The Organization of Indian Textile Technology before and after the European Arrival

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Histories of technological change are so embedded within the historical experience of English industrialisation that until a couple of decades ago - before the advent of revisionist views - technology was synonymous with industrialisation or what was known as the industrial revolution and received more attention than any other aspect or this revolution's history (Chapman 1972, 17). On the contrary, Indian textiles technology has not been that well-researched, not least perhaps because there were no (as far as we know) Indian Kaye, Crompton, Hargreaves, Arkwright; instead, the East India Companies' trade has received more attention by historians who have thus established the commercial and subsequently political links between India, South East Asia, China and, above all, Europe. What little exists on Indian technology, scattered in numerous studies, does not provide by any means a coherent picture of the industry's technological evolution and cautions against generalizations. The problem is exacerbated by the conflation of the two concepts of science and technology. In studies where the concept of knowledge - encompassing science and technology - is used, India has been dismissed as 'traditional', without organization for dissemination of knowledge and with social barriers erected among castes (Mokyr based on Morris 2002, 251), although some scholars have been more reluctant to adopt a cultural determinism point of view for the development of useful knowledge (Jones 1988, 103). This paper clarifies first views on Indian technology and whether it 'stagnated' for centuries before and after European arrival and then presents a chronology of textile technology, the 'history' of the spinning wheel, the weaving looms and dyeing techniques. The latter in particular is incorporated into the analysis in the last part of the paper by looking at dyeing techniques in India and the Ottoman Empire and their competition with a nascent industry in the Hapsburg Empire, in order to provide a comparative vantage point.

Technological change in South Asia. Why did it not happen there?

The history of technological changes is nearly always associated with the history of science. Two broad approaches have dominated research and writing on history of science. The first, arguing from an essentialist point of view, postulates that science originated in Europe and its origins are to be found in the western scholarly tradition as it evolved from the sixteenth and seventeenth century onwards. The second approach – most evident in the work of Needham on Chinese history of science – postulates that science is universal (Chakrabarti 2004, p. 3). Without delving into epistemological issues of such a broad base this paper configures technological developments in the cotton textiles industry. The historical context of these developments was punctuated by the arrival of European commercial powers in South Asia, their encounter with the Indian economy and society and their gradual predominance over the subcontinent, between 1600 and 1800.

The organization of Indian technology for the period up to 1800 can be seen as a response to the 'challenge' of European demand, similar to the challenge the superior quality and low-cost labour characteristics of Indian textile industry posed to European economies and which led them to technological change. The rise of commercial manufacture in India however, has to be seen as "a much more complex nexus of extensive interdependencies taking form in early modern times' than the model of response to new markets would suggest (Perlin 1983, 36). It is for this reason that 'European arrival' – as appears in the title – does not mark a technological watershed in the subcontinent's textile technology. It is nevertheless a historical development that cannot possibly be ignored especially since it placed the Indian textile industry in its specific historical trajectory.

"In the field of technology, the existing socio-economic set-up prevented a breakthrough. The Indian economy was parochial, based on an economic unit often no bigger than the village or estate" (Sangwan 1991, 34). This sort of gross and largely inaccurate generalizations (especially the one on the parochialism and the village-based Indian economy) obscure more than elucidate the reasons and conditionality of an "Indian"

technological "breakthrough" before a "European" one.[1] Still, when it comes to scientific and technological progress, factors such as education – or the lack of – in the sense of university-centred transmission of knowledge, absence of scientific thought and a persisting influence of religion and superstition are usually marshalled to account for why India did not have a scientific revolution (Sangwan, 1991a, 32-34, 1991b, 8). The artisans, although having little control over production due to financial constraints, are also partly blamed for an aversion to changes in technology or considering them of secondary importance (Sangwan 1991b, 13). Above all though it was hierarchy and the Indian system of social organization that inhibited progress on both science and technology: "the caste system might have helped in retaining perfection in science and the arts initially but it limited the scope for further improvement." (Sangwan, 1991a, 34-5).

This argument on the stagnation of Indian thought in late medieval times due to its restriction to unchallenged teaching of classical astronomy, mathematics and medicine, assumes– by implication - that 'technology' (looms, spinning wheels, finishing techniques) had also 'stagnated'. This is symptomatic of the still strong tendency to associate 'science' with 'technology' and study them under a common framework. If India's scientific thought (in the sense of medicine, mathematics and astronomy) had 'stagnated' by late medieval times – as the argument goes – there is no reason to assume that the level of technology remained in a stasis too, especially since productivity of textiles and the profits resulting continued to rise in the seventeenth and especially during the eighteenth century. Profitability of course depended also on the low-cost and abundant labour of the Indian textile industry.[2]

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[1] The above terms in inverted commas have meanings that are usually taken for granted. However, Europe in the eighteenth century was as – if not more - fragmented as India. India cannot be considered a single - and definitely not a unified - entity, due to the gradual disintegration of the Mughal Empire, the rise of the Marathas in the Deccan, the gradual acquisition of political control of territories by the English East India Company (EEIC) post-1757, but also because of the already fragmented administration of South India, where, following the waning power of the Vijayanagar kingdom, regional states flourished (Metcalf and Metcalf 2005, 24). p. 27. Also, after decades of misconceptions who viewed the Mughal Empire as a typical form of oriental despotism, it is now emerging as a "complex, nuanced and loose form of hegemony over a diverse, differentiated and dynamic economy and society" (Bose and Jalal 2004, 27).
The terms India and Europe will not be used in inverted commas but the qualification should be borne in mind.

