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Industrial Organisation

Transition from Pre-Industrial to Industrial Forms

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Introduction

Current perspectives on the Industrial Revolution emphasise continuity rather than discontinuity; new estimates of the growth of industrial output and gross domestic product exhibit only gradual and intermittent increases between 1700 and 1830. To some degree these findings on the Industrial Revolution overall rely on new assessments of the the industrial sector. In contrast to a long tradition of literature focussed on rapid changes in technology and work organisation - machinery, steam power and the factory system - the new perspectives point out the low productivity gains and traditionalism of most industries, apart from cotton and iron, between the eighteenth and early nineteenth centuries. N.F.R. Crafts has argued that one small and atypical sector, cotton, possibly accounted for half of all productivity gains in manufacturing: it was a modern sector floating in a sea of tradition. He draws the conclusion that

'...not only was the triumph of ingenuity slow to come to fruition, but it does not seem appropriate to regard innovativeness as pervasive.' (Crafts 1985: 87)

Industrial performance during the first industrial revolution now seems unremarkable, and was characterised at the time by huge differences among industries, and an overall outcome of only gradual growth in output. But our understanding of why this was the case is, as yet, based only on aggregate estimates

of value added for groups of industries. There has been little investigation recently into the factors which lie behind these estimates, and the extent to which they provide an adequate indicator of the nature of change taking place in the industrial sector. Two such factors are technical change and industrial organisation. The success or failure of the fundamental components of innovation to yield results within the accepted conventional period of the Industrial Revolution must be a subject for investigation rather than assumption.

The purpose of this chapter is to chart and to analyse the development of industrial organisation over the period. It will take industrial organisation beyond the well-known history of the transition to the factory system. After outlining the many different forms of organisational innovation in the period, the chapter will raise questions about currently accepted indicators of Britain's industrial performance during the Industrial Revolution.

Economic historians have certainly not been unaware of the significance of industrial organisation for the performance of individual industries. Recent examples include Lazonick and Von Tunzelman. (Lazonick, 1986; Von Tunzelman, 1978, chap. 7). Among the leading interpreters of the industrial revolution as a whole, both J.H. Clapham and David Landes put it at the forefront of their their explanations. (Clapham 1926: chaps 5 and 6; Landes 1969) But even they did not attempt to systematically disentangle the components of organisation, the constraints on these and the efficiency gains which were meant to affect productivity growth. For the most part, recent economic

historians have been less inclined to seek out wider patterns of organisation and to generalise on their effects. Industrial organisation is not amenable to quantitative measurement, and consequently it has fallen between the concerns of business historians, historians of technology and social historians.

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II. The Components of Industrial Organisation and Economic Analysis

The first question we must answer is what precisely we mean by industrial organisation in an economy which has not yet industrialised. There is a tacit assumption among economists that discussions of industrial organisation only apply to the contemporary economy with its high levels of commercial and market development. But such issues apply just as significantly to the British pre-industrial and early industrial economy. Market relationships in this economy were widely developed, though frequently on a more regional than national basis.

Recent research in microeconomics and industrial economics has sought to gauge the effect of a number of aspects of industrial organisation upon output, efficiency and profitability. These include access to markets and degree of market power within an industry, the institutional framework of an industry - free market, contractual arrangements and the components of transactions costs. Combining empirical research with theory, economists have also explored business structures, in an attempt to reach a definition of the firm. The questions to be asked concern the prevalence of family or large-scale

firms, proprietorial or managerial capitalism, and whether an industry is structured around goals of mass production or of flexible specialisation? Other research enquires into what styles of work organisation and hierarchy prevail in firms - workshop production, putting out arrangements or factories?

Recent theory has investigated the scale of the firm and the impact of scale upon profitability. It has also analyzed the evolution and behaviour of firms as organisations. Some recent research has attempted to connect industrial structures to their institutional environment.

Research on the size of the firm and profitability follows the tradition of the 'Chandler thesis' of the drive to large scale organisation, what he calls 'the logic of managerial enterprise'. Large scale along with high volume production, the so-called 'American system of manufactures' were combined with carefully defined managerial hierarchies. The results were economies of scale, but also of scope in keeping to core production technologies; both led to process and product innovation. The advantages went to those who made the first-mover investments to create a managerial enterprise. They gained competitive advantage even across nations, and took the laurels of the second industrial revolution. (Chandler, 1990)

Do the lessons of the 'logic of managerial enterprise' also apply to the first industrial revolution? The Chandler thesis of the drive of competitive pressures to large scale production lies behind many of the associations once supposed to have existed

the growth of productivity and the increasing capacity of mines, blast furnaces, mules and looms. But scale and scope also apply to the structures of enterprises.

