HOW ADAM SMITH FOUND INSPIRATION IN FRENCH TEXTS ON PIN MAKING IN THE EIGHTEENTH CENTURY

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Adam Smith found inspiration in French texts on pin-making to illustrate his theory of the division of labour. He used secondary sources that, we argue influenced his understanding of the strong division of labour and opportunities for productivity improvements in the pin-making industry. The original and secondary texts are examined here to understand how Smith interpreted them to develop his theory. Additional archival sources describing French pin-making in the eighteenth century are also studied and are shown to partially contradict Smith's theory of the division of labour.

Adam Smith used four French sources on pin-making: *Journal des sçavans*, 1761, Delaire's article "Pin" in Diderot's *Encyclopaedia* 1755, Duhamel's *The pinmaker's art*, 1761, and Macquer's *Portative arts and crafts dictionary* 1766 (Peaucelle, 2006). At the time, other French texts also described French pin making, including activities in Normandy. They were either manuscripts based on field observations, published dictionary items or articles in serial publications on the arts and crafts (Peaucelle, 2007). These technical texts are relatively unknown both in and outside of France. The objective of this article is to examine how Adam Smith used them to develop his theory on the division of labour. We detail their content and origin to highlight Smith's influences as well as the points he omitted in his work. A number of technical and numerical details are given to remain faithful to the original texts and to avoid misrepresentations.

In the first part of our text, we study all the eighteenth century French pin making texts. These texts are closely linked and copy one another. Copying without quoting was common practice for the time. We will pay particular attention to an original feature in this technical literature: the link between the practical and the economical aspects of pin-making. While emphasis was placed on the tools and the worker's motions, production rhythms and wages were also often given. The value added per pin-maker (Billettes, 1700) and the cost price per pin (Perronet, 1765) are two economical aspects which were computed before that of "productive power" by Adam Smith. It was the only case in the French arts and crafts descriptions that an economic analysis completed a technical description.

In the second section, we debate how Adam Smith interpreted the French pin-making texts, the information he selected and the conclusions he drew about the pin making industry. We will see that the original texts do not support Smith's analysis. The workers were specialized in eight or nine trades, and not eighteen as Smith understood. In a workshop there were many workers for heading but very few for cutting the pins, for example. Attempts to divide this latter operation further were unsuccessful One of the original texts that Smith did not consult also provides an example of production without specialisation where productivity was a hundred times higher than Adam Smith

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believed.

In the third section, we examine what local sources reported on pin making at the time. These texts help understand how pin-making was organized. We will see that both specialized and non specialized labourers worked together in workshops. While the different workshops all used the same tools, the organization of work was not standardized. One of these texts was also used by Charles Babbage who argued that wage differentiation was another advantage to specialisation (Babbage 1832).

1. French texts about pin making

There are many published French texts on pin making including early manuscripts. Such a profusion of writings reflected initialement au XVIIe siècle the State's desire to control the arts and crafts industries and au XVIIIe siècle une fascination pour la technique de la part des philosophes des lumières (Pannabecker, 1996). Le métier de pinmaker était singular economics had been noted early on. These technical descriptions are unexciting as the authors never use them to develop a theory of the introduction of technologies in the production process.

Adam Smith consulted four texts: the *Journal des Sçavans*, and the texts authored by Delaire, Duhamel and Macquer. These were major publications based on a number of previous original works. Four original manuscripts, authored by Billettes, Guéroult, Savary and Perronet were particularly important. Adam Smith did not read these texts that were conserved in Duhamel's papers at the Academy. We present them here to explain the wealth and diversity of published writings at the time.

We will begin by presenting the key features of each text in chronological order. The use and interpretation of texts by other authors will then be discussed.

1.1. *Billettes*

The French Administration knew about national pin making from the 1660s onwards when the Dutch ambassador provided statistics of goods purchased by the Dutch in France. Pins and combs were traded for 500,000 French pounds (Huet, 1712, 108-109). Exactly how and where the pins were made however was poorly understood. The first texts on pin making were written in the course of a larger project to describe all of the arts and crafts.

In 1675, King Louis XIV asked the French Academy of Sciences to describe the arts and crafts (Pinault, 1990, 7). The goal of the Royal Administration remains unknown. One explanation may be that the King was preparing the Revocation of the Edit de Nantes of 1685 which chased the Protestants out of France. At the time, Protestants held many industrial interests.

The Academy of Sciences had little motivation to undertake this work. A new five person group was appointed for this task in 1692 with Billettes who would later enter the Academy in 1699. Gilles Filleau des Billettes (1634-1720) most probably read a report written by a local trade inspector in 1692. "From the year 1692, trade inspectors were ordered to send to the Court a report on the state of their sector" (Savary, 1723, Préface, XIX). Billettes' report for the Academy contained the list of pin-making operations, the labour rhythms and some drawings. Billettes had one illustrative plate made in 1702 showing the tools and workers at each tool. It was reported that "Mr. des Billettes read out a precise description of the Art of the Pin-Maker" (*Histoire de l'Académie Royale des Sciences*, 20th November 1700, 382). This communication went unpublished however, contrary to Academy practice.

The initial report and the communication were both lost but the 1702 plate and Billettes' handwritten draft are both in the Academy of Sciences archives (Billettes, 1700). Billettes described a pin-making process that involved drawing out the wire, straightening the wire, cutting the sections, pointing, refining, slicing shorter, heading, yellowing, whitening, drying, piercing the papers, and putting the pins in paper. There were 12 operations although the word 'operation' wasn't used. No noun designated the worker who performed each operation. The 1702 plate shows

two workers pointing, one cutting wire, and a fourth heading, all using their tools. The tools are again separately drawn on the bottom of the plate. This presentation style was later used by Diderot in his *Encyclopaedia* for the all arts and crafts. Billettes began using it as early as 1693 (Salomon-Bayet, 1970, 236).

Billettes' draft also gives the production rhythms for ten operations. He computed the time it took to make 220,000 pins as 32 days for one worker (Figure 1). Globalement The productive power was 6 875 pins per day. Dans une partie non reproduite de la note, Using the price of raw materials and the selling price, Billettes computed the value added. Naturally he didn't use this expression. With the rhythms he calculated the maximum daily wages, 16 sols 6 deniers. Mais Billettes ne dispose pas des salaires des pin makers. Or the usual daily wage of workers in Paris of around 30 sols. These theoretical maximal wages were very low. The situation appeared inconsistent to Billettes that he explored two possible "solutions": either increase the productivity or decrease the wages for certain operations. But his production rhythms were already high (later articles gave much lower rates). Billettes thought that women should work on operations where wages were lowest. Billettes didn't know however if this was true (Peaucelle, 2007, 146). It is probably for this reason that Billettes' communication was not published. La note manuscrite reflète une réflexion économique sur la technique, reliant coûts, salaires et rythmes de travail. Manquant d'informations, Billettes formule plusieurs hypothèses pour retrouver une cohérence.

per day……pointing	220 thousand
Heading	14 thousand
Drawing 3 toises[1] for 216 shanks[2] and one minute for the 3 toises, or 180 toises per hour	
I measure the shanks at one inch therefore the toise gives 72, therefore 3 toises gives 216.	
I count that only a boy draws per minute 3 toises and so per hour 180 toises giving 129600, and we count the day as 10 hours , so we draw	
per day the value of	129 600 shanks
For the straightener per day idem	129 600
To make the sections by 500 at each cut, per day	300,000
To refine them per day (to point)	220,000
Slicing shorter per day	300,000
Putting the head per day	14,000
Yellowing, whitening and drying	300,000
Piercing and putting in paper per day	20,000
Rounding the total down to	220 thousand
Which gives roughly	
to thread and straighten up	2 ¾ days
to refine	1 day
to slice, long or short, to yellow and whiten	2 ¼ days
to head	15 days
to pierce and put in paper	11 days
	32 days

Figure 1 Extract from Billettes' draft manuscript at the Academy of Sciences.

