The Rise of Calico Printing in Europe and the Influence of Asia in the Seventeenth and Eighteenth Centuries[1]

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From the seventeenth century the brilliance and fastness of colour and the exotic nature of imported Asian textiles attracted European consumers. The limited knowledge of colouring agents and the general absence of textile printing and dyeing in Europe were, however, major impediments to the development of a cotton textile printing and dyeing industry in the Old Continent. For many decades, Europeans were unable to produce pure cotton cloth and had great difficulty in replicating mordant-based textile printing and dyeing. However, they had an incentive to learn the 'secrets' of calico printing in the East (especially India and Turkey) in order to substitute home-produced goods for imported products. This paper aims to chart the rise of a European calico printing industry in the late seventeenth and eighteenth centuries by comparing it with those regions of Eurasia where the printing and dyeing of cotton textiles had been an important productive activity for centuries.

The success of European cotton textile production was not just the result of major technological breakthroughs in spinning and weaving. By the early nineteenth century Europeans were able to produce cotton textiles that could rival high-quality Indian goods. How this phenomenon came about is still a subject for research. Under review are complex analyses of Europe's technical knowledge, technological receptivity and innovation, with particular attention paid to textile dyeing and printing in

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which Europe had never excelled.[2] This paper thus starts by considering the historiography concerned with the dyeing and printing of textiles in eighteenth-century Europe. Most historians have downplayed the role of India and Turkey, but have underlined how the European invention of copper plate printing and subsequent roller printing had a profound impact on the productivity of the cotton industry, lowering the cost of textiles and improving their design. Much less has been said on the relationship between calico printing and the rising field of chemistry. The second part of this paper asks if chemistry was essential for the improvement of calico printing. Did that source provide – as Joel Mokyr might argue for the eighteenth century as a whole – a wider epistemological base on which to develop colouring practices and processes? And how did it relate to the body of knowledge on textile printing acquired from Asia?

1. Calico Printing: Factories and Fashion

The *toile* entitled *Les Travaux de la Manufacture* (1783) is often quoted as an example of an artefact reflecting on its own making.[3] It shows a printshop in Jouy-en-Josas belonging to the famous calico printer Oberkampf in the early 1780s.[4] Various painted vignettes of the productive process are arranged in a composition reminiscent of the

[2] Out of the three dyeing processes, namely substantive dyeing (by solving dyes in water), mordant dyeing (with the action of mordants), and vat dyeing (by using vats with alkaline liquids), Europe effectively used only the latter. S. Robinson, *A History of Dyed Textiles* (London, 1969), pp. 22-5.
[3] One of the most thorough and comprehensive descriptions of the process of calico printing at the end of the eighteenth century can be found in J. Lettice, *Letters on a Tour Through Various Parts of Scotland, in the Year 1792* (London, 1794), pp. 192-7.
[4] R. Chenciner, *Madder Red: A History of Luxury and Trade. Plant Dyes and Pigments in World Commerce and Art* (Richmond, 2000), p. 38; M. Drosson, 'Cotonnades peintes et imprimées, techniques de fabrication jusqu'en 1800', in *Le Coton et la Mode: 1000 Ans d'Adventures: 10 Novembre – 11 Mars 2001, Musée Galliera* (Paris, 2000), pp. 103-5.

Arcadian scenes for which Oberkampf was famous throughout Europe. This artefact was powerful propaganda. It was printed in several colours and was collected avidly by several amateurs and museums in the nineteenth century. More than any other eighteenth-century calico piece, the *Travaux* has come to embody calico printing as a productive activity and as an artistic product. Craftsmanship and industrial organisation are woven together in a design that is at the same time a narrative of industrial achievement and the reification of European material culture. The *Travaux* also confirmed the European nature of calico printing. Even before the take off of cotton manufacturing in Europe in the last two decades of the eighteenth century, such an artefact left no doubt about its quintessentially European and industrial nature.

The symbolic value of this *toile* is still so powerful that its motif has been used in a recent award-winning depiction of Glasgow in which the industrial scenes are replaced by pictorial representations of deindustrialisation in what was once one of Britain's most famous industrial cities.[5] Drug addicts and scenes of poverty and degradation take the place of the industrious men portrayed in Oberkampf's *toile.* Even the rather disingenuous shift from France to Scotland does not seem to affect the overall intent of the artistic 'transposition': the 1783 *toile* is an icon of European industrialisation and as such serves the purpose of diachronic comparisons. Both the recent and the old *toiles* tell us that little or no link between calico printing and its Asian origin was recognised either in 1783 or in 2004.

That has occurred because seventeenth and eighteenth-century calico printing have been analysed mainly by focusing on the European industrial structure underpinning the sector's development. Chapman and Chassagne, for instance, see calico printing as the first stage of European industrialisation based on cotton textiles which started with the finishing

[5] *The Guardian*, 14 January 2005, p. 8.

stages of production.[6] Europe developed sufficient skills to produce cotton textiles physically and visually similar to imported Indian calicoes. The high percentage of imported white Indian cotton textiles entering the port of London in the late seventeenth century and throughout the eighteenth century confirms this assumption. By the late eighteenth century, Europeans began to acquire competitive advantages over India in spinning as well. A stream of technological inventions and innovations were accompanied by the new organisational structures (factories). This produced a tremendous increase in productivity and a sudden narrowing of the gap in the cost of production between the high-wage area of Europe and the low-wage area of central Asia.

The spill-over between calico printing and cotton spinning has been elaborated for the British case by emphasising the geographical relocation of the calico printing industry from London to Lancashire in the 1760s and 1770s.[7] The accumulation of capital and the overlap between inventions in printing and spinning link these two different stages of the production.[8] This perception has recently produced a series of studies that have contextualised calico printing within an emergent eighteenth-century industrial path, not just for France and England, but also for other prominent European calico-printing centres such as Amsterdam,

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[6] S.D. Chapman and S. Chassagne, *European Textile Printers in the Eighteenth Century: A Study of Peel and Oberkampf* (London, 1981). See also S. Chassagne, *La Manufacture de Toiles Imprimées de Tournemine-Les-Angers (1752-1820)* (Paris, 1971).

[7] S.D. Chapman, 'David Evans & Co. The last of the old London textile printers', *Textile History*, 14 – 1 (1983), pp. 29-56. The first calico printing establishment in Lancashire was probably Claytons' factory at Barber Bridge near Preston which was founded in 1764. P.C. Floud, 'The British calico printing industry, 1676-1840', *Ciba Review*, 1 (1961), p. 3.

[8] Id., 'Fixed capital formation in the British cotton industry, 1770-1815', *Economic History Review*, 23 – 2 (1970), pp. 235-66; Id., 'Industrial capital before the industrial revolution: an analysis of the assets of a thousand textile entrepreneurs, c. 1730-50', in N. B. Harte and K. G. Ponting, (eds.), *Textile History and Economic history: Essays in Honour of Miss Julia de Lacy Mann* (Manchester, 1973), pp. 113-37; Id., 'British marketing enterprise: the changing roles of merchants, manufacturers, and financiers, 1700-1860', in S.D. Chapman, (ed.), *The Textile Industries. II. Cotton, Linen, Wool and Worsted* (London and New York, 1997), pp. 287-310.

Barcelona and Basel.[9] When the overall picture of calico printing in the eighteenth century is considered (figure 1), we realise that economic historians have been concerned mostly with mundane managerial, financial and technological issues. By contrast, art historical scholarship has examined late seventeenth- and eighteenth-century calico printing mostly by considering issues of design.[10]

Cotton printing is one of the major areas of eighteenth-century design, important not only for its connections with fashion, but also for traditional narratives of the 'invention of the modern designer'. Before printed cottons were introduced to Europe, textile 'design' was done through the weaving of the yarn, the mixing of fibres and the use of different colours. The articulation of design came to life in the process of making. To set up a loom was an expensive and long activity that could take months. By contrast, calico printing presented an immediate relationship between the drawing stage and the final impression of the design on the textile material.

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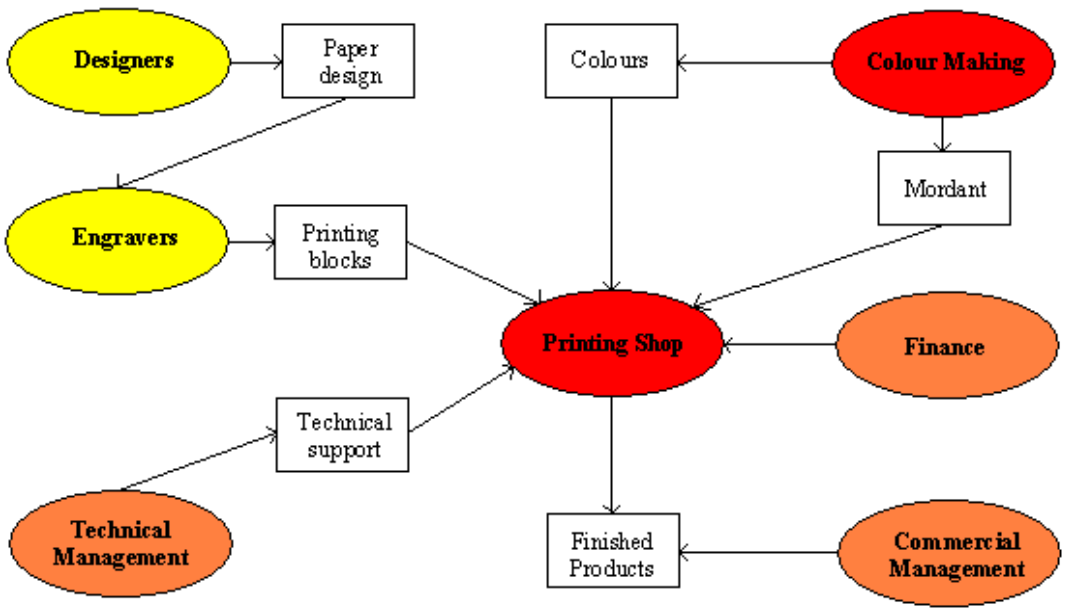
[9] C. Simon, 'Labour relations at manufactures in the eighteenth century: the calico printers in Europe', *International Review of Social History*, 39 (1994), pp. 115-44; A. Nieto-Galan, 'Dyeing, calico printing, and technical exchanges in Spain: the Royal Manufactures and the Catalan textile industry, 1750-1820', in R. Fox and A Nieto-Galan, (eds.), *Natural Dyestuffs and Industrial Culture in Europe, 1750-1880* (Canton, Mass., 1999), pp. 101-28; M. Vicente, 'Artisans and work in a Barcelona cotton factory', *International Review of Social History*, 45 (2000), pp. 1-23; J.K. Thomson, 'Technology transfer to the Catalan cotton industry: from calico printing to the self-acting mule', in D.A. Farnie and D.J. Jeremy, (eds.), *The Fibre that Changed the World: The Cotton Industry in International Perspective, 1600-1990s* (Oxford, 2004), pp. 249-82.

[10] M. Carlano, 'The Henry Clouzot collection of printed textiles at the Philadelphia Museum of Art: highlighting some early Dutch printed fabrics', *Bulletin of the Needle and Bobbin Club*, 39 (1939), pp. 29-50; W. Born, 'Cotton prints of the eighteenth and nineteenth centuries', *Ciba Review*, 76 (1949), pp. 2794-5; T. Osumi, *Printed Cottons of Asia: the Romance of Trade Textiles* (Tokyo, 1963); F. Irwin, 'Scottish eighteenth-century chintz and its design', *Burlington Magazine*, 107 (1965), pp. 452-8 and 510-14; H. Clark, 'The design and designing of Lancashire printed calicoes during the first half of the 19th century', *Textile History*, 105 – 1 (1984), pp. 101-18; P. Sykas, 'Calico catalogues: nineteenth-century printed dress fabrics from Pattern books', *Costume*, 33 (1999), pp. 57-67; F.M. Montgomery, *Printed Textiles: English and American Cottons and Linens, 1700-1850* (London, [1970] 1999).

Figure 1. ***The Organisation of Calico Printing in the Eighteenth Century***



In a sense, calico printing allowed the design activity to be disassociated from the material itself. The textile became a passive receiver of a design that could exist independently on paper. The separation between designer, engraver and craftsman, and the transposition of motifs from prints to textiles are just two of the wider issues surrounding discussions over specific decorative solutions.[11] The relationship between technology, knowledge of colouring agents, business entrepreneurship and fashion was particularly close in the late eighteenth- and early nineteenth centuries, especially with reference to copyright protection.[12] Scholarship has concentrated on the nature of property rights in design and invention, and has underlined how the entrepreneurial achievements of major calico printers were challenged – but in many cases also confirmed – by a rise in the piracy of patterns.