Crouzet has argued that the industrialist proper only emerged at the end of the eighteenth century with the specialisation of investment to core production activities. The earlier versatility of businessmen and women and their absence of specialisation in investment were, in his view, archaic traits. Examples were the merchant-manufacturers with interests in many investments and in widespread activities.

Thomas Griggs, the mid-eighteenth century Essex clothier also kept up activities in the grocery trades, real estate, cattle fattening, malting and pawnbroking. John Glassford the Glasgow tobacco lord built up an enterprise which also included brewing, tanning, bleaching, dye and vitriol-making, textile printing and hosiery (Crouzet 1985: 7) Very large scale vertically integrated multi-plant enterprises such as the cotton mills owned by the Peels and the Arkwrights and the ironworks owned by the Darbys and James Foster are described as more frequent in the early Industrial Revolution than later. By contrast, the cotton spinners who ran a single unit with one proprietor or two or three partners became the 'industrialists par excellence' of the Industrial Revolution. (Crouzet 1985: 17) But equally important to those enterprises which expanded in scale but simplified their scope were those like the classic textile merchant-manufacturers who controlled not only spinning mills but hundreds and thousands of dispersed handloom weavers. The historical route to 'scale

and scope' in fact had many branches, and the 'Chandler thesis' can provide no exclusive model of the development of eighteenth and nineteenth-century industry.

Together with the rise of the large scale firm, economists have placed the drive to the increasing concentration of market power in fewer and fewer firms as the principal parameters of modern industrial organisation. Adam Smith saw the restriction of the market as a behavioral characteristic of the capitalist class; Marx and Engels saw increasing concentration and monopoly power as the inevitable outcome of the capitalist drive to increase profitability.

Industrial economists have seen the drive to increasing market shares as an outcome of the increasing scale of production. But industrial organisation during the eighteenth and early nineteenth centuries did not follow these trends. Indeed for many industries technological and organisational transformation brought about the disintegration of former monopolistic and oligopolistic structures. And for this period at least, while there were considerable pressures on small producers in many industries, market opportunity was such that there were few instances for more than the very short term of the other extreme of industrial concentration and monopoly power.

The hold of the Blackwell Hall factors on the woollen industry was broken in the course of the eighteenth century both through the new competition from Yorkshire, and through their own actions in extending credit to new entrants to the industry. The woollen companies in many towns lost their powers to enforce rules on entry and production standards. The small

clothiers lost their former niche, but the large established producers now had to contend with new undercapitalised 'inferior' clothiers. (Mann 1971: 98)

Mining, by the nature of geological factors leant itself to concentration in the hands of a few landowners, but ownership did not necessarily or even commonly go with proprietorship, for many mines were leased. In the earlier eighteenth century, and in the case of the Forest of Dean right up to the end of the century, mining technology and the scale of working allowed the proprietorship of working miners who leased smaller collieries. These were succeeded by large scale enterprises built on partnerships of merchants, bankers, landowners and other industrialists. But the best known instance of monopoly power in the industry belonged to the early not the later eighteenth century. This was the 'Grand Allies', a partnership of coal owners in the Northeast formed over the period 1710 to 1726 for joint stock mining and for restricting output and raising prices. Only the geographical shift of mining on Tyneside in the third quarter of the century broke its power. (Flinn 1984: 38-42).

The iron industry provides yet another well-known instance of monopoly power in the eighteenth century. The Ironmasters' Associations go back to the mid seventeenth century, and at the local level fixed selling prices and prices of raw materials and labour. But the scenario by the later eighteenth and early nineteenth centuries was one of failure of co-operation and fierce regional competition. The depression in the industry in the early nineteenth century was associated with competition and excess production. (Birch 1967: 106-13; Hyde, 1977).

For this period industries did not fit into any 'logic of managerial enterprise' which associated scale, scope and market power. We may thus go on to ask what did dictate the behaviour of firms and its outcome in terms of industrial performance. Recently economists have looked at businesses as organisations subject to evolutionary and genetic processes. Economic agents are assumed to behave according to routine rules - these rules evolve through a 'search' process similar to mutation in biological evolutionary theory. The results could be similar to Chandler's in the drive to the large scale firm and greater industrial concentration. (Nelson and Winter 1982: 9, 17, 349).