The first technical observation of pin making listed the tools, the operations with these tools, and their rhythms. It completed the presentation with the first analysis of the economics of production. These points were present in all later texts.

[1] One 'toise' was the equivalent of six *pieds du roi* or approximately 1.949 metres.

[2] The 'shank' was a pin without a head.

1.2. *Guéroult*

After the death of Louis XIV in 1715, the project to describe the arts and crafts industries was repeated. Local administrative authorities made inquiries and a road and bridge engineer in Alençon by the name of Guéroult wrote a handwritten report with 75 drawings of the tools, without workers, and 28 collected samples of pins, wire, and materials. Both the original report and the samples were lost but a handwritten copy of 57 pages remains with 21 drawings (Guéroult, 1717).

Guéroult was most probably Mathieu de Guéroult de Boisrobert, an army officer and son-in-law to Alexandre d'Aspres, lord of an estate close to Laigle. He was wounded in the Battle of Fleurus in 1690 (Chenaye-Desbois, 1778, Tome XII, 881). He was reassigned to the Royal Administration of roads in Alençon.

Guéroult begins by describing the drawing of the wire. He then describes pin making in "the manufacture of François Housses, the best pin-maker at Laigle. Their pins are sold in Paris at Delastre in Huchette street and at Loupiat in Saint Honoré street" (Guéroult, 1717). The pin making manufactory was a workshop with a wooden floor to allow the reprocessing of brass filings.

Guéroult distinguished many 'operations' although he didn't use the word. The first operation was wire drawing. Wire drawing was located outside the workshop and the wire drawers were specialized in this operation. Wire drawing was complex: the wire roll was first placed in a boiler with wine acid for one hour, it was then beaten on a block (spanking), placed in the boiler again for an hour, and then beaten again. The wire finished clean and yellow. The drawing itself then began. The wire was placed in the hole of the drawplate, a small amount of wire was drawn, the size of the wire was checked, the wire was rolled onto the bobbin, the crank was turned, and the wire was lubricated before entering the drawplate. The operation was repeated between 4 to 12 times until the correct wire size was reached. Such detailed description is typical of the technical writing style at the time and was no doubt tiring for the reader.

Guéroult's report gave a very accurate description of production process including the working rhythms for 7 operations. While he didn't count the operations, Guéroult only used seven nouns to identify the trades: the straightener who straightened the brass wire and cut the sections, the pointer and another pointer to soften the points, the shank cuter, the head turner, the head cutter who softened the brass, the paper punchers and the women who putted the pin head. The names of the workers for four other operations - yellowing, whitening, drying, and winnowing - are unknown. The use of different trade names could imply the specialization of workers, however this is not certain. The trade of workers who putted the heads was not named. Guéroult reported that they were women (Guéroult, 1717, 17). Given the work rates we can see that women were twice as numerous as men even though they only performed two operations (heading and putting). Pins were mainly made by women.

Guéroult didn't say how many workers were in the workshop. There were four people for heading (Guéroult, 1717, 16). Each worked 7,000 pins per day. The workshop production would appear then to be 28,000 pins a day[3]. However the first worker straightened the wire for 120,000 pins. A balance between the specialized trades was impossible. Many workers weren't specialized in the workshop or they worked successively in several different workshops. Guéroult however didn't speak about the organization of labour. He placed emphasis on the technological process, the tools, the rhythms and the motions.

Guéroult's report was sent to the Academy of Sciences. Billettes requested more information and Guéroult completed his report. Billettes ordered four new plates dated 1718 to be made based on Guéroult's report. They were drawn in the same style as the 1702 plate, showing the tools and many characters working on the tools. In 1720, after the Billettes' death, the academician René Antoine Ferchault de Réaumur (1683-1757) took over the arts and crafts description project. Texts were published about other trades by Carré, Jaugeon, La Hire, Saulmon, Lémery, and Réaumur himself.

[3] This differs from the 48 000 pins manufactured by 10 workers in Smith's workshop.

Nothing was published about pin making, although Réaumur did write a handwritten report that was very close to Guéroult's text and was published by Duhamel in 1761 as we will later see.

1.3. *Savary*

The first printed text about pin-making is an article in the *Universal trade dictionary,* published in 1723 by Savary. Jacques Savary des Bruslons (1657-1715) was director of customs and collected for his own use all available information from the central Royal Administration and Academy. This information formed the basis of his dictionary. His work was finished by his brother Louis-Philémon Savary (1654-1727). In his article entitled "Pin", he described the pin maker's guilds and charters and also the relocation of pin making to Normandy. The Paris pin makers knew of provincial production because their 1601 charter forbade the reselling of these cheaper pins and also imposed taxes upon them.

Savary had no doubt heard of Billettes attempt to bring together both technical and economical aspects of pin making. He wrote:

"Few goods sell for less than pins, yet no other is handled by so many before being sent to market. One can count more than twenty five labourers, working in succession, starting from the pulling of the brass wire off the spinner up until the pin is attached to paper".

(Savary, 1723, Article "Espingle")

The division of labour appears quite pronounced. Savary had seen the five plates held by the Academy of Sciences representing the work of pin-making, and counted the number of characters that were drawn. The characters were however drawn in Paris to explain the use of tools and many operations and workers were drawn several times. One explanation is that Savary did not have Guéroult's text to help interpret the plates. He may not have detected the repetition of operations and the workers executing them.

Ephraïm Chambers copied Savary's article in his *Cyclopaedia*. He wrote:

"Notwithstanding that there in scarce any commodity cheaper than pins, there is none that passes through more hands ere they come to be sold. They reckon twenty-five workmen successively in each pin, between the drawing of the brasswire and the sticking of the pin in the paper".

(Chambers, 1728, Article "Pin")

Savary's misunderstanding led both the French and English to believe there was a significant division of labour between twenty-five workers in the pin making manufactories.

Savary also gave some technical details about pin making such as the country of origin of brass wire, the way pins were arranged on paper sheets, the numbering system for size differences, the production sites of Laigle and Rugles in Normandy where the merchants stamped the wrapping paper, and the whitening process using tin or silver paste.

He knew the charters of the pin making guilds and explained how an apprentice pin-maker could become a master. To become a master in the ancient guilds, it was necessary to pass a standard test at the end of an apprenticeship. After four years as an apprentice and one year as a journeyman, the worker passed the "chef-d'oeuvre". The pin-makers' "chef-d'oeuvre" "involved making one thousand pins which once finished must be seen and presented in the presence of all the masters so that they may give their opinions" (Savary, 1723, "pinmaker"). The test required an apprentice to perform all of the operations.

