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ECONOMICS 303Y1

The Economic History of Modern Europe to 1914

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Lecture Topic No. 10:

**II. GREAT BRITAIN AS THE HOMELAND OF THE INDUSTRIAL
REVOLUTION, 1750-1815**

**K. The Industrial Revolution in Consumer Goods: the Cotton Industry (and
Other Textile Industries)**

K. The Industrial Revolution in Consumer Goods: the Cotton Industry (and Other Textile Industries):

The Economic History of a Consumer Goods Manufacturing Industry

1. The Importance of the Industrial Revolution in Cottons:

a) Textiles in the Later-Medieval European Economy: for the proper historical background

i) Textiles represent one of the three most important needs of wants, in human consumption:

i.e., in terms of **FOOD, CLOTHING, AND SHELTER**

ii) **basic needs – i.e., necessities:** i.e., basic clothing and footwear (cloth or leather)

(1) for protection against elements: the cold, the heat, rain, snow, sand storms

(2) for other forms of physical protection against physical abrasions (to avoid cuts, scratches, other wounds)

(3) for protection against personal shame (perceived, imagined, or real):

■ i.e., personal modesty, in that nudity (partial or total is and has been taboo in most societies):

■ consider the recent public debates about the role of dress in Asian, European, and North American societies

iii) **more luxurious needs:**¹

(1) personal satisfaction in fashion, dress style, etc.: the need for personal adornment

(2) status symbols: to assert one's social status and rank, if not personal identity

(3) **Sumptuary Laws** and the assertion of social and political status, rank, values: indeed in medieval and early modern Europe the aristocracy had their governments pass legislation — known as Sumptuary Laws – prohibiting the lower classes (including the mercantile bourgeoisie) from imitating their dress.²

(4) These fashion-oriented and status needs may be the most important component of the regional and international trade in textiles – since peasant 'homespun' clothing was almost universal

iv) **The major textiles, in rank order of importance in European and World economic history:**

(1) **The wool-based textiles (from sheep), in three formats:** ³

¹ See (but only if you are really interested in this topic), my two recent publications: John Munro, 'The Anti-Red Shift – to the Dark Side: Colour Changes in Flemish Luxury Woollens, 1300 - 1550', *Medieval Clothing and Textiles*, 3 (2007), 55-95; John Munro, 'Three Centuries of Luxury Textile Consumption in the Low Countries and England, 1330 - 1570: Trends and Comparisons of Real Values of Woollen Broadcloth (Then and Now)', in Kathrine Vestergård Pedersen and Marie-Louise B. Nosch, eds., *The Medieval Broadcloth: Changing Trends in Fashions, Manufacturing, and Consumption*, Ancient Textile Series, vol. 6 (Oxford: Oxbow Books, 2009), pp. 1-73. With 17 tables and 6 graphs (figures).

² See n. 1 above.

³ See David Jenkins, ed., *The Cambridge History of Western Textiles*, 2 vols. (Cambridge and New York: Cambridge University Press, 2003), in particular these chapters:

a) John Munro, 'Medieval Woollens: Textiles, Textile Technology and Industrial Organisation, c. 800 - 1500', pp. 181-227;

- woollens (made from short-fibred wools): heavier weight, generally more expensive, with the finest varieties being articles of luxury consumption
- worsteds (made from longer-fibred wools): generally much lighter, and generally cheaper, more oriented towards mass consumption.
- ‘stuffs’: mixed woollen-worsted fabrics, intermediate in weight and values

(2) **Silks:** originally Asian, but became a European import-substitution industry

- originally and generally (medieval era), ultra-luxury consumption
- early-modern era: silk fibres mixed with woollen or worsted yarns, linen fibres, goat’s hair etc. to produce medium quality textiles.
- in England, the first textile industry to become mechanized, in 1720, was the silk industry: with water-powered silk-throwing (spinning) machinery
- but this was not the road to modern industrialization: and will not be considered further

(3) **Linens:** made from flax fibres: from coarse and cheap to very fine and luxurious

(4) **Fustians:** a mixed fabric textile with

- a linen warp (foundation yarn on the loom)
- and a cotton weft (woven with a shuttle between sets of warp yarns)

(5) **Cottons:**

- The most important Asian textile manufacturing industry (with silks): providing a very major import into European, by the East India Companies, from the 1660s
- genuine cottons, having cotton fibres for both warp and weft, were not manufactured in Europe until the Industrial Revolution: the key to this lecture is why and how?

iv) **For these reasons textile manufacturing and the textile trades (including trade in the fibres and raw materials) have always been one of the most important economic activities:** indeed across the known world

(1) certainly throughout medieval, early-modern, and modern Europe (to the mid 19th century) textiles always constituted the single most important industrial manufacture and most important industrial commodity

b) John Munro, ‘Medieval Woollens: The Western European Woollen Industries and their Struggles for International Markets, c. 1000 - 1500’, pp. 228-324.

c) Herman Van der Wee (in collaboration with John Munro), ‘The Western European Woollen Industries, 1500 - 1750’, pp. 397-472.

d) David Jenkins, ‘The Western Wool Textile Industry in the Nineteenth Century’, pp. 761-89.

entering into regional and international trade.

(2) In England, wool-based textiles (and wool itself) had always been, and by far, the single most important manufacturing industry and provided England with its most important exports

- as already seen in the lectures on foreign trade: noting that as late as the 1640s, wool-based textiles still accounted for 92.5% of England's total export revenue
- such wool-based textiles (woollens and worsteds) remained Great Britain's single most important export until the early 19th century (1805), when they were superseded by cotton textiles: for reasons to be explained in this lecture

(3) In the 19th and early 20th centuries: cotton textiles (but along with the other textiles) always constituted the first or primary form of modern industrialization,

- providing the largest employment in the industrial sector in all the countries studied in this course: France, Germany, Russia, and also Belgium and Holland – and in the rest of the industrializing world: the United States, Japan, India
- And for Great Britain, once more the single most important export: from about 1810 to 1850, accounting for almost half of the total value of exports (over 40%).⁴

(4) **The Factory System of Production:** For many economic historians, the true importance of the Industrial Revolution in cotton textile manufacturing lies in

- providing the very model or paradigm of the factory system of production for indeed mass production
- and thus necessarily mass consumption at vastly lower prices.

b) **Cotton Textiles vs. Iron in the Modern Industrial Revolution:**⁵

i) **Textiles and metallurgy**, as I have said before, provided the two spearheads of modern industrialization in Western Europe, from at least the 16th century;

ii) **certainly iron & cotton were the twin spearheads of the actual 18th-century Industrial Revolution, along with coal-fired steam power**, as the true catalyst of industrial changes and economic growth..

iii) **Last day we investigated the Industrial Revolution in iron-manufacturing**, as a revolution in the production of capital or producer's goods (even if also producing some consumer goods).

⁴ See Table 4, below, in the Appendix

⁵ The most recent study is: Douglas Farnie, 'Cotton, 1780 - 1914', in David Jenkins, ed., *The Cambridge History of Western Textiles* (Cambridge: Cambridge University Press, 2003), Vol. II, pp. 721-60. But see also the classic study: Stanley Chapman, *The Cotton Industry in the Industrial Revolution* (London, 1972).

(1) We saw that the essential metamorphosis of iron-manufacturing into a truly capitalist industry had already taken place in England, during the late 15th century:

- with introduction of the blast furnace (iron smelter).
- itself, introduced into England from the Low Countries or Rhineland Germany (whose origins there can be traced a century earlier, to the 1380s)
- the blast furnace, as I stressed last day, produced a true industrial metamorphosis in this era: converting an artisan handicraft industry into a genuine capitalist industry (for reasons explained in last week' lecture)

(2) 18th-century Industrial Revolution in metallurgy: involved chiefly chemical processes to utilize coal throughout:

- using purified coal as coke for both smelting and refining
- and coal-fired steam power, again in both processes.

(3) That resulted in turn in another industrial re-orientation:

- an industrial concentration about coal-fields,
- with both vertical and horizontal integration of the industry (mines, smelters, refiners, slitting mills, etc.)

(4) that led in a quantum leap-forward in industrial scale: from 350 tons to over 10,000 tons p.a.

(5) **Oligopolistic competition:** was also the result of such industrial concentration

- and that quantum- rise in industrial scale,
- involving both vertical and horizontal integration (chiefly of smelting and refining):
- i.e., an industry dominated by a few very large producers, with serious barriers to entry, leading to either unstable competition or some forms of price-fixing: **as price-makers.**

iv) **Today, we investigate the Industrial Revolution in cotton-manufacturing, essentially as a revolution in producing consumer goods,** and one that became Britain's overwhelmingly dominant export in the 19th century:

(1) **It involved a genuine capitalist metamorphosis only from the later 18th and early 19th centuries:**

- i.e., in contrast to the iron industry, during the Industrial Revolution era itself
- from a traditional peasant handicraft into an urbanized, steam-powered factory system of capitalist production

(2) But, in contrast to the Industrial Revolution in metallurgy, it did not thereby involve or create:

- the same scale economies, to anywhere near the same extent
- nor did it lead to as much industrial integration, and industrial concentration

(3) **Instead, it provides us with the classic case of pure competition:** the closest approximation to pure competition to be found in the Industrial Revolution era and throughout the 19th century

- with a homogenous, undifferentiated product (thus no monopolistic competition, as with differentiated products)
- and with so many producers and so many buyers that no one group could determine the price, which was instead determined by weekly public auctions: **as price takers.**
- Thus, its relatively small-scale modes of production, with, in so many factories, a continued separation of its key components – in spinning and weaving – provided an industrial structure that was the exact opposite to that of the iron industry (or virtually the opposite), who were **price makers.**

c) Features of this Capitalist Metamorphosis in the Cotton-Manufacturing Revolution

i) The most dramatic of all industrial changes:

(1) from what is called the ‘putting-out’ system, as a small-scale, rural, peasant handicraft system of production,

- which largely took place in the homes of peasants or farmers, and
- with the ownership of most of the tools (if not the raw materials) still in the hands of the artisans themselves.

(2) to become a fully mechanized, large scale, steam-powered urban factory system of production.