Such models can also be broadened out to explain a variety of organisational structures, including current trends to 'quasi-disintegration'. Within a framework of evolution, market forces select those firms which by choice of their organisational structure, minimise their costs. This includes capacity to adapt to exogenous uncertainty in a flexible and innovative way. The organisation is a vehicle of its genes, and thus subject to efficient selective sorting through market mechanisms. More recent research in biology has emphasised the positive effects of the genetic polymorphisms of populations; similarly survival against uncertain market forces may be better achieved with a plurality of organisational structures within an industry. (Jacquemin, 1987, pp. 150, 183, 199).

If models which accommodate the polymorphic aspects of organisation seem much more suited to today's production methods, then they may also be more suited to the analysis of past

production methods. Learning from the computer revolution and Japanese manufacturing methods has brought alternatives to models based on mass production: batch production, flexible specialisation, just-in-time technologies and network capitalism have integrated small scale production and large scale enterprise. These alternatives are not just new organisational inventions; they have a past in the histories their specific industries. (Kenney and Florida 1988: 133-8)

The 'genetic' characteristics of industrial organisations are similar to the organisational paradigms of firms. Technology and organisational structures develop along certain trajectories. The past history of an industry affects the parameters of these trajectories, and the breakthrough into altogether new paradigms. There is an extent to which 'how to do things' and 'how to improve them' are embodied in 'organisational routines' which through repetition and incremental improvement make some firms good at exploring certain technical, market or managerial opportunities. There are organisational indivisibilities attached to these routines. (Dosi, 1988, pp. 1131, 1131) The paradigm thesis applied to technology argues that opportunities are paradigm bound, and there is a gradual exhaustion of technological opportunities along particular trajectories. New paradigms emerge bringing new opportunities for product development and productivity increase. (Dosi, 1988, p. 1138)

The paradigm thesis has incorporated tradeoffs between large scale and small scale production, that is between economies of scale and flexibility. Thus if different firms take up different positions on the tradeoff between flexibility and scale

economies, there should be a distribution of varying plant sizes even when the propensity to innovate is neutral with respect to size. (Dosi, p. 1155)

Finally, the paradigm approach defines industrial performance and structures as endogenous to the process of innovation, imitation and competition. Technological and behavioral variety among firms is both the outcome and a driving force of technological and organisational change. Interfirm differences in learning result from their own histories, internal organisation and institutional context. But these differences in turn become the driving force of change, creating competitive incentives or threats to innovate. (Dosi, p. 1158).

Recent approaches to explaining industrial structures: the 'logic of managerial enterprise', evolutionary models, and technological and organisational paradigms all rely on a driving factor, which is on the whole treated as a catalyst - the market. But these models are subject to many limitations in explanatory value if we are to consider their application to explaining new production systems during the Industrial Revolution. Most assume some pre-industrial past based on the artisan, family and guild, and existing from time immemorial. The purpose of the theories is to explain the transition to higher, more efficient forms of industrial organisation associated with the freeing of the market, the rise of large scale production and the development of vertical and horizontal integration. All of these are assumed to be associated with the rise of the factory system.

There is an underlying teleology to most of this research.

It has focussed on the inevitable road to market power, large scale production and hierarchies, only recently attempting to incorporate the now fashionable 'flexible specialisation'. Most economic models have thus far failed to locate changing industrial structures within the historical, social and institutional structures which define the framework of social connection constituting an industrial organisation. Such structures exist both at the level of the industry and at the level of the region in which it operates. Institutional rigidities, and not just market, managerial or technological failures account for industrial demise or loss of 'competitive advantage'. (Hodgson, 1988, p. 268) This institutional environment, social division and historical structures will be explored through the rest of this paper to explain industrial organisation during the industrial revolution.

Thus we must now turn to the range of organisational structures which existed in the pre-industrial and early industrial period, and their social and regional backgrounds.

Organisational structures in the early industrial period

Clapham's view was that Britain abounded in ancient and transitional types of industrial organisation before 1830. But beside this we must put a considerable number of large scale capitalist structures which dominated the public imagination of the day. Putting out systems coexisted with artisan and cooperative forms of production, and many of these systems frequently interacted with some type of large scale centralised production or proto-factory. One region like the Kentish Weald

in the sixteenth and seventeenth centuries had a rural textile industry organised on a putting out system employing peasant labour, but it also had an important iron industry organised in centralised units around water-powered blast furnaces.

