

Technical innovations at the service of cheaper labor in pre-industrial Europe. The Enlightened agenda to transform the gender division of labor in silk manufacturing

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In 1749, Jacques de Vaucanson patented his or *tour pour tirer la soie* or spindle for silk reeling. Vaucanson's mechanized spindle soon was adopted by most silk producer regions in Europe, at a time when silk was a main luxury commodity in Western trade and manufacturing production. In this article I analyze the introduction of this innovation in Spain in the second half of the eighteenth century. I describe how the Enlightened reformist government promoted its adoption, the main advantage in relation to former spindles being that it could be handled by women, given that less physical effort was needed. Although supported by decades of political and financial support, the diffusion of the Vaucanson spindle was limited. Nevertheless, this case is interesting because it fitted perfectly with a central aspect of the labor agenda of Enlightened reformists: to increase women's labor force participation in order to reduce productive costs and make industry more competitive; and to permit men's labor to be 'reallocated' to agriculture, public works and the army. Technological innovation is thus analyzed as part of the economic and social agenda of the period.

Keywords: silk manufacture; pre-industrial Europe; gender division of labor; gender wage differentials; 18th-century Spain

1. A technological innovation for a strategic sector

In 1749, Jacques de Vaucanson patented his *tour pour tirer la soie* or spindle for silk reeling. In that same year he presented his invention to the Academy of the Sciences in Paris, of which he was a member.¹ Jacques de Vaucanson was born in Grenoble, France, in 1709, and died in Paris in 1782. In 1741 he had been appointed inspector of silk manufactures by Louis XV. He set about reorganizing the silk industry in France, in considerable difficulty at the time because of foreign competition. Vaucanson's invention was intended to replace the traditional Piémontes method, and had an immediate impact upon the silk industry in France and all over Europe.

In the *Art de la Soie* volume of the *Encyclopédie* published by Diderot and d'Alambert,² a good reflection of the technological level existing at the time in silk manufacturing, three spindles for 'tirer la soie' were presented: the *tour de Piémont* (Figure 1), the *tour d'Espagne* (Figure 2) and the *tour de Mr. Vaucanson* (Figure 3). Vaucanson's mechanized spindle improved on existing machines, guaranteed a cleaner and finer thread, and better quality silk, all of which helped to produce a more competitive silk. The impact of the Vaucanson spindle was due not only to its comparative advantages in comparison to existing machines, but also to the strategic importance of the silk industry for European silk producing countries. Silk was the most expensive textile and, as a luxury commodity, it was the object of significant industrial and trade interests.³ Silk producer countries, such as France, Spain and Italy, prohibited exports of raw silk (and, in the case of France and Italy, there were prohibitions on the export of technology and the emigration of qualified workers as well), and as a means to develop their own manufactures,

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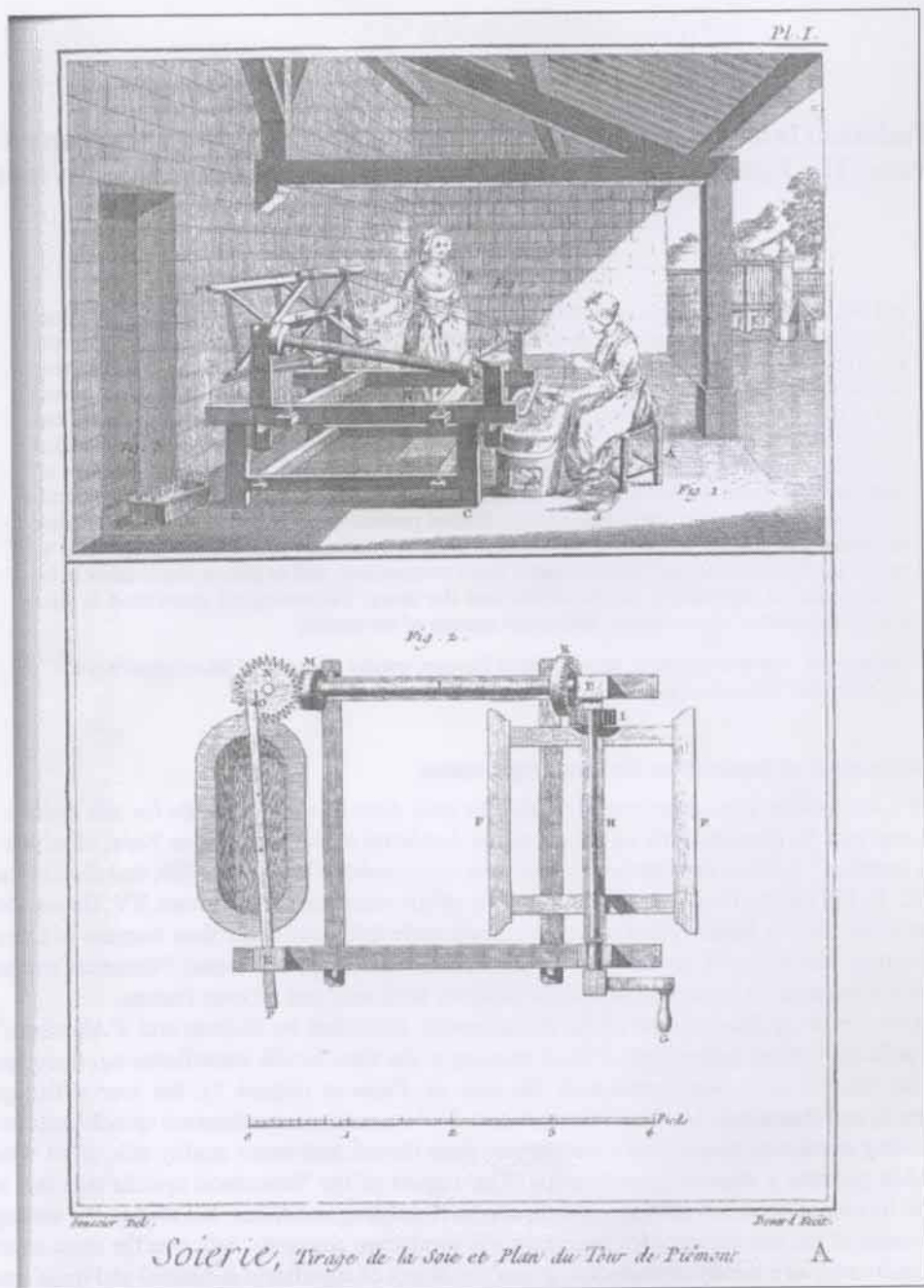


Figure 1. *Art de la Soie, Encyclopédie* published by Diderot and d'Alambert. *Soierie, Tirage de la Soie et Plan du Tour de Piémont*. 'The illustration represents the action of reeling the silk of the cocoons, and two girls occupied positions with one at the crank (lever) of the spindle, and the other one at the boiling pot. This operation is usually done in the months of June or July, when there is no need for the closed space of a workshop because of the warm weather.'