As with industrial narratives, the thrust of art historical scholarship has been confined to Eurocentric narratives of economic development. Although the legacy of Indian textiles on eighteenth-century European calicoes has not been denied,[13] art historians and textile experts have

[11] The distinction between 'designers' (that included engravers) and printers, dyers and painters was characteristic not only of Europe. Abbé Carré, for instance, tells us that in the 1670s in Madras the Palis specialised in the design and tracing of the motif, whilst the painters belonged to a different cast. In Gujarat, engraving was a separate trade, distinct from the art of drawing and from the art of 'making chintzes'. Dyers, because of their relatively large-scale set up, were often localised in specific villages.

[12] A.K. Longfield, 'William Kilburn and the earliest copyright acts for cotton printing designs', *Burlington Magazine*, 95 (1953), pp. 230-3; T. Kusamitsu, 'British industrialization and design before the Great Exhibition', *Textile History*, 12 (1981), pp. 77-95; D. Greysmith, 'Patterns, piracy and protection in the textile printing industry 1787-1850', *Textile History*, 14 – 2 (1983), pp. 165-94; L. Kriegel, 'Culture and the copy: calico, capitalism, and design copyright in early Victorian Britain', *Journal of British Studies*, 43 – 2 (2004), pp. 233-65. This type of analysis, however, has concentrated mainly on the relationship between producers and consumers and on the dynamics between large and small producers engaged in calico printing.

[13] See for instance G.P. Baker, *Calico Printing and Painting in the East Indies in the XVIIth and XVIIIth Centuries* (London, 1921); P.J. Thomas, 'The beginning of calico-printing in England', *English Historical Review*, 39 (1924), pp. 206-16; Id., 'England's debt to Indian handicraft : an account of the beginnings of calico printing in England', *Indian Journal of Economics*, 12 – 4 (1932), pp. 457-72; J. Irwin and P.R. Schwartz, *Studies in Indo-European Textile History* (Ahmedabah, 1966).

suggested that early limitations in the use of colours and the capacity to reproduce only pale shades on cottons created a divergent design path for Europe when compared to original highly colourful Indian designs.[14] This is a conclusion that, although backed by surviving artefacts, is somewhat limited as it concentrates solely on issues of design. Industrial and art historical studies of calico printing, although complementary, can not be taken as exhaustive. The very cores of the process of calico printing, the printing shop and colour making, are still relatively understudied (in dark grey in figure 1). It is here argued that these processes owed a great deal to Asian knowledge. The process of dyeing can not be fully understood without referring to the way in which Europeans made sense of it firstly by borrowing Asian knowledge and skills and later by re-interpreting them through 'scientific' methodologies. Calico printing shows how global connections allowed Europe to acquire skills and knowledge in textile techniques previously unknown in the West. Global trade in dyestuffs and direct access to printing on the Indian subcontinent fostered a process of European experimentation in the printing and dyeing on vegetable-based fibres using bleach-resistant colours.[15]

2. Going East in Search of Indian Knowledge

European inferiority in textile printing and dyeing in the seventeenth century was summarised by John Ovington, who during this travels to Surat in 1689, noted how 'In some things the artists of India out-do all the ingenuity of Europe, viz., the painting of chintes or callicoes, which in Europe cannot be paralleled, either in their brightness and life of colour or

[14] See S. Robinson, *A History of Printed Textiles* (London, 1969), p. 22.
[15] M. Fennell Mazzaoui, 'Introduction', in M. Fennell Mazzaoui, ed., *Textiles: Production, Trade and Demand* (Aldershot: Ashgate, 1998), pp. xv.

in their continuance upon the cloth'.[16] Like Ovington, many other Europeans were impressed by the bright colours of Indian cottons and admired the precision of their design.[17] Another mid-seventeenth-century traveller, the Frenchman Boullaye-Le-Gouz, explained that 'Hitherto it is not known how the natives apply so successfully the colours to the 'foyes' and '*toiles peintes'* in such a way that they lose nothing in the washing, and added that he 'showed some in France to several dyers, who were filled with admiration at them, assuring me that the dyes of India are pure and quite simple, whereas those of Europe are inferior'.[18]

The inferiority of European textile printing was even more pronounced and was recognised as the prime reason for the success of Asian textiles on European markets. These early references to printing and dyeing techniques in India were not merely the result of an 'ethnographic' interest in the customs and productive traditions of the East Indies. Most of these early accounts were searching for a systematic understanding of the key issues in the commission, provision and dispatch to Europe of various sorts of calicoes, baftas, simians and chintzes. The local differences in productive techniques or the specialisation of production of specific regions were recorded with great care, but had little impact on the way Europeans understood the productive process as a whole.[19]

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[16] J. Ovington, *A Voyage to Surat in the Year 1689*, ed. H.G. Rawlingson (London, 1929), p. 167.
[17] See for instance the description by Bernier of the palampores of the King of Aurangzeb representing large vases of flowers. F. Bernier, *Travels in the Mogul Empire A.D. 1656-1668* (London, 1916). See also: Baker, *Calico Printing*, p. 6; M. Bellezza Rosina, 'Tra oriente e occidente', in M. Cataldi Gallo, ed., *I Mezzari: tra Oriente e Occidente* (Genoa, 1988), pp. 15-17.
[18] F. La Boyllaye-Le-Gouz, *Les Voyages et Observations du Sieur de La Boullaye-Le-gouz Gentilhomme Angeuin* (Paris, 1653), p. 166. Cit. in Baker, *Calico Printing*, p. 19.
[19] See for instance N. Downton, *The Voyage of Nicholas Downton to the East Indies, 1614-15 as Recorded in Contemporary Narratives and Letters*, ed. Sir William Foster (London, 1939), pp. 85, 95-6, 102-4.

Maxine Berg, in her studies of the import of 'exotic' products from India, China and Japan in the seventeenth and eighteenth centuries, has argued for a European drive towards imitation of imported commodities. The goods themselves with their visual and tactile attributes stimulated desires that in turn produced attempts to replace them with European-made products. She notices how so many of the commodities initially imported from the East were eventually produced at home.[20] They were partially adapted to suit European tastes and expectations, but rarely relied on the original technologies used to produce them in the East.[21] Whilst Europeans were keen to 'appropriate' the products that they saw in markets and bazaars, they did not take back to Europe the technologies and practical expertise associated with them.

One of the possible explanations is that the immediacy of artefacts was not matched by a substantial European engagement with Asia in terms of any coherent understanding of how productive processes were carried out.[22] Time and effort had to be put in the observation of craftsmen and artisans. However, as in the case of cotton textiles, Europeans were occupied mostly with trade and because of the complex chains of subcontractors and middlemen, had little occasion to observe how production was carried out. In the case of dyeing and printing, it is also unclear to what extent Europeans relied on Indian texts in order to fully understand the processes of production. Those texts included the *Mir'āt ul Istelah* of Anand Ram Mukhlis, an eighteenth-century lexicon with entries for dyeing and tie-dyeing[23] and the *Nuskha Khulāsatul Majarrebat* (transcribed c. 1766) an anonymous medical treatise that

[20] M. Berg, 'In pursuit of luxury: global history and British consumer goods in the eighteenth century', *Past and Present*, 182 (2004), pp. 116 and 123.
[21] See in particular J. Styles, 'Product innovation in early modern London', *Past and Present*, 168 (2000), pp. 124-69.
[22] H.K. Naqvi, 'Dyeing of cotton goods in the Mughal Hindustan', *Journal of Indian Textile History*, 7 (1967), p. 46.
[23] Ibid.

dedicates a full chapter to dying and printing. The chapter's style suggests that the author was a craftsman and the text was in fact a rather precise disquisition on the raw materials, vessels and processes adopted in dyeing.[24]

Limited direct observation and uncertain engagement with technical texts would explain why before the third quarter of the seventeenth century information about Indian calico printing had been sporadic – confined mostly to the references from the Portuguese Duarte Barbosa in the early sixteenth century and the Frenchman François Bernier who travelled to India in 1665.[25] However by the 1670s the quantities of Asian textiles imported into Europe had become so substantial that new measures for the protection of European manufactures were advocated. Europe's urgent need was to produce textiles that could rival their Asian competitors in terms of colour and design. If the product provided, as Berg would argue, the initial incentive for product innovation and import substitution, it was also clear that European knowledge of dyes and textiles printing was not sufficiently developed to produce any immediate breakthrough.

Of course, it is difficult to show a clear correlation between the search for knowledge in the East and the rise of calico printing in Europe. But surely the interest of Europeans to in cotton printing and dyeing were clear enough and those cases of 'borrowing' from India were written by Frenchmen in the 70 years between 1678 and 1747, a period that coincided with initial phase of European expansion for the new textile

[24] Both documents are in the India Office Library at the British Library. Ibid., pp. 46-7.
[25] Barbosa spent sixteen years in India working for the Portuguese government. His *El Livro* is an important testimony of the structure of trade and the relationship between Muslin merchants and Portuguese traders. See also R. Pfister, 'The Indian art of calico printing in the Middle Ages: characteristics and influences' *Indian Art ad Letters*, 13 (1939), p. 24.

printing industry.[26] Between 1678 and 1680, Georges Roques wrote a 333-page manuscript containing a detailed analysis of the production of textiles in Ahmedabad, Burhanpur and Sironj. The French East India Company's Lieutenant Antoine Georges Nicolas de Beaulieu was the author of a second manuscript probably compiled around 1734.[27] Finally, the third document was produced as a series of letters by Father Coeurdoux, a missionary from the Society of Jesus who lived in India between 1742 and 1747.[28]

In 1966 the Roques manuscript was unearthed at the Archives de la Bibliothèque Nationale in Paris.[29] Although Roques' account includes several parts on matters not related to textiles, it has been studied mostly

[26] There is also a fourth document that provides substantial information on dyeing and printing, the account of the Dutchman Daniel De Havart written c. 1680 and published in Dutch in 1693. In this he describes calico painting in the district of Palakollu: 'First they receive a rough cloth, then they wash it white, they beat some karkayal, put it into milk, wherein the white cloth is put, and afterwards it is dried; after that they fold it according to their manner and beat it smooth in order that is would be more close; then they sponge over it, and they make paint of certain redwood, wherewith the first fraught is done on the sponge, and when they desire to have several colours, for instance, red, violet, green, etc., then all those places are rubbed with alum-water, they mix each according to this knowledge and are further painted according to the musters which they have lying at their sides. D. Havart, *Op- en ondergang van Cormandel, in zijn binnenste geheel open, en ten toon gesteld: waar in nauwkeurig verhandeld word een ware, en duydelijke beschrijving van alles, wat...* (Amsterdam, 1693). Cit. in J. Irwin, 'Indian textile trade in the seventeenth century. II. Coromandel coast', *Journal of Indian Textile History*, 2 (1956), p. 31. Another, although much later document containing valuable information of calico painting is William Roxburgh's *Plants of the Coromandel Coast* (London, 1795). See in particular P.R. Schwartz, 'The Roxburgh account of Indian cotton painting: 1795', *Journal of Indian Textile History*, 4 (1959), pp. 47-56 and D. Arnold, *The New Cambridge History of India: III.5: Science, Technology and Medicine in Colonial India* (Cambridge, 2000), p. 20.

[27] P.R. Schwartz, 'French documents on Indian cotton painting: (I) the Beaulieu ms, c. 1734', *Journal of Indian Textile History*, 2 (1956), p. 7.

[28] Robinson, *History of Printed Textiles*, p. 112. Coeurdoux's letters from Pondicherry were published partially in 1742 in volume XIV of the *Lettres Édificantes et Curieurses*. Baker, *Calico Printing*, p. 11.