(3) **modern industrial capitalism:** in terms of ownership, organization, and labour relations, by which the factory workers were totally divested from any control over the means of production.

ii) **Cotton manufacturing, like iron-manufacturing:** also involved a two-stage production process, in which innovations in one process necessitated innovations in the other:

(1) Spinning the fibres into yarn for weaving:

- the warp yarn: the strong foundation yarn stretched between the rollers on the loom
- the weft yarn: the yarn inserted between sets of warps to produce the woven cloth

(2) thus weaving the cotton yarns (warp and weft) into cloth:

iii) **But this industrial metamorphosis into modern industrial capitalism did not happen overnight:**

(1) it occurred first in spinning, and only much later in weaving;

(2) and overall it took more than 70 years, from the 1760s to the 1830s or 1840s, to be achieved.

(3) Thus again the relative ‘slowness’ of the Industrial Revolution

(4) even so: the consequences were, both economically and socially, truly ‘revolutionary’.

d) **For foreign trade:** cottons had a particularly large impact: to repeat the foregoing

i) **cotton yarns and textiles together provided Great Britain with its overwhelmingly largest export in**

the 19th century: by 1801-05, the value of cotton exports was surpassing that of woollens and worsteds combined, which had historically dominated British industrial exports.

ii) **by the 1820s, as the table on the screen shows,** cottons were accounting for almost **half** of the value of domestic exports (excluding re-exports) – about 47% of the total

iii) **manufactured cottons's share of total exports:**

(1) peaked in the early 1840s, with about that same share (48%), and

(2) then declined relatively to about one-third to the late 1890s,

(3) and then to about one-quarter (25%) in the early 20th century: to the eve of World War I.

**Exports of British Cotton and Woollen Manufactures (Yarns and Fabrics)
in millions of pound sterling and as percentages of total domestic exports
in quinquennial means, 1796-1800 to 1911-15**

Year	Domestic Exports	Total Exports	Cotton Manufactures Yarns & Fabrics	Cottons as % of Domestic Exports	Woollens & Worsteds Yarns & Fabrics	Woollens as % of Domestic Exports
1796-1800	32.9	43.5	4.2	12.4%	7.4	22.7%
1801-05	39.9	51.1	8.0	20.3%	7.1	17.8%
1806-10	42.2	52.4	14.5	33.9%	5.9	14.1%
1811-15	42.9	45.8	17.5	40.4%	6.3	14.4%
1816-20	40.3	51.4	16.3	40.6%	6.9	17.2%
1821-25	37.3	45.3	17.3	46.3%	6.2	16.5%
1826-30	35.9	42.5	17.2	47.7%	5.0	14.0%
1831-35	40.5	48.1	19.2	47.3%	6.1	15.1%
1836-40	50.0	59.6	23.7	47.5%	6.3	12.6%
1841-45	54.0	62.7	24.1	44.7%	7.5	13.8%
1846-50	60.9	71.6	25.7	42.4%	8.0	13.1%
1851-55	88.9	105.2	31.8	36.2%	10.6	12.1%
1856-60	124.2	149.1	44.1	35.4%	13.8	11.1%

**Exports of British Cotton and Woollen Manufactures (Yarns and Fabrics)
in millions of pound sterling and as percentages of total domestic exports
in quinquennial means, 1796-1800 to 1911-15**

Year	Domestic Exports	Total Exports	Cotton Manufactures Yarns & Fabrics	Cottons as % of Domestic Exports	Woollens & Worsteds Yarns & Fabrics	Woollens as % of Domestic Exports
1861-65	144.4	190.8	48.7	33.7%	20.1	13.8%
1866-70	187.8	234.7	70.3	37.5%	26.6	14.2%
1871-75	239.5	297.7	75.3	31.5%	31.5	13.2%
1876-80	201.4	258.0	68.5	34.0%	21.0	10.4%
1881-85	232.3	295.3	74.4	32.0%	22.5	9.7%
1886-90	236.3	298.5	71.4	30.3%	24.6	10.5%
1891-95	227.0	287.5	66.3	29.2%	21.8	9.6%
1896-1900	252.7	313.7	67.1	26.7%	20.6	8.2%
1901-05	296.9	367.2	79.1	26.6%	20.5	6.9%
1906-10	397.5	487.8	100.9	25.4%	27.0	6.8%
1911-15	456.4	560.2	111.7	24.4%	30.5	6.7%

Source: B.R. Mitchell and Phyllis Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), pp. 281-84, 295-305.

iv) **note, from the same table, that woollens & worsteds exports, as proportional share of total domestic exports (by current values):**

- (1) fell from just over 20% in 1797-1800 to 14% by the late 1860s – and was thus still substantial;
- (2) and to 10% by the late 1890s (6.7% in 1911-15).

v) **At same time the cotton industry also generated a growing volume of imports,**

- raw cotton from the Middle East (Syria), then the southern U.S. (Virginia, Georgia, North and South Carolina, Alabama, Mississippi, in particular).
- since obviously England could not grow her own cotton.

vi) **So, for both exports and imports, this rapidly expanding industry had an exceptionally important impact**

on entire foreign trade sector, including finance, insurance, shipping, etc.

e) **Overall, the cotton industry provided backward and forward linkages of great importance in the economy:**

i) perhaps unmeasurable in overall importance,

ii) but in terms of direct contributions to industrial employment and to the GNP probably no more than 5% - 8%.

2. Quantity vs. Quality in the Industrial Revolution in Textiles

a) **Several years ago**, PBS presented a series called **Quality or Else**, on the current innovative trend called *Total Quality Management Systems (TQM)*, as developed and perfected by modern Japanese industry, involving the following: ⁶

(1) **Total Organization:**

- everyone from the CEO of the firm through the line or product workers to suppliers has to be committed individually and collectively to product quality maintenance and improvement
- management must supply continuously upgraded information and training to achieve these goals.
- ‘quality at the source’ must be the driving goal.

(2) **Total Life Cycle of the Product:** quality improvements must begin with the product design and continue through to the final production and distribution of the product

(3) **Total Commitment:** everyone in the firm – from top to bottom – must be committed to the principle of product quality improvement

b) **somewhat ironically this is a system that American management experts,**

(i) led by the once famous William Edwards Deming, had introduced into Japan during the Post-War military occupation,

(ii) but one that the Japanese subsequently developed into a far more effective system.

c) **In his introduction, the PBS commentator contended that, while the 18th-century Industrial Revolution was based upon quantity considerations,** the current and ongoing ‘industrial revolution’ is based much more on **quality** considerations.

d) **In my view this is very misleading:** though I must warn you that my following views are not those propounded by economic historians of the Industrial Revolution (So I may be wrong!!)

i) **my story on the ‘industrial revolution’ in cottons is based on the following thesis:**

⁶ I am indebted to Prof. Francis Wolek, of Villanova University, for supplying me with this information on the principles of Total Quality Management.

(1) that the initial and primary considerations leading to that ‘industrial revolution’ were radical **quality** improvements to capture foreign markets.

(2) and, to repeat, you will not find this story in any of the standard textbooks.

ii) **So let us now proceed:** with the story of the modern industrial revolution in cottons.

(1) If you agree (as I hope that you do) that technological change provides the fundamental essence of the modern Industrial revolution, then:

(2) Obviously we must fully understand the technology of the textile industries: and thus the nature and importance of the technological changes – those designed to overcome fundamental problems that arose, in particular, in using cotton fibres, especially when export demand changed.

3. Early History and Structure of the English Cotton Industry

a) **Origins of the English cotton or fustian industry, as a ‘putting-out’ craft:**

i) **It began in the later 16th century:**

(1) as an imported *fustians* industry, making fabrics from both linen and cotton fibres:

(2) as one of the many textile industries that Flemish Protestant refugees, fleeing Spanish Persecution (from the ‘Revolt of the Netherlands’ from 1568), had introduced into East Anglia -- especially into Norfolk -- from the late 1560s.

(3) This was one of this era's so-called ‘New Draperies’.

ii) **By the early to mid 17th century**, this fustian industry had migrated

(1) From East Anglia to the north-west of England, to Lancashire, and

(2) also to the adjacent regions of the West Riding of Yorkshire and south-west Scotland.

iii) **regional advantages:** in Lancashire and adjacent Yorkshire (and later Scotland)

(1) a much better climate for spinning cotton: cool and moist, but with only moderate temperature variations, and fairly constant humidity.

(2) ample supplies of clean water and of rural labour, at low cost

b) **Fustians:** and the origins of the modern European ‘cotton’ industry

i) **what are so frequently called cottons are in fact fustians:** a hybrid textile made of linen and cotton, to be explained now more fully: in terms of its two yarns, known as

(1) **the warp:** the strong foundation yarns, necessarily linen warps made from flax

(2) **the weft:** the soft cotton yarn actually woven between the separated warp yarns using a shuttle

(3) see the drawing of a horizontal loom - on the screen: with warps stretched between the warp beam at the rear of the loom and cloth beam at the front, both rotating in one forward direction only.

ii) **Furthermore, Europe had never enjoyed a true cotton industry of any major importance**, before the Industrial Revolution, except for some production of all-cotton handkerchiefs and other similar small light fabrics.

iii) **the nature and crucial role of warp yarns in all weaving:** ⁷

(1) the warps are the primary or foundation yarns that are stretched between the two rollers, with one roller at each end of the loom: the warp 'beam' or roller, and the cloth 'beam' or roller

(2) these were linen warps spun from flax, and were very strong yarns.

(3) alternate warps are pulled apart by hooks and wires attached to a foot-treadle, in order to permit the passage the shuttle carrying the other, secondary yarns, called the wefts, between these warps.

(4) Why linen rather than cotton?

- Because linen, with coarse long fibres, was the stronger yarn, with sufficient strength to withstand the stress that these weaving processes imposed on the warps;
- or conversely, the cotton yarns as spun in Europe were too weak to withstand that stress. [More on this subject later]

v) **the secondary weft yarns:** those that were inserted between the alternating warp yarns.