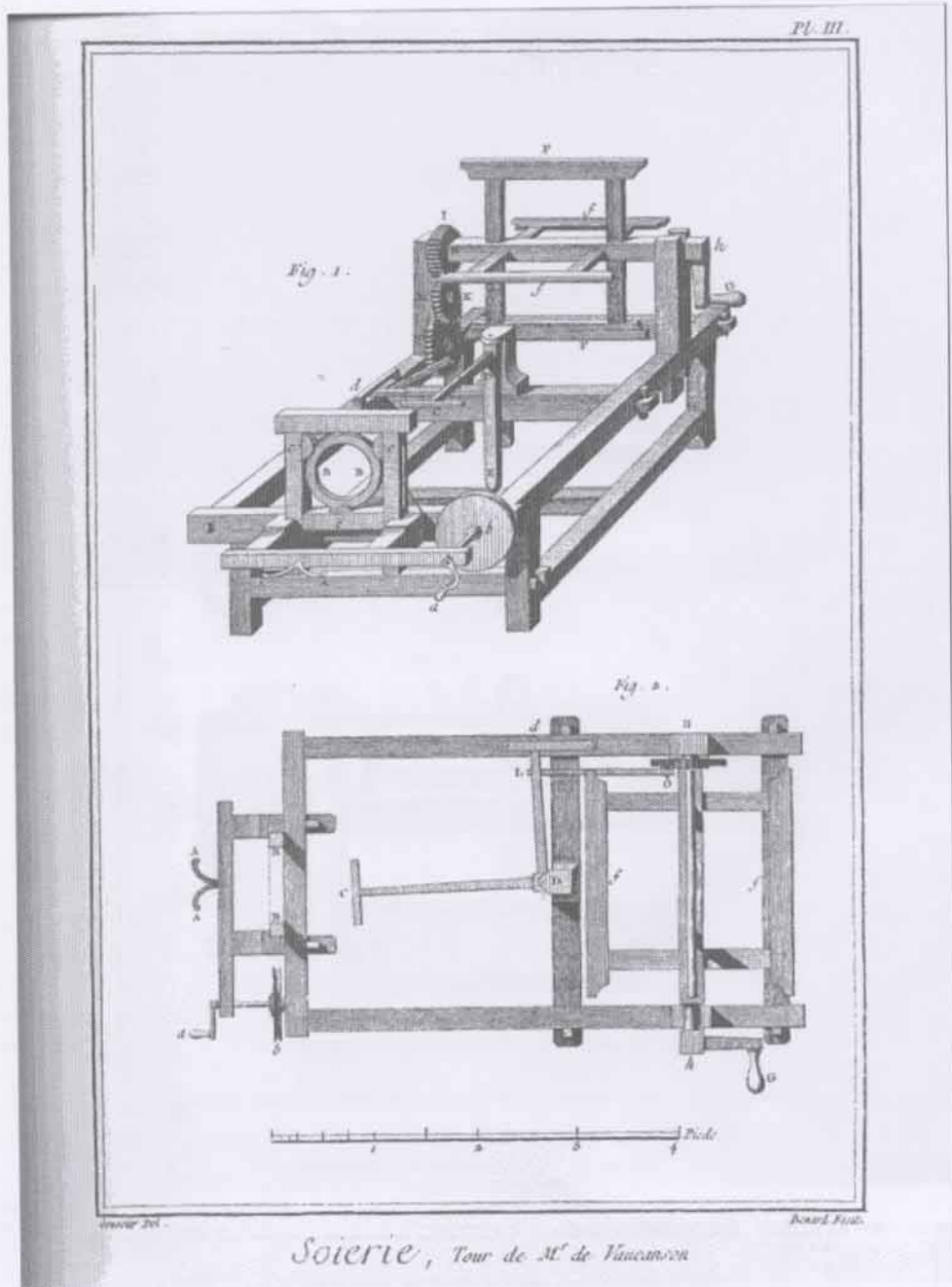


Figure 3. *Art de la Soie*. Developments of Vaucanson's spindle.

advantage in relation to former spindles was that it could be handled by women, given that less physical effort was needed because machines were smaller and lighter.

Despite decades of uninterrupted political and financial support, the diffusion of the Vaucanson spindle was apparently very limited. Nevertheless, this case is interesting because it perfectly exemplifies a central aspect of the labor agenda of the Enlightened reformists: to increase women's

labor force participation (a) because the wages paid to women were lower and this would reduce productive costs and make Spanish industry more competitive; and (b) because women's increased participation in manufacturing would permit men's labor to be 'reallocated' to agriculture, public works and the army. Technological change, thus, appears within the framework of the economic policy agenda and the constant reshaping of the gender division of labor.

2. The reeling of the silk as a put-out activity

Silk filament was first made into cloth in Ancient China. Production of raw silk and later its weaving was introduced in Spain and Italy by the Arabs in the eighth century, where guilds of silk weavers were established to conduct this trade in the early Middle Ages. The weaving of silk was then rapidly introduced to France, and to England in the seventeenth century by French Huguenots.

The silk industry was based upon a complex integrated manufacturing cycle. The first stage, called sericulture, consisted of the production of raw silk thread, unwinding (or 'reeling') filaments of silk by hand from the cocoons produced by the larvae of silk moths. Silk worms tended by families that fed them fresh mulberry leaves produced the essential cocoons. When mature, cocoons were placed into very hot water to soften the sticky gum that holds the filament together. The ends of the filament were found and then unwound. This process is called reeling. The silk filament was then put on to large reels, or swifts. Unlike cotton or wool, silk is not spun but twisted. Throwing involves the processing of the twisted thread using two sets of revolving bobbins that rotate at different, carefully adjusted, speeds.

The first stages of the production process took place in the countryside, as a seasonal activity: peasant women harvested the leaves of the mulberry trees from family mulberry orchards, fed the silk worms and prepared the silk filament. These preparatory stages constituted the basis of the entire silk industry, because the quality, resistance and shape of the thread obtained determined the quality of the yarn later produced.⁵ This also explains why most technical innovations developed and eventually adopted by the silk industry depended on these preparatory stages.

The subsequent stages of production were twisting, re-reeling, followed by weaving and dyeing, and they took place in the city, either in workshops, often under the guilds' control (such as the weaving and dyeing), or at home by women (such the twisting and the second reeling).

Although the collection of the mulberry leaves and the cultivation of the silkworms had to be done on the farm, nothing prevented silk reeling from being re-located to an urban site. However, this never occurred. For peasant economies silk was a totally commercial product, and thus an essential source of cash for small landholders. According to a contemporary, in 1783 in the area of Valencia, 'most of the silk crop had to be woven by mid-June, because the rent had to be paid by Saint John (23 June), and landholders need to sell the silk so that they have cash and can pay the rent.'⁶ As will be seen later, the heavily seasonal character of the crop conditioned the entire silk business, and particularly the organization of labor around the year, and accounted to a large extent for the decisions taken by the peasant-producers about the techniques and machines used.