[29] For an overview of the history of the manuscript see: P.R. Schwartz, *Printing on Cotton at Abhmedabad, India in 1678: from an Unedited Manuscript in the Bibliothèque Nationale, Paris* (Ahmedabad, 1969), pp. 1-3.

for cotton printing and dyeing.[30] The centrality of the subject can be gathered from the very opening of Roques' description:

> There can be no doubt that it would be most harmful to the State were we to neglect our own production of light silken and woollen materials in favour of Persian and Indian cottons. It can, however, only be a good thing to know how these people set about applying the colours to their cotton cloths, which not only do not run or fade when washed but emerge more beautiful than before. Everyone can see for himself how useful this would be when he envisages what the possibilities could be for our cotton, linen and hemp cloth.[31]

Roques was partially continuing a 'commercial' tradition intent on providing information about quality control, competitors, seasons of production, and the system of orders.[32] However his manuscript includes an in-depth explanation of the processes of dyeing and printing as performed in Ahmedabad and is a key source of knowledge on how mordant block printing was carried out in eighteenth-century India.[33]

The Beaulieu manuscript, written in 1734 and now preserved at the Muséum National d'Histoire Naturelle in Paris, was perhaps the most

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[30] I. Ray, 'Of trade and traders in the seventeenth-century India: an unpublished French memoir by Georges Roques', in Lakshmi Subramanian, ed., *The French East India Company and the Trade of the Indian Ocean: a Collection of Essays by Indrani Ray* (New Delhi, 1999), pp. 1-62 and Id., 'The trade and traders in Ahmedabad in late seventeenth century: extracts from George Roques' MSS', in *Ibid*., pp. 63-76.
[31] Cit. in C.A. Alvarez, *Homo Faber: Technology and Culture in India, China and the West from 1500 to the Present Day* (The Hague, 1980), p. 61.
[32] Schwartz, *Printing on Cotton at Abhmedabad*, pp. 4-8.
[33] Id., 'L'impression su coton à Ahmedabad (Inde) en 1678', *Bulletin del la Société Industrielle de Milhouse*, 726 – 1 (1967), p. 2. The Roques manuscript has also helped to end a long debate about the extent of cotton printing in India and particularly in Gujarat. Irwin suggested that block printing was introduced in the early modern period from Iran. The activity is mentioned by Thevenot in Agra in 1666 and by Tavernier in in Gujarat in 1667. Irfan Habib suggests that most Indian cotton textiles were either resist or mordent printed (a position not entirely supported by surviving artefacts) and were widespread in India already in the fourteenth century. See J. Irwin, 'Textiles', in L. Ashton, ed., *Art of India and Pakistan: a Commemorative Catalogue of an Exhibition held at the Royal Academy of Arts, London, 1947-48* (London, 1950), pp. 201, 203-4; and Irfan Habib, 'The technology and economy of Mughal India', *Indian Economic and Social History Review*, 17 – 1 (1980), pp. 9-10.

successful of these late seventeenth and eighteenth-century accounts of Indian calico printing.[34] Schwartz suggests that Beaulieu had been asked by the well-known chemist Charls-François Du Fay de Cisternay to pursue the study of cotton printing in India. Du Fay was not only the official inspector of dye works and mines and Inspecteur of the Parisian botanical gardens, but also one of the most famous chemists of his time.[35] It could be the case that a thorough analysis of the process became possible thanks to Du Fay's precise instructions based on observation and evidence. Unlike previous accounts, the Beaulieu manuscript concentrate entirely on the production of chintzes. It also follows a 'scientific' style of analysing the productive process based on the description of each productive stage after which a piece of cloth was taken and attached to the manuscript. It was not just the thoroughness of Beaulieu's analysis that makes the account so important. It also appears that the manuscript was widely circulated. It was used by the Basle calico printer Jean Ryhiner in his 1766 *Matériaux pour la Coloration des Étoffes* (published only in 1865) and by Chevalier de Quérelle in his *Traité sur les Toiles Peintes* of 1760.[36] In both cases, the authors argued that Beaulieu had produced a *vademecum* of printing that, when properly followed, allowed Europeans to achieve results comparable to those obtained in Asia. The relatively obscure Sieur Beulieu was thus in all probability a vehicle for European scientists and technologists to gather information about productive processes and natural and technical knowledge in a remote, but key area of the globe. Thus the French East India Company gained and transmitted Indian knowledge to the West.[37]

More than any of the previous travellers and industrial spies, the Jesuit Coeurdoux was aware of the importance of Indian knowledge and

[34] For a description see *Sublime Indigo* (Paris, 1987), p. 223.
[35] Schwartz, 'French documents', pp. 6-7.
[36] Alvarez, *Homo Faber*, p. 61.
[37] See for instance Arnold, *New Cambridge History of India*, p. 20.

the contribution that his letters might make to development of European calico printing. By the time that Coeurdoux was writing, European ambitions had moved on from the acquisition of commercial advantages in Eurasian textile trade. He saw that 'knowledge is to be acquired here which, if transmitted to Europe, would possibly contribute to the progress of science or to the perfection of art'.[38] Coeurdoux, like Beaulieu and Roques before him, strongly believed in the value of Indian knowledge of calico printing. Their missions was to codify the processes of production into clear descriptions that could be subsequently applied in Europe, and therefore copying the entire productive process.

Their faith in the 'uncomplicated usefulness' of the knowledge that they were carrying back with them to Europe must however be questioned on at least two levels. Firstly, the perspective audience, as the Beaulieu case suggests, was a small group of proto-scientists for whom descriptions of productive processes provided inputs for theories that eventually came to influence the development of textile printing and dyeing from an organic/mechanical art to a chemical/synthetic industry. Secondly Europe was not just looking to India for such knowledge. For example, there is no proof that attempts to learn the 'secrets' of Indian cotton printing, especially in the 1730s and 1740s, meant that Europeans were unable to replicate fast colours before that date. Schwarts concludes that all evidence suggests that the European ability to produce fast colours depended on the transmission of workshop practices from the Near East (in particular from Turkey), rather than from Indian knowledge.[39] Thus the role of Roques, Beaulieu and Coeurdoux was to improve rather than establish European cotton printing and dyeing. Until the 1740s, even the highly developed printing works in Marseilles, using

[38] Cit. in Alvarez, *Homo Faber*, cit., p. 60.
[39] Schwarz, 'French documents', pp. 3-23. This hypothesis is confirmed by the so-called Alexander Papers now at the Library of New York, consisting of a series of fast-coloured European cottons dated 1726.

the most advanced Anatolian techniques, could manufacture only products of low quality for slaves and popular markets in Guinea Blue cloth, and other cheap textiles printed in just two colours.[40]

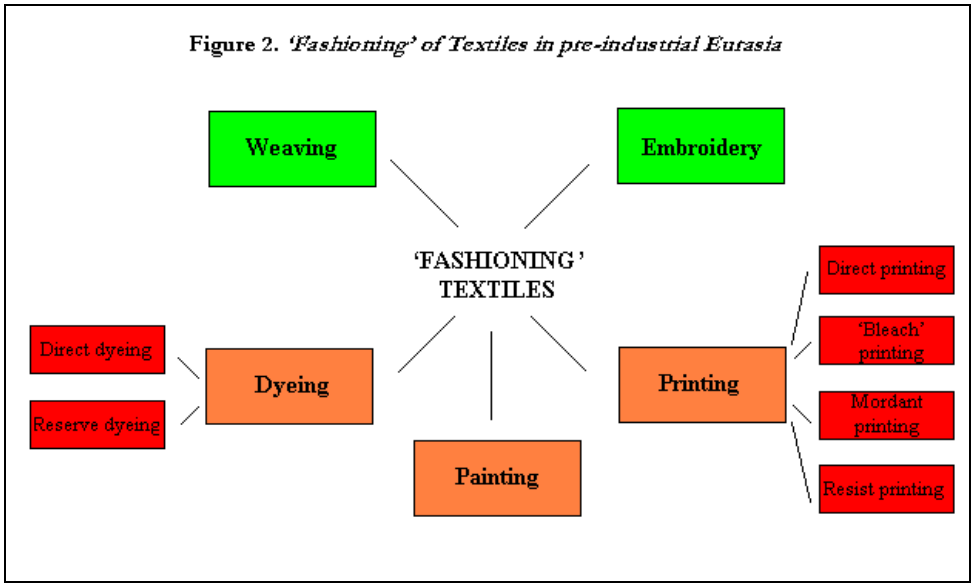
3. The Birth of Calico Printing in Europe

Whilst Europeans had acquired substantial knowledge of dyeing fibres in the Middle Ages, the accounts of Roque, Beaulieu and Coeurdoux suggest that they had little familiarity with the printing on textiles. Woollens, but also silks and velvets were patterned on the loom and their design was the result of complex methods of weaving and finishing. From the later Middle Ages rudimentary engraved wooden blocks were used to print simple designs on linens and woollens, but this specialised industry never succeeded in expanding beyond the Rhenish provinces of Germany or in upgrading its production to high-quality printed textiles.[41] The 'fashioning' of textiles in Europe relied mainly on weaving and embroidery (figure 2).

[40] O. Raveux, 'Les débuts debuts de l'indiennage dans les pays d'Aix (1758-1770)', *Industries en Provence*, 4 (March 2004), p. 1.

[41] A.K. Longfield, 'History of the Irish linen and cotton printing industry in the 18th century', *Journal of Royal Society of Antiquaries of Ireland*, 58 (1937), p. 26. The earliest reference to textile block printing is the Italian *Trattato della Pittura* written 1437 by Cennino Cennini and published only in 1821. See D. King, 'Textiles and the origin of printing in Europe', *Pantheon*, 20 (1962), p. 29. Tax records and artefacts show how block printing was practiced in Augsburg in around 1475. *Ibid*., pp. 23-30. King observes how artefacts are of limited use in understanding the relevance of textile printing in Europe in the Middle Ages. A large part of medieval printed textiles are fakes and were acquired by nineteenth-century collectors who ignored their dubious provenance.

Figure 2. *'Fashioning' of Textiles in pre-industrial Eurasia*



By contrast Asia (and India in particular) had developed a variety of processes that can be roughly distinguished into the three broad categories of dyeing, painting and printing. Europe engaged in 'direct' dyeing (dyeing on the yarn or piece) but had little knowledge of reserve dyeing (dyeing with wax in order to create motifs) or dyeing with mordants. Although textile historians believe that most Indian cottons were painted (a specialisation of Golconda called '*qalamdar*' or '*qalamkar*'),[42] in other areas such as Musulipatam, Nizampatam, Narasapur, Armagaon and Madras both techniques were in use.[43] In West India and Gujarat most chintzes were printed through the use of wooden blocks by using one of the various techniques that included direct printing, bleach printing (bleaching the design on an already dyed cloth), 'mordant printing' (printing with mordants and then bleaching the unmordanted areas) or resist printing (printing a viscous substance, followed by dyeing, followed by the cleansing of the substance).

This enormous variety of processes, combined with the local availability of high-quality dyes and the capacity to use mordants - not only in dyeing and painting but also in printing - made Indian textile production extremely articulated when compared to its European counterpart.[44] In the sixteenth and seventeenth centuries Europeans tried to paint textiles mainly by using oil and water colours (Illustration 5).[45] The influence of Indian motifs and the use of floral designs suggest that these 'oilcloths' were produced to imitate the Indian calicoes and *pintados* imported into Europe by the East India Companies after 1600 and before

[42] J. Irwin, 'Golconda cotton paintings of the early seventeenth century', *Lalik Kala*, 5 (1959), pp. 11-48.
[43] A.I. Tchitcherov, *India: Changing Economic Structure in the Sixteenth to Eighteenth Centuries: Outline History of Crafts and Trade* (New Delhi, 1998), p. 72.
[44] Until the 1960s it was believed that most Indian cotton textile production was painted, whilst the European production was printed. Research by Irwin, Schwarz and Floud has disproved that view.
[45] P.C. Floud, 'The origins of English calico printing', *Journal of the Society of Dyers and Colourists*, 76 (1960), p. 275.

that by the Portuguese Careira da India and Levantine merchants.[46] Incentives to develop a European textile printing industry were already present in the early seventeenth century and in 1619 a certain George Wood was granted a 21-year patent for the printing and staining of linen cloth in England and Wales.[47] But it is most likely that these early printed linen cloths were very coarse and their colours were far from permanent.

A real uprising in textile printing in Europe seems to have occurred during the last quarter of the seventeenth century. It is a matter of debate where calico printing first appeared. The imitations of *toiles peintes* produced since the 1660s in Marseille and shortly thereafter in Dauphiné, Vivarais, Languedoc, Poitou and Normandy emerged from printing coloured designs by means of wooden blocks, what the French called *moules* (molds). In all probability they were no different from the medieval non-fast coloured printed textiles produced in Germany.[48] Furthermore, the inferior quality of these early European printed cottons, fustians and mixed linens had little to do with printing itself or with the imitation of the complex and fashionable designs of Indian calicoes. Europeans had to overcome their incapacity to produce long-lasting colours.[49] Whilst they were able to produce high-quality *petit teints* (colours that faded with light and washing), until the mid seventeenth century they were unable to produce *grand teints* (permanent colours resistant to light and washing).