[2] This is only one among several debates among South Asian historians; see, for example, on the abundance or scarcity of labour, Parhasarathi's (2002, 74-5) disagreement with Chaudhuri and Prakash, who argue that there was abundance of labour and scarcity of capital, a situation not

Indian textiles economy remained lucrative and successful and - judging from the European experience - technological innovation did not require scientific breakthroughs (with the exception of chemistry and its impact on dyeing). Then why did mechanization not happen in India? In order to resolve the conundrum and identify the contours of India's technological level but also its needs it is necessary to disassociate 'science' from 'technology'. A different working definition of technology would have to include the organization of production and the transmission of skills, a definition which includes organisational innovation (Bruland 2004, 119). This definition has led to the conclusion that in early-nineteenth-century England the cotton textiles sector was not driven by technical innovations but resulted from "a complex interaction between technology, work organisation and managerial practices" (Bruland 2004, 141), i.e., the factory. In this respect, the transition from the independent status of weavers, what Weber called 'price workers' to a coerced employment for the EEIC - Weber's 'wage workers' - is a major organizational innovation, which - it can be assumed - inhibited overall technological change and therefore growth. Until 1730s, when the shuttle was invented, Europe and India (but also other cotton textiles-producing regions) were at the same technological level. The analytical emphasis on skills (in all stages of production) is all the more pertinent in the case of the Indian textile industry precisely because highly specialised technical skills and the lower than anywhere else production costs were the two pillars of the industry's success (Chaudhuri 1996, 35). In pre-mechanized times differences in skills could be significant and it was this difference that above all resulted to the superior quality level of Indian textiles, in other words its comparative advantage. Still, ideas that the shift in comparative advantage in the cotton textiles was a result of changing labour costs are still widespread (Bradberry and Gupta 2005) and higher labour costs in England may have propelled the search for labour-saving technology (Chaudhuri 1974, 180-181).

Alternative interpretations of English industrialisation present it as a diffused (comprised not only of 'leading sectors' such as cotton textiles), gradual and dispersed, i.e. regional, process that involved significant product innovation (McCloskey 1981, 109; Berg and Hudson 1992). This picture presents an analogy with the Indian economy in the eighteenth century, in the sense of the geographically dispersed production of cotton

conducive for labour-saving and important technological innovation. Parthasarathi on the contrary argues that the seventeenth and eighteenth centuries were characterised by labour shortages.

textiles (in all stages of production), and the impressive product (cloth) innovation, responding to European demand. It is also the case – perhaps even more today than in the past – that as far as English industrialisation is concerned, we "lack a general theory able to account for the major breakthroughs in technology that occurred in textiles over the eighteenth century" (O'Brien 1996, 155). Recent scholarship brings into question the standard 'challenge and response model' since "there are no assurances that the shuttle could have launched the powerful sequence posited by simplistic versions of the model" (O'Brien 2005, 6). It is also worth noting that the history of English technological change is highly personalized in the form of biographies of mechanics and inventors while the Indian story, reflecting the state of sources and historical tradition no less, is highly de-personalized with no references to individuals. Given the state of research on Indian technology [3] and the lack of sources compared to the abundance of sources for a European history of technology it is probably more appropriate to refrain from attempting a formulation of a general theory able to account for why the major breakthroughs in Indian did not happen. Instead, a general interpretative survey presented here may provide comparative points for the better understanding of the dynamics of cotton textiles and the factors that generated the emergence of this first truly global industry from the early modern period onwards.[4]

Most works on Indian technology can be summarised as pessimistic arguing that Indian society was hardly inclined towards process innovation. Habib is the main proponent of this pessimism (Habib 1978-9 and Habib 1980, for medieval times). One of the most prominent historians of South Asia, Chaudhuri, argued that India was 'caught' in a low-level equilibrium trap and the limits of its technology were manifest before English industrialisation, indicating that India was nowhere near an endogenous industrial revolution in the eighteenth century. 'Institutional impediments', such as absence of progress in scientific knowledge and absence of intellectual space for the diffusion of inherited skills are combined with the low wages argument to answer the question why an industrial revolution did not take place in India. (Chaudhuri 1996, 69-72, 75).[5]

[3] An example can illustrate the point: some scholars call *charka* the spinning wheel (Arnold 2000, 94). More recent work states that *churka* is the instrument used for cleaning cotton (Wendt 2005, 97).

[4] The next stage of this research, in collaboration with Giorgio Riello, includes comparison of Indian with the Ottoman, Chinese as well as the European organisation of textile technology.

[5] The latter argument though, on the low wages of Indian weavers, has been substantially challenged (Parthasarathi 1998).

Chaudhuri goes on to argue that in the eighteenth century there was no reason why India's superior weaving techniques and overall specialization of production were in need of mechanization; when the challenge did come, he argues, in the nineteenth century Indian businessmen imported machinery (Chaudhuri 1996, 76). An alternative view draws our attention to institutional changes that may have affected the organization of production and in particular the level of expertise: "the changing structure of the textile industry, the organization of labour in the work place or in changes in the quality of products for a growing market reduced skills inputs but increased size of production and its orientation towards distant markets" (Perlin 1983, p. 54).