Even within a single industry, diverse forms of organisation prevailed at different stages of production. In eighteenth-century West Yorkshire, small artisan clothiers built and used their own cooperative mills for some of their preparatory processes. In eighteenth-century Lancashire, the Peels centralised their calico printing and spinning establishments, but ran extensive putting-out networks among weavers. In eighteenth-century Birmingham small artisans in the hardware trades gathered together to build a centralised processing unit which supplied their brass and copper, and they 'put out' the production of parts and pieces in much the same way as did the nineteenth-century watchmakers of Coventry who relied on the outworkers of Warrington and Prescott. While putting-out prevailed in much of the Scottish linen industry, in Dundee the spinners dealt directly with the manufacturer. While the woollen industry of the West Country and the worsted industry of West Yorkshire were model examples of putting-out, the woollen industry of the West Riding was the seat of independent artisan production. The survival of the small independent clothiers was ensured well into the nineteenth century, when in the face of the advantages of machinery and concentration in some processes, these clothiers formed cooperative or company units (Clapham, Hudson). When large scale factories were forming in Lancashire, Faucher wrote of Birmingham in 1830 'whilst capitals tend to

concentrate in Great Britain, they divide more and more in Birmingham.' (Berg, p. 86)

Recent debates on proto-industrialisation started from the assumption of gains in profitability in this pre-factory industry derived from the regional specialisation and division of labour in the organisational innovation of the putting-out system. But subsequent research demonstrated the co-existence and dynamism of both artisan-based and putting out systems. Putting out systems dominated by large scale merchants might meet their match in the small scale artisan. Artisan-organised production was the dynamic industrial structure of the urban villages, suburbs and unincorporated towns of eighteenth-century Britain in areas such as Birmingham and the London suburbs.

In addition to putting out systems, artisan and cooperative manufacturing systems, there were those forms of industrial production which were centralised from the outset, as in mining and metal processing, and in the protofactories which existed in the silk industry, in calico printing, in pinmaking and in some of the factory colonies of the West Country woollen industry. But even among such centralised works, there were enormous differences of scale. In 1719 London had 123 calico printers, but of these only three had a large labour force, and large here meant 205, 121 and 49 employees respectively. (Crouzet 1985: 30)

One industry, metalworking, could contain classic large scale capitalist works such as Crowley's ironworks at Winlaton, and at the same time the extensive division of labour found in a putting out framework as in Peter Stubs' Warrington filemaking business. There was the Bristol wireworks producing pins in a

proto-factory, or indeed Matthew Boulton's newly designed Soho works side by side with dispersed and impoverished nailmakers exploited in a highly developed putting-out system. Furthermore, the existence of centralised plant and processes did not prevent seasonal or even family divisions of labour between industry and agriculture in the time honoured manner of the textile putting-out industries.

What is striking is the pluralism of manufacturing structures in the pre-industrial and early industrial period. It is furthermore difficult to confine any one of these structures to a single formula, for no structure was static. They adapted to changing market conditions but also to institutional and social change with more or less success within their own individual industries and regions. The conditions for the emergence of specific industrial structures and the factors affecting how they changed lie not just in market forces and competitive pressures, for these cannot be presupposed. They lie fundamentally in institutions and social structures within industries and communities.

As we shall see, even with the Industrial Revolution, there was no linear development of organisational structures from small scale to large scale, proprietorial to managerial, or dispersed to centralised systems. The social values of domestic workers and artisans themselves are as significant to these issues as the social framework of the entrepreneurial class. The strength of artisan values reverberated in many industries and communities in the resistance to factories and to mechanisation, ultimately determining the location of much factory-based

industry.

Explaining organisational choices

The story of the industrial revolution is frequently told in terms of the lead provided by the textiles industries, and especially of cotton. This is just as often set out as a series of transitions from artisan workshops to the putting-out system and from thence to the modern factory system. Likewise in centralised industries such as mining and ironworking huge increases in scale and capitalisation are set alongside mechanisation. But in fact, features of all these types of work organisation and various permutations on them existed within and between the various textiles and metallurgical industries from before the eighteenth century. Let us turn first, then to textiles.