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[46] L.A. Driessen, 'Calico printing and the cotton industry in Holland', *Ciba Review*, 48 (1944), p. 1749; E. Homburg, 'From colour maker to chemist: episodes from the rise of the colourist, 1670-1800', in Fox and Nieto-Galan, *Natural Dyestuffs*, p. 222. It is most likely that Indian textiles had arrived in Europe before the opening of the oceanic route to India around the Cape of Good Hope. Although this is not confirmed by surviving artefacts, the Middle East was the link between India and Europe. There are numerous records of Middle East cotton textiles being imported into Europe in the Middle Ages. It is not possible to know where they were originally produced.

[47] G. Turnbull, *A history of the calico printing industry of Great Britain* (Altrincham, 1947), p. 18.

[48] C. Woolsey Cole, *French Mercantilism, 1683-1700* (New York, 1943), p. 165.

[49] O. Raveux, 'Espaces et technologies dans la France méridionale d'ancien régime: l'example de l'indiennage marseillais (1648-1793)', *Annales du Midi*, 116 – 246 (2004), p. 157.

Although France was the first country to engage in textile printing, in the following decades the new 'art' became centred in the Netherlands. Jean Ryhiner stated in his 1766 book that the Swiss learned cotton printing from the Dutch. In Marseille in the 1650s and 1660s and in Amsterdam in the 1670s, Armenians were employed to 'draw and colour or dye all kinds of East Indian cottons, which has never before in this country been practiced'.[50] The Ryhner family itself originated in Holland and moved to Basle only in the late seventeenth century. From Basle, calico printing spread to Mulhouse and Neuchâtel and from there back to France after the ban was lifted in 1759. Even an ancient centre for the production of cotton textiles like Augusta (which contained the famous calico printers George and Jeremiah Neuhofer) learned the process from a Dutch worker.[51]

In England, William Sherwin of West Ham near London took out a patent in 1676 'for invention of a new and speedy way for producing broad calico, which being the only true way of the East India printing and stayning such kind of goods'.[52] His patent equated quality with the precision of what was the 'original' East India Printing. Fifteen years later, and after Sherwin's patent expired, several printworks were active in and around London in areas like Bermondsey, Bromley, Lambeth, Old Ford, Poplar, Richmond, and Wapping.[53] Among their owners were French Huguenots (refugees from France following the Revocation of the Edict of Nantes in 1685) who had worked in similar undertakings in the Netherlands before arriving in London.[54] Peter Floud who studied the early calico printing businesses around London, concluded that until 1715 the productive methods remained rather primitive and the overall growth

[50] Cit. in Homburg, 'From colour maker to chemist', p. 221.
[51] F. Brunello, *L'Arte della Tintura nella Storia dell'Umanità* (Vicenza, 1968), p. 215.
[52] Montgomery, *Printed Textiles*, p. 16.
[53] Chapman, 'David Evans & Co', pp. 31-2; J. Irwin and K.B. Brett, *Origins of Chintz* (London, 1970), pp. 3-5.
[54] Robinson, *History of Printed Textiles*, p. 15.

of the industry in Britain was confined to a restricted number of establishments on the outskirts of the capital city.[55]

From these early starts to the triumphalist glorification of calico printing by Oberkampf in his *Travaux*, took just three generations. One of the reasons for such dynamism has been seen in the status of the occupation, independent of the early-modern corporate structures dominating urban crafts.[56] The trade relied instead on foreign skills and entrepreneurship. In many cases the peculiar status of the new trade was legitimised by the public authority which granted privileges and exemptions. Calico printing, for instance, was introduced in Genoa in 1690 by an Armenian workman who was not only allowed to exercise his trade outside the guild system, but also given the monopoly of the activity for ten years.[57] Small semi-independent cities such as many burghs in Switzerland or the principalities of Germany provided a receptive institutional context for calico printing to flourish as a privileged trade.

By contrast, the late seventeenth and the first half of the eighteenth century saw little progress in calico printing and dyeing in countries like France that had effectively introduced the trade into Europe. The anti-calico legislation and the following ban on production, trade and consumption in 1689 had a negative effect on the development of the cotton industry in the country.[58] France had the potential to become the European leader in cotton textiles well before 1750, both because of its early successful engagement in the technical aspects of calico production, as well as its unchallenged European prominence in fashion and textile design. During the long ban lasting from 1689 and 1759, production was instead confined to those cities and small areas that were

[55] Floud, 'Origins of English calico printing', p. 278.
[56] Simon, 'Labour relations', p. 277.
[57] M. Cataldi Gallo, 'Indiane e mezzari a Genova', in M. Cataldi Gallo, (ed.), *I Mezzari: tra Oriente e Occidente* (Genoa, 1988), p. 25.
[58] Woolsey Cole, *French Mercantilism*, p. 165. See the more recent research by Raveux, 'Espaces et technologies', pp. 155-170; Id., 'Débuts de l'indiennage', pp. 1-8.

not directly administered by the Central government and enjoyed autonomous jurisdiction such as Marseille, and only later did production develop in centres such as the Arsenal in Paris (1746), Angers (1753), Rouen (1755) and Nantes (1758).[59]

Holland and Switzerland were the two major beneficiaries of the legislation against the import and production of calicoes enacted in most European countries during the later seventeenth and the first half of the eighteenth centuries. In both countries printing flourished, especially in the production of export goods. Already in 1740 there were more than 100 textile print-shops in Holland, 80 of which were in Amsterdam.[60] In the late 1750s the Fabrique-Neuve near Neuchâtel in Switzerland employed more than 300 workers.[61] The development of calico printing in Switzerland was not just the result of a local tradition in fustian and pure-cotton handkerchief production in the northern part of the country, next to the South German border. Centres like Neuchâtel sold cottons to consumers in Lorraine, Alsace and Germany. The repeal of prohibitions in France in 1759 provided further stimulus to development as the Swiss industry could then supply a country with enormous population and a relatively confined commitment to calico printing.[62]

By the 1760s most European countries (except Britain) had repealed their anti-calico laws thus allowing printing both on cottons and linen on an unprecedented scale. By this time calico printing gave work to

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[59] H. Clouzot, *La Manufacture de Jouy et la Toile Imprimée au XVIIIe Siècle* (Paris and Brussels, 1926), pp. 8-9; S. Chassagne, 'Calico printing in Europe before 1780', in D. Jenkins, ed., *The Cambridge History of Western Textiles* (Cambridge, 2003), i, pp. 523-4. For a discussion on the geography of the French calico printing industry in the late eighteenth century see: *Toiles de Nantes des XVIIe et XVIIIe Siècles* (Mulhouse, 1978), pp. 8-9 and Chassagne, *Manufacture de Toiles Imprimées de Tournemine*, pp. 47-51.

[60] G. Verbong, 'The Dutch calico printing industry between 1800 and 1875', in Fox and Nieto-Galan, *Natural Dyestuffs*, p. 195.

[61] Homburg, 'From colour maker to chemist', pp. 219-58.

[62] P. Caspard, 'Manufacture and trade in calico printing at Neuchâtel: the example of Cortaillod (1752-1854)', *Textile History*, 8 (1977), p. 152.

more than 12,000 workers in Spain. Barcelona, where Estaban Canals had founded the first printwork in 1738, was one of the major centres of production in Europe.[63] Other entrepreneurs were active in more than one centre of production. Rodolphe Wetter, who had set up and 'English blue' calico printshop in Marseille in 1745 was now operating also in Antwerp and in Orange, where he possessed one of the most celebrated printworks in Europe [64] Johann Heinrich Schüle was the owner of a major printing activity in Augsburg. In 1760 the Swiss Oberkampf opened his business in Jouy, sensing the potential to supply the vast French market through production *in situ*. He was followed a few years later by the opening of another major European calico printshop, that of Robert Peel of Lancashire.[65] Calico printing was becoming established also in central Europe. Prague developed the trade from 1767 and twenty years later 12 firms employed more than 1,000 men with 314 printing tables.[66] By the late eighteenth century calico printing had reached an enormous size not only in Britain and France, but also in other European countries (table 1). Neuchâtel, for instance, was still one of the most dynamic centres of calico printing in the continent. In 1797 it produced a total of 160,000 pieces, more than three times the production of other large calico-printing centres such as Mulhouse, Barcelona, Manchester or Prague. The Fabrique-Neuve now employed more than 600 workers.[67]

[63] Chenciner, *Madder Red*, p. 70. For a comprehensive analysis of calico printing in Barcelona see J.K.J. Thomson, *A Distinctive Industrialisation: Cotton in Barcelona, 1728-1832* (Cambridge, 1992), in particular pp. 50-95.
[64] Clouzot, *Manufacture de Jouy*, p. 8.
[65] Chapman and Chassagne, *European Textile Printers*.
[66] F.W. Carter, 'The cotton printing industry in Prague 1766-1873', *Textile History*, 6 (1975), pp. 132-4, 145.
[67] Caspard, 'Manufacture and trade in calico printing at Neuchâtel', pp. 150-1.

Table 1. Calico Printing in Europe in the eighteenth and early nineteenth centuries

Place	Year(s)	Number of manufactories
Augsburg	1790-1800	9
Neuchâtel	1766	17
Neuchâtel	1797	6
Mulhouse	1806	14
Geneva	1785	11
Geneva	1806	4
Alsace-Loraine	1790-1800	37
Hamburg	1790-1800	21
Barcelona	1754	11
Franconia	1790-1800	7
France	1806	186
Prague	1787	12
Seine-Inférieure	1806	46
Switzerland	1790-1800	59
Ghent	1793	12
Austria	1790-1800	18
Saxony	1790-1800	56
Bohemia-Moravia	1790-1800	31
Belgium	1790-1800	14
Prussia	1760	16
London	1719	23
Silesia	1790-1800	8

Source: J.K.J. Thomson, 'State intervention in the Catalan-printing industry in the eighteenth century', in M. Berg, *Markets and Manufactures in Early Industrial Europe* (London, 1991), p. 75.

4. The Invention of European Superiority

Francis Bacon summarised in the seventeenth century the great achievements of Europe in the previous 200 years in his famous intellectual triptych composed by the compass, gunpowder and the printing press. Bacon saw navigation, military force and knowledge as the three major areas of European achievement in what historians later termed the early modern period. He was the unwilling initiator of a

Eurocentric tradition of thought theorising on Europe's ascendancy to world dominance in the period roughly stretching from the voyages of discovery of the late Renaissance to the triumphal leap of the Industrial Revolution, three centuries later. Historians have long since debated about the real and perceived importance of Bacon's major catalysts for European dynamism. For example, the compass was fundamental to oceanic navigation. Gunpowder opened new possibilities for the use of force. The printing press was key in the process of intellectual dissemination of new ideas and has remained a structural element of Western cultural and social life ever since. Bacon's framework rapidly became part of the self-representation and categorisation used by Europeans in relation to the increasingly frequent contacts with other 'civilizations'. European categories of analysis became Eurocentric when simply juxtaposed to random and uncritical observations of the extra-European world. Although the development of calico printing in Europe owed much to extra-European knowledge, it was instead the European 'exceptionalism', its dynamic search for understanding and its capacity to re-interpret it that became central in later narratives of the development of the sector.

Comments about the beauty and aesthetic qualities of Indian chintzes and calicoes are abundant in the travel diaries of seventeenth- and eighteenth-centuries Europeans intent on capturing desirable idiosyncrasies and peculiarities of the Indian subcontinent. They commented upon people, things and practices worthy of note, but qualified their views with pessimistic comments about the poverty of workers and the primitive state of industries. Notwithstanding the humility and openness of some of them (Roques, Beaulieu or Courdoux) a sense of European superiority was being shaped through racialised views of 'civilizations' and their degree of development. Prasannan Parthasarathi has shown how quantitative evidence does not support a case for lower

standards of living in India when compared with Europe in the eighteenth century, thus disproving a point that is periodically reiterated in contemporary European sources and was later fully accepted by historians.[68]

Said warned against the danger of 'orientalising' the Orient, by creating images of what existed only in Europeans' minds.[69] Intellectual, cultural and social structures produced by Europe and fostered by Europeans become the yardstick by with otherness was constructed. Cotton textiles provides a wide-ranging example of this process. The Dutch and English East India Companies were extremely careful to avoid business risks, so much so, that with the expansion of the calico trade in the 1660s and 1670s they provided the decorative motifs for Indians to imitate in order to supply 'exotic' products suitable for European taste.[70] Back in Europe, these cotton textiles were sold as 'original' and 'genuine' Oriental products.[71] Of course, one can interpret this as an attempt to secure maximum profits through the maintenance of aesthetic canons behind European taste. But the frequent requests for light (blue on white, or red on white) instead of dark (white on blue or white on red) calicoes was also the expression of European resistance and the necessity to embrace 'otherness' through more familiar forms. The East India Company even sent a sample of the tree of life, deemed from Scandinavian mythos, for imitation to India. One of the merits of Indian calico production, as seen by the late seventeenth-century Frenchman Tavernier was the perfection by which 'the workers print their callicoes according to the designs given them by the foreign merchants'.[72]

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[68] P. Parthasarathi, 'Rethinking wages and competitiveness in the eighteenth century', *Past and Present*, 158 (1998), pp. 79-109.
[69] E.W. Said, *Orientalism* (London, 1978).
[70] Styles, 'Product innovation'.
[71] D.A. Farnie, 'The role of cotton textiles in the economic development of India, 1600-1900', in Farnie and Jeremy, *Fibre that Changed the World*, p. 397.
[72] Cit. in Ffister, 'Indian art of calico printing', p. 15.