The standard and quasi-nationalist position of 'de-industrialisation' has been revised by looking at specifically "the adaptation and survival of handloom weaving" (Arnold 2000, 94), but, we may add, of cleaning, spinning and finishing too, as these were no less important parts of the process. Indian and other scholars have researched the state of Indian technology (always in association with 'science', as mentioned above) and inevitably reflected upon earlier, pre-colonial times. Deepak Kumar, for example, has argued that with the establishment of imperial hegemony, 'popular local knowledge and skills suffered an eclipse and in its place came science for profit, science for accumulation of capital aiming at the full exploitation of raw materials and maximum profit at minimum cost' (Kumar 1980). True as this may be for the colonial period, it is difficult to argue convincingly that in pre-colonial times 'science and technology' were employed in non-profit ways or that their employment did not aim at the lowest cost possible or even that 'modern' market practices were not in operation. What is important though from the above account is the 'popular local knowledge and skills' and the role these may have played in the transmission of knowledge of textile production techniques. The paper does not look though to what extent these skills may have 'suffered an eclipse' under colonial rule.

Indian Technological Change. A Chronology

Any account of Indian technological evolution will have to go back to medieval times, when the major developments in textile technology occurred. Although authors disagree as to the exact period – even century on some occasions – of each technological step towards increasing productivity and perfecting quality, existing works allow for a

chronological mapping of these developments. These are shown in the following table, essential for future work on a comparative analysis of Indian textile technology. The dates signify, alas, not inventions and technological turning points but points in time when pieces of information refer to.

Table 1. Chronology of textile technology

Date / Period	***Event***	***Source***
2nd – 6th C	The carder's bow was introduced	Ramaswamy, 1985
11th C	Earliest reference to a weaving site – inscription	Ramaswamy, 1985
11th C	The application of resins to confine colours to patterns and of mordants to take colours, very common during the century.	Rahman, 1992
1184	Evidence of the operation of the vertical loom	Ramaswamy, 1985
12th C	Clear reference to the tie and dye technique	Ramaswamy, 1980
12th C	Probable that block printing existed	Ramaswamy, 1980
1173 and 1223	Dyeing gradually an independent profession-dates record tax imposed on dyers	Ramaswamy, 1985
12th C	On the basis of inscriptional evidence the patterned or draw loom can be traced back "positively", introduced by Muslims from Persia	Ramaswamy, 1980
13th C	Reference to brokers in the textile trade	Ramaswamy, 1985
1257	The spindle wheel was in use in Persia	Habib, 1969.
1270	The spinning wheel in its simplest form is illustrated in China in a manner indicating its general use	Needham, *Science and Civilization*, iv, Part 2 in Rahman, 1992
1301-2	Reference to the hand-spindle	Habib, 1979.
1313	Multi-spindle wheels illustrated in China	Habib, 1980.
13th and 14th	Two important instruments for cleaning cotton, were the wooden worm-worked roller (charkhi) and the bow scotch (Kaman). They had come into use by the centuries.	Habib, 1980 and Rahman, 1992
14th C	The spinning wheel which was so crucial to the increase in yarn production came with the Turks	Ramaswamy, 1985
14th C	Calico printing	Habib, 1980
14th C	Evidence of spinning wheels powered by water	Rahman, 1992
14th C (end)	Earliest tax on looms (Tamil region)	Ramaswami, 1985
1426	Evidence of concentration of weavers around	Ramaswami, 1985

	temples and assignment of streets	
1480	The U shaped flyer rotating around the spindle evident in Europe	Habib, 1980
15th C	Evidence on emergence of weavers-merchants and operation of several looms at one site	Ramaswamy, 1985
16th C	First mention of tax on carders	Ramaswami, 1985
15th -16th C	The invention of the draw loom appears to be an indigenous achievement	Ramaswamy, 1991
1538	Inscription from Tirupati shows specialization in weaving with the use of a draw loom – probably imported by Muslims	Ramaswamy, 1991
17th C	Looms identical with Europeans since 13C depicted	Habib, 1980
17th C	Weavers' residential shift from temple premises to coastal villages and company settlements	Ramaswamy ,1985
Late 17th C	Alterations to looms in Madras and Fort St David to fit the demands of European market	Ramaswamy ,1985

During medieval times the main changes across the production process occurred. Tools for cleaning, spinning and weaving laid the foundations and determined the course of the industry for centuries to come. The looms used were basically the same in North and South India, although the southern weaving tradition probably developed earlier (Varadarajan 1984, 67). Between 13th and 14th centuries spinning wheels were even powered by water (Rahman 1992, 814). Historians disagree though when it comes to the issue of stagnation of Indian textiles technology. On the draw loom, the one producing patterns of colours, for instance, inscriptional evidence – which is where most of the information comes from - is marshaled to show the loom was not brought from Persia in the 17th century but that it can be dated instead since the 11th (Ramaswamy 1980, 230). These sorts of differences make the writing of an Indian history of technology a difficult task. The argument on stagnation is best encapsulated in Habib's point that the technical capabilities of the horizontal loom had been practically exhausted and further development could not be reached until the arrival of Kaye's flying shuttle (Ramaswamy 1980, 231), which means that between the twelfth and nineteenth century no technological changes occurred in the weaving of ordinary cloth – a very long lag indeed. Also, the similarities between Chinese, Indian Persian (and possibly Ottoman) textiles tools manifests the technology transfer that took place within these economies over a

number of centuries, as the example of the Indian and Chinese spindle wheels demonstrates (Baines 1977, 45).