1.4. *Perronet*

Jean-Rodolphe Perronet (1708-1794) succeeded Guéroult in 1737 as a civil engineer in Alençon. In 1747, he created the first French bridge and road engineering school in Paris, l'Ecole des Ponts et Chaussées (Vacant, 2006). He too observed pin making in 1739 and took accurate measures

(Perronet, 1740). He described the technical process, drew many of the tools used throughout the process, gave both the rhythms and the wages and he computed the production cost for ten different pin sizes. Perronet wrote another unpublished manuscript about wiredrawing (Perronet, 1739) where he used the word "operation" for the first time to describe each step in the process where a tool was used. This word was then used in the *Encyclopaedia* to describe other technical processes. It was also adopted by Adam Smith. The drawing operation was repeated up to 12 times to obtain the required diameter of the pins. Perronet also gave the rhythms. He computed the wages of the drawers and the production cost for each wire size.

Perronet's pin-making report was very similar to Guéroult's report although it was not a copy. The figures were different. Perronet's first operation was to straighten the wire. This specialized worker also cut the wire into sections. The second worker was the pointer, the third was the softener pointer, the fourth was the cutter of the shanks, the fifth operation was the head turning, the sixth was the head cutting, and the seventh was the head softening. The worker for this last operation was not named.

While Perronet didn't describe the workroom, the eighth operation is clearly performed outside the main workshop. It is the head putting. The headers were specialized workers and Perronet forgot to mention that they were women working at home. He described how materials were weighed as they entered and left each house to avoid theft. A materials register was kept for each labourer working outside the workshop. "When the headers take back their pins to the manufacturer, they [the pins] are weighed to maintain a materials account [input and output] for the workers of each place" (Perronet, 1765). Based on pin sizes, the number of pins produced and the header's salary were then calculated. They were paid according to quantities produced just like the other workers. A wage ledger was also kept for these labourers working at home.

When the pins came back to the main workshop, the turner washed them in acidic water. This ninth operation didn't have a specialized worker. The same worker also whitened the pins as the tenth operation. The pins were then dried and winnowed by non-specialized workers. These pins were carried in a basket for the paper punching and to put them into paper (the eleventh and twelfth operations). The naming of the trades and the rhythms indicate that there were 9 specialized workers, including two men who turned the wheels to point.

The cutting of shanks (the fourth operation) also had a specialized worker. He cut 36,000 pins per hour. The daily production of a large workshop was not enough to occupy this worker for the whole day so he worked in several workshops. "The scissors form a callus of flesh on the right hand which is an inch thick and which is even useful for them for this function" (Perronet, 1765).

Perronet gave the rhythms for seven operations (Table 1). They are lower than those reported by Billettes and by Guéroult.

Operation	Daily production (number of pins)	Time taken to make one pin (seconds)	
Straightening the wire	108,000	0,35	6%
Pointing	108,000	0,2	4%
(the turner)			
Pointing again	108,000	0.2	4%
(the turner)			
Cutting the shanks	420,000	0.1	2%
Making the heads	144,000	0.2	4%
Heading	10,000 to 12,000	3.3	61%
Putting	36,000	1.1	20%
	Total time to produce one pin	5.85	100%

Table 1: Production rates according to Perronet 1765

Perronet sent copies of his text to his friend Diderot in 1755 and later to the Academy of Sciences in

1761, which he later joined in 1765. His friend Diderot published the entire text in an article entitled "Pin maker" in the *Encyclopaedia*, in the 1765. It was a volume of plates. These plates were drawn in accordance with Perronet's drawings.

1.5. *Delaire and the 18 operations*

The most well known article on pin-making is the article "Pin" in the *Encyclopaedia* volume 5 from 1755 (Diderot, 1755, 804-807). It was written by Alexandre Delaire. This long text explicitly numbers 18 operations. The first was the yellowing of the brass wire, the second the drawing. The naming of the different trades refers to five operations ("straightener", "pointer", "cutter", "head turner", "head sticker") however his detailed description implies that there were 18 different trades. The division of labour into 18 trades wasn't explicitly written. Delaire didn't give any rhythms for these operations.

Delaire described in succession each of the 18 operations, as Smith would later do, with no mention that some operations were repeated. The reader is given the impression of a pronounced division of labour as each operation appears to belong to a separate profession.

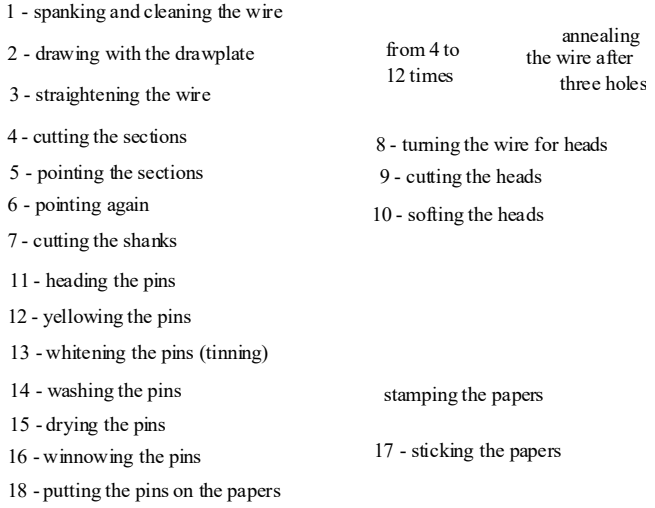

Figure 2 The 18 operations with Delaire's numbers in Diderot's Encyclopaedia (from Peaucelle, 2007, 53)

Delaire wrote as if he had personally observed workshop activity: "this article is written by Mr. Delaire who describes the manufacture of pins in the workshops with the workers themselves" (Delaire, 1755, 807). But this was not true. An analysis of the parts of Delaire's article reveals his sources. The technical vocabulary was copied from previous descriptions of pin making, authored by Savary, Guéroult, Perronet, and Réaumur.

Diderot implied that he had observed activity in the workshops to describe the arts and crafts. That would have been too costly. Instead, it would appear that he often reused the documentation held by the Academy of Sciences. As the arts and crafts project was not progressing, this approach would also have been a way of publishing material that had been collected over a long period.

When the first volume was published in 1751, the Jesuits, Diderot's intellectual enemies, claimed that 22 articles were "closely copied from the *Trade dictionary* that should have been referenced" (*Journal de Trévoux*, February 1752, 303-304, in Slatkine edition, 1986) and others taken from their *Trévoux dictionary*. The article entitled "needle" was very similar to Savary's work. For example, Savary described a needle as a "small piece of polished and thin steel, pointed at one end and pierced at the other, used to sew, to broider, to weave a tapestry, to stitch, &.c" (Savary, 1723, "Needle"). Diderot described it as "a small, thin instrument made of polished ice hardened steel, & usually pointed at one end, & pierced with a longitudinal opening at the other" (Diderot, 1751, "Needle"). Delaire defined a pin in almost the same words: "a small metallic

instrument, straight and pointed at one end, used as a removable fastener for clothes and fabrics, to affix the different folds given to garments, to handiwork & wrappings" (Delaire, 1755).