State policies acknowledged the crucial role of these first stages by protecting its status of rural industry. One of the protective measures of the silk sector enacted by the State in the eighteenth century was a prohibition on the speculative purchase of the cocoon; this was intended to guarantee for farmers the benefits of the crop's added value: 'so that the farmer, with the industry of his Family, perceives the Utility of the thread ... The purchase of the cocoon is forbidden, so that the Farmer, with his family's industry, collects the utility of the yarn.'⁷

This division of labor between town and country reflected in the two main figures in the silk business: the *Labrador cosechero* (the farmer collector of raw silk) and the *Comprador*

fabricante (the purchaser of the raw silk and manufacturer). The later purchased the silk thread in the countryside, and took it to the city to be processed, a classical put-out model.

3. The introduction from top to bottom of the Vaucanson spindle in Spain

All over Europe, the second half of the eighteenth century witnessed the massive intervention of the State in the regulation of economic activity. In the context of deep changes in the trade positions of European countries, with Spain losing its economic and political power to new powers, the Enlightened reformist governments identified the expansion of the manufacturing activity as a central economic and political goal. They did this through writings, legislation and the support of private and public institutions. Increase of industrial output meant a diminution of the Spanish large trade deficits, given growing consumption of luxury goods (mainly satisfied with imports).⁸

The ideas of Enlightened reformers became a powerful instrument of economic policy in the final decades of the eighteenth century. Thanks to the financial and political support of the State, their works were widely published, and schools and priests were obliged to read and transmit their ideas, and to act upon them. The authorities in Spain were very aware of the advances taking place in Britain, France and the Low Countries, and of the fact that foreign manufactures were preferred to the national ones because of their quality and design. King Carlos III and his counselors decided upon an explicit policy that supported industrial modernization, even changing traditional policies such as those that had previously rejected. Spanish Enlightened governments now became enthusiastic advocates of foreign methods, manufacturers, technicians and technology. By importing these, the King and his advisors believed that the 'problem was solved' and Spain would catch up with the European industrial powers.

The intervention and reform of silk manufactures was a central element of this general plan of modernization of industrial activity. In the second half of the eighteenth century silk manufacture in Spain was of growing importance. Silk cultivation and processing was extended in many areas of Central, South and Mediterranean Spain, where the climate was adequate. However, expansion was most marked in those few areas where the complex integrated structure of the sector was more developed. Its importance became strategic, as the demand for luxury goods was expanding faster than the general demand for normal consumption goods, and that silk was the preferred textile of the aristocracy, the Court and the Church both to dress in and to cover the walls and furniture of their palaces. During this period, Lyon and other silk centers in Italy and France had become strong significant producers, locations of technological innovations, and the sources of most of the expensive imports. At the same time, however, increasing both foreign and internal demand and rising prices worsened the structural problems of the sector, lowering the quality of the product, and paving the way for an industrial and commercial crisis already visible in the 1780s.

In the main center of raw silk production in Spain, the region around of Valencia, production figures followed approximately this tendency (see Table 1).

These data are in agreement with figures provided by contemporaries: 'It is commonly judged that, according to a prudential calculation, this Kingdom [Valencia] produces every year a million and a half pounds of Silk', the parish priest Ortells wrote in 1783, the source of his data being the famous botanist from Valencia, Antonio José Cavanilles.⁹ More recent calculations, that use sources that record the Guild's official market for the city of Valencia, indicate that on average

Table 1. Silk production in the region of Valencia in the second half of the eighteenth century (in pounds).

1762	1770	1784	1791	1799	1810
1,150,000	2,000,000	1,500,000	701,603	560,293	557,264

Source: Martínez Santos, *Cara y cruz de la sedería valenciana*: 93.

at least 400,000 pounds of silk prepared in the countryside were taken to the city every year and sold there before the crisis that started in 1810.¹⁰

In this context, references to the 'Vaucanson spindle' began to be found. The adoption of the *torños de Vaucanson*, also defined as 'modern spindles', and the subsequent rejection of the traditional spindles, now defined as 'old', became the subject of publications, prizes and campaigns organized by local and national reformers. In the following years a campaign to promote the new method was launched by the government, the societies of the enlightened, local institutions and, last but not least, the Church. The Church was very keen to promote economic growth as it had an economic interest – its 'tithes' took a ninth on output). Books and booklets were published praising the new invention, prizes were offered and granted; and members of the government, as well as civil and religious institutions, became directly involved in the diffusion of this technical innovation.

The first step took place in 1769, when Monsieur Reboul and his son were granted by King Carlos III a privilege to introduce to Spain the spinning of the silk 'according to the invention of the famous machine maker Monsieur Vaucanson.' In partnership with another Frenchman, Joseph Lapayese, the Rebouls established a new factory in Vinalesa, equipped with Vaucanson spindles. This was only a league from the city of Valencia, one of the traditional centers of silk production in Spain since the Middle Ages, and still flourishing at the time. Despite its many problems, the factory consolidated and production grew from the 363 pounds in the first year to 2615 in 1777. Lapayese remained as manager of the factory when the Rebouls left. He published in 1779 the famous *El arte de hilar ... según el método de Mr. Vaucanson* [*The art of spinning ... according to the method of Vaucanson*], where he presented the *Vaucanson a la Española*, a Vaucanson spindle modified by his young partner Toulot and himself, in order to solve the problems that had appeared. The book was soon recognized as the official statement of the state-approved technology to be used in silk spinning.

This initiative was followed by the government with even greater interest. Miguel de Muzquiz, the minister of Finance, who had a property in nearby Sueca, a few kilometres from the city of Valencia, became heavily involved in the project as well. In 1773, Muzquiz ordered his silk harvest be reeled with four Vaucanson *torños* established under the supervision of Reboul. We have a detailed account of this story thanks to the work written in 1780 by Francisco Ortells y Gombau, who witnessed the experience while in charge of the parish of Sueca. Published in 1783, *Disertación descriptiva de la hilaza de la seda, según el antiguo modo de hilar, y el nuevo llamado de Vaucanson* was printed by order of the *Real Junta particular de Comercio y Agricultura*, heavily implicated in the diffusion of the new method. According to Ortells, 'wishing his Excellence that this new invention was perfected with no loss for the farmers, collectors and Industrials, according to the pious intentions of His Majesty, and in advance of the Silk Factories of this kingdom.'

Both the Valencia and the national Boards of Trade and Agriculture became enthusiastic defenders of the new spindle, offering prizes to silk manufacturers and distributing free Vaucanson spindles. The bishop of Valencia offered a prize for the best dissertation describing the two ways of spinning the silk, 'with a practical and clear instruction so that the farmer can adjust and use the Vaucanson spindle in his barrack, occupying less soil than the old one.'¹¹ It was this competition that provided the origin of Ortells' book.

The main advantages of the Vaucanson spindle, as exposed in the writings by Lapayese and Ortells, were:

- (1) Greater cleanliness. In the old spindles, needles were made of glass and (from the large pot in which the cocoons boiled to the distaff for spinning) had three large holes, through which many impurities and parts of the silk worm passed. In the Vaucanson spindle, the

needle had 'very subtle holes', and so only the pure thread passed through. This was important for the manufacturers who purchased the thread, because the quality of the following stages (reeling, twisting and dyeing), and particularly the possibility that the thread might break, depended to a large extent of the quality of the thread. Impurities made it weaker.