It is generally believed that no attempts to introduce European technology in India were made in the textiles industry with one exception, that of the silk industry in Bengal (Bhattacharyya 1970). Two factors can account for this lack of technology transfer: firstly, the fact that Europeans were not at a technologically more advanced level than Indian artisans – and therefore there was no need for technology transfer and secondly, that change in the looms suggested by some Europeans in the seventeenth century could have been time consuming and costly (Qaisar 1982, 83). Similarly, in the eighteenth century, no attempts to introduce textile machines technology to India were made by the EEIC, which by the late eighteenth century was controlling textile production. It has also been argued that a second type of loom, Kaye's fly shuttle, patented in Bury in 1733, "was perhaps introduced by the Company" (Bag 1982, 84) in 1815 in a textile mill at Broach. This is curious because for the new machinery, an Act passed in 1774 made it an offence to "export tools or utensils used in manufacturing cotton or cotton and linen mixed"; the Act was extended in 1781 to include sketches, models or specifications (Mantoux 1961, 258). Under this legislation – and provided it was strictly and successfully enforced – it is not surprising that there were no efforts to introduce technological innovations in India. Still, there were changes in the textile production: the numerous filatures system in reeling and the drum warping. The EEIC introduced the numerous filatures for reeling in several factories and brought Italian reelers to teach the Italian technique (Bag 1982, 84). This shows that the Company faced considerable competition by Italian producers and to this challenge it responded by introducing new technology in India. Assuming that there were no prohibitions on the export of machinery and tools from England there is no reason why this technology transfer could not have taken place and at a much quicker pace in the cotton textiles industry in the eighteenth century just like it did in the late nineteenth and early twentieth century, the era when the traditional industry modernized and led Indian industrialization (Roy 1999). The absent input of European technology (looms and spinning machines) on Indian textile production suggests that European arrival, establishment and domination had a small, if at all, impact on Indian textile technology.

The Geography and Social Organization of Textile Technology

All stages of the production process in India, the cultivation of the crop, cleaning, spinning, weaving, bleaching, dyeing and printing were distributed or separated in small or larger regions. This aspect of textile manufacturing has not received appropriate study and it is arguably important that the development of manufacture occurred on the existing "infrastructure of markets and entrepreneurial functions, without being confined to coastal regions" (Perlin 1983, 71). There is no evidence that the four major production centres (the Coromandel Coast, Bengal, Gujarat, Punjab) developed different techniques and / or innovations, which means that textiles technology was quite equally diffused across these production clusters. It is South India in general and the Coromandel Coast in particular that have attracted considerable interest by scholars, due to the early fruition and longevity of the textile industry there and the abundant documentation that the early involvement of European companies has generated. Old as well as more recent works have shown the wide distribution of textile-producing centres along the plains from the eastern Godavari river delta and along the Coromandel coast and its hinterland (Arasaratnam 1990, Brenning, 1990, Parthasarathi 2002, Wendt 2005). It is also an inherent feature of the industry throughout the period and in all regions that the several and complex stages of production required the employment of different and separate groups of craftsmen which meant that no central control of the production could be enforced by a ruler (Chaudhuri 1996, 49). It has to be noted though on the issue of skills and renowned dexterity of Indian spinners and weavers that, however diffused, it was not the same all over India. In South Indian for example, it has been shown that the knowledge and skills of weavers deteriorated as one moved from north to south (Parthasarathi 2002, 8).

The social and political organization of textile production taken into account in the literature and necessary for any encompassing explanation of the role of technology refers primarily to the stratification inherent in Indian society As far as weavers were concerned, the transition from their status as independent producers – compared with the putting out system developed in Europe and the state-directed production in the Ottoman Empire – to Company-controlled producers is considered of paramount importance. This transition has been amply documented (Hossaid 1988, Arasaratnam 1990, Parthasarathi 2002). More recent work attempts to address the balance between the

majority of work on weaving and trade and the initial processes of production, namely cotton cleaning and spinning while looking at the social organization of the workers in all stages (Wendt 2005, 93). Reference to and consideration of the social organization is necessary, to the extent that it affected the reproduction of techniques and dexterity in spinning, weaving and finishing.

The processing of the crop is the first stage where technological innovations or for that matter stagnation do matter. The process of cleaning the crop – to start with - was extremely labour-intensive. The simple, very labour-intensive but also very efficient in terms of producing strong thread tool was a foot roller separating the cotton from its seeds (Naqvi 1968, 149). The *churka* or *charkha* was another instrument for cleaning cotton (Wendt 2005, 97). The spinning part of the production chain was done predominantly by women too, mostly poor, who, in areas where was not produced locally had to buy cleaned cotton and often returned to the same markets to sell yarn. This meant that they did not rely on merchants and were operating as petty merchants themselves (Wendt 2005, 114). This is an interesting view and implicitly argues for a problematization of the fixed categories of workers-as-spinners who relied on merchants for engaging in market transactions.