To respond to his critics, Diderot published an entirely new article on the 'pin'. He had access to the Academy's documentation and the five plates. He borrowed Perronet's handwritten report and paid a freelancer to write a synthesis of the different sources. Alexandre Delaire had studied literature and knew very little about technology (Kafker & Kafker, 1988).

There were 71, 77, and 58 technical terms used in Guéroult's, Réaumur's and Perronet's reports respectively to describe the operating process. There were 169 different terms. Delaire could have chosen to translate these words into more readily understood language to improve the readability of his text. Instead, he kept his text technical and used 75 specialized terms: 64 were extracted from the three previous texts, nine were old words probably usual at this time and he invented two obscure technical words. The use of these words lent Delaire's text a certain linguistic style, and gave pin making a mysterious feel. A close examination of these four texts shows that Delaire's was a synthesis of the three others.

Delaire numbered each operation so as to keep the attention of readers that may be discouraged by the use of strange technical terms. His numbering gave the impression that operations were performed sequentially. This approach was most probably inspired by the way Diderot himself numbered the instructions to authors of the different articles on the arts:

"Here is the method we followed for each art. We treated 1° the material, the places where it can be found […] 2° the main products made from it, & the way they are made, 3° the name, a description, & a drawing of tools & machines were given, [...] 4° The workers & main operations were explained and presented [...] 5° the exact terms used by the art were collected & defined".

(Diderot, 1751, *Discours Préliminaire*, xxxix)

Delaire's article was well received and the new edition of Savary's *Trade dictionary* in 1759 included his text in full. Perronet as a contributor was probablement disappointed parce que Delaire avait complètement omis le calcul du prix de revient, ce qui était sa contribution majeure. He later gave his report to Duhamel, and asked Diderot to publish his own text (Perronet, 1765).

1.6. *Duhamel*

The Academy of Sciences began publishing the *Description of the arts and crafts* item by item in 1761. It was edited by Henri Duhamel du Monceau (1700-1782). The second item was the *Art of the pin maker* (Duhamel, 1761) making up 77 printed pages. Duhamel mixed four sources: Réaumur's text that had been mostly copied from Guéroult, Perronet's text, his own personal recollections of pin making in Normandy, and the remarks from Chalouzière. Bazile François Legrand de Boislandry de Chalouzière was a land owner and a Norman judge near Laigle. These texts were cut and pasted to follow the manufacturing process. Each author was clearly identified.

As Duhamel's approach was to juxtapose texts from different sources, there are a number of contradictions. For example, the operation involving the reheating of heads (Delaire's operation 10) was contested by Réaumur who claimed that reheating was performed using a brass spoon and not an iron one (Duhamel, 1761, 28). Chalouzière added that this step didn't exist (Duhamel, 1761, 76). The largest differences concerned the work rates. For example, for point making Réaumur used Guéroult's figure of 72,000 per day while Chalouzière corrected this number to 244,000 (Duhamel, 1761, 19 and 76). Similarly, Réaumur claimed that the shank cutter made 180,000 pins per day whereas Chalouzière estimated his production at 540,000 (Duhamel, 1761, 24 and 76). The putter made 7,000 pins per day according to Réaumur and 12,000 according to Chalouzière (Duhamel, 1761, 33 and 76). Perronet either gave numbers in between these values or ranges.

The authors differ as to how operations are divided. Perronet quoted six trades and Duhamel quoted nine. Perronet listed 12 operations and Duhamel divided his text into 17 sections (Duhamel, 1761, 1-3) although the process had only 13 operations. The sections numbered 3, 14, 15, and 17

were not part of the process. Only 9 operations were similar. Duhamel first identified the wire drawing and secondly the washing. These two operations were not in Perronet's text. Duhamel separated the cutting of the sections as an operation performed by a specialized cutter. Both writers agreed on 5 other operations: pointing and softening, cutting of the shanks, turning the head, cutting the head. Duhamel included head softening as part of this last operation. He counted heading as two separate operations. Washing in acid, whitening, and drying were also counted as unique operations.

Duhamel gave a second list of 15 operations (Duhamel, 1761, 42) that was closer to Delaire's 18 operations. Both authors described the same process, based on the same sources but did not identify the same operations. In both cases the number of operations was determined by the way the description was broken down and not by the specialization of workers.

Duhamel used all of Perronet's text concerning rhythms and costs. He used the economic aspects to describe the main features of pin-making, the low prices and the large number of operations.

Chalouzière, Duhamel's local contact, insisted on the importance of the low salaries in Normandy:

"As production is based in a small provincial town, and for a large part in the surrounding country side, where foodstuffs are cheap; one can easily pay labourers low wages; as labourers are always willing to work, so long as they are given a recompense that allows them to live".

(Duhamel, 1761 Chalouzière, 46)

Duhamel published seven plates, the first in 1702, four in 1718 and three others from Perronet's drawings. Each was in the same style as the 1702 plate: they showed labourers at work and the detail of the tools used.

After the publication of Duhamel's text by the Academy of Sciences many periodical reviews referred to it. For example Fréron noted:

"you will be surprised, Sir, of the industry, the combination, & and above all the promptness with which are executed all the operations necessary for the making of such a useful bagatelle as a pin. It is in L'Aigle, in Normandy, where the best pins are made".

(*Année Littéraire*, 1761, Tome 5, 344).

The 12 operations involved in brass pin making were then enumerated. Fréron's account remained true to Duhamel's text. He appeared to take pleasure in contradicting the 18 operations identified in Diderot's 1755 *Encyclopaedia*. Fréron was one of Diderot's main rivals.

The *Journal des sçavans* was a monthly review published in Paris from 1665. In the eighteenth century, the review was closely linked to Academy of Sciences and published the minutes of its meetings. It also covered the latest scientific publications. In November 1761, it reported on the publication of Duhamel's *Art of pin maker* by citing the start of the text:

"No person could not be surprised by the low price of pins ; but one would be even more so when one learns of the number of different operations, most often very delicate, that are needed to make a good pin […] For each of these operations there is an article giving all the necessary details to perfectly understand this art".

(*Journal des sçavans*, 1761, 745)

The commercial success of Diderot's *Encyclopaedia* opened a new market for short dictionaries (for example La Combe de Prezel, 1761). They often had an article entitled 'pin'. From 1782 to 1791, the famous publisher Pankoucke reprinted all the texts describing the arts and crafts trades including that of pin making in 1783, those published by the Academy and in Diderot's *Encyclopaedia* (Lacombe, 1782-1791).

1.7. *Macquer*

In 1766 Philippe Macquer published the *Portable dictionary of the des arts and crafts*. He was the brother of Pierre-Joseph Macquer (1718-1784), a member of the Academy and a teacher of Lavoisier, a renowned chemist. The Macquer family was originally from Scotland. They followed the English King James II when he went into exile in France in 1690. Macquer copied Duhamel's *Description of the arts and crafts* but he condensed it. He described the operations in a simple way. The first operation for pin making was the drawing of the wire.