The development of a European textile printing industry was fostered by protective ideologies over the skills, taste and technical capacities of Indians craftsmen. Even the East India Company, widely seen as the defender of Indian interests, could not ignore textile printing in Europe. 'Now of late they are here in England come to a great practize of painting large branches for hanging of Roomes', commented a East India Company employee in the late seventeenth century, 'and we believe that some of our callicoes painted after that manner might vent well, and therefore have sent you some patterns of which we would have you send us 2,000 pieces'.[73] European production was setting its own standards because it had direct access to consumers and could quickly assess their preferences. Dress historians underline how the low price of cotton textiles allowed for the spread of fashion across the social hierarchy. If on the one hand such notions were shaped by the exotic motifs and brilliant permanent colours of Asian textiles, on the other the yearly and seasonal variations of fashion could be captured only by attentive scrutiny of the market.

The East India Company's monopoly of access to products did not necessarily imply a competitive advantage. Once European calico producers perfected their techniques at a sufficient level to satisfy the popular markets, the 'copy' could become more appealing than the original. It is in this light that we should read the continuous concern of the East India Company to supply products that could sell well and swiftly. And their worries were not just about the latest colour or European consumers' preferences for lighter shades. 'The floweres must run through the whole piece from end to end', reported one dispatch to India, 'whereas, the Flowers have of late been observed to have been begun at each end of the piece. insomuch that in the middle they have, instead of

[73] Cit. in T. Osumi, *Printed Cottons of Asia: the Romance of Trade Textiles* (Tokyo, 1963), p. 17.

agreeing, been opposite to one another'.[74] A language of standardisation, precision and exactitude in following specifications was paramount not only in the productive process but also in finishing: 'They [calicoes] must be either 13 or 15 yards on a fine calico. Half of fine bunches of four colours, viz., the ground work drawing black, filled up with red and peach blossom color and the twigs or spring green'.[75]

The suggestion here is that Europe possessed advantages developed early on contacts. In 1643 the East India Company was proud to venture on an experiment of technology transfer by sending dyers, bleachers and weavers to India to teach their skills to the locals as it was common opinion that although they did a good job on 'mixt colours', Indians had 'no skill to dye good Blacks greenes and watchetts'.[76] This was not confined to cottons, but extended to silk, as reported by Bowrey from Bengal in 1668: 'The English East India Company keepeth many [English] tradesmen att worke here by order of the Company, as dyers, weavers, throwsters, &c. beinge English men sent on purpose for the orderinge theire silke after the English custome, and for dyinge a good black, a colour the Natives could never dye well'.[77] This construction of a European sense of superiority was not peculiarly English. The Dutch physician and botanist Du Havart dismissed Indian textile production *en masse*: 'the chintzen, which are painted at Calicot, after the designs which are given to the painters, which they imitate well, for the natives are so stupid that they are unable to produce anything original; but they can imitate and produce a perfect copy; but one chintsen is not always as good as another, although both may have been painted by the same

[74] *Ibid*.
[75] *Ibid*.
[76] Cit. J.Q. Ahsan, *The Indian Response to European Technology and Culture (A.D.1498-1707)* (Delhi, 1982), p. 84.
[77] *Ibid*.

hand'.[78] Similarly the French Abbé Raynal was equally derogatory when he wrote that calico painting done by Indians owed 'more to the antiquity of the art than to the fertility of their genius. There is one thing apparent in the conjecture, and it is that they have not advanced a single step in the art for many years'.[79]

Historians have unwittingly accepted these judgements by shifting perspectives from behavioural or racial characteristics to contextual causes which include a long list of negative factors affecting the development of eighteenth-century Indian textiles. For instance, as recently as 1991 Indian historian Satpal Sangwan explained that in the eighteenth century 'the veneration for the practices and professions of their ancestors checked the spirit of invention among Indian workmen'.[80] This assertion is backed by explanations that range from the 'evil of the doctrine of caste', to the withdrawal of intellectuals from economic and public life, to the lack of interest of merchants in production, to religious dogmas and superstitions, to an anti-technological bias caused by an over-reliance on the proficiency of Indian textile artisans.[81] In the last fifty years, however, the work of Irwin, Schwarz and other scholars of Asian textiles has provided a corrective against narratives of European hegemony in world textiles which became central to the Industrial Revolution.[82] This strand of scholarship developed within art history

[78] D. Havart, *Op- en ondergang van Cormandel*. Cit. in Baker, *Calico Printing*, p. 21.
[79] G.T.F. Raynal, *Histoire Philosophique et Politique des Etablissements et du Commerce des Européens dans les Deux Indes* (Amsterdam, 1770), vol. i, p. 399. Cit. in Baker, *Calico Printing*, p. 21.
[80] S. Sangwan, *Science, Technology and Colonisation: an Indian experience, 1757-1857* (Delhi, 1991), p. 13. See also Id., 'Why did the scientific revolution not take place in India?' in D. Kumar, (ed.), *Science and Empire: Essays in Indian Context (1700-1947)* (Delhi, 1991), pp. 31-40
[81] *Ibid*., pp. 10-14.
[82] J. Irwin, 'Origins of the 'Oriental style' in English decorative arts', *Burlington Magazine*, 48 – 625 (1955), pp. 106-14; Irwin and Schwartz, *Studies in Indo-European Textile History*; J. Irwin and M. Hall, *Indian Painted and Printed Fabrics* (Ahmedabah, 1971). See also the articles on cotton textiles published in the *Journal of Indian Textile History* in the 1950s and 1960s.

analyses and object-based observations of surviving artefacts in Western and Asian museums, has carefully corrected the view of seventeenth and eighteenth-century Europeans by showing the slow progress and relative backwardness of European textile printing.

5. A Colour Revolution

This early development of calicoes in Europe was also the result of dyeing as well as printing techniques. Calicoes were seen as new because the process of production involved dyeing as well as printing at times together and at times as subsequent productive stages. Moreover, the dyeing of cotton textiles by Indians differed from the art that European craftsmen had successfully exercised for centuries. It involved the knowledge of mordants, and implied experimentation with new dyes and in particular with two basic colours including the so-called madder red or Turkey red and blue (indigo).

Mordants were known in pre-1700 Europe.[83] Alum, iron, copper and tin had been used for many centuries by salters and dyers throughout Europe. By then engagement with mordants had always been limited to a restricted array of mordants and dyes. Alum, for instance, was the key to mordant-based cotton printing and dyeing but came mostly from Asia Minor and, in Europe, in small quantities from just one small village of Tolfa, near Rome.[84] This lack of high-quality dyes and abundant mordants was accompanied by the difficulty of using them on vegetable fibres. European expertise in mordant-dyed textiles had been entirely confined to wool. They were accustomed to a mordant-dyeing process based on a single immersion, whilst cotton textiles needed continuous immersions in

[83] In the 1620s the Dutch chemist Drebbel discovered the dyeing of bright red through tin-mordanted cochineal. The process was later adopted by the Gobelin's dyeworks and by the London dyeworks at Bow. Robinson, *History of Dyed Textiles*, p. 32.
[84] D. Hopking, *The Art of the Dyer, 1500-1700* (Bristol, 2000), pp. 17-19.

different mordants before and after dyeing, with a process of drying after each immersion. The straightforwardness of the process used by Europeans was simplified by the fact that animal fibres did not allow for the clearing of un-moderdanted areas. The final product was a cloth in one colour without patterns or shades.[85]

Furthermore the European expertise in the use of mordants had been confined to dyeing rather than printing. This was not simply due to the different chemical and physical composition of vegetable and animal fibres. Alum and iron mordants could be used for printing only if they were mixed with suitable thickeners to form a viscous substance that did not spread beyond the area to be printed. Once mordants had been printed, the viscous substance had to be removed in order to allow the madder or indigo dyes to fix through a further process of dyeing.[86] The discovery of suitable thickeners was an important factor for the development of calico printing in Europe and constituted a definite departure from Asian methods of production. Although Indian experience provided invaluable expertise of both mordants and the process of dyeing, it did not offer much help in the use of thickeners. There is no contemporary evidence showing any use of thickeners in Indian calico and chintz production. This probably means that the process was carefully done by painting the mordant, rather than printing it. Historians of textiles and science are still questioning if mordant printing was a European invention or if it was adopted in Marseille in the middle of the seventeenth century from the Middle East (Table 2). What is certain is that mordant printing allowed for much higher productivity than hand painting. Its adoption throughout Europe in the following 80-90 years testifies the willingness to connect the new knowledge of mordants and dyes with time-saving productive processes.

[85] Turnbull, *History of the Calico Printing Industry*, p. 18.
[86] Floud, 'Origins of English calico printing', pp. 278-9.

Table 2. Adoption of Calico Printing with Mordants in Eighteenth-Century Europe

Place	Year
Marseille	1648
Amsterdam	1676
London	1677
Ireland	1693
Barcelona	1736

Source: Tables 1, 3, 4 are based mainly on J.K.J. Thomson, 'Technology transfer to the Catalan cotton industry: from calico printing to the self-acting mule', in D.A. Farnie and D.J. Jeremy, *The Fibre that Changed the World: The Cotton Industry in International Perspective, 1600-1990s* (Oxford, 2004), pp. 250-2. Additional data has been found in F. Little, 'Cotton printing in Ireland in the eighteenth century', *Bulletin of the Needle and Bobbin Club*, 22 (1938), p. 15; P.C. Floud, 'The English contribution to the early history of calico printing', *Journal of the Society of Dyers and Colourists*, 77 (1960), pp. 344-349; P.C. Floud, 'The English contribution to the development of copper-plate printing', *Journal of the Society of Dyers and Colourists*, 76 (1960), pp. 425-34; S. Chassagne, 'Calico printing in Europe before 1780', in D. Jenkins, ed., *The Cambridge History of Western Textiles* (Cambridge, 2003), vol. i, p. 524 ; O. Raveux, 'Espaces et technologies dans la France méridionale d'ancien régime: l'example de l'indiennage marseillais (1648-1793)', *Annales du Midi*, 116 – 246 (2004), p. 157.

Dyes were as essential as mordants in the development of European calico printing and dyeing. The knowledge of dyeing with indigo and Turkey red spread from the Netherlands to Switzerland in the 1680s, probably through a Swiss dyer who had worked in Holland. The process was quickly adopted in the German states and the Hanseatic towns.[87] Again, most of the experience accumulated by Europeans had been in the use of fugitive dyes (table 3) easily available in Europe. Europeans for instance, had little knowledge of how to produce colour green and used a

[87] R. Traupel, 'Rise and decline of the Swiss calico printing industry', *Ciba Review*, 105 (1954), p. 3767. Switzerland, in particular, specialised in the production of Turkey-red squares (subsequently also printed) known in Italy, Germany, Bavaria and the Ottoman Empire by the name of *fazzoletti d'Esslinger* from the town that specialised in this production.

combination of yellow and blue for dyeing.[88] The dyeing of fast colours relied mostly on 'exotic' substances such as cochineal, quercitron, walnut, and most important of all, indigo and madder.

Table 3. Textile Colours in the Eighteenth Century and Their Dyes

	Fast	Non Fast
Blue	Indigo Woad	Violet Logwood
Red	Cochineal Madder Gum Lac	Orchilla (turnsole) Safflower (saffron; sastranon; carthamus) Brazilwood and other red woods
Yellow	Weld Young Fustic Quercitron	Tumeric Yellow Berries Pomegranate Mango bark
Fawn	Walnut Alderbark	Sanders Wood
Orange		Anato Fustic
Green		Verdigris Blue Copperas
Greys / Black		Soot

Source: S. Fairlie, 'Dyestuffs in the eighteenth century', *Economic History Review*, 17 – 3 (1965): 488-510; L. Varadarajan, 'Indian textile technology in the pre-industrial period', *Indica*, 21 – 2 (1984), pp. 66-7.