The growth and transformation of the cotton industry was to be sure a unique one. But the other major textile industries - wool and worsted, stocking knitting, silk and linen also grew, took on new forms of industrial and work organisation and developed new technologies. They were not unchanging 'traditional' industries. Why did such a variety of industrial organisation prevail across the textile industries?

Fig. 1: The Growth of the Textile Industries 1730-1815

Experiences across the textile industries reveal some patterns. There did seem sometimes to be a correlation between capitalist control, especially in the form of concentration or high degrees of market power and the use of putting out systems. Conversely independent proprietorship and competitive structures

coincided with artisan structures. But the great counter-example to this dualism was the cotton industry itself where the putting-out system developed in an industry with low levels of concentration.

Why different systems existed long before the industrial revolution can be explained only in part by the effects of costs of production and markets; social structures and institutions were even more fundamental. The woollen and worsted industries are good examples. Both industries developed contrasting structures in different regions - small independent clothiers dominated the Yorkshire woollen industry, but highly concentrated ownership, putting-out systems and proto-factories prevailed in the West Country. There were independent craftsmen in the the Norfolk worsted industry, but large scale merchant manufacturers with putting out systems in Yorkshire worsteds. (Hudson, 1981; Wilson, 1973; Chapman, 1973)

Fig. 2 - Organisational Structure of the West of England and Yorkshire Woollen Industries in 1757

The subsequent decline of the worsted industry of Norfolk and the woollen industry of the West Country cannot be put down to the superiority of any single system of industrial organisation in Yorkshire. The extent of industrial concentration or competitive structures in each industry and region can to a large extent, however, be explained by local landholding structures which could create wide social divisions within a community or not, and by the heritage of guild or corporate structures which restricted entry to an industry or prevented aggrandisement. (Berg, 1985, chap.9)

These factors also affected the appearance of centralised units, or mills and factories in both wool and worsted. Mills existed from early times in the case of water-powered fulling mills, and were later developed for some other processes. But they were used for specific processes and were incorporated into existing artisan and putting-out structures. (Hudson, 1987)

The framework knitting industry started out as a trade of independent yeoman farmers in Midland villages of middling wealth and relatively egalitarian social structures. But there were rapid changes in the market in the eighteenth century with the introduction of silk and cotton mix stockings. This, combined with the breakdown of landholding patterns in Nottingham into a much more divided rural society of landless squatters and large scale landowners, accounts for the emergence of a new system marked by a sharp division between producers. There were large scale hosiers with high entry thresholds operating vast putting out systems and centralised units, and the knitters themselves who were largely degraded outworkers. (Rogers, 1981; Levine 1987). Capitalist concentration and a large, flexible and weakened labour force created ideal conditions for the proliferation of a mercantile putting out system.

Silk, the country's primary luxury industry during the seventeenth and eighteenth centuries contained both the best examples of the first factories- highly capitalist enterprises employing child labour - and one of the country's most highly skilled and traditionally organised artisan groups. These two systems confronted each other across the throwing and weaving branches of the industry. Factories, which were started in the

throwing section of the industry in the first quarter of the eighteenth century, did not extent to weaving for another hundred years. The divide was furthermore one between province and metropolis, country and town. The strength of guild structures, the Spitalfield Acts and corporate structures as in Coventry reinforced the strength of the urban weavers, as against the suburban or rural outworkers who produced lower qualities or different goods and used different technologies.

The cotton and linen industries developed both putting-out structures and artisan industry, and soon the most widespread and rapid transition to factory production. It was cotton above all which seemed to present the unity between new industrial organisation and industrialisation in its road to the factory system. But this new organisation did not coincide with or require industrial concentration. A putting-out organisation existed from the earliest days in the form of middlemen, factors, chapmen or dealers, and in some cases merchants in linen, then fustians and cottons. But there was no market control by a small group; the small yeoman capitalist was the backbone of the system.

Pre-existing mercantile networks in linen and calico printing played the vital role in introducing cotton as a new product. Capitalist structures came with the new product, but the market opportunities created by a new product and the relatively open social structures of the cotton region encouraged dispersed ownership and the rise of the small and medium scale factory as well as the well known industrial giants. In 1780 Britain had no more than 15 or 20 cotton mills, but seven years later there

were 145 Arkwright type mills. Before the end of the eighteenth century there were 900 cotton spinning factories. These ranged, however, from 300 Arkwright type factories - purpose built buildings of several stories employing over fifty workers - through 600 'factories' using jennies and mules, some of which were little more than sheds or workshops employing some dozens of workers.

