Perrin, F. (2022). On the Origins of the Demographic Transition. Rethinking the European Marriage Pattern, *Cliometrica*, 16(3): 431–475.

Plaisant, M. P., Finniss, G. P., Payen, J., Laissus, Y. (1958). *Brevets d'invention français, 1791-1902: Un siècle de progrès technique*, Institut national de la propriété industrielle, Paris, France: Ministère de l'Industrie et du Commerce.

Robin, C.-J.-N. (1855). Histoire illustrée de l'exposition universelle. Furne.

Soreau, E. (1959). Les Inventions Françaises Sous La Révolution, *Annales historiques de la Révolution française*, 31(157) : 240–251

Squicciarini, M. P., Voigtländer, N. (2015). Human Capital and Industrialization: Evidence from the Age of Enlightenment, *Quarterly Journal of Economics*, 130(4): 1825–1883.

Tivoli. (1799). *Le Courrier des spectacles, ou Journal des théâtres*, no. 964, Available Online: https://www.retronews.fr/journal/le-courrier-des-spectacles-ou-journal-des-theatres/13-octobre-1799/427/1511939/1

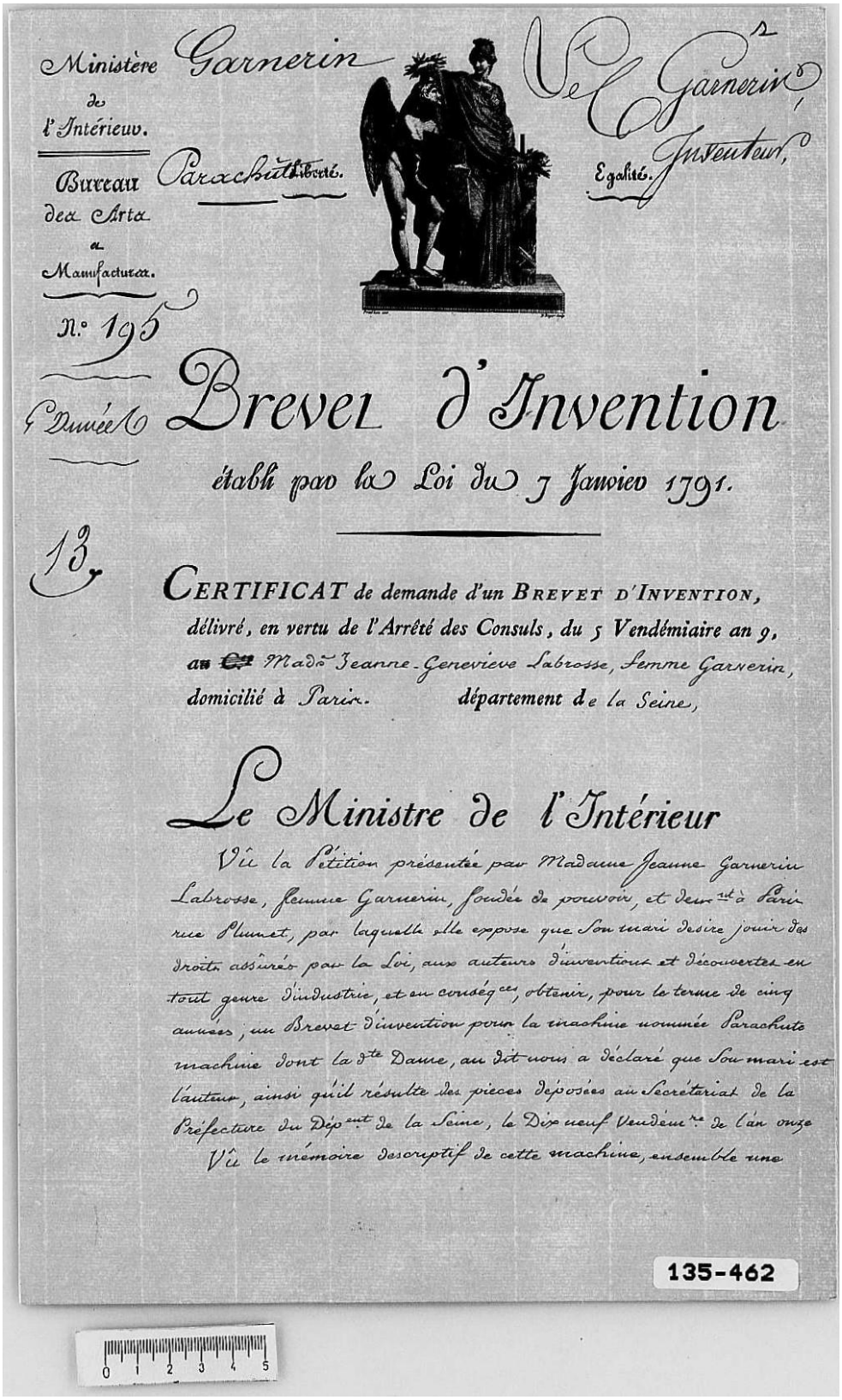
Appendix

Figure A: Digitized Information for Patent Granted to the Modern Parachute Invention

Cote du dossier	1BA185
Type de brevet	Brevet d'invention de 5 ans
Titre	parachute
Année de dépôt	1802
Déposant	GARNERIN Jeanne-Geneviève veuve, née LABROSSE
Observations	la déposante est l'épouse de André-Jacques GARNERIN, physicien aéronaute
Adresse du déposant	Paris (rue Plumet, faubourg Saint-Germain, Seine)/Paris (704, rue de Babylone, Seine)
Numéro de dépôt	Pas de numéro de dépôt entre 1791 et 1844