Macquer gave the rhythms for seven operations: 120,000 pins per day for the straightener, 30,000 pour the putter, between 8,000 and 9,000 pour the head maker. These are the same low rates as those given by Réaumur in Duhamel's 1761 text. They were originally reported by Guéroult in 1717.

Macquer identified two additional operations for which no rhythms were given: whitening the pins in the boiler, and putting them through the rubbing machine with bran.

1.8. *The multiple sources*

There were only three original sources based on observation of pin making: Guéroult (1717), Perronet (1739), and Chalouzière in Duhamel (1761). Four main publications were based on these three sources: Savary (1723; 1759), Delaire (1755), Duhamel (1761), and Perronet (1765). Many texts were often synthesized in the same publication, without giving any references. The notion of intellectual property wasn't shared by the authors at that time. The linkages between the different French texts are presented in Figure 3.

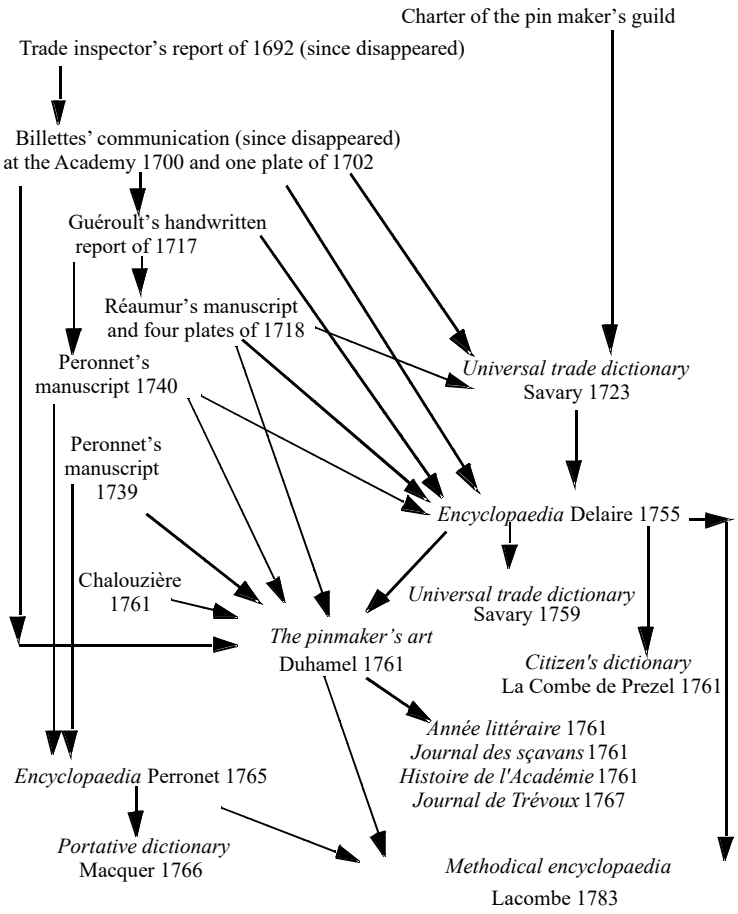

Figure 3 French texts on pin making in the eighteenth century (from Peaucelle 2007, 155).

These texts described the pin making techniques but the published texts omitted other aspects such

as the feminisation of the trade. Female headers and putters outnumbered men, two to one. In spite of the large number of texts, there was also a poor understanding of the social aspects of the trade. Work sharing in the manufactories was not of interest to those who described pin making. The true size of this industry was hidden. It is only by comparing different sources that we can deduce that there were around 1300 pin makers. There was no critical analysis questioning existing practices and opening new perspectives for observations. Their main mistake was to create the illusion of a division of labour between 18 labourers in each workshop.

2. Adam Smith's interpretation of the French texts

Adam Smith (Smith, 1981 [1776], 14-15) was right to choose pin making as an example: the techniques were thoroughly described, some operations required specialized workers, and work rates were available. But he no doubt did not read them closely enough. Several points were not as he thought they were: the division of labour did exist but between fewer than 18 trades; marked differences in work rates between operations meant that, if labour was highly specialized, worker numbers had to be adjusted; improved physical productivity was an objective yet an increase in the division of labour did not allow it; the productivity of non specialized craftsmen was better than Adam Smith thought. Each of these points will now be examined in turn.

2.1. *The division of labour*

Duhamel's text most probably gave Adam Smith the idea for the term "division of labour" as well as that of high productivity.

"All these operations are carried out, with the truth, with a marvellous celerity… It is in the promptitude of this operating that one of the perfections of art consists" (Duhamel, 1761, 3).

"No person could not be surprised by the low price of pins; but one would be even more so when one learns of the number of different operations, most often very delicate, that are needed to make a good pin. We will use few words to discover these operations, yet enough to stir the desire to learn the details; this enumeration will provide us with as many articles that make up the division of this work".

(Duhamel, 1761, 1)

We previously noted that Perronet, Delaire, and Duhamel disagreed on the way operations were divided and on their number. In spite of the differences between the counts, 12 or 18 operations, the different texts described the same process. Amid the confusion, Adam Smith chose the clearest description: Delaire's text with 18 operations. However, there were not 18 separate trades. Delaire only named five trades and Duhamel named nine.

Delaire's enumeration hides three repetitive operations (numbers 5, 6 and 7). Take for example operation 7, the drawing of the wire. The wire drawer used successively smaller holes until the required diameter for the pin size was reached. Twelve holes were used to draw the wire for pin number three, and seven for pin number eight, for example. The wire was annealed after three holes. The sections were two to five pins long and they were cut two or three times into shanks (operation 7).

Adam Smith didn't understand the repetitive fifth, sixth, and seventh operations. He wrote "a fourth [worker] points it, a fifth grinds it at the top for receiving the head" (Adam Smith, 1981 [1776], 15). It was easier to hold a section of wire on the grindstone if it was long. The sections were as long as two to five pins in length. The pointer made a point at each end. After pointing, each section end was cut to be a pin without a head (a shank). The eventual remaining piece in the middle came back for pointing. "Once cut, the sections are given to the pointer; he is the worker who makes a point at each end" (Duhamel, 1761, Réaumur, 18); "we can well imagine that the two points of a section are in fact the points of two different pins, & that these two pin lengths must be

cut" (Duhamel, 1761, Réaumur, 22); "When the sections are pointed at both ends, they must be cut to the length of a pin to make what is called a shank" (Duhamel, 1761, 2).

Adam Smith chose to write about the division of work into 18 distinct operations, yet there were only 8 or 9 different persons in the process. Les texts français ne montrent pas qu'il y avait une personne par operation.

2.2. *The different work rates*

Amongst all this confusion work rates are very important to compute the productive power of labour. Perronet calculated the cost price of a pin based on the cost of labour of 9 workers performing 7 operations: the straightener, the point maker, two grinders, two turners, the cutter, the head maker and the putter (Duhamel, 1761 Perronet, 43). Eleven operations that Delaire had identified were missing: cleaning the wire (1) and stripping it (2), for which Perronet costed separately (Perronet, 1739); cutting into sections (4) performed by the straightener; the three operations to prepare the head (8, 9, 10) were merged; and six operations 12 to 17 performed incidentally by workers specialized in other tasks.