Spinners seem to have been ubiquitous in South India but studies on other regions do not present striking differences: resident in raw cotton-producing as well as in cloth-producing areas, in and around weaving villages but not across the social order and usually separate residentially from other labouring groups, since it was primarily performed by 'pariah' groups, namely women at the lower end of the caste social scale (Wendt 2005, 135-7). Some spinners maintained close economic ties with weavers near Madras who in the late eighteenth century advanced money in return for a steady (in terms both of flow and prices) supply of yarn (Wendt 2005, 139).

There is general agreement on the spinning wheel or *ratnam* used in South India throughout the period (up until the early nineteenth century) (Partasarathi 2002, 60; Wendt, 140). More diverse appears to have been the dexterity of spinners which impacted on quality of the thread produced – of great variety itself. This piece of information relates of course to the issue of transfer of skills. Some spinning communities, it is argued, were 'depositories' of skills and knowledge, especially of skills

employed in the production of high quality thread and received different teaching or training (Wendt 2005, 143). Spinning was done by lower cast women who sold it directly to the weavers. British sources agree that spinning was done by women and children. The advance in cash by the Companies to merchants is argued that trickled down even to spinners and thus increased their income (Richards, 1993, 202). A traditional view by Tchitcherov argues that the shift from the domestic industry that spinning was for centuries to commodity production took place in two stages that can be identified: the first was the manufacture of thread by women, from cotton grown in the household. The second stage was the purchase of cotton by women to spin and sell as thread to the market (Tchitcherov 1965, 52). This development of spinning into a full-time employment generating income for the household was fuelled by the development of cotton manufacture which in turn was stimulated by the demand for Indian textiles from the mid to late seventeenth century onwards and drew even more into the spinning trade. The same author also argues that this development even brought down some social barriers between men and women and people from different castes (Tchitcherov 1965, 88) providing little evidence though that this break down of centuries-old barriers actually took place.

One of the most important forms of social organization seems to have been their residential pattern of weaving villages, which guaranteed better negotiating terms with merchants and later with Company servants, provided some form of social security and also resistance in case of coercion, since it was not rare that whole communities moved to areas where their labour would be better paid and not expropriated. It has to be noted though that the weavers with this degree of flexibility and mobility were probably the wealthier ones, since weavers in debt would use flight as a last resort, in times of dearth, war, expropriation or other calamity. The status differentiation among weavers was accentuated by differences in income. Most weavers owned (and worked in) one loom but some could own two to five and even fifteen or more looms, employing wage labour (Wendt 2005, 145).[6] There also disagreement that differences of income and status cut across the weaving 'community'. Head weavers – representing their weaving villages with foreign agents – common and 'coolie' weavers, full-time and seasonal weavers, rich and poor weavers constitute a mosaic of a complex social organization extremely difficult to

[6] Unfortunately very few studies conduct the kind of analysis provided in Wendt's thesis, which includes findings on incomes, wages and productivity.

pin down geographically as well as chronologically, although no evidence has been found on master weavers for eighteenth-century South India (Parthasarathi 2002, 17). What both old and new research agrees upon is that no 'investment' in technology was made by the richest weavers, who either hoarded gold or bought and owned cattle. The gradual domination and control of production by merchants and bankers stifled potential technical transition into new forms of production and process innovation, since they were indifferent to such changes and content with the intensified exploitation of workers in India (i.e. Bengal) as well as in Europe (Perlin 1983, p. 94).

The process of spinning high quality thread – the most lucrative– required special skills which were passed on from generation to generation by the women primarily occupied in the process. This should not be considered a 'closed' or 'backward' system of knowledge transmission. Transmission of spinning skills in the household was by far the most efficient way and – given that it used to take place in so many households – cannot possibly be considered 'closed' or exclusive. Recent research has also confirmed that predominantly female labour was occupied in cleaning and spinning, both processes often performed by the same women – in South India at least (Wendt 2005, 95).

The existence of weaving villages - usually around temples - dates back to the fifteenth century. Their location enabled priests to control the production and especially to control the revenues from the highly skilled and for that matter profitable trade. While this is hard to corroborate, by the seventeenth century villages of weavers was the norm rather than the exception in this part of the process. The weaving process has been rightly distinguished between the warping and weaving parts. Warping or preparing the warp for weaving was done in South India mostly by women and adolescent children in the household as late as the eighteenth century. Demand for long clothes involved as much as 55 to 95 kilometres of walking and laying out the warp. The whole process involved 'laying out the warp, sizing the threads with starch and fixing the thread to the loom' (Wandt 2005, 204-206). Handloom technology did not evolve perhaps for centuries as the chronology of textiles technology also shows. Most looms were horizontal and operated by one person. Thread went through combs which, albeit simple, could take some time to adjust to production of different kind of cloth. For this reason weavers were usually reluctant to change the type of cloth they produced (Wendt 2005, 238). Market reasons account for the reluctance of Indian weavers to change their looms and

adjust them to European requirements. In the seventeenth century, Gujarati weavers for instance had already adjusted their manufacturing techniques to suit Middle Eastern customers (Chaudhuri 1996, 42).

A Comparative Vantage Point: dyeing techniques in India, Ottoman Empire and Europe.