Date de dépôt	11/10/1802
Date de délivrance	16/11/1802
Observations générales	Le brevet porte le n°195 du Bureau des arts et manufactures. Le dossier contient une correspondance d'un litige sur le brevet publié dans la collection des Descriptions des machines et procédés.
Mot clé moderne	PARACHUTE
Mot clé historique	PARACHUTE
Classe	06. MARINE ET NAVIGATION/06.4 AEROSTATION, AVIATION

Source: INPI

Figure B: Image of the front matter of the modern parachute patent application



Ministère de l'Intérieur.

Bureau des Arts et Manufactures.

N.° 195

Garnerin

Parachute libéré.

Garnerin, Inventeur,

Egalité.

4 Année

Brevet d'Invention

établi par la Loi du 7 Janvier 1791.

13

CERTIFICAT de demande d'un **BREVET D'INVENTION**, délivré, en vertu de l'Arrêté des Consuls, du 5 Vendémiaire an 9, à Madame Jeanne-Genevieve Labrosse, femme Garnerin, domicilié à Paris. département de la Seine,

Le Ministre de l'Intérieur

Vû la Pétition présentée par Madame Jeanne Garnerin Labrosse, femme Garnerin, fondée de pouvoir, et demt à Paris rue Plumet, par laquelle elle expose que Son mari desire jouir des droits assurés par la Loi, aux auteurs d'inventions et découvertes en tout genre d'industrie, et en conséquence, obtenir, pour le terme de cinq années, un Brevet d'invention pour la machine nommée Parachute machine dont la dite Dame, au dit nom a déclaré que Son mari est l'auteur, ainsi qu'il résulte des pieces déposées au Secrétariat de la Préfecture du Dépt de la Seine, le Dix neuf Vendémre de l'an onze