The cost calculations indicate that work was divided amongst 11 people, plus an additional worker for drawing (operations 1 and 2), or between 9 specialists if one considers the point maker and the grinder as interchangeable. But we should also take work rates into account.

The work rate is different for each operation. To balance out the work load of 9 specialized operations, a 'large' workshop needed to occupy 21 people to produce 9 dozen batches of 12,000 pins per day (Table 2). The workload was never perfectly balanced. Too many workers on one operation could perform other tasks that don't show in this count.

Operation	Number of workers	Daily production (number of batches of 12,000 pins)
3 Straightening the wire + cutting the sections	1	9
5 Pointing the sections	1	9
5 (the turner)	1	
6 Pointing again	1	9
6 (the turner)	1	
7 Cutting the shanks	1/3	11
8 + 9+10 making the heads	1	12
11 Heading the pins (women)	11	9
18 Putting into paper (women)	3	9

Table 2 Typical workforce of a pin factory producing 9 batches of 12,000 pins per day using 21 specialized workers, according to the work rates provided by Perronet 1765.

Can we say then that, in this workshop, the production of 9 batches per day was divided amongst 21 workers? Can we say that work was divided into 7 trades (straighteners, turners, point makers, cutters, head makers, headers, putters), some of which were performed concurrently by several workers while others laboured repeatedly on the same piece? This question is essential for Adam Smith's theory, for he argued that if several individuals worked on the same activity, they could be further specialized.

2.3. *Failed work improvements*

The eleventh operation (heading) was longer than the all of the 17 other operations. If Adam Smith's theory is true, it should be possible to accelerate the process by dividing up this operation. The French pin makers did trial such a change as described by Duhamel. He separated the heading activity into two operations: the passing of the shank in the head and the hitting of the head to fix it. The women who performed the first motion with their left hand, also performed the second with their right hand and foot at the same time. To head the pins a child was employed to thread the head onto the shank. But this was useless.

"To stick at least cost, there are workshops where children have to pass the shank in the head; but it was necessary to put the head at the end of the shank. It is now considered more efficient to thread and hit by the same worker".

(Duhamel, 1761, 34)

This attempt to divide labour did not increase productivity. In this case more specialized labour was not more productive.

Adam Smith ignored this failed trial even though it was reported in one of the texts he consulted. This example counters his theory on the division of labour and he omitted to mention it.

He also overlooked another observation. The French authors described the same pin making activity but with a different division of labour: 25 workers for Savary in 1723, 18 operations for Delaire in 1755, 12 operations for Perronet in 1761, 10 for Macquer in 1766. These numbers seem to show that the division of labour was decreasing over time. This is contrary to Smith's theory that the division of labour must increase. Adam Smith neglected to report these figures.

2.4. *Average productivity*

Authors, with the exception of Delaire, often reported work rates for the longest operations. Adam Smith extracted this information from Macquer's *Portative dictionary* (1766) which he had bought during his travels in France (Mizuta, 1967). He computed that 10 workers could produce 480,000 pins per day. From the work rates for seven operations (see Table 3) he added the grinder who worked at the same rhythm as the point maker and the two turners. He deduced the production time per pin and the average productivity of 4800 pins per day and per person (Table 3). This productivity calculation ignored the initial wire drawing (1 and 2) and the operations 4, and 12 to 16.

Workers	Output (pins per day)	Production time (seconds per pin)
Straightener	120,000	0.36
Point maker	72,000	0.6
Turner	72,000	
Grinder (to point again)	72,000	0.6
Turner	72,000	
Cutter of shanks	190,000	0.23
Head cutter	144,000	0.3
Header	8,500	5.08
Paper piercer	96,000	0.45
Putter	30,000	1.44
	Average 4,800/worker	Total 9.06

Table 3. Execution time for each pin making operation according to Macquer's (1766) rhythms.

French authors agreed that the time needed to make a pin was not a function of its size; however,

Smith argued to the contrary: “They exerted themselves, make among them about twelve pounds of pins in a day. There are in a pound upwards of four thousand pins of a middling size” (Smith, 1981 [1776], 15).

2.5. *Baseline productivity*

Adam Smith compared the production levels with and without a division of labour. He did not have any data so he invented an apprenticeship scenario.

> “A workman not educated to this business (which the division of labour has rendered a distinct trade), nor acquainted with the use of the machinery employed in it (to the invention of which the same division of labour has probably given occasion), could scarce, perhaps, with his utmost industry, make one pin in a day, and certainly could not make twenty”.
>
> (Smith, 1981 [1776], 14)

He goes on to conclude that dividing the work into 18 separate operations would multiply productivity by a factor of 240.

Smith’s conclusion is excessive. He could have found a more realistic example in Savary’s account of the “chef d’oeuvre”. The worker made 1000 pins. How long did it take to produce these thousand pins? Probably half a day and the test of all the pins lasted the remaining half-day. The productive power of labour would be some 2000 pins per day and per pin-maker working without any division of labour. Productivity improvements would not have been as spectacular as Adam Smith imagined. They would have been closer to a factor of 2.4 rather than 240.

The calculation of a baseline productive power is an approximation. The two situations are not comparable. A worker in an exam situation would reduce his work rate to improve quality. Furthermore, the process was longer. It began with the wire drawing. The tools were also less sophisticated. Pins were headed using a hammer on a small anvil and they were whitened using silver paste. The differences in productivity could be explained by this change in tooling.

Adam Smith also neglected physiology as a limit to the division of labour. He would have known that an ordinary horse cannot run faster than the race winner. Both animal and human muscles have a maximal speed. Dividing labour will not lead to production increases when these limits have been met.

3. Analysis of the facts

Adam Smith read Duhamel’s, Delaire’s and Macquer’s texts as well as the *Journal des sçavants* (Peaucelle, 2006). He borrowed the idea of the division of labour and the productivity measures. He selected some details and neglected others; Macquer clearly explained that work was divided amongst 8 or 9, and not 18 specialized trades. If Smith had read Savary’s text more carefully he would have noted that non specialized production was less productive, around 2.4 times so, but not 240 times less. Smith exaggerated the importance of the division of labour in pin making when he used it as an example. He also neglected to mention the failed attempt to split the eleventh operation (heading) as well as the apparent diminution in the division of labour over time from 25 to 10 operations.

Adam Smith does not appear to have studied the differences in production rates between operations. These differences influenced the workforce and completely modified the notion of specialization. Rather than organizing work as a succession of tasks on an assembly line, workshops probably required a more complex organization where workers had to be more polyvalent to balance differences in workloads between operations.

Smith’s pin making example was an appropriate one to illustrate the organization of labour within an industry. However the texts present a situation that sometimes only moderately supports the theory of the division of labour and sometimes contradicts it. Other documents on the pin-

making industry bring us to question this theory.

3.1. *The mix of specialized workers and non specialized workers*

The French texts do not directly discuss the organization of labour. Pin makers may or may not have been specialized. The distinction between trades may have been, as was the case for Delaire, purely literary (Delaire, 1755). Production was based in Laigle and its environs. There were some workshops in the town but a large part of the production was undertaken by families in their homes spread throughout the forest (Sicotière, 1861, 62).