(1) The wefts were was not subjected to the same stress as the warps,

(2) and thus could be spun from short-fibred cotton: a much softer, finer yarn.

vi) **This type of textile industry came into medieval Europe (late 11th or 12th century) from Egypt,**

(1) where the industry had originated, perhaps in the 10th century: reputedly in an industrial suburb of Cairo, known as al-Fustat

(2) this new textile industry used local flax for linen and imported Indian cotton;

(3) the medieval Egyptian textiles imitated those produced in western Asia (Iraq-Iran) and India.

vii) **From the 13th century, the manufacture of fustian textiles**, though not pure cottons, spread:

(1) from Italy, first to north-west Europe,

⁷ For the technological details of textile production, and for the changes in textile technology during medieval and early modern time, see: John Munro, 'Textile Technology,' in Joseph R. Strayer, et al., eds., *Dictionary of the Middle Ages*, 13 vols., Vol. 11 (New York, 1988), pp. 693-711; reprinted in John Munro, *Textiles, Towns, and Trade: Essays in the Economic History of Late-Medieval England and the Low Countries*, Variorum Collected Studies series CS 442 (Aldershot, Hampshire; and Brookfield, Vermont: Ashgate Publishing Ltd., 1994); and John Munro, 'Medieval Woollens: Textiles, Textile Technology, and Industrial Organisation, c. 800 - 1500', in David Jenkins, ed., *The Cambridge History of Western Textiles* (Cambridge and New York: Cambridge University Press, 2003), chapter 4, pp. 181-227. A working-paper version of this chapter may be found on my Home Page, at: <http://www.economics.utoronto.ca/ecipa/archive/UT-ECIPA-MUNRO-00-05.html>

(2) and then to South Germany;

(3) and the South Germans succeeded the Italians in dominating the fustians industry in early-modern Europe.

viii) **The predominance of Indian/South Asian cotton textiles:**

(1) As noted earlier, both the Dutch and British East India Companies had created a fashion revolution in late 17th-century Europe by importing South Asian cotton calicoes and muslins,

(2) especially those that had been printed in exotic designs (with wood-block printing techniques).

(3) For another century these Asian cotton textiles dominated world markets for this kind of light, cheap, and very decorative, brightly printed textiles.

(4) While some Indian cotton calicoes were evidently also fustians, with a linen warp, certainly the higher grade calicoes and Indian muslins were pure cotton, in both warp and weft.

c) **Indian versus European Cottons: the importance of spinning**

i) **How and why were the Indian-Persian cotton industries able to produce a fine, durable all cotton cloth (warp and weft):** when the Europeans evidently could not do so?

(1) One very common suggestion: the combination of a warm moist climate, ideal for spinning, plus abundant application of highly skilled labour.

(2) But this answer is incomplete and quite unsatisfactory (especially concerning the climate).

(3) In my view the answer lies in the technological nature of spinning and the relative labour costs involved.

ii) **spinning, it must first be understood, is a triple process:**

(1) **drafting** or drawing out the fibres from the mass of carded cotton (which are called rovings).

(2) **twisting** together the filaments into a strong yarn: the strength and fineness together of a yarn is dependent entirely on the amount of twist thus imparted to the yarn.

(3) **winding-on** that twisted collection of fibres onto a spindle.

iii) **Drop-Spindle Spinning:**

(1) the most ancient and virtually universal, world-wide spinning technique:

- it uses a weighted, conical spindle of stone or bone, shaped like a top:
- as it drops, with the fibre attached to top, the spindle rotates rapidly,
- thus drawing out or drafting the thread
- while also twisting the threads very tightly into the yarns (for weaving).

(2) There was, until the Industrial Revolution, no better method for producing yarn that was both very fine and very strong, with an even consistency throughout the yarn.

(3) The Indian, Persian, and other South Asian industries continued to use this ancient though superior technique of spinning (referred to in the literature as 'hand-spinning') for warp yarns.

(4) But they probably used the spinning wheel (certainly Asian in origin) for the weft yarns.

iv) European Textile Manufacturing and the Spinning Wheel:

(1) Introduced into western Europe in 13th century;

- via the Islamic cotton industries of Spain and Sicily;
- ironically, of Asian origin, and very possibly Indian (or at least South Asian).

(2) The spinning-wheel came to displace drop-spindle spinning in Europe, rather gradually, from the 13th to the 16th centuries, with a slow diffusion in western Europe.

(3) The spinning-wheel economized enormously on labour, increasing productivity about 200-fold;

(4) but it did so at the expense of strength and quality:

- the yarn it produced was both inferior in fineness and was much weaker,
- because of the very uneven nature of the spinning
- with alternate thick and thin portions of the yarn.

(5) Indeed it was widely resisted, especially in spinning warp yarns in most of the textile industries.

(6) It was significantly improved in the later 15th century by the addition of the 'Saxon Flyer' for automatic winding on, while twisting (see the diagram).

(7) the Saxony Wheel was widely used chiefly in the linen and worsted industries,

(8) but certainly not for spinning cotton warps in the fustians industry.

(9) So, the spinning wheel consequently could not be used to spin cotton-warp yarns:

- early-modern Europe was no longer willing to devote enormous amounts of cheap labour in spinning warps by using the ancient and traditional drop-spindle (as were the Asian industries).
- As noted earlier several times, labour was becoming relatively scarce in the 17th and early 18th centuries.

(10) The resolution of this problem of spinning cotton warps would be the chief task of the 18th century Industrial Revolution in cotton textiles, as we shall see later.

d) Spinning and the Nature of the 18th-Century Industrial Revolution in Cotton Textiles:

i) it began with the mechanization of spinning to overcome all these problems,

(1) the very heart of the industrialization of the modern cotton industry lay in the mechanization of spinning to produce yarns that were specifically designed to be both:

- much stronger and
- much higher quality

(2) and indeed made it finally possible for Europeans to produce an all-cotton cloth competitive with the Indian textiles in both quality and price.

ii) **The precise cost element of pre-industrial spinning is difficult to measure:**

(1) but I can cite you evidence from the 16th-century Florentine drapery of the famed Medici Company, which show that spinning, along with preparing the wools for spinning, accounted for 67% of the pre-finishing 'value-added' manufacturing costs;

(2) and something similar may have been true for cottons also.

iii) **but I must stress that quality was as important as**, or more important than, costs and price: **N.B.** If two similar goods are priced the same by quantity, the superior-quality good is thus the cheaper good.

e) **The Pre-Industrial Organization: Putting-Out in the Rural Cotton-Fustian Industry:** a Rural Handicraft Industry with a 'Putting-Out' or 'Domestic System' of Production:

i) **a traditional putting-out or domestic system of production:**

(1) a mixture of commercial capitalism and peasant handicraft production,

(2) by which production took place in the homes of the artisans, who primarily used their own tools.

ii) **The role of the merchant capitalist: who** was called a 'clothier:'

(1) he provided the artisans with the raw materials (flax and cotton) and credit;

(2) and he dealt directly with the master-weavers:

- both in furnishing the inputs of production
- and then receiving the manufactured cloth from the weaver, for sale to merchants

iii) **The role of the master-weaver:**

(1) Usually the master-weaver, rather than the clothier himself, put the raw materials out to be worked up into yarn:

- handing out the materials to almost exclusively female workers
- who spun the flax into warp-yarns and the raw cotton into weft yarns.

(2) The weaver and his assistant then wove these two yarns into cloth.

(3) Sometimes these weavers were wage-earning employees of the clothier (who owned the looms).

(4) but more commonly they were semi-independent industrial contractors, with their own looms,

- who bought raw these materials from the clothiers and
- then sold the cloth, when woven, to the merchant clothiers.

(5) most of these artisans owned their own tools and worked in their own homes,

- thus bearing these fixed capital costs,
- while receiving working capital from the clothiers or from the master-weavers in the form of credit.

iv) **the finishing processes**

(1) The clothiers then sold the completed woven cloths to wholesale merchants,

(2) who then normally commissioned the cloth bleaching and finishing (if not transacted by the weavers).

v) **The production processes in spinning and weaving:**

(1) preparation of the yarns for spinning:

- the raw flax was prepared for spinning by retting, hackling, and by combing;
- the raw cotton was prepared by carding (using two wire brushes).

(2) Spinning the two fibres, for warps and wefts: Both fibres were spun into yarn on foot-powered spinning wheels, with a single-spindle, spinning one yarn at a time:

- cotton more on the Great Wheel;
- linen, usually on the Saxony wheel, with the flyer attachment.

(3) the two yarns were woven into cloth on narrow handloom, fitting in well in weaver's cottage.

(4) The linen warps were stretched on the loom,

- between the two rollers;
- a shuttle containing the cotton-weft was passed between the warps, separated by the foot-treadle.

(5) The master weaver usually employed an assistant, though often not really necessary on the narrow looms used in fustian-cotton weaving.

vi) **Final finishing of fustians (cottons):**

(1) cottons, when so woven,

- were first bleached (with Hydrochloric acid – HCl, water, sunshine: over two weeks)
- and then calendared (pressed) and dyed.

(2) From the early 18th century, cotton cloths increasingly came to be printed rather than dyed;

(3) and this method of textile printing was borrowed from India, with dyes on wooden carved blocks producing various exotically shaped and coloured designs.

(4) By the mid-18th century, the Swiss, French, and British had all surprisingly gained superiority over the Asian industries in block-dyed textile printing.

4. **The original markets for English fustian textiles: changes in domestic and foreign trade**

a) **The original market for the English fustian industry was strictly domestic:**

i) **in the 17th century, the only available market for this small**, very peripheral textile industry – the ancestor of the cotton industry of the Industrial Revolution – was domestic: just England itself

ii) **certainly the quality of these hybrid linen-cotton textiles was far too poor:** to enable English merchants to capture any overseas markets, against foreign competition:

iii) **even in the domestic market**, English fustians did not compete effectively with imported South Asian

calicoes

iv) **for the role of the English East India Company in importing South Asian cotton calicoes and muslins:** see the previous lecture on English foreign trade: lecture topic no. 5 (6 October 2010).

v) **note in particular that these Asian cotton textiles:** were both very light and relatively cheap

b) **The role of English Mercantilism:** in changing the fortunes of the English fustians industry

i) **Somewhat ironically,** this new industry gained control over the domestic market as an accidental byproduct of one of the most famous episodes in English Mercantilism.

ii) **When the East India Company began importing vast quantities of Indian and Persian calicoes and muslins from the 1680s,** those imports provoked very hostile reactions within England:

(1) England's major textile industry, in the form of woollen and worsted manufacturers, appealed to Parliament for protection.