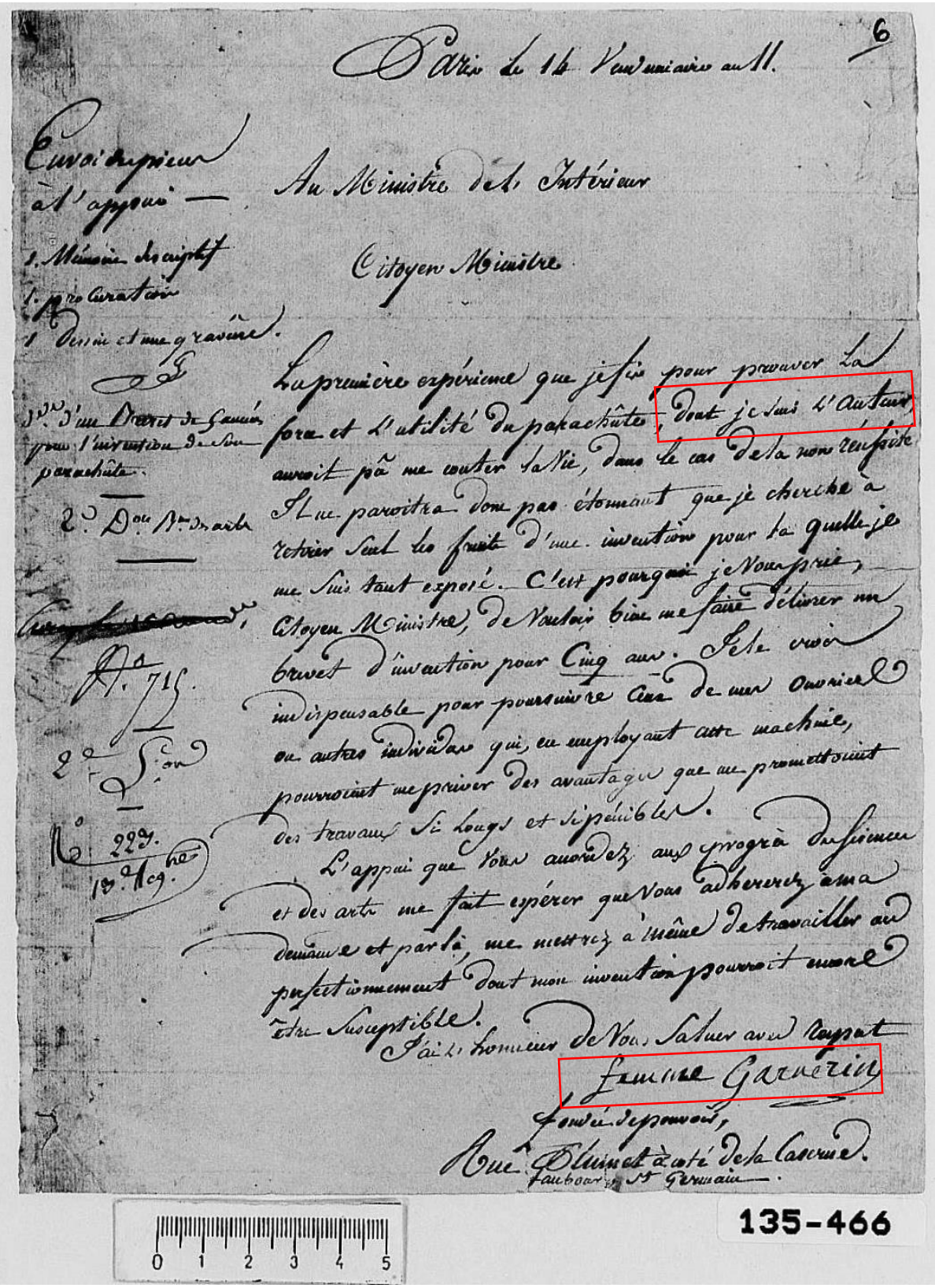
Vû le mémoire descriptif de cette machine, ensemble une

135-462

Source: INPI.

Notes: The font of the application folder is filled in by the patent administrators who belong to the department of interior affairs. It includes much of the essential information: name of inventor, year, type of patent, and address or name of the city.

Figure C: Jeanne-Geneviève Garnerin's Letter



Source: INPI.
Notes: Letter written by Jeanne-Geneviève Garnerin, appealing to the Minister of Interior Affairs regarding a litigation by a third party to acquire her patent. She describes the patent as "of which I am the author".