(Crouzet 1985: 32)

Fig. 32 Capital Investment in the Cotton Industry, 1788

The social and institutional conditions giving rise to this plurality of capitalist structures across the textile industry produced a long heritage. Most of the early industrial structures so far described were not left behind with industrialisation, but intensified. Factories indeed became more widespread, but until the 1830s at least, they were to be found mainly in industries where they already existed. It was still the case that decentralised, workshop, artisan and putting out systems were successful and profitable, and indeed compatible with a substantial degree of technological change. And as such they continued to develop over the eighteenth and nineteenth centuries.

There was no single route to the factory system across the textile industries, and the end result for each of them was a distinctive one. The woollen and worsted industries in Yorkshire developed different factory types, reflected in different degrees of concentration, size and labour forces. In the 1780s the West Riding had 221 scribbling, carding and slubbing mills in the woollen industry, while in 1800 there were

still only 22 worsted mills. By 1835 there were 1,333 woollen and worsted mills. (Crouzet 1985: 33) But what kind of mills was another question.

Fig. 4 Percentage of Labour Costs of Woollens in Each Process
1724-1830

The factory sector in the Yorkshire woollen industry developed out of the 'company mills', centralised processes shared by artisan clothiers. It remained closely connected to the artisan sector, and by the 1830s 75 per cent of factory workers were men from artisan woollen backgrounds. The Yorkshire woollen mills were small scale ventures, and weaving was not mechanised in the industry until the 1860s. The West of England, long marked by extreme social division, by the early nineteenth century, had given over almost entirely to large factories supplying outworking weavers. The Yorkshire worsted mills were altogether larger scale concerns than the woollen, owned by former putting-out merchants, and employing predominantly female and juvenile labour.

Fig. 5 Average Hourse Power and Average Numbers of Workers in
Yorkshire Woollen and Worsted Mills, 1838 and 1850

The size of average mills varied considerably across the major textile industries - in the early 1830s linen mills employed an average of 93.3; silk 125.3, cotton 175.5, and wool only 44.6. (Clapham, p. 196)

Such differences within the factory sector were one matter. But other textile industries intensified their earlier decentralised organisation; where social division was already

marked these were ideal conditions for the emergence of sweated outwork. 'Sweating' at this time involved extremely low wage labour at highly subdivided but dispersed manufacturing processes. Such production was generally organised under several levels of subcontracting. This became the predominant form of manufacture in nineteenth-century framework knitting in Nottinghamshire, complemented by a number of large scale factories. It also emerged in the silk industry with the decline of the Spitalfields silk weavers, and the social divide between the silk ribbon weavers of Coventry and the women and children in the outlying rural parishes. In Spitalfields, the masters, on average large scale entrepreneurs, dealt directly with the weavers. In Macclesfield and in Coventry a system of intermediaries, 'the undertaker system' prevailed from the eighteenth century until the 1820s, then went into decline to be succeeded by direct dealings between the manufacturer and the weavers.

The general effect of capitalist competition and technical change at the end of the eighteenth century was to intensify existing differences in the manufacturing structures of the textile industries, rather than to endorse any single structure. Strongly based artisan systems in the wool and silk industries maintained their structures in the face of capitalist competition well into the industrial period. The Spitalfield weavers were sweated workers by the end of the Napoleonic Wars, but their counterparts in Coventry developed the compromise of the 'cottage factory' which sustained the artisan until the 1860s when new free trade legislation sacrificed the whole industry. The

woollen sector of the West Riding developed its own cooperative or 'company mills' which remained viable until the 1850s and 1860s, when falling rates of profit brought restructuring and concentration in a large scale factory sector.

Putting out industries took the route of the factory system or sweating; the direction determined it seems by the prior strength of the socioeconomic base and the market in the industry concerned. Worsted, linen and cotton took the profit opportunities of a rising market, and centralised processes in factories; framework knitting and some silk weaving followed cost cutting manoeuvres into intensive sweating.

This diversity in the experience of textiles, the classic factory industry of the period needs to be set beside that of the classic decentralised, workshop industries - the engineering and metal manufactures.