Indigo, perhaps more than any other dye or mordant, shows how European receptiveness could be severely limited by established

[88] J.E. Satchell, Glover, J.M., Ryder, M.L., Taylor, G.W. and H.E. Garland, 'The Kendal pattern book', *Textile History*, 21 – 2 (1990), p. 235. In India blue and black were obtained from *Indigofera Tinctoria* (producing black with iron acetate). Red was obtained from *Rubia Cordifolia* or *Morinda Citrifolia*; yellow from turmeric (*Curcuma Longa*), pomegranate or mango bark extracts. Different shades were acquired by combining dyes. L. Varadarajan, 'Indian textile technology in the pre-industrial period', *Indica*, 21 – 2 (1984), pp. 66-7. See also Id., *South Indian Traditions of Kalamkari* (Bombay, 1982), pp. 46-59 and Id., *Traditions of Textile Printing in Kutch: Ajrakh and Related Techniques* (Ahmedabad, 1983), pp. 43-65.

interests and clumsy regulations. The indigo plant was widely cultivated in tropical climates and one of the most important regions of production was Gujarat. Here indigo was harvested and transformed into small blocks of pulverised substance that was exported to Baghdad and Aleppo and from there to Europe. Indigo was a luxury dye that allowed the production of deeper shades of blue than those obtained by the European-grown woad.[89] For woad growers, the potential competition from indigo was considered to be a threat already in the sixteenth century. Its use was first banned in France in 1598 (a ban that persisted until 1737). In Britain indigo was denounced as the 'food of the devil' and its use was allowed only in conjunction with woad.[90] Along with cotton fibres, indigo began to be produced on plantations in the West Indies in the early seventeenth century, and became available in larger quantities and cheaper prices.[91]

European merchants and travellers in seventeenth-century India had been captivated by the deep blue indigo-dyed cotton textiles with designs in red, green and yellow. They were produced there through a resist dyeing process based on the waxing of the areas to remain un-dyed. This labour-intensive procedure allowed for the production of 'white on blue' rather than 'blue on white', which would have meant the waxing of most of the cloth.[92] During the last quarter of the seventeenth century Europeans adopted not only the product but also the process of production with waxing and a process of tepid indigo fermentation at 115F (compared to dyeing with woad at 170F). By the early eighteenth century they were already experimenting with improved techniques, unknown in Asia. The most important of these was the use of cold vats (or *cuve à*

[89] Woad *(Isatis tinctoria)* is a biennial plant native to northern Europe and the British Isles, and is a source of a blue dye (indigotin).
[90] J. Balfour-Paul, *Indigo* (London, 1998), pp. 56-7.
[91] S. Fairlie, 'Dyestuffs in the eighteenth century', *Economic History Review*, 17 – 3 (1965), p. 498.
[92] L. Dolza, 'How did they know? The art of dyeing in late-eighteenth-century Piedmont', in Fox and Nieto-Galan, *Natural Dyestuffs*, pp. 139-45.

froid) obtained by dissolving indigo in iron sulphate (*couperose*). This process originally invented in England in 1734, quickly replaced the hot fermentation of indigo, which damaged the reserve (those parts that were not to be dyed and were covered in wax) (table 4). The process allowed for higher quality and saved fuel.[93]

Labour and material saving processes could be obtained by building on the knowledge of dyes acquired in the East and by analysing the properties of substances in different processes. This probably meant continuous experimentation rather than pure research as in the case of the second half of the century. Mechanical, as well as chemical understanding, was paramount in the early phase of development of cotton printing in Europe. The continuous recourse to printing, instead of pencilling, drawing and waxing by hand, was influenced by the European engagement with book printing and engraving, the transposition of complex patterns and motifs, through the use of tools that allowed repetition, standardisation and flexibility. It is not surprising, for instance, to find that European calico printers, although applying a productive process from Asia, adapted it to print rather than pencil the resist substance. This was the first step towards a product innovation congruent with European preferences for light-coloured cotton textiles, the so-called ‘blue on white’.

[93] For a more detailed discussion see: Raveux, ‘Espaces et technologies’, pp. 163-4.

Table 4. Innovations in Indigo Dyeing and Printing in Eighteenth-Century Europe

Place	Year
Use of Cold Vats	
England	1734
Wax Printing	
Germany	1689 (?)
Rouen	1709
English Blue	
England	1730s
Switzerland	1730s
Marseille	1744
Bremen	1745
Basle	1745
Barcelona	1746

Source: See table 1.

Probably the most important innovation involving indigo was the discovery of a method for printing indigo – rather than dyeing it – through the use of potash, quicklime and orpiment. The fact that the technique was called 'English blue', '*Englischblau*' or '*blue d'Angleterre*' suggests that it was originally discovered in England.[94] It consisted in reality of two different processes. The so-called 'pencil blue' was introduced in the 1730s and involved the addition of orpiment and gum in order to increase the time before oxidisation. This allowed indigo to be applied by 'pencils' or brushes thus creating positive blue designs on white cotton textiles.[95] The second process, called 'China blue' was developed, again probably in England, a few years later and was based on the printing of indigo in its un-dissolved state. A paste of indigo mixed with a thickening agent was printed and fixed through lime baths.[96]

[94] Floud, 'English contribution, p. 8.
[95] Balfour-Paul, *Indigo*, p. 160.
[96] Both processes are described meticulously in P.C. Floud, 'The English contribution to the early history of calico printing', *Journal of the Society of Dyers and Colourists*, 76 (1960), pp. 344-9.

Raveux has argued that the success of Marseille cotton printing in the period between 1720 and 1755 was the outcome of two distinct but complementary 'strands' of innovation. It was not just the case of creating new knowledge of dyeing and printing, but of building upon notions and practices from the East to diversify production and reduce the cost of manufacturing. In Marseille the influence of Ottoman technical knowledge remained central in the city's success in cotton printing and dyeing. The first manufacture '*pour teintre des toiles propes à la fabrication des vanes d'indianes*' was set up by two Frenchmen with the help of two Armenian painters who were probably connected with the large community of Armenian traders operating in Marseille.[97] After 1720, however, Marseille picked up a new wave of innovation, this time from Northern Europe. The '*blue Anglais*' (otherwise called '*blue au pinceau*') was diffused to Marseille by an English workman employed by the Swiss-born entrepreneur, Wetter, in 1744.[98] The mobility of 'experts' and the promptness of adoption of these new productive processes in the numerous calico-printing centres of Europe are remarkable. The 'open technique', as analysed by Hilaire-Pérez and Garçon for communities and groups of individuals, can be here extended to include networks spanning Europe from London to the Netherlands, from Switzerland to Marseille and Barcelona.[99] The professionalisation of colour makers and colourists as well as the constant participation of scientists and entrepreneurs in calico printing and dyeing were key elements that created a self-sustaining relationship between human capital and innovation.

[97] Chassagne, 'Calico printing in Europe', i, pp. 516-17.
[98] Before 1737 the use of indigo for textile dyeing remained prohibited in France. Although Dufay's publication instilled a change in the law, prejudice against indigo remained. So much so that Wetter was refused a patent by the Chamber of Commerce for the '*blue anglais'.* Chapman and Chassagne, *European Textile Printers in Europe*, pp. 105-6.
[99] A.-F. Garçon and L. Hilaire-Pérez, 'Open technique' between community and individuality in eighteenth-century France', in F. de Goey and J.W. Veluwenkamp, (eds.), *Entrepreneurs and Institutions in Europe and Asia, 1500-2000* (Amsterdam, 2002), pp. 237-56.

‘English blue’ inaugurated a new phase. For the first time Europeans were able to produce cottons with blue designs on white backgrounds thus following the taste formed by imported and home-produced blue porcelains.[100] Even more important, ‘pencil blue’ and ‘China blue’ allowed for the substitution of resist methods with more straightforward processes of production. Waxing was not only very time-consuming but also extremely laborious when several colours were applied. By contrast, ‘pencil blue’ allowed the production of cheap multi-coloured printed textiles, especially in blue and red.[101] The success in the use of blue indigo created a series of opportunities for experimentation with other dyes, in particular red, traditionally a difficult and expensive colour to obtain for European textile production.

The demand for good red-dyed cloth had been traditionally high and European dyeing methods had never produced totally satisfactory results. In the 1740s France imported 5-6,000 bales of red cloth from the Levant each year. It even sent part of its home production of cottons and woollens to be dyed in Turkey where the madder-red ‘Turkey’ process was performed with great success. It is not surprising that attempts were made to set up madder-red dye houses on French soil by bringing Greek and Turkish dyers from the Levant. Madder, much more than indigo, was a specialisation of Turkey. The Levant, rather than India, was instrumental in providing precise knowledge about its use and commercial exploitation. Existing commercial contacts – especially in raw and manufactured cotton goods – between Marseille and the Levant constituted an important factor affecting technological and knowledge transfer. ‘Adrianople’ red was first successfully used in France in the late

[100] Floud, ‘English contribution’, p. 8.
[101] Homburg, ‘From colour maker to chemist’, p. 233. It must be noted how instead the ‘China Blue’ was performed mostly in monochrome pieces such as the Oberkampf’s *toiles* that were famous for their design detail. Balfour-Paul, *Indigo*, p. 160-1 and Floud, ‘English contribution’, p. 348.

1740s and became commercially viable in the following decade through a process that combined dyeing, mordanting and bleaching.

Liliane Hilaire-Pérez has recently examined the life of Claude Flachat, a traveller, entrepreneur and innovator who was instrumental in learning the properties of madder and in replicating dyeing and printing techniques of the Middle East.[102] Flachat spent several years of his life in the Levant and carefully observed all aspects of the economic, social and cultural life of the region. Back in France, in 1756 he set up a Turkey-red dyeworks at St. Chamond, not far from Lyon. He employed a Turkish master dyer, two dyers from Adrianople, two *étameurts* (tin-smiths) from Constantinople, a Persian spinner, a Smyrna *arçonneur* (thrummer), and two Armenian vitriol makers.[103] Flachat was not just a careful observer of productive processes and market opportunities. He combined in-depth understanding of the great variety of productive specialisations with business acumen, thus becoming one of the earliest *manufacturiers-innovateurs* that characterised eighteenth-century textiles and manufacturing generally.[104]

Turkey red was introduced into other parts of Europe partly through Levantine workers. In 1768, for instance, two Amsterdam merchants opened a Turkey-red dyework in partnership with a Turkish master living in Holland.[105] However, the technique was mainly learned from France. Johann Zeller of Zurich opened the first Turkey-red dyehouse in Switzerland in the early 1760s after spending some years working in Nîmes.[106] John Holker, the English spy, entrepreneur and official of the

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[102] L. Hilaire-Pérez, 'Culture techniques et pratiques de l'échange, entre Lyon et le Levant : inventions et réseaux au XVIIIe siècle', *Revue d'Histoire Moderne et Contemporaine*, 49 – 1 (2002), p. 105.
[103] *Ibid*., pp. 105-8.
[104] Raveux, 'Espaces et technologies', p. 157.
[105] Driessen, 'Calico printing', p. 1749.
[106] Chenciner, *Madder Red*, p. 69. Aikin attributes to John Wilson of Ainsworth the first commercial use of Turkey red in England, the secret of which 'he procured from the Greek dyers of Smyrna'. J. Aikin, *A Description of the County from Thirty to Forty Miles*

French government, was with all probability one of the earliest and most trusted sources of information about madder-red dyeing in England. Although he is famous for transferring British technology into France by setting up a state-of-the art spinning 'factory' in Rouen in the 1750s, he also invested heavily in dyeing, setting up the first Adrianople dyehouse in the city.[107]

If knowledge of indigo printing and dyeing was moving from England to continental Europe (and in particular France), the case of madder was the reverse. When the French were successfully experimenting with madder in the mid-1750s, in Britain the Society of Arts was advertising a premium of £50 for 'dyeing cotton yarn of the same red colour as that which is dyed in Turkey'.[108] Several attempts were made in Britain to gather information about madder-red dyeing directly from Turkey, but it is most likely that the technique was first successfully performed in England thanks to French expertise. In the early 1780s two Frenchmen called Borelle and Papillon set up Turkey-red dyehouses in Manchester and Glasgow respectively.[109] The relative backwardness of

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Round Manchester (London, 1795), p. 165. Wilson Had received a premium of £50 for the dyeing of cotton yarn in Turkey red by the Society for the Encouragement of the Arts and Manufactures. W. Bailey, *One Hundred and Six Copper Plates of Mechanical Machines, and Implements of Husbandry…* (London, 1782), i, p. 195.