Although more is known about dyeing in the coastal areas, where, due to the centuries-old trade with South East Asia and the Middle East and the presence of European companies the industry developed, advanced stages of the finishing process of cotton textiles production were by no means confined to the coastal areas but spread inland as far as Hindustan and specifically in Delhi, Lucknow and Farrkhabad (Naqvi 1980, 59). The geography of dye crops cultivation and the geography of textile production did not coincide and distances were covered by complex networks of distribution and transport that served the industry (Wendt 2005, 79). The techniques used in dyeing were fairly simple and varied slightly depending on the dye. Indigo, madder, turmeric and safflower were the most common plants used. After soaking the cloth in dung which helped to fix the mordant on the fibre, cloth was washed and bleached. Then the cloth was soaked in oil and alkali for softening and removing dirt. The last stage involved steeping the cloth into the dye infusion and then in the mordant solution (Bhardwaj and Jain 1982, 74). From the eighteenth century onwards India begun to export large quantities of dyes to Europe, where there was a great demand. When the West Indies substituted the production of indigo with coffee and sugar, India became the principle source, since it had a comparative advantage both in quantity as well as in quality of dyes. India continued to enjoy a comparative advantage in indigo at least until well into the nineteenth century as the exports of indigo to Britain – the main importer – continued to increase. The quality of Indian indigo surpassed the quality of French and Spanish indigo cultivated in the Caribbean (Bhardwaj and Jain 1982, 76). If indigo and the blue dye was a privilege of Indian textiles economy though, madder and the red dye produced from it developed with particular success in the Ottoman Empire and it was from there that its techniques of preparation were diffused in Central and Western Europe. The publication of a book recently (Katsiardi-Hering 2003) on artisans and the transfer of technical

knowledge of dyeing from Ottoman Greece[7] to the Hapsburg Empire attempted in the eighteenth century provides extremely interesting insights on the process of trial and error that "Europe" followed in the long road to technological and living standards divergence.

The particular process and characteristics of the red dyeing techniques were considered to have been particularly hard to achieve and, as a result, to diffuse. Additional difficulties were added by the fact that until the mid – late eighteenth century and in fact not until the early nineteenth, few works were published on the process of dyeing and the intricacies of its technique. Although there had been recipe books written and even published earlier - the earliest published in Lyons in 1766 following the migration of dyers from Edirne, Istanbul and Smyrna and the establishment of a factory there – disseminating technical knowledge was not enough. Because of the delicacy of the process and the expertise involved, climate conditions (air and water) could have significant impact on the success of the dyeing process (Chenciner 2000, 188-190). French recipes and the importance of accumulating knowledge of chemistry played a role in the development of a French production of red dye. Less well known is a recipe (arcanum) submitted to the Hapsburg authorities in 1757 by Panayiotis Vengelinos, who went to Vienna and set up a workshop with exclusive privileges (funding, tax exemption) by the authorities. The 'secret' recipe was locked away by the authorities who did not sell it despite several offers, they did encourage though the development of an imperial industry of red dye cotton yarn as well as the cultivation of cotton and madder. Several other Greek or Austrian merchants got involved and workshops were founded in or around Vienna. The industry though failed to succeed because of the competition faced by the Thessalian (where Vangelinos came from) artisans and merchants who continued to supply superior quality dyed yarn to central Europe, but also due to the necessity to import raw materials (Katsiardi-Hering 2003, 161 and 319-320).

The 'recipes' as recorded in France and Austria do not present differences other than in the sequence in the stages of the process. The same ingredients were used and the only significant difference seems to be the amount of yarn dyed at each time (in Le Pileur's

[7] During the period under consideration for the transfer of dyeing techniques (mid 18th – early 19th century) Greece did not exist as a state entity of course. The uncommon phrase Ottoman Greece is used only to denote the upland area of Thessaly (in today's central Greece) where Greek-speaking Christian Orthodox populations lived.

recipe 100 lbs, in the Vangelinos one 50lbs).[8] The similarities are due to the fact that both recipes came from the Ottoman Empire and the same centres of production of red dye and involved most significantly the emigration of artisans and not just copying the technique. The transmission of skills was of paramount importance for the successful dyeing of the yarn and French economic environment was more conducive to the successful development of the industry and its diffusion from there to Alsace and Silesia., than the Hapsburg one, whose authorities were often timid in developing an integrated cotton textiles industry. Based on extensive networks of merchants and artisans situated in many important emporia in the Levant and Central Europe, the industry in Ampelakia and Central Thessaly for nearly fifty years (1750s-1800s) monopolized the trade in dyed cotton yarn in Central Europe. The industry declined only due to 'internal' competition – even between Vangelinos and his compatriots- and the import of machine-made yarn from Britain in the nineteenth century (Katsiardi-Hering 2003, 320).

The codification of dyeing techniques and its diffusion or concealment as a state secret – in the French and Hapsburg case respectively – can by no means taken as a sign of European-only awareness of the significance of the codification process. Indians can not be accused of ignoring this significant step in the move towards greater efficiency in textiles production. India Office Library in London holds an anonymous medical treatise entitled *Nuskha Khulasatul Mejarrebat* (A Treatise of Abstracts of Proven Medicinal Prescriptions), which includes a chapter in dyeing and printing. This work was transcribed in 1766 and almost certainly comes from an earlier date; its style is lucid and suggests someone literally hands-on with an intimate knowledge of the process (Naqvi 1980, 59). The detailed account contains seventy-seven processes of dyeing cotton for forty-eight different shades. Apparently the Hindustani dyers produced their dyeing material as well, thus eliminating the need to import dyestuffs, a constant problem for European finishing process until the cultivation (albeit limited) of madder in South France in the mid eighteenth century. This provided a significant comparative advantage since in Thessaly (in the Ottoman Empire) dyestuffs had to be imported too from madder – growing areas, mostly in Anatolia and some – but not many – regions in the Balkans.