(2) it complained that these foreign calico imports were injuring their domestic markets.

(3) though only English worsteds were comparable in lightness and price to be affected by calico imports

iii) **From the 1690s Parliament imposed various restrictions on calico imports:**

iv) **Finally, with the Calicoes Act of 1721, Parliament completely banned:**

(1) not just the import but also the wearing of any imported calicoes and muslins

(2) The real beneficiaries, however, were the Lancashire and Yorkshire producers of cotton-fustians, because their products were a much closer substitute for the Indian calicoes than were any worsteds let alone woollens of the traditional English textile industry.

c) **Consequences of Mercantilist exclusion of the much superior Indian calicoes**

i) **unintentionally,** the series of import restrictions, culminating in the Calicoes Act of 1721 allowed the native fustian industry to gain full control over the domestic market, as it now did

ii) **probably the native industry would not have done so,** had competition from Indian calico imports continued to flow into Great Britain.

iii) **In no way, however,** could these British fustians compete with Indian calicoes or muslins in any of the overseas markets (or even colonial markets):

(1) because the product was too coarse and inferior in quality, and uncompetitive in price.

(2) And these fustians would remain uncompetitive in export markets until the revolutionary changes in technology of Industrial Revolution.

iv) **Thus capturing the overseas markets (including colonial markets -- where Indian calicoes were still sold) provided the key incentive for technological change in the cotton industry:** i.e., to produce true cotton fabrics of high enough quality and low enough price to compete with Indian calicoes and muslins.

d) The crucial role of India: the decline and fall of the Mughal (Moghul) Empire, civil wars, and British conquests

i) Importation of Indian cotton yarns, to be woven in England, was one possible alternative solution, after the passage of the Calicoes Act (which banned only imports of the cloths)

ii) **But from the 1720s, civil wars in India seriously disrupted trade and largely prevented that alternative solution:**

(1) The Mughal (Moghul) Empire (1526 -1857),⁸

- a Muslim empire created by invading Turkic Timurids from the north (via Afghanistan), founded by the Turkish chieftain Babur, in 1526,
- had reached its peak about 1700, in conquering most of the Indian subcontinent

(2) Aurangzeb (1658-1707), great-grandson of Akbar the Great (1556-1605), the greatest Mughal emperor (grandson of Babur),

- had brought the Empire to its greatest extent,
- but did not pursue Muslim-Sikh-Hindu unity, and was opposed by both Muslims and Sikhs
- but especially by the rising power of Hindu Marathas, in southern India (the Deccan region: modern day Maharashtra state)
- After Aurangzeb's death in 1707, his successors could not maintain the unity of the Mughal Empire, which began to disintegrate

(3) From 1720s: continuing civil wars with the Marathas and the Sikhs, and foreign wars with the Persians, brought about the slow disintegration of the Mughal Empire, allowing the British and French to expand their control over most of India

(4) economic consequence of this warfare: disrupted the supplies and the export trade in both cotton textiles

⁸ Moghul was the Persian word for Mongol. Columbia Encyclopedia: Mughal (mūgūl') or Mogul (mō'gəl, mōgūl'), Muslim empire in India, 1526-1857. The dynasty was founded by Babur, a Turkish chieftain who had his base in Afghanistan. Babur's invasion of India culminated in the battle of Panipat (1526) and the occupation of Delhi and Agra. Babur was succeeded by his son, Humayun, who soon lost the empire to the Afghan Sher Khan. Akbar, the son of Humayun and the greatest of the Mughal emperors, reestablished Mughal power in India. At the time of Akbar's death (1605), the empire occupied a vast territory from Afghanistan E to Orissa and S to the Deccan Plateau. Mughal expansion continued under Akbar's son Jahangir and under his grandson Shah Jahan, who built many architectural marvels at Delhi and at Agra (including the Taj Mahal). Aurangzeb, expanded Mughal territory to its greatest extent, but at the same time the empire suffered the blows of major Hindu revolts. The most serious of these was the Maratha uprising. Weakened by the Maratha wars, dynastic struggles, and invasions by Persian and Afghan rulers, the empire came to an effective end as the British established control of India in the late 18th and early 19th cent. However, the British maintained puppet emperors until 1857.

and cotton yarns

iii) **The important overseas trade roles of the British East India and Royal African Companies:**

(1) as seen earlier (lecture on English foreign trade), the British (and Dutch) East India Companies had developed important colonial import and re-export trades in South Asian calicoes and Muslins

(2) While the Calicoes Act of 1720, had totally excluded the English market for these textiles, there were enough foreign markets available to which these textiles were re-exported

(3) the Royal African Company:⁹ played a major role in exporting these Asian cotton-based textiles to West Africa (part of the triangular trades noted earlier)

(4) But the civil wars in India, from the 1720s especially, as noted disrupted the supplies of these Asian textiles

(5) Merchants of the Royal African Company experimented in substituting English-made calicoes that were fully cotton, using domestically spun yarns;

(6) but these low-quality English textiles had a distressing tendency to fall apart,

(7) and the West Africans rejected them as grossly inferior to the real thing:

(8) i.e., they wanted traditional Indian calicoes and muslins, and they were not so eager to buy the British products, especially the all cotton fabrics

(9) they were, however, somewhat more receptive to the linen-cotton fustians, which did not fall apart;¹⁰

(10) but these were still regarded as much too inferior to the South Asian textiles.

(11) At the same time, British merchants were also demanding a cotton yarn

- that was fine and smooth enough, evenly spun, to take certain difficult dyes,
- Turkey Reds in particular, dyes that would hold fast in the fibre, and withstand bleaching.

iv) **conclusions: the crucial role of foreign trade:**

(1) These events involving India and West Africa – the British East India Company and the Royal African Company – concerning the disruption in the supply of both Asian calicoes (and muslins) and Indian cotton yarns provide most of the reasons why the English, from the 1720s, sought the technical innovations to produce all-cotton yarns that were as fine as and as strong as those produced in South Asia (using the class

⁹ A very major incorporated joint-stock company, one that survived the 1720 South Sea Bubble crisis.

¹⁰ This view is questioned, though not very convincingly, in C. Knick Harley, 'Cotton Textile Prices and the Industrial Revolution,' *The Economic History Review*, 2nd ser., 51:1 (February 1998), 49-83, citing J.E. Inikori, 'Slavery and the Revolution in Cotton Textile Production in England,' in J. Inikori and S.L. Engerman, eds., *The Atlantic Slave Trade: Effects on Economies, Societies, and Peoples in Africa, the Americas, and Europe* (Durham N.C., 1992), pp. 158-67.

drop-spindles)

(2) Subsequently also, when relative peace was restored in India, allowing a resoration in supplies of Asian calicoes and Muslins, English merchants and textile industrialists had all the more reason to succeed in this quest for technical innovations to allow them to compete with the Asian textiles

5. The Mechanization of Spinning: the First Stage

a) Causes and Origins of the Revolution in Cotton Spinning:

i) **Traditional theory:** that it was necessitated by an innovation in weaving, namely John Kay's Flying Shuttle of 1733:

(1) A shuttle (containing the weft yarn) was attached to elastic slings operated by a pull-cord and hammer.

- to knock the shuttle back and forth across the loom, returning the shuttle to the weaver
- and thus eliminating the need for the second weaver on the other side of the loom;
- undoubtedly this labour-saving device did speed up the weaving process considerably.

(2) Since this device could double weaving productivity, and since one weaver had usually required five spinners,

- historians have traditionally argued that Kay's Flying Shuttle created an even greater imbalance between spinning and weaving,
- indeed a bottleneck that required increased productivity in spinning.

ii) **But this theory is fallacious,** for the following reasons:

(1) because the first attempts to mechanize spinning had already occurred, i.e., before Kay, in the 1720s;

(2) and the first feasible spinning machine was produced at exactly the same time, in early 1730s, by those unaware of Kay's Flying Shuttle.

(3) The Flying Shuttle first spread in the worsted and woollen industries

(4) and only much later in cotton or fustian weaving (which performed on a narrow loom that used only one weaver to begin with).

iii) **We must instead look to other factors for the technological innovations in spinning:**

(1) and, in particular, a possible labour scarcity with a stagnant population in the early 18th century?

(2) or the crucial role of foreign trade, involving India and Africa, as just explained

b) **The Wyatt and Paul Spinning Roller of the 1730s:** the initial innovation in spinning:

i) **Two English textile artisans, John Wyatt and Lewis Paul,**

(1) began work on this in the late 1720s or early 1730s, creating a working model by 1733,

(2) and then patented the machine in 1738.

ii) **This was a water-powered machine with rotating rollers:** that drew rovings of carded cotton onto several spindles.

iii) **In 1740s and 1750s, they established several water-powered factories:**

(1) to run spinning rollers and also carding machines that they also devised;

(2) but they were failures, forcing Wyatt and Paul into bankruptcy.

iv) **1758:** Wyatt patented another spinning machine, which also was failed.

v) **Importance:** however, lay in demonstrating the essential principle of the later successful machines, namely water-powered rollers (throstles).

c) **James Hargreaves' Spinning Jenny (1764-70):**

i) **Hargreaves (1720 - 1778) claimed to have invented this machine in 1764,**

(1) but the first recorded evidence is 1767;

(2) and it was not patented until 1770.

ii) **in essence,** it was a mechanically simple but vastly improved version of the traditional spinning wheel, which had rotated only a single spindle:

(1) his machine contained a frame with not just one but many spindles for winding on the yarns: at first 8, then 80, and then 100 spindles.

(2) with his machine, a large foot-powered wheel rotated a bar or axle that in turn rotated the individual spindles on the frame: rotation of these spindles drew out, twisted, and then wound on the yarn.

(3) **Other main feature:** a moving carriage that contained rovings of carded cotton (on bobbins):

- in moving the carriage further away from the rotating spindles, the spinner increased the tension and attenuated the yarn,

- thus spinning the yarn more and more finely onto the spindles, and so improving quality.

iii) **Hargreaves' Spinning Jenny was hand or foot powered:**

(1) it required no mechanical power;

(2) and, as a machine that was very simple and cheap to build as well, it fitted in perfectly within the traditional domestic or cottage system of production.