[107] W. Wescher, 'John Holker, a promoter of the French textile industry', *Ciba Review*, 12 – 135 (1959), p. 10. See also D. Cardon, 'Textile research: an unsuspected mine of information on some eighteenth-century European textile products and colour fashions around the world', *Textile History*, 29 – 1 (1998), p. 98.

[108] Turnbull, *History of Calico Printing Industry*, p. 12. The prize for Turkey red was awarded only in 1766 and the following year the society offered prizes for yellow and green dyes.

[109] Brunello, *L'Arte della Tintura*, p. 239; N.E.A. Tarrant, 'The Turkey red dyeing industry in the Vale of Leven', in J. Butt and K. Ponting, eds., *Scottish Textile History* (Aberdeen, 1987), pp. 38-9; T. Griffiths, P.A. Hunt and P.K. O'Brien, 'Inventive activity in the British textile industry, 1700-1800', *Journal of Economic History*, 42 – 4 (1992), p. 888. The first successful attempt at replicating Turkey-red dyeing in Britain in 1785 is often attributed to Charles Taylor of Manchester, although it is not clear if he received the £2,500 prize promised by the Manchester Chamber of Commerce. Robinson, *History of Printed Textiles*, p. 22; A. Clow and N.L. Clow, *The Chemical Revolution: a Contribution to Social Technology* (London, 1952)), p. 169; J. Edmonds, *The History and Practice of Eighteenth Century Dyeing* (Little Chalfont, 1999), p. 34.

Britain in red dyeing can be explained by the complexity of the process. France was again at the forefront of innovation as Laurent Weter, a prominent Mulhouse calico printer, introduced a technique for dyeing Turkey red 'in the piece' (rather than 'in the yarn' as previously done) by printing with acid and then discharging the red dye from the printed parts through a solution of chlorine of lime.[110]

One of the areas in which European manufacturers most differentiated their products from Indian, and other Asian printed textiles was in the use of mechanical devices. As already observed, of all the possible ways of 'fashioning' textiles, Europeans had excelled in weaving and embroidery. Their knowledge of dyes was until the late seventeenth century very limited and non-existent for reserve dyeing. Painting, another major Indian tradition in cotton textiles, was never seen as a possible avenue for advance. It was very labour-intensive and the cost of labour in Europe was high compared to India.[111] Printing was however a much simpler activity based on the engraving of a wooden block and the subsequent impression of the colour or mordant on the textile (Illustration 8). Multi-coloured calicoes implied a process in several stages with subsequent impressions on the same cloth. In order to match different colours with a certain degree of precision, wooden blocks were normally rather small (10 x 5 inches). A square yard of cotton textile in one colour required at least 26 impressions .[112]

Although we now know that wood block printing was widely performed in India in the early modern period, it is most likely that the use

[110] S.D. Chapman, 'Quality versus quantity in the industrial revolution: the case of textile printing', *Northern History*, 21 (1985), p. 184; Tarrant, 'Turkey red dyeing', p. 41.
[111] The calico printer Ryhiner commented in 1766 that 'because the use of painting instead of printing demands a greater degree of skills and is much slower, which means that even granted all things equal we could never adopt their methods, for we lack skilled craftsmen and could not keep the maintenance costs so low'. Cit. in Berg, 'In pursuit of luxury', p. 115.
[112] Compare this with the average copper plate measuring 1.20cm x 70cm. Clouzot, La *Manufacture de Jouy*, p. 14; Robinson, *History of Printed Textiles*, p. 18. Robinson states incorrectly 52 wooden blocks per yard.

of wood blocks on linen, cotton and fustian textiles in Europe was the result of medieval practices generated in Germany. Europe's reliance on printing rather than painting made it paramount to find a process that was not only faster but could also produce better-quality textiles. Book printing and engraving had reached new heights by the early eighteenth century. Techniques had been perfected to reproduce paintings in the form of etchings and popular prints. The rough and unsophisticated visual appearance of woodcut prints in the form of seventeenth-century ballads and sonnets, contrasts with the polished and accomplished prints of the mid-eighteenth century such as Hogarth's famous series. Printing on textiles underwent a series of major technical changes in the second half of the eighteenth century, all of which were closely tied to the technology of artistic production on paper.

The first major innovation used copper plates, instead of the traditional wooden blocks, and was first applied by Francis Nixon of Drumcondra near Dublin in 1754.[113] The use of copper plates was not just another process innovation. Its main aim was to improve the quality of the product and allowed for precise replication on textiles of complex designs and, more commonly, of scenes from fables, representations of the countryside, and commemorative battles. The visual 'language' of cotton textiles dramatically changed thanks to the use of copper plates. The process was quickly adopted throughout Europe, first in England, and later in France, Germany and Switzerland (table 5). Oberkampf, a relative late comer (1773) to the process of calico printing with copper plates i, became in just a few years the best-known producer of *toiles* in Europe.[114]

[113] P.C. Floud, 'The English contribution to the development of copper-plate printing', *Journal of the Society of Dyers and Colourists*, 76 (1960), pp. 425-6.
[114] Chassagne, 'Calico printing in Europe', i, p. 520. Oberkamft's brother, however, had seen copper plates in use at Morat, near Neuchâtel in 1770. Floud, 'The English contribution to the development of copper-plate printing', p. 427.

Table 5. Innovations in Calico Printing in Eighteenth- and Early Nineteenth-Century Europe

Copper-plate printing		
	Ireland	1754
	England	1756
	France	1763
	Augsburg	1766
	Barcelona	1770
	Orange	1770
	Colmar	1770
	Mulhouse	1782
Cylinder printing		
	England	1783
	France	1801
	North America	1809
	Barcelona	1817

Source: See table 1.

The second innovation was the invention of the rotary printing machine patented by the Scot, Thomas Bell, in 1783. Attempts to perfect a printing machine had started at the very beginning of the century when a wooden printing roller was used in Moravia. In a similar vein, Keen and Platt invented a three-colour roller in 1743.[115] However, the real leap forward came only in 1783 when Bell (who worked at Livesey, Hargreaves Hall and Company in Preston) patented a method of printing from engraved cylinders. Two years later he was printing in six colours.[116] Roller printing must have appeared revolutionary compared with Indian painting if we consider that according to Beaulieu it took an Indian craftsman two weeks to paint a calico seven metres long.[117] Potter calculated in 1851 that whist the average calico printworks could print 6

[115] Floud, 'British calico-printing', p. 4.
[116] Robinson, *History of Printed Textiles*, p. 26. The process was adopted in Alsace and Jouy in 1797, in North America in 1809 and in Barcelona in 1817. G. Pitoiset, *Toiles Imprimées, XVIIIe-XIXe siècles* (Paris, 1982), p. 8; and Thomson, 'Technology transfer to Catalonia', p. 252.
[117] E. Depitre, *La Toile Peinte en France au XVIIe et au XVIIIe siècles: Industries, Commerce, Prohibitions* (Paris, 1912), p. 5.

pieces (equal to 168 yards, at 28 yards a piece) per day, machine printing allowed the printing of between 200 and 500 pieces a day (5,600-14,000 yards), thus increasing productivity from 30 to 80 times.[118] But the gap between Indian and European production was not just the result of different levels of productivity. Both copper plates and rotary printing made the productive processes extremely capital intensive. European producers could expect to generate a profit only from large runs with the identical designs as the cutting of a roller probably cost on the region of £7. The high fixed costs were partly covered by the high productivity obtained through the use of machines. The productivity of a roller, for instance, was at least 20 times higher than that of a wooden block.[119]

Technical innovation, experimentation and the use of machinery in calico printing can be understood only by considering the rapid but also geographically diversified expansion of this branch of textile manufacturing in Europe. The presence of Armenian, Turkish and Greek workmen and the increasing knowledge of products and productive methods from India were accompanied by the willingness to build upon such acquired knowledge. The adoption of non-European techniques was central but not all-inclusive, as product and process innovation continued towards solutions that could be at times labour-saving and at other times represented the re-definition of 'exotic' techniques within European parameters. As underlined earlier, this process was nurtured by distancing European practices and processes from their original Asian source. The familiar visual message conveyed in Oberkampf's *toile* was not only the result of a specific use of European stylistic features. The dominant presence of a large copper printing machine, the architectural

[118] Robinson, *History of Printed Textiles*, p. 24.
[119] Chapman, 'Quality versus quantity', p. 179. Chapman argues that such industrial methods were suitable for the production of lower-quality textiles not because of the large output of identical design on which they had to rely, but also because until the 1840s roller printing machines could print only in three colours, against the fifteen colours that could be used in block printing. *Ibid*., pp. 179-80.

references to what we would now call ‘proto-factories’, or the recognisable dyehouses set the entire productive process at the beginning of a new European industrialising vision for the future, rather than at the end of a process of adoption and re-interpretation of extra-European techniques, processes and products.

6. Art, Science and the State

The transformation and re-interpretation of calico printing cannot be set apart from wider changes in other parts of the economy or from the cultural *milieu* of eighteenth-century Europe. As Sarah Lowengard has ingeniously demonstrated, the eighteenth-century search for colour extended well beyond the realm of textiles. Josiah Wedgwood, one of eighteenth-century Europe’s best-known entrepreneurs and innovators, spent several years of his life experimenting with colours on pottery.[120] His support for science (physics, mathematics, geology, and, in particular, chemistry) reveals a further feature of European technical and technological innovation. ‘Science’ – either in the form of a theoretical construct or as a methodology of experimentation or analysis – became another catalyst for European innovation. By the 1730s, for instance, the very concept of fastness for colours became part of the realm of precise measurement and scientific investigation. Du Fay systematically tested all known dyes providing a general scale of fastness that provided a benchmark for the rest of the century. This in turned allowed Berthollet to provide the first chemical explanation of mordants.[121]

[120] S. Lowengard, ‘Chemistry in colour: ceramics and glass in 18th-century Britain’, *Endeavour*, 26 – 3 (2002), pp. 102-3. See also Id., ‘Colour quality and production: testing colour in eighteenth-century France’, *Journal of Design History*, 14 – 2 (2001), pp. 91-103.
[121] Fairlie, ‘Dyestuffs’, p. 506.

Science, based upon research into the abstract principles of mechanical workings and chemical reactions, distanced of calico printing and dyeing from its Indian and Levant origins. A century after the early practical experimentations with exotic dyes and mordants, European scientists could provide comprehensive explanations not only on 'how' productive processes had to be performed, but also on 'why' such processes followed precise scientific rules. Bancroft, the author of the celebrated *Experimental Researches* (1794), admitted that the merit of Indian dyers had been their capacity to precipitate indigo into a semi-solid form and their skill in dissolving it according to specific operations performed.[122] However, he also exemplifies the sense of superiority that the late eighteenth-century European experimental nature of chemistry had acquired over Indian craft techniques: 'Even the operations of callico printing, as predicted by the people of India, and which above all others have been considered as the result of an improved state of chemistry', commented Bancroft, 'are in many respects highly inconvenient, and encumbered with useless parts which a little chemical knowledge would have taught them to reject, as indeed they were rejected by the people of Europe'.[123] The success of European calico printing was according to Bancroft more a matter of experimental validation, rather than accidental discovery. India had provided a set of useful, but not entirely reliable practices that Europeans had improved thanks to their chemical knowledge. The inferiority of Asia in chemical matters, became, according to Bancroft, evident from their complete reliance on alum as a mordant, which ignored the properties of lead and iron as fixing agents. Europeans had not simply learned the practicality of calico printing, but had been able to contextualise its process into a clear set of chemical laws. The

[122] E. Bancroft, *Experimental Researches Concerning the Philosophy of Permanent Colours; and the Best Means of Producing Them, by Dying, Callico Printing, &c* (London, 1794), p. xxx.
[123] *Ibid*., p. xlvi.

result had been the acquisition of industrial efficacy in cutting out useless stages of production, and the deployment of a wider range of processes of production that included the printing and dyeing of yellows as another 'European invention'.[124]

Bancroft's work was surely not a monument of gratitude to Asian textile printing, as it attributed most of the European calico printing industry's achievement to European chemistry. He was representative, however, of a reconstruction of the history of calico printing, based on European achievement, discovery, scientific method and industrial structures of production. Even authors with weaker credentials in chemistry such as Charles O'Brien (a prolific writer on calico printing), agreed that the Indian tradition had developed for centuries along the lines of Bancroft's 'accidental discoveries' and the only merit of India was the pureness of its water.[125] Indeed, this is the only reference that O'Brien ever made to Indian calico printing in his voluminous writings on the printing and colouring of cotton textiles.