Adam Smith did not consider the differences between work rates and workloads. We noted previously that worker specialization may have created problems for the balancing of workloads. Several specialized workers were generally assigned to longer operations. Workers assigned to shorter operations were less specialized. Given the constraint of workload balancing, specialization would have been variable. It was the non specialized workers, such as the workshop manager who performed the necessary activities to balance workloads. Specialization did exist but it was variable, and existed parallel to non specialized workers who demonstrated the same work rates. In small workshops there was less specialization. It existed by virtue of the exchange of specialized workers and half worked pieces between workshops. Wire drawing and head making was often performed by workers in their homes.

In 1794 an inventory of workshops was undertaken in Bourth, 10km from Laigle. 500 pin makers worked in 70 workshops. The average of 7 workers per workshop however is misleading. 40% of workers were employed in small workshops of 6 people of less, 40% in workshops of 7 to 9 workers, and 20% in large workshops with 10 to 20 workers (Marchand, 1966, 35). Workshops of different sizes coexisted. The organisation of labour varied according to the size of the workshop. It was not standardized. There were no economies of scale, nor any productivity gains in large workshops where pin makers could be more specialized. No workshop would have had a significant advantage over another. The productivity of labour and the level of wages were the same. More divided labour wasn't more productive. The theory of the division of labour does not hold true in Smith's first example, that of pin making.

The 1807 census inventoried four specialized trades in pin making at Bourth including 54 wire drawers, 3 point makers, 68 head makers and 30 putters as well as three non specialized trades, 83 pin makers, most probably workshop owners, 9 pin labourers and 42 journeymen (Marchand, 1966, 30.). Non specialized workers who were able to perform several if not all trades worked besides specialized workers. Specialization was not sufficiently advantageous to become an industry standard.

A contract registered by a local lawyer is proof of these non skilled workers. The worker was contracted

"to work the pin trade all ways such as to draw the wire, cut sections and shanks, make points, make heads, hit, whiten, etc. for a year, in exchange for lodging, food, cleaning and housekeeping and 45 French pounds wages for the year".

(Le Maréchal, 1901, 286, 20th January 1746)

The work rates of this non specialized worker would most likely have been the same as those of his specialized colleagues as they all used the same tools. As a generalist he brought organizational flexibility to the specialized workers.

We can conclude that work was sometimes specialized, sometimes not specialized. Different labour arrangements were possible without influencing productivity. It all depended on tooling. This juxtaposition of different ways of organizing refutes Adam Smith's theory.

3.2. *The link between operations and tools*

An operation was defined by the use of a tool. The illustrative plates were drawn and interpreted this way. This could be understood to mean that there was also a specialized worker per operation. Adam Smith introduced the idea that operations could be divided independently of the use of tools. Could work be divided up even more finely? Could two labourers use the same tool where one was enough? Would productivity improve? There was no example available in the pin making industry. The failed attempt to divide the head making operation showed that this was not feasible. The maximal division of labour corresponded to the number of tools employed successively. It depended on the technology. To increase the division of labour it would be necessary to change the technology.

The case of pin making shows that this antiquated technology allowed several different organizations of work. The same worker could perform several different operations. In reality, the maximal division of labour was not reached.

3.3. *Babbage and wage differences*

Charles Babbage (1791-1871) read Perronet's text. He remarked how daily wages differed by operation. The men performed operations 1 to 10 and 12 to 16; they earned from 10 to 18 sols per day. The women worked on operations 11, 17, and 18 and they earned from 4 to 8 sols per day.

Babbage showed that wage differences explained the advantages of dividing labour as described by Adam Smith. He compared the work performed by a polyvalent labourer with work divided amongst several workers. One person performing the work alone would have been paid the wage for each operation. A day's wages would be calculated by weighting the average wage for each operation by the time spent. The result would be a wage lower than the maximal wage. As this worker knew how to perform the highest paid operation, he would prefer to earn this wage. A qualified worker would be motivated to only perform the better paid operations. A factory owner would have to pay him the highest wage to have the entire process executed. The cost of labour and the price of pins would then be higher. It would be more advantageous for the owner to divide the work according to skill and only pay high wages to workers performing difficult tasks.

Babbage succinctly expressed his theory

"The higher the skill required of the workman in any one process of a manufacture, and the smaller the time during which it is employed, so much the greater will be the advantage of separating that process from the rest, and devoting one person's attention entirely to it".

(Babbage, 1830, 186)

If a skilled worker is required for a short operation, someone should become specialized.

"If the entire process was to be undertaken by one worker then he would have to be skilled in the most difficult operation and all his time should be paid at the corresponding rate. The division of labour however, that favoured improvements in skills through repetitive work for those performing a single task, also reduced costs for the entrepreneur who paid the lowest price for unskilled or lowly skilled tasks assigned to unskilled workers and only employed skilled workers to perform difficult tasks".

(Verley, 1994, 12-13)

Specializing workers with different skill levels meant that they could be paid different wages. This would have lowered the cost price for an entrepreneur. It would allow lowly skilled workers to find paid work. Skilled workers would earn a better wage for the more difficult work they perform. Owners and workers would have a common interest in specialization and the wage differential it affords. Babbage's theory gives an entirely different perspective on the division of labour. He highlights its effect on wages and costs, factors that are entirely independent from productivity.

In Norman pin making during the eighteenth century, men earned the highest wages and were polyvalent enough to replace one another. They would not have replaced women who worked for lower salaries. The variable specialization between men and women can be explained by flexibility

seeking behaviours and workload adjustment in an industry where the flow of goods was ever changing.

4. Conclusion

The French studies of 18th century pin making were undertaken with the intention of publishment through the Academy of Sciences. They responded to a royal order concerning all arts and crafts. Several texts were written, often copying, completing and contradicting one another. They had no particular scientific objective beyond the precise description of techniques used. The authors did not develop any arguments or critical appraisal.

There was also no attempt by the Academy of Sciences or by the *Encyclopedia* to use these observations to develop an economic theory of productivity as Adam Smith later did. Yet Savary was surprised at the low cost of pins and at the large number of laborers working in succession. His observations were sufficient to develop a theory of the economic effects of the division of labor, but he did not use them to do so. Duhamel was also close to theorizing this relationship but he instead concluded that low prices were a consequence of low labor rates in the provinces.

Billettes was the only member of the Academy to understand that the data was economically incoherent. Yet nothing was published. The only trace of his thinking can be found in his notes, and in particular the calculation of value added by worker that he compares to wages. Perronnet used pin making to illustrate how to compute cost price. While these two approaches are unique amongst all the writings of the time on the arts and crafts, their impact on economic thought is far less than Smith's productivity theory.

French economists at the time, such as François Quesnay (1694-1774), did not comment the Academy of Science's technical descriptions or those published in the *Encyclopedia*. They discerned neither specialization in the workshops nor high productivity. The dominant economic intellectual movement in France at the time, physiocracy, was more interested in agriculture than industry and the crafts that were not considered to be productive activities. Jean Claude Marie Vincent de Gournay (1712–1759) and Anne-Robert-Jacques Turgot, Baron de Laune (1727–1781) recognized the importance of the industry but did not comment the descriptions of the pin making process as Smith did. To Adam Smith's credit, he chose to study the pin industry and its mechanization that was more visible in 18th century England than in France.