- (2) Greater uniformity and beauty of the thread. The common fraud of adding oil to the silk filament to make it heavier was rendered much more difficult by the much smaller holes of the Vaucanson spindles.
- (3) Double crossing (or 'double cross') of the fibers before arriving to the reel, 'doubtless the main advantage' of the Vaucanson spindle.
- (4) Opening up silk manufacturing to women in order to reduce production costs.

Given the apparent technical advantages of the new spindle, and the heavy institutional support to its adoption, a rapid and massive abandonment of the old technology could have been expected. But this was not the case. In 1789, twenty years after Carlos III granted Reboul the privilege to introduce in Spain 'the invention of the famous machine maker Monsieur Vocanson', the official assessment of the experiment balance of the effort suggests a clear failure. In that year the government discussed the possibility of implementing a regulation to impose the Vaucanson spindle as the only authorized method of silk reeling. This was finally rejected by the national Board, in a reasoned report written by Jovellanos, a famous Enlightened reformer and then minister.¹² Yet in Valencia, the Board of Trade did approve the project, although the available evidence suggests that it had no real impact on the sector.

What is more important here is that this debate prompted an assessment of the attempts for more than 20 years to introduce the Vaucanson *tornos* in the region of Valencia. The results were quite poor: when asked for the amount of silk produced by the Vaucanson spindles, one witness told the Board in Valencia that the factory of Lapayese produced 4000 or 5000 pounds per year; another 1000 or 1500 pounds were produced by the factory maintained by the Guilds; Manuel Francisco de la Torre produced 600 pounds, 'and may be some other could declare fifty or one hundred pounds' more. Less than 8000 pounds out of a regional output of between 400,000 and 1,500,000 pounds of silk (Table 1).¹³ After two decades and the amounts of money spent, this was a very modest result and suggests that the actual diffusion of the Vaucanson spindles was very limited.

Why were farmers so reluctant to adopt the Vaucanson *tornos* if it was such an improvement relative to the former technology? It seems that it was not so clearly advantageous. Let us see what the minister Jovellanos said in his report that recommended a rejection of the policy of imposing by decree the Vaucanson spindles. Jovellanos was a firm believer in the benefits of free trade, and his opinions were always in favor of deregulation: while acknowledging problems in silk manufacturing (frauds, increasing competition on the part of England and, particularly, France, 'whose manufactures of silk are currently the object of our envy'), prohibitions and new regulations were never the solution advocated by Jovellanos. In his opinion, only the personal benefit of individual farmers and consumers (Smith's 'invisible hand') could guarantee the adoption of a new machine or artefact.

Jovellanos began by pointing out the important financial and political support already granted by the State to this invention. The 'method invented by Vaucouson in 1750, introduced in Valencia by Roboull in 1759, and perfected by the machine of Francisco Toullot, has achieved all the protection that it could have wished from the Government'. The first obligation of the Government, 'to diffuse the lights,' had already been accomplished.¹⁴ The work by Lapayese 'has been so generously protected, despite being so scarcely propagated until this day.' Yet the feeble results came as no surprise to Jovellanos. Farmers' scarce enthusiasm for the new spindles was explained because the old ones were 'cheaper, easier to fix up, handier to use, more rapid and above all better

known.' 'Besides,' continued Jovellanos, 'the bad quality of the silk thread obtained with the old method was more due to the conditions under which silk reeling took place in the countryside, than to the *torno* used.'

By all accounts, in fact, the new method also had its disadvantages: Vaucanson spindles were more expensive, more difficult to mend when broken, and consumed much more raw silk. Higher costs of production were expected to be compensated by the higher benefits obtained as a result of the greater quality of the silk produced. But this greater quality of the silk reeled had been obtained *in factories*, where workers were closely surveyed and a standard of quality higher than in domestic workshops was established.

Given that the new *ornos* did not seem to be a better technique for small silk producers, the question, then, was not why were farmers reluctant to adopt them, but why had the Vaucanson spindles been presented by the Enlightened reformers and governments as such an interesting technological innovation. To respond to this question we now must turn to the organization of labor, and most in particular to the gender division of labor.

4. A new spindle to change the gender division of labor in industry

As in most other industrial activities, one of the most characteristic features of silk manufacturing was the strict gender division of labor existing in the sector. Women took care of the silkworms, collected the fresh mulberry leaves and fed the cocoons, always trying to keep a stable temperature.

Peasant women around the kingdom carry out an immense work in the rearing of the silk worms: they do not eat nor sleep restfully until seeing the collection concluded, and each quality of cocoons separated; and at the moment of taking out the cocoon this fruit is taken from their hands so that men can take it to perfection, as if they [women] were not able to spin the silk, or as if Men had not at the same time that they employ themselves in the spinning other tasks that women can not do.¹⁵

Women were also in charge of classifying the cocoons, a task that required a great deal of expertise in identifying the higher quality silk producers by their appearance and separating them from the defective ones, etc. According to Ortells, men were in charge of the reeling of the silk in most places. 'With the exception of the villages around the city of Valencia, nowhere [do] women reel the Silk ... only men understand the reeling of the silk ... there are male Reelers extremely skillful and intelligent in the Art.'¹⁶

However, the suggestion that women did not spin was untrue. Ortells himself mentions 'the exception of the villages around the city of Valencia' and in the first pages of the book mentions that 'male and female spinners' were obliged to pass an examination.¹⁷

Furthermore, we have abundant evidence of women reeling silk in places in Spain other than Valencia. In Talavera de la Reina, in the province of Toledo, near Madrid, a royal factory, later to be famous, was created in 1748 under the direction of the Lyonnaise Jean Ruliere and financed by King Fernando VI. This specialized in velvet silk and golden and silver yarns, and catered mainly for royal and noble families in Madrid, and the Church; the factory employed around 1000 workers, of which between 20 and 25% were silk spinners, all of them women, including masters and apprentices.¹⁸

In any case, in the region of Valencia men were the ones mostly winding and reeling the silk.¹⁹ This was the key point of the argument, since the new spindle was presented as necessarily worked by women (since it was a lighter artefact), which means that its introduction would be carried out with a radical change in the division of labor. This was seen by Ortells as both the main advantage of the new spindle and the main obstacle to its adoption.

In his ministerial report of 1789, Jovellanos refused to accept further protection for the *ornos de Vaucanson*, accepting, nevertheless, the establishment of public schools for providing instruction in silk spin reeling. This would teach 'women and girls, according to the Vaucanson's method,'

as well as the distribution of prizes and spindles to the best performing girls, and 'to the farmers in which household a wife or daughter knows how to spin with the new method.' This distribution of helps, recommended by Jovellanos to the government as the solution to the problems of the sector, 'will have the following advantages: firstly, it will diffuse the new method and its advantages ... secondly *it will concentrate the art of silk reeling in women, subtly banishing the male spinners, and with them their old spindles*; and thirdly it will introduce the use of the new spindle in the sharecropper families, and once settled in them together with the method of how to use it, it will pass traditionally from one generation to another' (My italics).