[8] See the contrast between the two 'recipes', Le Pileur's method in Chenciner 2000, 192 and Vangelinos in Katsiardi-Hering 2003, 285-289).

It is the particular case of the red-dyed yarn that constitutes an interesting point of comparison between Indian and Ottoman techniques and specialization and the transfer of these techniques to France and Austria. Indigo in India and madder in the Ottoman Empire became sought after by Europeans for the colouring of dyes.[9] The French and Hapsburg responses to substituting the large amounts of red cloth imported demonstrate the varied strategies adopted by different European economies in catching up with the comparative advantages enjoyed by economies further East.

Conclusion

The 'problem' of technological stagnation or adaptation is essentially one of causality, since it is contrasted to the European advance after the latter took place. There is no reason why Indian technological change and development should have followed the European trajectory, but still the reasons why this did not happen remain obscure (Washbrook 1988, 79). The present research will hopefully provide a stepping stone for beginning to understand better the reasons behind this historical 'failure'. Considerable emphasis has to be placed on skills and the transmission of technical knowledge through community, caste and other forms of social organisation – kinship and locality in the case of the Thessaly industry. The association of science with technology, important as this may have been for Europe, mattered little in the Ottoman Empire and India, as the latter two enjoyed comparative advantages that allowed them to maintain their primacy in producing high quality cotton textiles and exporting them to Europe as well as satisfying 'domestic' demand without developing an epistemic base similar to the European one. Examining particular aspects of the organisation of textile technology in the context of the divergence debate seems more appropriate than constructing overarching theories of 'progress' or even more arguably 'modernization'.

[9] For the European demand for red cloth, see Giorgio Riello, 'The Rise of European Calico Printing and Dyeing and the Influence of Asia in the Seventeenth and Eighteenth Centuries', unpublished paper.

References

Arasaratnam, S., 'Weavers, Merchants and Company: The Handloom Industry in South-Eastern India 1750-1790', in Sanjay Subrahmanyam (ed), *Merchants, Markets and the State in Early Modern India*, Delhi: OUP, 1990.

Arnold, David, *The New Cambridge History of India: III.5: Science, Technology and Medicine in Colonial India*, Cambridge: Cambridge University Press, 2000.

Bag, A.K., 'Technology in India in the Eighteenth-Nineteenth Century', *Indian Journal of History of Science*, 17, 1, 1982, 82-90.

Baines Patricia, *Spinning Wheels. Spinners and Spinning*, Tiptree: Anchor Press, 1977.

Bhattacharyya Sabyasachi, 'Cultural and Social Constraints on Technological Innovation and Development: Some Case Studies', in Surajit Sinha (ed), *Science, Technology and Culture: A Study of the Cultural Traditions and Institutions of India and Ceylon in Relation to Science and Technology*, New Delhi: Research Council for Cultural Studies, India International Centre, 1970.

Bose Sugata and Ayesha Jalal, *Modern South Asia. History, Culture, Political Economy*, New York and London: Routledge, 2nd edition 2004.

Brenning, Joseph, 'Textile producers and production in late seventeenth century Coromandel' in Sanjay Subrahmanyam (ed), *Merchants, Markets and the State in Early Modern India*, Delhi: OUP, 1990.

Broadberry Stephen and Gupta Bishnupriya, 'Cotton Textiles and the Great Divergence: Lancashire, India and Shifting Comparative Advantage, 1600-1850', http://www2.warwick.ac.uk/fac/soc/economics/staff/faculty/broadberry/wp/cotdiv11.pdf

Bruland Kristine, 'Industrialisation and technological change' in Roderick Floud and Paul Johnson (eds), *The Cambridge Economic History of Modern Britain. Volume I: Industrialisation, 1700-1860*, Cambridge: CUP, 2004.

Chapman, Stanley, D., *The Cotton Industry in the Industrial Revolution*, London: McMillan, 1972.

Chaudhuri K.N., 'The Structure of Indian Textile Industry in the Seventeenth and Eighteenth Centuries' in Tirthankar Roy (ed), *Cloth and Commerce: Textiles in Colonial India*, London : Sage Publications, 1996.

Chicherov, Alexander, *On the socio-economic structure of pre-colonial India : handicraft production in the XVIIth to early XIXth centuries*, Moscow : U.S.S.R. Delegation, 1967.

Habib, Irfan, 'Technological changes and society in the 13th and 14th Centuries', Presidential Address, Medieval India Section, 31st session of the Indian History Congress, Varansi.

Habib, Irfan, 'Technology and Barriers to Social Change in Mughal India', *Indian Historical Review*, v (1978-9): 152-174.

Habib, Irfan, 'The technology and economy of Mughal India', *Indian Economic and Social History Review*, XVII – 1 (1980), pp. 5-34.

Hossaid Hameeda, *The Company Weavers of Bengal: The East India Company and the Organization of Textile Production in Bengal*, 1750-1813, Delhi 1988.