We have demonstrated here that Adam Smith's description of pin making was over simplified. We did not evaluate the impact of his economic theory. More work is needed to understand how Adam Smith established the relationship between the division of labor and productivity. The weak probative value of his pin making example takes nothing away from the reach of his economic ideas.

References

Babbage, C. 1832, *On the economy of machinery and manufactures*. London: Knight.

Billettes, G. 1700, *Handwritten manuscript in file 'Billettes'*, archives of the French Academy of Sciences.

Chambers, E. 1728, *Cyclopaedia or an Universal dictionnary of Arts and Sciences*. London : Midwinter.

Chenaye-Desbois (de la), F.-A. 1778, *Dictionnaire de la noblesse*. Paris: Boudet

Delaire, A. (1755). *Encyclopédie*, tome V article 'Épingle' [Encyclopaedia, fifth volume, article 'Pin']. Paris: Briasson.

Diderot, D., Le Rond d'Alembert, J. 1751-1780, *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers* [Encyclopaedia or reasoned dictionary of the sciences, the arts, and the crafts]. Paris: Briasson.

Duhamel du Monceau, H.-L., Ferchault de Réaumur, R.-A., Perronet, J.-R., Legrand de Boislandry de Chalouzière, B.-F. 1761, *L'Art de l'épinglier* [The pinmaker art]. Paris: Saillant et Noyon.

Guéroult 1717, *Description générale de la fabrique d'épingles de latton et de fer de la manière dont elles se font à Laigle, Généralité d'Alençon* [General description of brass and iron pin making and the way they are made in Laigle, near Alençon]. Handwritten manuscript. Paris: Library of the ENPC School, cote 333 MS 2385.

Huet, P.-D. 1712, *Le grand trésor historique et politique du florissant commerce des Hollandois dans tous les états et empires du monde* [The great historical and political treasure of flourishing Dutch trade throughout all the states and empires of the world]. Rouen: Ruault.

Kafker, F. Kafker, S. 1988, *The encyclopedists as individuals: a biographical dictionary of the authors of the Encyclopédie*. Oxford: The Voltaire Foundation.

La Combe de Prezel, H. 1761, *Dictionnaire du citoyen ou abrégé historique et pratique du commerce* [Citizen's dictionary or historical and practical summary of trade]. Paris:Grangé.

Lacombe, J. 1782-1791, *Encyclopédie méthodique des arts et métiers mécaniques* [Methodical encyclopaedia of mechanical arts and crafts]. Paris: Pankoucke.

Le Maréchal, A. 1901, *Documents tirés des minutes du tabellionage de Rugles* [Documents extracted from the minutes of the Rugles' solicitor's archives]. Archives de l'Eure cote 3F353. Rouen: Lestrinant.

Macquer, P. 1766, *Dictionnaire portatif des arts et métiers, contenant en abrégé l'histoire, la description et la police des arts et métiers, des fabriques et des manufactures de France et des pays étrangers* [Portative dictionary of the arts and crafts, including a concise history, description and policy of the arts and crafts, of factories, and manufactories in France and in foreign states]. Paris: Lacombe.

Marchand, E. 1966, *La fabrication des épingles et le travail du fer à Bourth en pays d'Ouche à la fin du XVIIIe siècle et au début du XIXe* [Pin making and iron work at Bourth in the Ouche county at the end of the eighteenth century and at the beginning of the nineteenth century]. Paper presented at the *90th national congress of learned societies, modern and contemporary history section, Nice 1965*. *Actes du 90ème congrès national des sociétés savantes, section d'histoire moderne et contemporaine* Paris: Bibliothèque Nationale. tome III, pp. 9-38.

Mizuta, H. 1967, *Adam Smith's library: a supplement to Bonar's catalogue with a checklist of the whole library*. Cambridge: University Press.

Pannabecker, J.R. 1996, "Diderot, Rousseau, and the mechanical arts: disciplines, systems, and social context" *Journal of Industrial Teacher Education* 33, 4, 6-22

Peaucelle, J.-L. 2006, "Adam Smith's use of multiple references for his pin making example", *The European Journal of the History of Economic Thought,* 13, 4, 489-512.

Peaucelle, J.-L. 2007, *Adam Smith et la division du travail, la naissance d'une idée fausse*. Paris: L'Harmattan.

Perronet, J.-R. 1739, *Explication de la façon dont on tire le fil de leton à différentes grosseurs, dans la ville de Laigle en Normandie par le moyen de la filière pour en faire des épingles et différents autres ouvrages* [Explanation of the way brass wire is drawn for several sizes in the town of Laigle in Normandy by means of a drawplate to make pins and several other works]. Handwritten manuscript. Paris: Library of the ENPC School, cote MS 2383.

Perronet, J.-R. 1740, *Description de la façon dont on fait les épingles à Laigle en Normandie* [Description of the way pins are made at Laigle in Normandy]. Handwritten manuscript. Paris: Library of the ENPC School, cote 333 MS 2385.

Perronet, J.-R. 1765, *Encyclopédie*, tome 1 of the plates, article 'Epinglier'[Encyclopaedia first volume of the plates, article 'pin maker']. Paris: Briasson.

Pinault, M. 1990, *L'Encyclopédie* [The encyclopaedia]. Paris: Presses Universitaires de France.

Salomon-Bayet, C. 1970, "Un préambule historique à une académie des arts" [A historical preamble to an academy of the arts], *Revue d'histoire des sciences et de leurs applications.* 23:3, 229-250.

Savary des Brûlons, J. 1723, *Dictionnaire Universel de Commerce* [Universal trade dictionary]. Paris: Estienne.

Savary des Brûlons, J. 1759, *Dictionnaire Universel de Commerce* [Universal trade dictionary]. Copenhague: brothers C. & A. Philibert.

Sicotière (de la) L. 1861, *Opuscules II, Notes statistiques sur le département de l'Orne* [Statistical notes on the Orne department]. (Archives of the Orne department, cote RES 2327).

Smith, A. 1981 [1776], *Inquiry into the nature and causes of the Wealth of Nations*. Glasgow edition of the works and correspondence of Adam Smith, Vol. 2. Oxford (Oxfordshire): Clarendon; New York, NY: Oxford University Press.

Vacant, C. 2006, *Jean Rodolphe Perronet (1708-1794): premier ingénieur du roi et directeur de l'École des ponts et chaussées* [*Jean Rodolphe Perronet (1708-1794): first engineer of the king and director of the bridges and roads engineering school*]. Paris: Presses de l'École Nationale des Ponts et Chaussées.

Verley, P. 1994, *Entreprises et entrepreneurs du XVIIIe siècle au début du XIXe siècle* [Firms and managers from the eighteenth century to the beginning of the nineteenth century]. Paris: Hachette.

Année Littéraire, 1761.

Journal des sçavans, 1761.

Journal de Trévoux, 1752.