The fact that the new spindle permitted women to perform a task previously done by men appears as its main advantage. Why was this, according to its defenders, so important?

The silk industry had developed in the region of Valencia to provide raw material for other silk manufacturing regions, such as Toledo or Granada. But by the eighteenth century these centers were declining, while Valencia had become the main silk textile area. The importance of the local growth of mulberry trees, and the increasing production of raw silk, eventually led to the development of a local industry to process it.

The unwinding and preparation of the silk thread was a very seasonal activity. Mulberry leaves were collected in the second half of May, and from that date onwards, a rapid period of preparation and commercialization began: almost 70% of total sales of silk in Valencia took place every year in the period between June and August. 'This was no doubt due to the entrance into the market of the small collectors, who needed to rapidly sell their production in order to face the more immediate charges affecting their holdings. Only in the months more distant from the collection season the large producers and speculators, who benefit from higher prices, entered into action.'²⁰ It is likely that a gender division of labor developed here by which women tended and cared for the cocoons while men unwound and reeled the silk, using very fast and heavy machines, which allowed them to end the job in a few weeks.

What was the problem with this? First, the quality of the silk thread produced was poor. Rapidity of throughput was much more important than quality of the product, and fraud was widespread. As in most 'putting-out' manufactures, there was very little room for control quality of the manufacturing process at home by the putting-out merchant, and the result was, according to contemporary reformers, bad quality thread: often it was dirty and oily because, although strictly forbidden, oil was put into the process to facilitate the separation of the filament and make the thread heavier. When this arose it increased the complaints from the merchant manufacturers and was thought to be a cause of low competitiveness. A greater quality of the silk produced was, according to its defenders, one of the main advantages of the new spindles.

A second reason linked the new machine with a change in the gender division of labor. The fact that the unwinding and reeling of the silk was the men's task meant a scarce supply of male labor for other tasks, that is, increasing wages and higher labor costs. Since the Middle Ages, and as a result of the agricultural techniques practiced by the Moors, the region of Valencia was an area of irrigated agriculture. In the eighteenth century, increasing demand for food by urban and export markets was followed by the expansion of the irrigated land and, among other crops, the cultivation of mulberry trees increased, to create one of Spain's most dynamic agricultural economies. Yet as Ortells pointed out, and contemporaries were well aware of, the demand for (mostly male) labor was much higher in regions with irrigation. Precisely because silk production had developed in regions of irrigated agriculture, the problem of high wages and scarce supply of male labor was more acute here. Supply of male labor could scarcely meet the demand in these regions, and high wages were the consequence. On the other hand, while the government was aware of the need to increase industrial and commercial competitiveness, intensification of textile industries was not possible with highly paid male workers who belonged to guilds. The employment of women and children would allow lower production costs and greater benefits.

In this context, the *tornos* de Vaucanson, worked by women, appeared as a helpful mechanism in the attempt to redefine the gender division of labor. If men returned to agriculture, and women and girls took over the spinning of the silk, both agricultural and industrial prices would lower, and silk manufactures would gain competitiveness in urban and foreign markets. The enthusiastic defense by the State of the new technology must be understood within the context of the Enlightened agenda to reshape the gender division of labor.

5. The Enlightened agenda to reshape the gender division of labor as a policy for economic growth

In 1774, 14 years before the priest Ortells wrote his passionate defense of the Vaucanson spindle, the most influential reformer and politician of the second half of the eighteenth century, Pedro Rodríguez de Campomanes (1723–1802), published his *Discurso sobre el fomento de la industria popular*. The impact of this work was exceptional. Hoping to use it as a privileged instrument to divulge the 'Lights', 30,000 copies were printed at the expense of the State, and Carlos III, paradigm of Enlightened king, ordered their distribution to every society, reformist group, town and parish priest in Spain and in the American territories. Intended as a bible of economic reform for impoverished Spain, the *Industria popular*, as it was popularly known, advocated rural manufactures as the best strategy for the country's economic recovery. Rural manufactures would allow for the population to combine agriculture and industry, would solve the problem of seasonal agricultural unemployment, prevent migration to the cities (and thus political unrest) and keep industrial wages low. Domestic industry in the countryside, and not urban factories, was the solution to the lack of industrial growth.

One of the most interesting points of Campomanes model was his conviction that an *adequate* gender division of labor was crucial for economic development. And that, on the contrary, the fact that the existing gender division of labor in Spain was a wrong one was one of the main causes accounting for the country's economic and social backwardness. According to the social structure of Ancient Regime societies, in which nobility, clergy and people (groups to which members belonged by birth) had very different social rights and duties, the foundation of eighteenth-century economic thought on the division of labor was the conviction that social groups had a natural origin (they were defined by Nature, in turn created by God). To each group corresponded a different a function, and thus social differences were nothing more than the expressions of naturally (godly) determined different places.

The division between women and men, defined as two different species, with radically different intellectual and physical capacities, legal rights and economic functions, was also fundamental for the economic organization of society. Women and men were born different, and governments had to ensure that this natural order was respected and maintained. However, as has often been pointed out, there was a deep contradiction in the fact that gender differences were always described as natural or God-created (in any case, pre-social), when at the same time so many mechanisms and efforts were developed to ensure that gender differences were created, learned, and imposed. Many examples show how governments and the Church inspired, implemented and continuously reinforced this policy: one was the educational system; another, the internal organization of workhouses for the poor, where girls were taught the necessary abilities to become good wives or servants, while boys were taught the jobs demanded by guilds or sent to the public works or to the Army.

According to Campomanes, female labor had to be employed in manufactures and domestic services, while men should be employed in the Army, public works and agriculture.

Women [from 15 to 20 years old] can be taught at the expense of the State many exercises that are now occupied by men with damage of the society, such as cooks, hairdressers and certain works of

pasementerie, forming in this way servant girls of good morals, well instructed in the Christian doctrine ... In this way the indecency that men comb women's hair will end, the number of male Cooks will diminish, and many other trades that are womanish and improper of men will be taken back to the sex to whom they belong.²¹

It was not simply by moral convenience. Wages played a major role. Prices of both agricultural and industrial commodities had been rising for the entire century, with the subsequent social unrest, that was becoming a real political menace. For Enlightened reformers, the reason that agricultural wages has increased was the scarce supply of men, caused by their preference to work in manufacturing, or in domestic service under the protection of a noble family, that is, in 'light' work more proper of women.²² The constant flow of poor men and women to the cities, while at the same time (as foreign and national travelers noted) the countryside was abandoned and agricultural production was incapable to feed the population, was seen as a central problem to solve. Men should be taken out of textile manufacturing. Campomanes had already identified the problem in 1778, when discussing the high price of textiles in Madrid. 'A weaver of ordinary cloth makes more than 10 *reales* per day', which is caused 'for two reasons: the short number of weavers, who have their clients imploring them, and the prices of the fabrics rise,' and the fact 'that this operation is performed by men,' for which there is no reason, because in Northern Spain 'women are the ones who weave the cloth.' Men should, then, be replaced by women, because the women

Will be happy to make five *reales* per day instead of 10, now paid to the male weavers. I must insist that the public administration is obliged to employ women in this and similar works, and the way to achieve it is teaching girls and no men.²³

In fact, the first battle of this war was to be fought against the institution that had the monopoly of technical knowledge, the guilds, which excluded women from the manufacturing of luxury goods. Despite repeated admonitions, the Guild of Silk Cord-makers of the city of Valencia made the nation's government furious in 1779 by its resistance to accept that girls being taught silk reeling techniques.