(3) Indeed, it strengthened and expanded the domestic or cottage system of production.

iv) **Obviously, with up to 100 spindles,** the Spinning Jenny vastly speeded up production, increased labour productivity.

v) **but it increased the supply of only half the yarn required for fustians or cottons:**

(1) namely, the cotton *weft* yarns.

(2) Since the yarn it produced was very fine and weak, suitable only for the weft, the jenny did nothing to

increase the supply of the *warp* yarns,

(3) which consequently still had to be made of flax (i.e., linen), certainly for good-quality strong fabrics.

(4) and spun with the existing technology, i.e., the Saxony wheel spinning one linen yarn at a time,

v) **Hence there was now a true imbalance in the production process requiring a complementary innovation:** a machine that could mass produce suitable warp yarns, cotton warp yarns this time.

d) **Richard Arkwright's Water Frame (1768-69):**

i) **Arkwright (1732 - 1792) was not the true inventor of this machine: but the key innovator**

(1) he had stolen the chief ideas from the true inventor, named John Highes,

(2) who in turn had borrowed the basic principle, water-powered rollers (throstles) from the Wyatt-Paul machine.

(3) Arkwright patented the machine in 1769, in fact just before Hargreaves patented his Spinning Jenny (though the jenny had preceded the water-frame).

ii) **The Arkwright Water-Frame:**

(1) thus involved water-powered rollers to spin the carded cotton fibres onto the spindles,

(2) producing very strong cotton yarns that could serve as the true warp yarns on the loom.

(3) This marks the true foundation of a genuine cotton industry, i.e., producing a fabric that was entirely cotton, in both warp and weft.

(4) The yarns so spun were of an evenness and consistency that would finally take the Turkey Reds: i.e., so that the dye was fast in the fibre.

(5) Nevertheless for high quality cotton fabrics the Spinning Jenny was still utilized exclusively for the weft, because its spun yarns were of much finer quality than the Water Frame's coarse yarns.

iii) **Arkwright was also the father of the factory system in cottons:**

(1) **1769:** he established a spinning factory in Nottingham, but this initial factory surprisingly was one using horse-power to run several frames.

(2) **1771:** he set up a water-powered factory at Cromford in Derbyshire, with a water-mill to run dozens of water-frames inside the factory.

iv) **Note: a comparison with the silk industry:**

(1) Much earlier, in 1720, a water-powered silk-factory had been established in England.

(2) But its founder, John Lombe, had simply copied the long-existing Italian silk-throwing factories, in Lucca and Bologna

- they date back to the 1280s, and virtually unchanged thereafter, over the centuries;
- silk-throwing was the method and the name for silk-spinning: i.e., the method of converting the raw

silk fibres, extracted from the silk-worm cocoons, into silk yarns.

(3) Nowhere did such water-powered silk-throwing factories lead to modern industrialization -- and silk remained a very minor industry in England.

(4) **Reason:** very limited markets and limited demand (limited to the wealthy upper classes).

v) **Arkwright's Carding Machine:**

(1) In 1775: Arkwright also devised a water-powered carding machine, to prepare the carded cotton rovings for spinning on the water-frame;

(2) these carding machines were integrated with water-frames in the factory.

e) **Samuel Crompton's Mule (1774-79):** the third innovation and final breakthrough

i) **Crompton (1753 - 1827) cleverly combined the essential features of the two prior spinning machines:**

(1) namely,

- Hargreave's the Spinning Jenny, with its one hundred or more spindles, worked all by one wheel, and the moving carriage to attenuate the fibres (producing very fine wefts)
- and Richard Arkwright's Water-Frame, with its water-powered rollers, to produce very strong warp yarns.

(2) The Mule thus permitted the simultaneous and very speed drafting or drawing out of the cotton fibres, while attenuating them (for fineness), twisting the fibres into yarn, and winding the spun yarn onto bobbins.

(3) the result was that the Mule produced yarns, for both warps and wefts, that were as strong as and as fine as the best produced in South Asian – as good as those in the best muslins

(4) Curiously enough, however (for reasons not fully explained), Crompton also first used horse-power before switching to water-power.

ii) **The original mule of 1779-80 (with horse power) had about 100 spindles**, as did the best Jennies;

iii) **by the end of the century**, the now water-powered mules with 300 spindles were common.¹¹

iv) **The cotton yarn so spun, with far greater twist than other methods,**

(1) was both strong and very fine in quality, to be stressed once more, with vigour

(2) thus finally making possible the manufacture of fully cotton textiles that rivalled the best Indian muslins in quality and price.

iv) **This provided the English cotton industry with the crucial breakthrough in foreign trade:** to compete successfully in foreign markets, and indeed quickly to dominate them.

v) **Numerical measure of fineness:**

¹¹ The optimum number was supposedly from 264 to 288 spindles.

(1) in terms of ‘counts’ (indicated by an ‘s’), which means the number of hanks, of 840 yards each, making up one pound weight.

(2) The higher the number, the finer the yarn, obviously.

(3) European hand-spinning, with spinning wheels, and the early jennies had counts of 20s;

(4) Crompton's mule began with a count of 80s and reached counts of 300s by 1800, though counts above 100 were really very rare.

(5) the bulk of commercial production in fact was for counts below 100, but certainly well above 20.

v) **Question of mechanical power:**

(1) to repeat the curious fact: Crompton's original mules were horse or even hand-powered, not water-powered;

(2) and they became water-powered, in factories, only from the 1790s.

(3) The shift from water-power to steam power only came in 1820s and 1830s.

(4) With steam power, mule-factories often had up to 3,000 spindles spinning: i.e., 10 or more mules with about 300 spindles each.

(5) with steam power, also, the industry shifted its location from rural settings, with water power, to towns and cities: chiefly in Lancashire, Midlands, and southern Scotland.

f) **Roberts' Automatic ‘Self-Actor’ Mules of 1825:** final stage of mechanization in spinning in Britain.

i) **Richard Roberts** (1789-1864):¹² provided a significant improvement to steam-powered mules, allowing them to start and stop automatically without damaging the yarn.

ii) **This meant a big leap forward in industrial scale**, with self-acting mules containing up to 1,600 spindles each.

iii) **It also provided a major factor in completing the shift from rural**, water-powered cotton mills to urban steam-powered mills.

g) **John Thorp's ‘Ring Spinning’ of 1830:**¹³

i) **This was an American modification of the self-acting mule**, too complex to describe here, providing much cheaper though lower quality spinning.

¹² In 1822, he also devised an improved power loom for weaving cottons: see below.

¹³ Answers.com: ‘John Thorp (born 1784, Rehoboth, Mass., U.S. — died Nov. 15, 1848, Providence, R.I.) U.S. inventor. He invented the ring spinning machine in 1828. By the 1860s it had largely replaced Samuel Crompton's spinning mule in the world's textile mills [except in Great Britain] because of its greater productivity and simplicity. The ring spinning machine is used in the textile industry to simultaneously twist staple fibres into yarn and then wind it onto a bobbin for storage. The yarn loop rotating rapidly about a fixed axis generates a surface referred to as a balloon.’

ii) **This device was widely adopted in American cotton mills,**

(1) but resolutely resisted in the British cotton industry during the 19th century,

(2) For this was an industry that stressed and specialized in high-quality spinning.

iii) **But in the 20th century,**

(1) the obstinate British finally had to bow to reality and adopt ring-spinning,

(2) though really much too little and too late to save their dying industry (ravaged by foreign competition and new products, such as rayon).

h) **Economic Results of the Technological Revolution:** on the screen

i) **dramatic increase in spinning productivity:**

Number of Hours to Produce 100 lb. Cotton Yarn

Indian Drop-Spindle Hand Spinners (18th century)	50,000+ hours
Crompton's original Mule (1779)	2,000
100-spindle Mule of 1798	1,000
Water-powered Mule of 1800	300
Robert's automatic steam Mule (1825)	135
Contemporary Machines (of 1972)	40

ii) **dramatic fall in price, from the evidence of Stanley Chapman:** of cotton yarn (100 hanks of 840 yards per lb.): from 38s 0d in 1786 to just 5s 2d in 1812, a fall of 86%, which is even greater in real terms, with considerable inflation between those two dates.

Prices in the English Cotton Industry

Spun Yarn Prices: 100s*			Woven Cotton Cloth Prices	
Year	Price	Index	Year	Index
1786	38s. 0d	100	1780	100
1812	5s. 2d	14	1815	32
			1860	13

* 100s or 100 count = 100 hanks of cotton, 840 yards per hank, making up one pound (1 lb.) of yarn by weight, as the measure of yarn fineness [12d to the shilling (s)]

Sources: Stanley Chapman, *The Cotton Industry in the Industrial Revolution* (London, 1972), p. 20; Roderick Floud and Donald McCloskey, eds., *Economic History of Britain*

Since 1700, Vol. I (Cambridge, 1981), p. 111.

iii) **On the screen as well are more recent estimates produced by both Knick Harley and Javier Cuenca Estaban:**¹⁴ about how much cotton prices fell during the Industrial Revolution.

- (1) both clearly show that cotton yarn prices fell sharply,
- (2) but Harley argues that they fell less than indicated by Cuenca Estaban's evidence.¹⁵
- (3) You can read all the evidence for this debate yourself, since I do not have time to discuss it here.

iv) **Harley's contributions:** to show that while mechanization certainly did cut costs dramatically:

- (1) prices for cotton warps fell more than did those for cotton wefts
- (2) the spinning revolution created a new product: very fine high count yarns
- (3) prices for these very fine spun yarns, of counts near 100s, fell much more so than the prices for lower count yarns.
- (4) that (as is also evident from Chapman's tables) the prices of yarns fell much more than did the prices of woven cotton products.
- (5) that much of the yarn was exported (about 20% - 30% of total output),
- (6) or used domestically by hosiery and lace-makers, rather than being woven into cotton cloths at home.

v) **Economic Significance of the Sharp Fall in Prices, to explain the nature of the Industrial Revolution**

- (1) The Industrial Revolution, everywhere, was essentially based on mass consumption
- (2) That is why, as I said earlier, the introduction of water-powered factories for spinning silk yarns (silk-throwing) did not lead to an industrial revolution
- (3) Here you can see that the impact of technological changes and then the factory system led to such very dramatic cost reductions and thus to falls in prices that it now allowed even the poorer, and broadly based strata of society to consume these products, en masse:
- (4) And thus, in essence, these technological innovations, converted the nature of the textile product and its

¹⁴ Knick Harley, former editor of the *Journal of Economic History* (until September 2005), formerly: at the University of Western Ontario, in London, and now at Oxford University; and Javier Cuenca Estaban, who received his Ph.D. from our department, teaching at the University of Waterloo, in Ontario, and, for part of the year, in Madrid.