Jones Eric, *Growth Recurring*, Oxford: OUP, 1988.

Kumar Deepak, 'Patterns of Colonial Science in India', *IJHS* 15 (1) 1980, 105-113.

Mantoux Paul, *The Industrial Revolution in the Eighteenth Century*, London: Methouen & Co, 1928.

McCloskey D.N., 'The Industrial Revolution 1780-1860', in Roderick Floud and D.N. McCloskey (eds), *The Economic History of Britain since 1700, Volume I, 1700-1860*, Cambridge: CUP, 1981.

Metcalf Barbara and Metcalf Thomas, *A Concise History of India*, Cambridge: CUP, 2005.

Mokyr Joel, *The Gifts of Athena. Historical Origins of the Knowledge Economy*, Princeton: Princeton University Press, 2002.

Naqvi Hamida Khatoon, 'Colour Making and Deying of Cotton Textiles in Medieval Hindustan', *IJHS*, 15, 1 (1980), 58-70.

Naqvi Hamida Khatoon, *Urban Centres and Industries in Upper India, 1556-1803*, London: Asia Publishing House, 1968.

O' Brien, P., Griffiths, T. and Hunt P., 'Technological Change during the first industrial revolution: the paradigm case of textiles, 1688-1851', in R. Fox (ed), *Technological Change: Methods and Themes in the History of Technology*, Amsterdam: Harwood, 1996.

O'Brien, Patrick K., 'The mechanisation of English cotton textile production from Kay (1733) to Roberts (1822)', Paper presented at the 5th GEHN Conference on 'Cotton, Textiles and Labour Intensive Industrialization since 1825', Osaka University, December 2004.

Parthasarathi, Prasannan, 'Rethinking wages and competitiveness in the eighteenth century', *Past and Present*, 158 (1998), 79-109.

Parthasarathi, Prasannan, *The transition to a Colonial Economy: weavers, merchants and kings in South India 1720-1800*, Cambridge: Cambridge University Press, 2001.

Perlin, Frank, 'Proto-industrial and pre-colonial South Asia', *Past and Present*, IIC (1983): 30-95.

Qaisar, Ahsan Jan, *The Indian Response to European Technology and Culture (A.D. 1498-1707)*, Delhi: OUP, 1982.

Rahman A., 'Science and Technology in Medieval India' in Debiprasad Chattopadyaya (ed), *Studies in the History of Science in India*, Vol II, New Delhi: Asha Jyoti, 1992.

Rahman, Abdur, 'Sixteenth- and seventeenth-century science in India and some problems of comparative studies', in *Changing Perspective in the History of Science* (Boston: D. Reidel Publishing Company, 1973), pp. 52-67.

Ramaswamy Vijaya, *Textiles and Weavers in Medieval South India*, Delhi: OUP, 1985.

Ramaswamy, Vijaya, 'Notes on the textile technology in medieval India with special reference to the South', *Indian Economic and Social History Review*, XVII – 2, 1980, 227-241.

Richards John F., *The Mughal Empire. The New Cambridge History of India* vol. I.5, Cambridge: CUP, 1993.

Roy Tirthankar, *Traditional Industry in the Economy of Colonial India*, Cambridge: CUP, 1999.

Sangwan Satpal, 'Why Did the Scientific Revolution Not Take Place in India?', in Deepak Kumar (ed), *Science and Empire: Essays in Indian Context (1700-1947)*, Delhi: Anamika Prakashan, 1991a.

Sangwan Satpal, *Science, Technology and Colonization. An Indian Experience 1757-1857*, Delhi: Anamika Prakashan, 1991b.

Subrahmanyam Sanjay, 'Rural Industry and Commercial Agriculture in late Seventeenth-Century South-Eastern India', *Past and Present*, 126, 1990, 76-114.

Tchitcherov Alexander I. *India. Changing Economic Structure in the Sixteenth-Eighteenth Centuries. Outline History of Crafts and Trade*, New Delhi: Manohar, 1965.

Varadarajan Lotika, 'Indian Textile Technology in the Pre-Industrial Period', *Indica*, 21, 2, 1984, 61-69.

Washbrook David A., 'Progress and Problems: South Asian Economic and Social History c. 1720-1860', *Modern Asian Studies*, Vol. 22, 1, 1988, 57-96.

Wendt, Ian Christopher, 'The Social Fabric: Textile Industry and Community in Early Modern South India', PhD, University of Wisconsin-Madison, 2005.

Wescher, H. 'Great Masters of Dyeing in 18th Century France', in *Ciba Review*, 18, 1939.

Bhardwaj H. C. and Kamal K. Jain, 'Indian Dyes and Dyeing Industry during 18th-19th Century', *JIHS* 17, 1, 1982, 70-81.

Chenciner, Robert, *Madder Red: A History of Luxury and Trade. Plant Dyes and Pigments in World Commerce and Art*, Richmond: Curzon, 2000.

Katsiardi-Hering Olga, *Technites and Technikes Vafis Nimaton. Apo ti Thessalia stin Kentriki Evropi (18os-arhes 19ou ai.*) [Artisans and cotton-yarn dyeing methods. From Thessaly to Central Europe (18th to beginning of the 19th century), Athens and Ampelakia: Hrodotos 2003.