My Council, having noticed how harmful it was for the fomentation of industry ... the exclusions established by some of their Ordinances of women from the works which are more proper and suitable to their sex than to men's, who for their robustness and strength seemed more convenient be applicable to agriculture, the armies and navy; and having present the fact that the Guild of Silk Cord-makers, *Pasementerie* and Button Makers of the City of Valencia has pretended to prevent that a School to teach the Girls all the relative to the industry of cord-making be established, as it was projected by the *Sociedad Económica de Amigos del País* of that said City ... We order: that with no pretext you prevent, obstacle, or by the guilds or other people be prevented or hindered, the teaching to women and girls of all those works and artefacts that are proper of their sex, and that they can freely sell, by themselves or on their own account, the manufactures they make.²⁴

Both for political reasons (increasing urban population was seen as a serious danger of political unrest since the 1766 revolt against Carlos III, fears later reinforced by the 1789 Revolution in France) and for economic reasons, the Enlightened reformers attempted to stop the flow of population to the cities. Their ideal of economic and social unit was the rural agricultural/industrial family: families living in small holdings, with men working (mainly) on the fields and women (mainly) on the looms; families self-regulating their supply of labor according to the seasonal needs of the demand; men and women living on below subsistence wages thanks to their high degree of self-sufficiency.

Silk manufacture was a very labor-intensive industry, and despite the high cost of the raw materials and machines, wages accounted for a high percentage of total costs.²⁵ This explains the interest in reducing labor costs, and replacing male by female labor was the simplest and easiest way of reducing them. Average daily wage for unskilled male workers was, according to

Campomanes, 4 or 4.5 *reales*, while by working at the looms at home, women and girls could make 1 or 1.5 *reales* per day.²⁶ Manufacturers and merchants in other European countries in the face of increasing foreign competition were doing the same. In the Bologna 'silk district', while the sector of dyed silks suffered a crisis, white silks remained competitive 'partly through agreements among manufacturers and also by taking on women and children as workers in order to reduce costs.'²⁷

6. Conclusions

This paper has described the adoption of a technical innovation in the second half of the eighteenth century, when European societies were becoming increasingly aware of the importance of modern, 'advanced' technology to increase industrial competitiveness. Because the State was strongly active in this process, a very articulate discourse was constructed and diffused around these innovations, and the State itself, in the hands of Enlightened reformers, became the main agent responsible for the transfer of both technology and qualified workers from foreign countries.

Adoption of technical innovations cannot be separated from its effects upon the existing labor organization. This can even be the main reason accounting for the failure or success of the process of adoption of an innovation, be this organizational or technical. Workers react to innovations, either to the point of ensuring their success or making their introduction impossible. In eighteenth-century Europe, the gender division of labor was strict, and every agricultural, industrial or services activity was labeled masculine or feminine (although labels often had opposite meanings in different places). Furthermore, regulations and prohibitions heavily restricted women's access to education and paid occupations. Labor policies oscillated between the need for a massive mobilization of the labor force to expand the supply of labor and thus to increase industrial competitiveness, and the need to maintain a family structure based upon the unpaid domestic work of women and girls, perceived as basic for social (and moral) stability. In such context, contemporaries were very aware of the strong impact of technical innovations (both machines and tools, and systems of organizing the work) upon the existing gender division of labor.

By using as a case study the introduction in Spain of the Vaucanson spindle for silk reeling, massively supported by the State since the 1770s, it has been possible to see (a) how a technical innovation was introduced as 'male' or 'female'; (b) that the fact that the new tool changed the traditional gender definition of the task was not relevant, which confirms that the gender identification of tasks is a social (re)construction; (c) how the fact that the new machine implied a redefinition of the gender division of silk reeling was seen as its main advantage by its defendants; and (d) that the main argument of the advocates of women's greater participation in manufacturing was the much lower wages paid to them. Only this justified women's paid work.

According to contemporaries, there were two main advantages in silk reeling performed by women with the new Vaucanson spindles. The first one, at the microeconomic level, was to lower labor costs. The feminization of a formerly male task, such as silk reeling, had an important impact on costs for the manufacturer, because women were paid much less. Although defenders of the new invention mentioned other advantages related to the better quality of the produce as well, the final and more decisive argument to adopt it was women's lower wages. The second advantage was at the macroeconomic level. The new spindles could be handled by women, and this was consistent with the policy of reshaping the gender division of labor, facilitating women's work in manufactures and men's work in agriculture, public works and the armies. In short, the advantages of the model defended by Campomanes (employing women and girls in domestic manufactures) were: (a) to make industrial commodities cheaper, while at the same time (b) ensuring an abundant supply of male labor in agriculture (and as a result, cheaper agricultural products), and (c) guaranteeing women's paid work compatible with their domestic obligations.

It can be concluded, in the first place, that as the gender division of labor is a cultural construction, the identification of certain tasks, and particularly of the use of certain techniques, tools, devices or machines, as 'masculine' or 'feminine', has constantly changed over time and between countries or regions. In fact, the same opinion-makers (politicians, reformers, technicians) who defined as masculine or feminine certain tasks, or prohibited women to perform certain jobs, or to enter certain occupations, were ready to use the opposite arguments if this was convenient for their interests. This also shows that the usual arguments justifying men's monopoly of certain jobs because of their greater physical strength were easily forgotten were other interests were at stake.

The second conclusion is the decisive role played by wage differentials in the (constant redefinition of) the gender division of labor. Women's lower wages permitted greater benefits, particularly in labor-intensive sectors. This of course has historically not sufficed to guarantee the hiring of women. In the nineteenth and twentieth centuries, powerful counter-mechanisms, such as unions and labor laws favoring men (mostly passed as a result of pressure from male unions) acted against the hiring of female cheaper workers.²⁸ But in the late eighteenth century, the State was determined, despite the resistances, to reallocate both female and male labor in the benefit of economic development. The place of women was domestic manufactures, both in the country and in the town. They produced goods at a much lower cost there, while at the same time working for free for their family and household. To the extent to which they helped this project, technological innovations were enthusiastically supported by the State.