¹⁵ J. Cuenca Estaban, 'British Textile Prices, 1770 - 1831: Are British Growth Rates Worth Revising Once Again?', *The Economic History Review*, 2nd ser., 47 (1994), 66-105: an attack on Harley and Crafts. For Harley's reply, see the citation in note 1. See also Javier Cuenca Estaban, 'Factory Costs, Market Prices, and Indian Calicos: Cotton Textile Prices Revisited, 1779 - 1831,' *The Economic History Review*, 2nd ser., 52:4 (November 1999), 749 -55.

market from one that had been for a quasi-luxury into a genuinely mass-consumption commodity: in this case, cotton yarns.

(i) Social Significance of Mechanization of Spinning:

i) **the steam-powered mules, especially the self-actors, quickly destroyed rural spinning**, whether spinning wheels or jennies, entirely operated by women.

ii) **but the water-frames (employing men, more commonly) were slower to die out**, since they were still used in making the cheaper calicoes.

iii) The Gender (Sex) Shift from factory mechanization:

(1) thus factory mechanization of spinning converted a largely female occupation into an exclusively male occupation;

(2) and male mule spinners were highly paid, at the apex of skilled industrial labour.

(3) Hence there were virtually no protests about the mechanization of spinning – since males had no cause for complaint, while female spinners were too defenceless to mount any protests.

iv) The initial period of mechanization in spinning:

(1) did nevertheless increase the demand for cotton weavers:

(2) and this did lead to a rise in weaver's piece-work wages, until the early 19th century.

6. The Mechanization of Weaving:

a) **John Kay's Flying Shuttle of 1733:** which we have already seen

i) **first attempt to improve weaving productivity**, occurring at very same time as first mechanical spinning machines (Wyatt and Paul).

ii) **Used first in the worsted and woollen industries**, and spread very slowly; not used in cotton weaving until much later.

b) **Mechanization of spinning was obviously the crucial factor:**

i) **ultimately, despite the above comments**, in creating a very large and growing imbalance in the production process;

ii) **thus traditional handloom weaving**, even when equipped with the Flying Shuttle, could not keep pace with the rapidly expanding yarn outputs, even if much was exported or used in other non-weaving textile industries (lace-making, hosiery and other forms of knitwares).

c) **Edmund Cartwright's Power Loom of 1785-87:** the first attempt

i) **Cartwright (1743-1823), was a clergyman** (Church of England – not a Dissenter), whose brother was a cotton manufacturer, who had complained about this new imbalance between spinning and weaving.

ii) **Cartwright responded to this challenge**, to prove that it was possible to resolve the problem: that everything in God's good world was possible.

(1) in 1785, he patented a water-powered mechanical weaving loom,

(2) and in 1787, he opened a factory with 20 water-powered looms.

iii) **But the factory failed and so did Cartwright:**

(1) the power loom was too clumsy and jerky,

(2) either breaking the warp yarns or producing poor cloth.

d) **Further Technical Improvements were necessary:** up to the 1840s

i) **Thomas Johnson's** power loom of 1803-05

ii) **Horrock's** improved looms of 1813-1821

iii) **Richard Roberts' automatic steam-powered loom** of 1822-30 (same inventor of the self-acting mule): he produced more than 4,000 looms a year by 1825

iv) **the 1820s:** therefore does mark the first spread of power looms in Great Britain.

v) **Kenworthy and Bullough:** improved self-acting power loom of 1842.

d) **The Very Slow Spread of the Power Loom:** from 1790s to 1840s was not just because of these technical problems.

i) **Supply of hand-loom weavers was very elastic:**

(1) an elastic and increasing supply of handloom weavers was well able to accommodate expansion of spinning

(2) number of handloom weavers had more than tripled: had risen from 75,000 in the 1790s to over 250,000 in the 1830s (when weaving was finally mechanized by steam power, in urban factories)

iii) **the role of Enclosures**

(1) Undoubtedly the spread of Enclosures and consequent peasant displacements produced an abundant (elastic) and cheap labour supply, in the form of male handloom weavers

(2) remember that textile manufacturing had long been a rural industry, allied with agriculture, and drawing most of its labour from the agrarian work-force

(3) Those displaced as tenants who did not want to migrate to towns or become agricultural labourers chose the much higher and better paying status of handloom weavers.

iv) **the question of relative labour and capital costs:**

(1) note, furthermore, that capital costs for weaving were much higher: that capital investments in power looms were far greater than in spinning mules.

(2) Consequently, so long as foreign markets and demand were unstable,

- it was generally cheaper to hire handloom weavers than to build power looms, if demand for cotton cloth suddenly rose.
- Otherwise, entrepreneurs risked having weaving factories, with large capital investments, lying idle during periods of trade slumps.

(3) But by the 1840s, Britain had captured the bulk of world markets in cotton textiles (at same time having successfully destroyed the Indian cotton industry),

(4) so that relatively stable markets and rising exports justified heavy fixed investments in weaving factories.

v) **Bitter opposition of male handloom weavers:**

(1) with very long tradition of being independent artisans working in their own homes

- they bitterly resented becoming wage-earning factory workers;
- and they bitterly resented both mechanization itself and factory discipline.

(2) in the 1790s, they burned at least one factory to the ground.

(3) **Question:** why was there not the same opposition to spinning factories?

(4) **Because**, as just noted, the new spinning factories replaced powerless female hand-spinners with well organized **male** mule spinners.

vi) **The fairly rapid shift from rural handloom weaving to urban steam-powered weaving factories in late 1830s and 1840s did produce certainly one of the major social tragedies of the Industrial Revolution:**

(1) rural handloom weavers were forced to accept sharply falling wages to compete with the new looms,

(2) and then they were totally displaced – only few of them went into into power-loom weaving.

7. The Mechanization of Raw Cotton Production: Eli Whitney's Cotton Gin

a) **Eli Whitney:** (1765 - 1825)

i) **a Connecticut Yankee who**, in 1792, devised a new machine for separating short-stapled cotton fibre from the boll or cotton seed,

ii) thus reducing the labour costs of cotton-picking to virtually nothing.

iii) his profits (rents) from this device help fund, if not found, Yale University, in its early days

b) **His machine marked real beginning of U.S. plantation economy in cotton:**

i) **Before his machine was developed, American cotton production had been negligible:**

(1) just some coastal or island cotton in Carolinas, called 'sea cotton,' with longer-stapled fibres that could be extracted by hand.

(2) But most of the southern soils were suitable only for short-stapled cotton whose labour costs in fibre-

separation had been prohibitive.

ii) **Cotton Gin** thus made possible a revolutionary expansion in American cotton production:

iii) **and it converted slavery (on verge of dying out, except on Virginia tobacco plantations) into a most profitable system:** Virginia, North and South Carolina, Georgia, Florida, Alabama, Mississippi, Arkansas (the states later forming the Confederacy).

c) **Economic Results:**

i) **Price of raw cotton produced in the American South:** fell by 75%.

ii) **American cotton exports expanded rapidly:** from just 500,000 lb. in 1793 to 120 million lb. [54,432,000 kg] by 1820, most of which went to the cotton mills of Lancashire and Scotland.

iii) **Thus,** the American south rapidly became the overwhelmingly dominant supplier for the British cotton industry.

8. The Economics of the Factory System of Production in Cottons

a) **potential economic gains from the factory system of production:**

i) **technological:**

(1) from the use of powered machinery, particularly with a central source of power (originally water-power, later steam)

(2) to drive many and different kinds of machines.

ii) **increasing returns to scale:**

(1) the economies of mass production from large-scale factories containing dozens of machines.

(2) But, as I shall stress in a moment, there were finite limits to such scale economies.

iii) **economies on transaction costs from industrial integration and concentration:** especially on transport, travelling, accounting expenses.

iv) **economies from factory discipline itself:**

(1) from the direct supervision and co-ordination of production (in so far as several stages of production were integrated under one roof).

(2) Obviously no such discipline could be imposed with the rural putting-out system, with unsupervised production and part-time work performed in cottages:

(3) the only discipline was the use of piece-work wages rather than time wages; and thus the non-payment for non-delivery of goods.

b) **economic gains by substituting capital for labour:**

i) **why were these technological changes really cost saving,**

(1) if capital had been expensive while labour, especially rural female spinning labour, had been so cheap?

(2) And when male mule spinners earned far higher wages?

ii) **Because the capital was not in fact so costly:** the early spinning machines, even the mules, cost only about £30 (ca. 1800).

iii) **And because labour productivity had been so dreadfully low:**

(1) as reflected in the equation: real wage = MRP_L – the marginal revenue product of labour;

(2) and thus the productivity gains from spinning in particular were so vastly greater than wage differences.

iv) **But also because rural putting out had meant a generally inelastic labour supply,** which was suitable only for fairly static demand.

(1) If demand then rapidly expanded, the weaver or clothier had to travel further and further afield to find new spinners;

(2) and he had to do so in competition with other weavers seeking to increase their output at the same time.

v) **Furthermore, and most importantly,** the new technology also improved the quality of the yarn, which I have argued was just as important a consideration as the costs and prices, if not more so.

c) **Integration and Industrial Scale in Cotton Manufacturing:**

i) **in contrast to the Industrial Revolution in iron-making,** the cotton-making revolution did not necessarily lead to fully integrated, large-scale factories: not same scale gains as in the iron industry, as the following table on the screen shows.