Notwithstanding the Eurocentric agenda of much of the scientific and practical literature on calico printing published in Europe, especially in the second half of the eighteenth and first half of the nineteenth century, we must consider it in the context of an economic system in which knowledge of calico printing was not yet widespread and varied substantially from producer to producer. Leslie Gordon Lawrie's *Bibliography of Dyeing and Textile Printing* shows how publications on textile dyeing and printing in Europe increased from 27 during the first half of the eighteenth century to 75 in the second half of the century and 112 during the period between 1800 and 1850.[126] Codification of information was instrumental in the advancement of calico printing in three ways.

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[124] *Ibid*., pp. 229 and 233.
[125] C. O'Brien, *A Treatise on Calico Printing, Theoretical and Practical: including the Latest Philosophical Discoveries - any way Applicable* (London, 1792), i, p. 56.
[126] L. Gordon Lawrie, *A Bibliography of Dyeing and Textile Printing* (London, 1949).

Firstly it provided a minimal knowledge on which to experiment. Secondly it facilitated the discovery and application of best practices. And finally it connected the practice of calico printing with theoretically-based explanations and instructions.

Codification had already started in the form of manuscripts. Beaulieu and Coeurdoux's manuscripts, for instance, were not just important for their 'practical observation' of the process of calico printing and dyeing in India. They were the starting point for the construction of a systematic analysis of calico printing as a technical and chemical activity. Coeurdoux's letters were widely used by several eighteenth-century writers including Bancroft himself. On a practical level, Oberkampf put to use this body of knowledge as he carefully followed Coeurdoux's descriptions to produce fast-dyed chintzes.[127] Codification allowed for the spread of best practices in the sector. Flachat combined practical applications of what he had learned in Anatolia with the publication of a treatise on Turkey red which was used widely by entrepreneurs such as the Swiss merchant Peter who set up his Adrianople red dyework in Strasbourg by following Flachat's account.[128] What to do and how best to do it was particularly relevant in the use of colouring substances. Books were written on how to grow madder, on the use of indigo, mordants and other colouring substances, on recipes for dyeing, etc. An area of particular importance in colouring and dyeing was the European engagement with Linnean ideas of ordering, categorising and classifying of substances.[129] From Linnaeus' *Species Plantarum* first published in 1753 to the publication of *Prodromous* by the French botanist Augustin Pyramus de Candolle in the early nineteenth century (where 43 different

[127] Floud, 'Origins of calico printing', p. 279.
[128] J.-C. Flachat, *Observations sur le Commerce et sur les Arts d'une Partie de l'Europe, de l'Asie, de l'Afrique, et Même des Indes Orientales* (Lyon, 1766). See Hilaire-Pérez, 'Cultures techniques', p. 105.
[129] C.A. Bayly, 'British orientalism and the Indian "rational tradition" c. 1780-1820', *South Asia Research*, 14 – 1 (1994), p. 2.

varieties of madder were listed carefully), the knowledge of dyeing agents increased dramatically.[130]

Codification was important as it facilitated the repetition of the process but also its subsequent verification. Hellol's *Théorie Chimique de la Teinture des Étoffes*, the result of a visit to Persia in 1737, was originally published in the *Memoires de l'Académie des Sciences* in 1740-41. Although Hellol's theories were based mostly on a mechanical understanding of chemical processes (rather than on chemical reactions), his book, as many other *Memoires* acted as a way of storing relevant information that could eventually be disseminated, verified or disproved. These constituted the foundations on which Maquer and Le Pileur d'Apligny were able to codify knowledge on dyeing in the second half of the century.[131] Later works, such as Bancroft's Experimental Researches and Berthollet's Essays on the New Method of Bleaching (1790), did not disdain to cite the practices of major calico producers. Both Bancroft and Berthollet discussed chemical matters with Oberkampf.[132]

The epistemological basis of textile printing did not grow simply through detached interests of famous chemists in one of the major branches of industry. The economic significance of textiles made research a matter of strategic importance for economic as well as political reasons at the local and national levels.[133] Protagonists of textile-printing research in France (such as Charles-François Du Fay, Jean Hellot and Pierre-Joseph Macquer) were connected to the hierarchies of the public

[130] Chenciner, *Madder Red*., p. 25.
[131] Cardon, 'Textile research', pp. 99-101.
[132] Bancroft, *Experimental Researches*, i, p. 114; C.L. Berthollet, *Essays on the New Method of Bleaching, by Means of Oxygenated Muriatic Acid* (Dublin, 1790), p. 106.
[133] It should be noted that the role of the French state in fostering chemical knowledge of dyes and dyeing was more pervasive than that of its British counterpart. L. Trevengone, 'Chemistry at the Royal Society in London in the eighteenth century, - IV', *Annals of Science*, 26 – 4 (1970), p. 332.

administration.[134] Jean Hellol, for instance, was drawn into the study of colours (especially kermes) not only by being the pupil of Du Fay, but via support from the French Académie des Science. In England Robert Boyle and Robert Hooke were among the many scientists who presented their findings on permanent colours at meetings of the Royal Society.[135]

Although historians recently became more sympathetic to notions of shared European knowledge and skills, we must not forget that the eighteenth-century world of textiles was also an arena of intense national and international competition. Cardon reminds us that spying, copying and continuous attempts to produce better and cheaper goods were common tactics in what he defines as an 'economic war'.[136] In this 'war' institutional, economic and scientific motives converge towards a creative effort for the improvement of production and the achievement of competitiveness. Information was central. The Englishman Holker, for instance, acted as a spy in England on behalf of the French government and became Inspecteur Général des Manufactures. In 1761 he sent the Rouen manufacturer Godinot four samples of English indigo-dyed cotton yarn, which could be bought at lower prices that the other eight samples of similar yarn from two Rouen firms.[137]

The drive for comprehensive knowledge of other countries' achievements in textile finishing is perhaps best captured in the manuscript volumes entitled *Echantillons d'Etoffes des Manufactures Etrangères Recuillis par le Marechal de Richelieu*, written in 1736. This was a European-made analysis of the comparative strength and weaknesses of the French textile industry. The manuscript engaged with minute details, as in the case of the cotton fabrics produced in Holland,

[134] R. Fox and A. Nieto-Galan, 'Introduction', in Fox and Nieto-Galan, *Natural Dyestuffs*, p. x; and B. Bensaude-Vincent and A. Nieto-Galan, 'Theories of dyeing: a view on a long-standing controversy through the works of Jean-François Persoz', in *Ibid*., pp. 4-7.
[135] T. Birch, *History of the Royal Society of London* (London, 1756-7), p. 401.
[136] Cardon, 'Textile research', p. 96.
[137] *Sublime Indigo*, p. 154.

which according to the Marechal could be recognised easily as they used ‘a finishing like that used in the Indies’ done with rice and grain from the Indies that ‘we can not imitate in France’ .[138]

The role of the state was not just confined to the gathering of information. The early travels by individual scientists, technicians and perspective entrepreneurs developed by the end of the eighteenth century into more systematic ‘missions’ organised under government patronage. The French revolutionary government, for instance, organised a scientific expedition to the Ottoman Empire in 1792 to study its natural history, geography, agriculture, medicine and commerce. Particular interest was given to the textile techniques and in particular to dyeing with Turkey red.[139] Printing was another area of concern.[140] In England, the *Instructions for Officers who Survey Printers of Calicoes &c* (1777) specified strict rules to be followed by Duty Inspectors who had to ‘discern when they [printers] print with false Colours’.[141] In many cases local institutions acted as catalysts for innovation and regulation. In the mid-eighteenth century, a certain Montoran was able to publish his *Rapport* on ‘*filés rouges*’ thanks to the backing of the Bureau du Commerce.[142] In Ireland the Dublin Society aimed to improve the standard of pattern drawing for industrial purposes. Its charitable activities extended both to woven design on silks and damasks, and to printed linens and cottons. From 1745 it offered a prize of £6 twice a year for young trainee pattern

[138] Se also M. Cataldi Gallo, ‘Indiane e mezzari a Genova’, in M. Cataldi Gallo, ed., *I Mezzari: tra Oriente e Occidente* (Genoa, 1988), pp. 29-31.
[139] The expedition was summarised in G.A. Olivier, *Voyage dans l’Empire Ottoman, l’Egypte et la Perse, fait par Ordre di Gouvernement pendant les Six Premières Années de la République* (Paris, 1801). See also A. Kinini, ‘La fabrication du rouge turc dans la Thessalie de la fin du XVIIIe siècle: les manufactures de la ville d’Ampélakia’, in Fox and Nieto-Galan, *Natural Dyestuffs*, p. 79-80.
[140] For the case of France see: P. Minard, ‘Réputation, normes et qualité dans l’industrie textiles française au XVIIIe siècle’, in A. Stanziani, ed., *La Qualité des Produits en France (XVIII-XXe siècles)* (Paris, 2003), pp. 69-89.
[141] *Instructions for Officers who Survey Printers of Calicoes &c* (London, 1777), p. 12.
[142] *Rapport fait au Bureau du Commerce par Monsieur Montoran sur le Commerce du Levant* (1753). See Kinini, ‘La fabrication du rouge turc’, p. 71.

drawers. The benefit for the wider textile community was apparent, as manufacturers were allowed to inspect the designs and make copies.[143]

As Agustí Nieto-Galan has observed, institutional efforts were not sufficient to provide the 'organised' transmission of chemical knowledge necessary for the development of calico printing.[144] As firm believers of the role of chemistry for the improvement of printing, scientists embodied knowledge of pure and applied research. Thus they were sometimes backed by learned societies but more often financed by entrepreneurs with capital interests at stake. This vision of technology and science does not seek to reduce the Enlightenment to a European cultural construction that established the continent upon a 'superior' trajectory of development. However, it warns against a positive and direct correlation between the enlargement of the epistemic base, as suggested by Mokyr, the growth of practical knowledge and economic development. This relationship was mediated by complex cultural constructions in which discourse on practical applications was influenced by wider structures on the value (absolute, but also increasingly relative to other continents) of a European epistemic base. That development was not the best possible of all paths, but the outcome of new approaches and visions of the European as well as extra-European world.[145]

7. Conclusion

Historians of science are now asking the question why Europe, instead of Asia, saw enormous scientific and technical progress in the

[143] Longfield, 'History of the Irish linen and cotton printing industry', p. 26.
[144] A. Nieto-Galan, 'Calico printing and chemical knowledge in Lancashire in the early nineteenth century: the life and 'colours' of John Mercer', *Annals of Science*, 54 (1997), pp. 3-4.
[145] Sandberg, for instance, who was a practicing dyer, preferred to follow Jacques Savary's indirect account of Indian calico production published in 1757 instead of using the substantial body of knowledge directly produced through observation of Indian textile printing. Chenciner, *Madder Red*, p. 184.

eighteenth century. Rather than emphasising the vantage point of the Europe, they underline instead the weaknesses of the Asian context.[146] Two areas of Eurasia as Western Europe and the Indian subcontinent did not possess a substantially different body of knowledge in the seventeenth century. Instead, what seemed to be different was how this knowledge was shared, moved, confirmed or disproved.[147] Europe manage to innovate by connecting practice and theory or by providing a conducive context in which prescriptive and propositional knowledge entered into a positive feedback system.[148] Why India did not do the same and whether this potential was suppressed by European colonization are matters of debate. For sure the presence of scientific societies, universities, professional bodies, and the wider dissemination of printed knowledge in Europe led to cumulative growth.[149] The European success in learning the printing and colouring techniques was based on a relatively small network of experts who circulated scarce knowledge of productive processes throughout Europe. They found employment in centres that already possessed an established tradition in cotton manufacturing, such as Barcelona where cottons of various types were being produced since at least the later Middle Ages.[150] The critical mass of entrepreneurs, scientists and technicians and their mobility over the continent surely provided major impetus for a rapid and profound improvement of calico printing and dyeing and by extension for cotton textiles as a whole.

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[146] Sangwan, *Science, Technology and Colonisation*, p. 8.
[147] A. Rahman, 'Sixteenth- and seventeenth-century science in India and some problems of comparative studies', in *Changing Perspective in the History of Science* (Boston, 1973), p. 66.
[148] On the concepts of prescriptive and propositional knowledge see: J. Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton, 2002).
[149] *Ibid*.
[150] C. Martìnez Shaw, 'Los orìgenes de la industria algodonera catalana y el comercio colonial', in Jordi Nadal and Gabriel Tortella, (eds.), *Agricultura, Comercio Colonial y Crecimiento Económico en la Espaňa Contemporánea* (Barcelona, 1974), p. 247.