Notes

1. 'Adjoint mécanicien le 28 janvier 1746, associé mécanicien le 30 décembre 1757, pensionnaire mécanicien le 9 juin 1768.' Jacques de Vaucanson is well known by historians of technology for his invention of what is regarded as the first automaton, with punch cards. This was subsequently perfected by Jacquard, the father of modern looms.
2. The 17 volumes of articles of the *Encyclopédie ou Dictionnaire raisonné des Sciences, des Arts et des Métiers* were published between 1751 and 1765. The 11 volumes of illustrations issued from 1762 to 1772.
3. In Italy, 'the most important and valuable manufacturing activity [was] the production and working of silk filaments and the weaving of silk fabrics. Silk was Italy's single most important export commodity in the eighteenth century.' Davis, 'Technology and Innovation', 87. For Italian silk manufacturing see also Poni, 'Alle origine del sistema di fabbrica,' and Guenzi, 'Tessitura femminile tra città.' For the British silk industry in the 18th and 19th centuries see Jones, 'Technology.' For the gender division of labor in the French silk trade see Hafter, 'Programmed Brocade Loom,' 'Women Who Wove,' and 'Politics of Silk Weaving.'
4. A first mention of this innovation is in Martínez Santos, 'Sobre la industria'. I thank Lourdes Benería, Cristina Borderías and Ruth Oldenziel for their helpful comments and suggestions on a first version of this paper. I also thank Cirila Quintero and Peter Wardley, and the rest of participants in session 14 of the *XIV International Economic History Congress* at Helsinki. Paloma Sarasúa helped me with some references difficult to find. Professor Daryl M. Hafter kindly allowed me to read her unpublished 2004 manuscript.
5. In order to improve the quality of the silk filament, to prevent the frequent sickness of the cocoons and to obtain strong and good quality 'seeds,' the Royal Economic Society of Valencia asked its vice-secretary in 1794 to write a summary with the latest innovations in the field. The text (Otero, *Instrucción sobre la Cría*) was known by the Society in that year and published, during the months of April and May, as a series of supplements to the *Diario de Valencia*, in order to reach a wider audience. It constitutes a perfect example of the importance of this first stage. Few tools are mentioned as necessary: scissors to finely cut the mulberry leaves, so that the silk worm eats better, and some kind of heater to warm up the room where the cocoons are being grown. The convenient temperature is given in Centigrade, for which a thermometer is recommended, although the author assumes that 'country silk collectors, to whom the simple name of thermometer intimidates,' measured the temperature approximately and by experience.
6. Ortells, *Disertación descriptiva*.
7. Ortells, *Disertación descriptiva*, 5, 7. This was probably the norm around Europe, with the apparent exception of Bologna. 'In Bologna, silk twisting had been carried out since the fifteenth century in what

- can only be described as factories, but elsewhere silk reeling and throwing was largely a domestic and decentralized activity.' Davis, 'Technology and Innovation,' 88.
8. These words on Italy could very well define Spain: 'The need to adopt and to adapt to the new technologies that were being developed elsewhere was certainly perceived to be a major problem by contemporaries, and from the mid-eighteenth onwards there were many Italians who saw the persistence of archaic techniques and methods of production as a primary reason for the failure to emulate the industrial expansion pioneered by the economies of north-western Europe.' Davis, 'Technology and Innovation,' 83.
 9. The quote in Ortells, *Disertación descriptiva*, 7. The source is Cavanilles, *Observaciones sobre la historia natural*.
 10. Franch, 'Comercialización de la seda valenciana,' 279. See also Díez, 'La crisis gremial.'
 11. Ortells, *Disertación descriptiva*, 14.
 12. Jovellanos, 'Informe extendido en la Junta,' 67-70.
 13. Martínez Santos, *Cara y cruz de la sedería valenciana*, 195.
 14. 'Having been published the art of spinning the silk by don Miguel Gerónimo Suárez, the book by don José de la Payese, the book by don José Antonio Valcárcel, an instruction formed by Robaull and translated by the same Valcárcel, and other little treatise by the priest of Foyos, which is an abbreviation of the method of la Payese.' Jovellanos, 'Informe extendido en la Junta,' 69.
 15. Ortells, *Disertación descriptiva*, 140-141.
 16. Ortells, *Disertación descriptiva*, 135.
 17. 'It is ordained the exam of Male and female Spinners, so that only those who understand it with practice enough work in the Silk Trade.' Ortells, *Disertación descriptiva*, 5, 7.
 18. Peñalver Ramos, *La Real Fábrica*. For silk production in the province of Toledo, and particularly the royal factory of Talavera, see Larruga, *Memorias políticas y económicas*. He underlines the problem of Spanish silk being taken out of the country (legally and illegally) as raw silk, to be woven by English, Dutch and French.
 19. The preparation of the silk thread was done by women in other countries: in Italy winders were women, 'who nearly always worked outside the town.' Massa Piergiovanni, 'Technological Typologies,' 548. In Britain silk was a women's industry, yet it was a different model of female labor. After the introduction of Lombe's silk-throwing machinery in 1719, mills sprang up all over the country. 'The spinning of the silk, unlike that of other textiles, was mechanized and centralized from the beginning of the eighteenth century . . . The twisting was done in the throwing mill' (Berg, *Age of Manufactures*, 242). The industry employed mostly female labor. In 1747 London, 'The silk-throwster, by a mill calculated for that purpose, throws the silk, and prepares it for the various uses of the weaver; he employs mostly women, to whom he gives but small wages: It is a very profitable business for the master . . .' (quoted in Hill, *Eighteenth Century Women*, 205). Preference for female workers was reinforced following increasing international competition: 'after the passage of the Free Trade Act of 1824, increased competition in silk manufacture encouraged the introduction of machinery that would cheapen production costs. At that point, factory owners could adopt machinery designated to be operated by women, which would keep labor costs down' (Valenze, *First Industrial Woman*, 93). Centralization of silk throwing in the mills with women and children as cheap wage workers was not so widely spread in Continental Europe. Around 1820, small twisting machines 'intended to be turned by hand', were presented in England as 'common in the south of France, where many artisans purchase their silk in the raw state, and employ their wives or children to prepare it by these machines.' But this was 'a method which is too expensive for this country' (Rees, quoted in Berg, *Age of Manufactures*, 243). In any case, literature on silk production focuses on weaving and the urban stages of production, generally controlled by the guilds and regulated by the State, and little is known of the first stages: rearing of the cocoons and preparation of the silk filament, which in large part had to be done in the rural areas, as a seasonal activity, by rural families.
 20. Franch, 'Comercialización de la seda valenciana,' 278.
 21. Campomanes, *Las cinco clases de pobres*, 160.
 22. Sarasúa, 'Una política de empleo.' In fact, tasks defined as 'feminine' were not the physically light jobs. For instance, laundry, which was recognized by the contemporaries as the hardest of all 'trades', was always done by women, both as part of their domestic duties and as a professional activity (Sarasúa, "'Hardest, Most Unpleasant" Profession'). Probably other factors played a role here: laundry was mostly privately done (women did not have to share the public space with men to do it); was very poorly paid; had absolutely no social prestige; and lacked a guild tradition.
 23. Campomanes, *Las cinco clases de pobres*, 200.
 24. 'Real Cedula of 12 of January, 1779 by which is ordered that with no pretext be prohibited or obstructed, by the Guilds of these Kingdoms or other persons, the teaching to women and girls of all those works