**Size and Distribution of Lancashire Cotton Firms:
in 1841 and 1856**

Category of Firm	Spinning Only	Weaving Only	Spinning & Weaving	TOTAL All Firms
A. In 1841				
No. of Firms	550	104	321	975
% of Total	56.4%	10.7%	32.9%	100.0%
Labour Force	66,835	9,522	112,031	188,388
% of Total	35.5%	5.1%	59.4%	100.0%

Horsepower	15,469	1,377	21,014	37,860
% of Total	40.9%	3.6%	55.5%	100.0%

B. In 1856

No. of Firms	591	344	516	1,451
% of Total	40.7%	23.7%	35.6%	100.0%

Source: V. A. Gatrell, 'Labour, Power, and the Size of Firms in Lancashire Cotton in the Second Quarter of the Nineteenth Century', *Economic History Review*, 2nd ser. 30 (1977), p. 98.

ii) **Comments:**

(1) As the table on the screen shows, only about a third of the cotton factories in mid-19th century combined spinning and weaving together

(2) though collectively they did account for 59% of employment in Lancashire and 56% of total mechanical power.

(3) Factories were not very large scale: of total of 975 cotton firms in Lancashire in 1841, only 9% (86) had more than 500 employees and over 100 HP.

(4) Instead middle-sized factories clearly predominated: those with 150 - 500 employees accounted for 75% of the total number of firms.

iii) **In fact, there were no impressive economies of scale, no increasing returns, to be achieved beyond such middle-sized factories:** no real gains from increasing the number looms and mules beyond a certain point.

iv) **Why was industrial integration so incomplete: thus limiting scale?**

(1) because mechanization of weaving came so long after mechanization of spinning: so that many established spinning factories reluctant to make drastic changes in structure to add on weaving (with which they were largely unfamiliar).

(2) From the mid 19th century, there was also an increasing trend to specialization in both high quality yarns and weaves:

(3) That involved a wide variety of yarn counts and weaves, with each firm specializing in a few lines.

(4) That necessarily resulted in having a larger number of small firms (since market for each type was limited).

(5) That a larger number of firms engaged only in spinning also reflects fact that much yarn was produced

for export, not for weaving domestically.

v) **Perfect Competition in the Cotton Industry:** The 19th-century cotton industry in Great Britain was one of the very few industries, perhaps the only important one, to approximate the conditions of perfect competition, namely:

(1) Production of identical or virtually homogenous commodities by many small-scale firms; and thus one firm's cotton yarn of, say a count of 40s, was no different from another firm's yarn with the same count.

(2) A market with auction-type sales: with so many such producers and so many buyers that no individuals or groups can influence the price (determined by in fact by weekly auctions).

(3) Thus an entrepreneur in the cotton industry – e.g., an owner of a spinning mill – was, as stressed earlier, **a price taker rather a price maker**

vi) **Contrasts with the British Iron Industry:** The iron industry, however, more closely approximated the more normal modern industrial organization:

(1) oligopolistic competition, with a virtually identical very large-scale producers, producing very similar or homogenous products, dominating the market (with either highly unstable prices, or prices fixed by collusion).

(2) In sum: the iron industry consisted of **price makers** (oligopolistic or monopolistic competition), while the cotton industry consisted of **price takers**.

9. Why Did Industrialization Begin in Cottons Rather Than in Woollens?

a) **Factors on the Demand Side:**

i) **market differences between woollens and cottons:**

(1) English woollens and worsteds had long ago captured their main markets, without the need for any technological changes, and benefited especially from growth of captive North American market.

(2) There was no significant foreign competition nor any potential growth in aggregate demand (by displacing that competition) to spur on technological and organizational changes.

(3) But as we've seen for cottons, on the contrary,

- that industry had no hope of even breaking into foreign markets to compete with either Indian or continental European cotton producers
- unless it could achieve a radical change in technology to improve quality and cut costs and prices.

ii) **capacity for market expansion was obviously much greater and more elastic for cottons than for woollens:**

(1) above all, because cottons became a far cheaper product aimed a far broader, truly mass market; while

market for quality woollens was narrow.

(2) cottons as a much lighter product were obviously much more suitable for the very area into which English commerce was rapidly expanding in the 18th century: in warmer, tropical zones.

(3) also as a lighter (and more washable) product, cottons offered a wider variety of textile uses: undergarments, bed-clothing, summer clothing.

iii) **Fashion revolution created by printed Indian muslins and calicoes:**

(1) and by the early 18th century the British had surpassed the Indians and continental Europeans in arts of textile printing

(2) and thus helped to shape and extend that fashion revolution.

b) **Factors on the Supply Side:**

i) **supply of cotton was also much more elastic and dependable than that of wool:**

(1) for cotton, at least from the time of Eli Whitney's cotton gin in 1790s until the 1850s.

(2) Obviously, in reaction to market changes, it was much easier to expand or contract the supply of raw cotton, as a plantation-grown vegetable crop, than it was to alter wool supplies;

(3) wool, as a animal product: sheep flocks could not be so easily increased or adjusted, thus providing for greater inelasticity of supply.

ii) **Cotton supplies were also much more regular than wool supplies:** (before the 1850s) by being imported in large bulk lots throughout the year, to permit and promote larger-scale continuous production.

(1) But wool, on the other hand, was grown locally in scattered English countryside, and was supplied only seasonally (with the May-June shearings, usually).

(2) Hence mechanization of woollen production would have meant leaving machinery lie idle for parts of the year.

(3) Only from the 1850s, when Britain began receiving large bulk wool imports year around from both hemispheres, from Saxony (north) and Australia (south), did Britain seriously begin to mechanize woollen and worsted production.

iii) **Technical Reason:** the nature of the fibres

(1) Cotton, though weaker than linen, was still more homogeneous and tougher than wools (especially for woollens), and was thus more suited than wool to the early textile machines, which were rather jerky, clumsy.

(2) Woollens, being a higher-quality product, could not afford to have their quality impaired by that early machinery.

(3) Paradoxical that, in the cotton-fustian industry, even the early spinning machines improved the yarn quality over hand-spinning.

(4) By the 1840s and 1850s, the quality of the machines, especially with self-acting mules and looms, had improved enough to be applied to worsteds and woollens -- first to worsteds, as the tougher, coarser fabrics.

TEXTILES IN EARLY-MODERN EUROPE

A. FUNCTIONS:

i) **basic needs – i.e., necessities:** i.e., basic clothing and footwear (cloth or leather)

(1) for protection against elements: the cold, the heat, rain, snow, sand storms)

(2) for physical protection against physical abrasions (to avoid cuts, scratches, other wounds)

(3) for protection against shame: i.e., personal modesty, in that nudity (partial or total) is and has been taboo in most societies)

ii) **more luxurious needs:**

(1) personal satisfaction in fashion, dress style, etc.:

(2) **Sumptuary Laws:** and the assertion of social and political status, rank, values.

(3) These fashion based considerations most important factor in international trade.

B. THE MAJOR TYPES OF TEXTILES IN THE EUROPEAN ECONOMY

(1) **THE WOOL-BASED TEXTILES (FROM SHEEP), IN THREE FORMATS:**

■ **woollens** (made from short-fibred wools): Old Draperies in England

■ **worsted**s (made from longer-fibred wools):

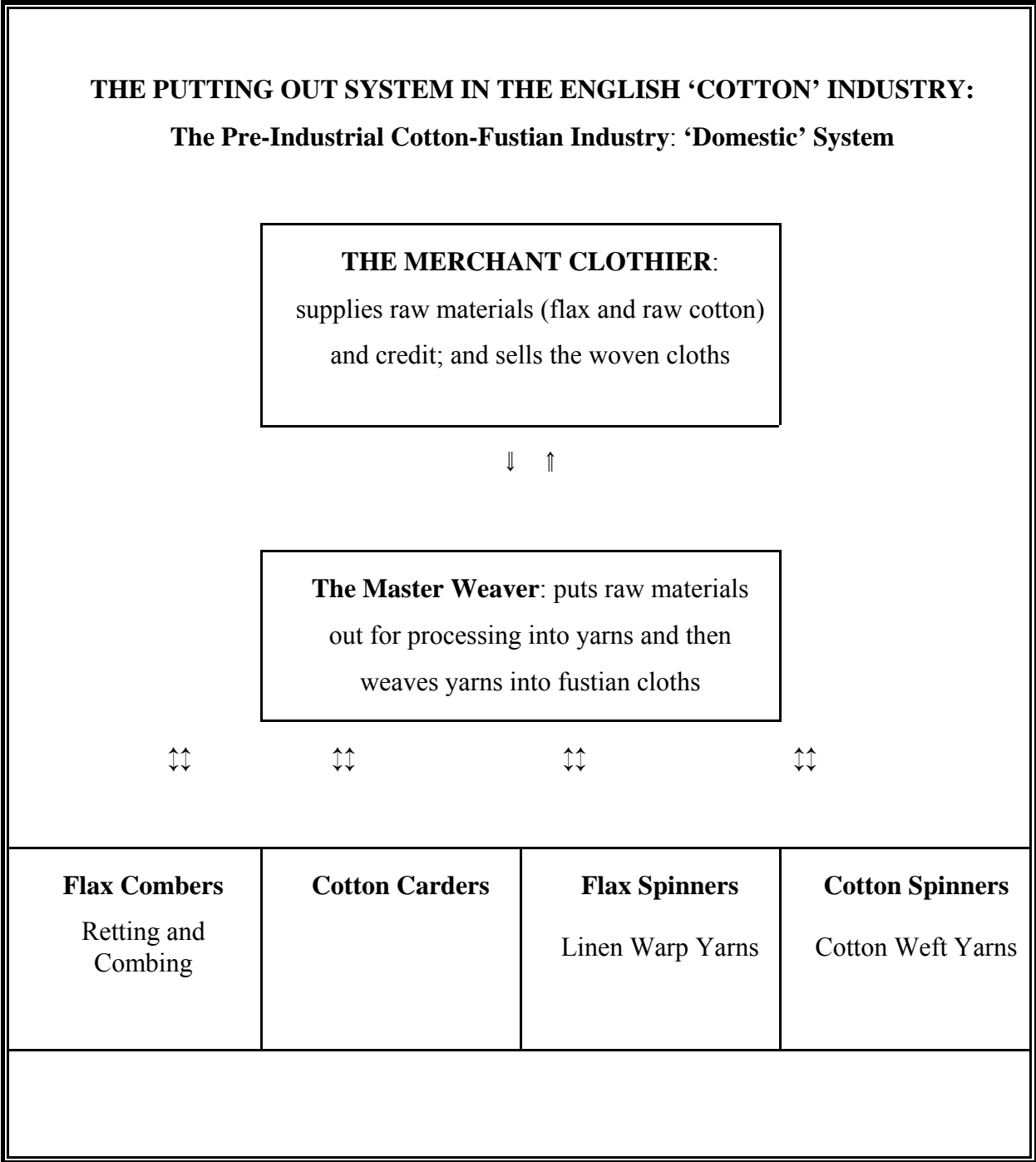
■ **'stuffs'**: mixed woollen-worsted fabrics: New Draperies in England

(2) **SILKS:** fibres from silkworms feeding on mulberry trees

(3) **LINENS:** made from flax fibres: from coarse and cheap to very fine and luxurious

(4) **FUSTIANS:** with a linen warp (foundation yarn on the loom) and a cotton weft

(5) **COTTONS:** Most important Asian manufacturing industry, and very major export; and genuine cottons were not made in Europe until the Industrial Revolution:



Ratio of Workers: about 10 each of combers and carders, warp and weft spinners, per master-weaver, who hired at least one weaving assistant.

Table 1. Exports of Indian Calicoes and Muslins by the Dutch and English East India Companies, 1753 - 55, in pieces and rupees

Years	DUTCH EXPORTS		ENGLISH EXPORTS	
	No. of pieces	Value in Rupees	No. of pieces	Value in Rupees
1753-54	279,800	1,670,336	345,267	2,287,128
1754-55	226,432	1,328,188	381,543	2,660,520
Annual Mean	253,166	1,499,278	363,405	2,473,824

1 Indian rupee = 1.5 Dutch florins (guilders) = 2s 6d sterling (i.e., £1 = 8 rupees)

Source: Sushil Chaudhury, *From Prosperity to Decline: Eighteenth Century Bengal* (New Delhi: Manohar, 1995), Table 7.12, p. 209.

Table 2: Percentage Shares of Different Categories of Indian Textiles Exported by the Dutch and English East India Companies, 1730 - 60

Textile Type	Dutch Textile Exports from India			English Textile Exports from India		
	1730s	1740s	1750s	1730s	1740s	1750s
Calicoes: Ordinary	46.40%	39.85%	55.69%	46.02%	30.60%	30.80%
Calicoes: Fine	14.99%	19.89%	12.66%	20.30%	22.49%	19.17%
Muslins	20.23%	26.22%	17.79%	24.44%	34.08%	39.26%
Silk Piece Goods	10.44%	10.08%	11.19%	3.18%	4.56%	6.36%
Mixed Piece Goods	7.94%	3.96%	2.67%	5.98%	7.88%	3.72%
Miscellaneous				0.08%	0.39%	0.69%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: Sushil Chaudhury, *From Prosperity to Decline: Eighteenth Century Bengal* (New Delhi: Manohar, 1995), Table 7.7, p. 192.

Table 3.

**Exports of Cotton and Woollen Manufactures (Yarns and Fabrics)
in millions of pound sterling and as percentages of total domestic exports
in quinquennial means, 1796-1800 to 1911-15**

Year	Domestic Exports	Total Exports	Cotton Manufactures Yarns & Fabrics	Cottons as % of Domestic Exports	Woollens & Worsteds Yarns & Fabrics	Woollens as % of Domestic Exports
1796-1800	32.9	43.5	4.2	12.4%	7.4	22.7%
1801-05	39.9	51.1	8.0	20.3%	7.1	17.8%
1806-10	42.2	52.4	14.5	33.9%	5.9	14.1%
1811-15	42.9	45.8	17.5	40.4%	6.3	14.4%
1816-20	40.3	51.4	16.3	40.6%	6.9	17.2%
1821-25	37.3	45.3	17.3	46.3%	6.2	16.5%
1826-30	35.9	42.5	17.2	47.7%	5.0	14.0%
1831-35	40.5	48.1	19.2	47.3%	6.1	15.1%
1836-40	50.0	59.6	23.7	47.5%	6.3	12.6%
1841-45	54.0	62.7	24.1	44.7%	7.5	13.8%
1846-50	60.9	71.6	25.7	42.4%	8	13.1%
1851-55	88.9	105.2	31.8	36.2%	10.6	12.1%
1856-60	124.2	149.1	44.1	35.4%	13.8	11.1%
1861-65	144.4	190.8	48.7	33.7%	20.1	13.8%
1866-70	187.8	234.7	70.3	37.5%	26.6	14.2%
1871-75	239.5	297.7	75.3	31.5%	31.5	13.2%
1876-80	201.4	258.0	68.5	34.0%	21.0	10.4%

Year	Domestic Exports	Total Exports	Cotton Manufactures Yarns & Fabrics	Cottons as % of Domestic Exports	Woollens & Worsteds Yarns & Fabrics	Woollens as % of Domestic Exports
1881-85	232.3	295.3	74.4	32.0%	22.5	9.7%
1886-90	236.3	298.5	71.4	30.3%	24.6	10.5%
1891-95	227.0	287.5	66.3	29.2%	21.8	9.6%
1896-1900	252.7	313.7	67.1	26.7%	20.6	8.2%
1901-05	296.9	367.2	79.1	26.6%	20.5	6.9%
1906-10	397.5	487.8	100.9	25.4%	27	6.8%
1911-15	456.4	560.2	111.7	24.4%	30.5	6.7%

Source: B.R. Mitchell and Phyllis Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), pp. 281-84, 295-305.

Table 4. The English Cotton Industry during the Industrial Revolution

Number of Hours to Convert 100 lb. of Cotton into Spun Yarn

Indian Hand Spinners (18th century)	50,000+ hours
Crompton's original Mule (1779)	2,000
100-spindle Mule of 1798	1,000
Water-powered Mule of 1800	300
Robert's automatic steam Mule (1825)	135
Contemporary Machines (of 1972)	40

* 100s or 100 count = 100 hanks of cotton, 840 yards per hank, making up one pound (1 lb.) of yarn by weight, as the measure of yarn fineness.

Source: Sidney Chapman, *The Cotton Industry in the Industrial Revolution* (London, 1972), p. 20;

Table 5. Prices in the English Cotton Industry, according to Chapman

Spun Yarn Prices: 100s*			Woven Cotton Cloth Prices	
Year	Price	Index	Year	Index
1786	38s. 0d	100	1780	100
1812	5s. 2d	14	1815	32
			1860	13

Sources: Sidney Chapman, *The Cotton Industry in the Industrial Revolution* (London, 1972), p. 20; Roderick Floud and Donald McCloskey, *Economic History of Britain Since 1700*, Vol. I (Cambridge, 1981), p. 111.

Table 6: Size and Distribution of Lancashire Cotton Firms: in 1841 and 1856

	Category of firms by functions			
	Spinning Only	Weaving Only	Spinning & Weaving	TOTAL Firms
A. In 1841				
No. of Firms	550	104	321	975
% of Total	56.4%	10.7%	32.9%	100.0%
Labour Force	66,835	9,522	112,031	188,388
% of Total	35.5%	5.1%	59.4%	100.0%
Horsepower	15,469	1,377	21,014	37,860
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B. In 1856				
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Source:

V. A. Gattrell, 'Labour, Power, and the Size of Firms in Lancashire Cotton in the Second Quarter of the Nineteenth Century,' *Economic History Review*, 2nd ser., 30:1 (February 1977), 98.

THE WOOL-BASED TEXTILE INDUSTRIES IN ENGLAND

Features	THE OLD DRAPERIES: WOOLLENS	THE NEW DRAPERIES: WORSTEDS AND STUFFS
Wools for Warps and Wefts	Short-stapled, very fine, curly, scaly, soft wools: very costly. Originally English: Shropshire, Herefordshire, Cotswolds, Lincolnshire.; later, with Spanish merino wools	Long-stapled, straight-fibred, coarse wools: relatively cheap; but in some hybrid or mixed fabrics, short-stapled wools were used for the weft. Some interwoven with goat's hair, silk, etc.
Wool preparation	After initial scouring, wools were oiled or greased (olive oil, butter)	Wools were left dry, ungreased, after scouring; but if short-stapled wools were used for the weft, they were oiled
Yarn preparation	wools were carded, warp and weft (though combed in medieval era)	wools were combed, at least for the warp; if short-stapled wools used for the weft, they were also carded
Spinning	carded wools were spun on the spinning wheel; in medieval era, combed warps were spun on the distaff or 'rock'; Saxony wheel with flyer in use by 16th century	combed wools originally spun with the distaff; but by the 16th century, the Saxony wheel was used for both warp and weft
Weaving	warp and weft yarns were woven on a broadloom with two weavers	yarns were more commonly woven on a single-weaver narrow loom
Fulling	When woven, the broadcloths were intensively fulled [usually at a water-powered fulling mill] to degrease the cloth, to felt and shrink the cloth by about half	Pure worsteds were not fulled (i.e., with dry worsted yarns for warp and weft); but hybrid fabrics with greased carded wefts were partially fulled, if only to degrease the cloth
Finishing	Fulled woollens were stretched on a tentering frame and subjected to preliminary napping; when dried renapped and shorn several times with large shears; and then dyed with costly dyes	No napping or shearing; woven cloths were subjected to simple bleaching and/or dyeing; and then calendared (pressed with steam irons); inexpensive dyes
Names	West Country, Suffolk, Essex broadcloths; later: Spanish medleys with Spanish merino wools	Worsteds, says, bays, serges, stuffs, bombazines, perpetuanas, honscots, ostades, etc. Mixed 'stuffs' with combed worsted warps and carded woollen wefts

warps: the foundation yarns stretched between the warp and cloth-beam rollers on the loom

wefts: the yarn, carried by a wooden shuttle, that is inserted between (above and below) groups of warps to effect the weaving.