- and artefacts that are proper of their sex, despite the regulations that in their Ordinances may the Masters of the respective Guilds have.' Guilds continued to prevent the entrance of women in a number of trades and this was one of the main reasons of their final dissolution by the European governments. In France, after 'the king's 1777 edicts to suppress France's guilds and reinstate them according to new plans ... The hardest regulation for Lyon's silk workers to swallow was the king's rule that women were now eligible to enter any guild whose work they could perform.' Hafter, 'Politics of Silk Weaving', 2. Only "after the reforms of 1786 letting women into the weaving guild and the suppression of the guilds themselves in 1791, women were free to set up their own workshops and perform as patron of their own business". Hafter, 'Politics of Silk Weaving', 11.
25. In Italy, for instance, 30–35% of the total production costs, of which the biggest part was to weavers. Massa Piergiovanni, 'Technological Typologies,' 546–7.
 26. Sarasúa, 'Una política de empleo,' 185.
 27. Massa Piergiovanni, 'Technological Typologies,' 559.
 28. Sarasúa and Gálvez, *¿Privilegios o eficiencia?*, 19ff.

References

- Berg, Maxine. *The Age of Manufactures, 1700–1820. Industry, Innovation and Work in Britain*. London: Routledge, 1994.
- Campomanes, Pedro Rodríguez de. *Las cinco clases de pobres*. Madrid, 1778.
- Cavanilles, Antonio José. *Observaciones sobre la historia natural, geografía, agricultura, población y frutos del Reyno de Valencia*. Valencia, 1795.
- Davis, J. A. 'Technology and Innovation in an Industrial Late-comer: Italy in the Nineteenth Century.' In *Innovation and Technology in Europe*, eds P. Mathias and John A. Davis. London: Blackwell, 1991.
- Díez, Fernando. 'La crisis gremial y los problemas de la sedería valenciana,' *Revista de Historia Económica* 10, no. 1 (1992): 39–61.
- Franch Benavent, R. 'La comercialización de la seda valenciana a finales del Antiguo Régimen: el "contraste" de la ciudad de Valencia,' *Revista de Historia Económica* 8, no. 2 (1990): 271–303.
- Guenzi, Alberto. 'La tessitura femminile tra città e campagna. Bologna, secoli XVII–XVIII'. In *La donna nell'economia, secc. XIII–XVIII*, Atti della XXI Settimana di Studi, Prato, Istituto F. Datini and Le Monnier, 1990: 247–59.
- Hafter, Daryl M. 'The Programmed Brocade Loom and the "decline of the drawgirl."' In *Dynamos and Virgins Revisited. Women and Technological Change in History*, ed. Martha Moore Trescott. Metuchen, NJ: The Scarecrow Press, 1979.
- . 'Women Who Wove in the Eighteenth-century Silk Industry of Lyon.' In *European Women and Preindustrial Craft*, ed. Daryl M. Hafter. Bloomington: Indiana University Press, 1995.
- . 'The Politics of Silk Weaving in Eighteenth-century Lyon', speech for the Textile Association of America, unpublished, 2005.
- Hill, Bridget. *Eighteenth Century Women. An Anthology*. London: Allen & Unwin, 1984.
- Jones, S. R. H. 'Technology, Transaction Costs, and the Transition to Factory Production in the British Silk Industry, 1700–1870,' *The Journal of Economic History* 47, no. 1 (1987): 71–96.
- Jovellanos, Gaspar Melchor de. 'Informe extendido en la Junta de Comercio y Moneda sobre sustituir un nuevo método para la hilanza de seda' [Report issued by the Committee of Trade and Currency on replacing a new method for the spinning of the silk]. In *Obras*. Madrid: Biblioteca de Autores españoles L (II), [1789] 1950.
- Lapayese, José. *Tratado del arte de hilar, devanar, doblar y torcer las sedas según el método de Mr. Vaucanson, con algunas adiciones y correcciones a él*. Madrid, 1779.
- Larruga, Eugenio. *Memorias políticas y económicas sobre los frutos, comercio, fábricas y minas de España ...*. Zaragoza: Gobierno de Aragón, [1789] 1995.
- Martínez Santos, V. 'Sobre la industria de la seda en Valencia a fines del siglo XVIII. Los tornos de hilar de Vaucanson.' Valencia: *III Congreso Nacional de Historia de la Medicina y de la Técnica* (1969): 317–27.
- . *Cara y cruz de la sedería valenciana (siglos XVIII–XIX)*. Valencia: Institució Alfons el Magnànim, 1981.
- Massa Piergiovanni, P. 'Technological Typologies and Economic Organisation of Silk Workers in Italy, from the XVIIth to the XVIIIth Centuries,' *The Journal of European Economic History* 22, no. 3 (1993): 543–64.
- Ortells y Gombau, Francisco. *Disertación descriptiva de la hilaza de la seda, según el antiguo modo de hilar, y el nuevo llamado de Vocanson. Escribióla el Dr. Francisco Ortells y Gombau, presbítero,*

- vicario de la parroquia de Foyos. *Imprimese de orden de la Real Junta particular de Comercio y Agricultura*. [Descriptive dissertation on the spinning of the silk, according to the old method of spinning, and the new one, called of Vocanson. Written by Dr. D. Francisco Ortells y Gombau, priest in the parochial of Foyos.]. Valencia, por Joseph y Thomás de Orga, 1783.
- Otero, Tomás de. *Instrucción sobre la Cría del Gusano de la Seda*. Valencia: *Diario de Valencia* (1794) (published as a series of articles on 4, 5, 6, 9, 11, and 15 April, and 3, 8, 11, 13, and 16 May).
- Peñalver Ramos, Luis Francisco. *La Real Fábrica de tejidos de seda, oro y plata de Talavera de la Reina. De Rulière a los Cinco Gremios Mayores, 1748–1785*. Toledo: Ayto. de Talavera de la Reina, 2000.
- Poni, Carlo. 'Alle origine del sistema di fabbrica: tecnologia e organizzazione produttiva dei mulini di seta nell' Italia settentrionale,' *Revista Storica Italiana* (1976): 444–98.
- Sarasúa, C. and Gálvez, L. (eds). *¿Privilegios o eficiencia? Mujeres y hombres en los mercados de trabajo*. Alicante: Publicaciones de la Universidad de Alicante, 2003.
- . 'The "Hardest, Most Unpleasant" Profession. The Work of Laundresses in Eighteenth, Nineteenth and Twentieth Centuries Spain.' In *A Social History of Spanish Labour. New Perspectives on Class, Labour and Gender*, eds. Vicent Sanz and José Antonio Piqueras. London: Berghahn, 2008.
- . 'Una política de empleo antes de la Industrialización: paro, estructura de la ocupación y salarios en la obra de Campomanes.' In *Campomanes y su obra económica*, eds. Francisco Comín and Pablo Martín Aceña. Madrid: Instituto de Estudios Fiscales, 2005.
- Valenze, Deborah. *The First Industrial Woman*. Oxford: Oxford University Press, 1995.