Workshop Industries - Metals and Engineering

The engineering trades, the Birmingham hardware and Sheffield cutlery trades all conjure up images of a workshop culture with characteristics of high degrees of skill, a large predominance of urban manufacture and the endurance of small-scale production. They were the locus of the innovative capital goods sector which Nathan Rosenberg credited with saving capital over the whole economy and with providing the prime mechanism for technological diffusion. Marx himself saw the paradox at the heart of industrial capitalism - the manufacture of the machines of large scale factory industry was conducted by small scale artisans; the source of the automatic power of the machine was lodged ultimately in the skill and craft of individual human

effort.

And so these industries based in the manipulation of metals have provided historians with examples for other models of industrial organisation - thus we hear now of 'batch' production and of 'flexible specialisation'. This is production based on short runs, entailing constant changes in design, set up and product, and thus not amenable to the 'flow-line' processes of mass production. The 'craft economies' in these sectors, it is argued, found their own route to industrialisation on the basis of a highly innovative small scale capitalism. Unlike the one-way drive to mass production or other unilinear evolutionary models of industrial organisation, these models recognised there were cases, most evident in current developments in micro-electronics, where the 'flexibility' of the manufacturing system in terms of variance of throughputs and variance of output outweighed the advantages of plant related economies of scale.

They also found historical precedents for this new found 'efficiency' of small scale production. The British engineering trades, the Birmingham hardware trades and the Sheffield cutlery trades were thus no longer condemned to 'backwardness' for their failure to make the transition to the large scale firm. Instead they offered 'flexible technologies', skill intensive processes, external economies, interchangeability and product choice. Artisan production during the industrial revolution was not, therefore, part of a world which was already archaic, but its own developing trajectory of industrial organisation.

The decentralised systems of the metal manufactures as much

as the factory systems of the textile industries displayed a great variety of forms. There was the great Winlaton iron works established in 1691 by Sir Ambrose Crowley. By the 1720s it was a massive manufacturing complex with forges, mills, furnaces, warehouses and workshops. (Wrightson and Levine, p. 79). Hardware manufacture on the site was conducted in the manner of 'internal contracting' widely practiced in factories a century and a half later. Clapham described the system thus:

'In their separate shops at the works, the masters-they were so called-of "Crowley's crew," who made nails, locks, chisels and all sorts of ironmongery-largely for export- got tools and materials from the works "ironkeeper," employed their own hammermen and prentices, and were credited with the selling price of their goods less cost of material; in which, it must be assumed, would be included some overhead charges and profit for Crowley, now Sir Ambrose, "ironmonger." (Clapham, p. 176)

Such factories were not uncommon in the metal trades in the eighteenth century, and continued so into the nineteenth century. In these factories, the manufacturer owned the premises, the power source and some of the heavier machinery, but he did not become deeply involved in the details of the manufacturing processes. Instead employees carried on the traditions of domestic manufacture by providing their own tools and paying for workspace and use of gas and power. In the brass manufacture, the head caster paid and supervised his own moulders and labourers; journeymen were employed on a payment by results system, and underhands were employed by journeymen at daywork rates. The journeyman in a large scale brass finishing works was designer, supervisor, toolmaker, tool setter and all-round workman. (Kelly, p. 43)

In the lighter "toy" or ornamental and light hardware trades of Birmingham women piecemasters ran groups of workers in

buttonmaking, papiermache and lacquering shops within large scale toy factories such as John Taylor's works, which in 1759 employed 600. Boulton employed 800-1,000 at Soho by 1770, but as Eric Roll pointed out, the factory was arranged in a series of shops, each located according to a systematic order, but only one basic operation was performed within each shop, and payment was made through an elaborate system of piece rates. Maudslay's engineering works was another showcase factory of the eighteenth century, set up according to the principles of production organisation specified by Samuel Bentham; it was followed in the early nineteenth century by James Nasmyth's more advanced version. But in both the workman remained a semiautonomous producer. (Berg, chap.11)

The small scale producer in the Birmingham and Sheffield trades as well as the engineering trades ran the whole range between artisan workshop and sweated garret worker. In 1825 there were 400 to 500 engineering masters in the London area employing 10,000 men. (Burgess, 218, 221). And by 1851 Britain had 677 engineering firms. Yet two thirds of these had fewer than ten employees and only 14 had more than 350. (Crouzet 1985: 35)

Birmingham in the eighteenth century contained some large scale and a substantial core of medium scale metal manufacturing firms deploying various forms of internal contracting and subcontracting. There was gunmaking, for instance, where the gunmaker owned a warehouse in the gun quarter, acquired semi-finished parts and gave these out to specialised craftsmen who undertook the assembly and finishing. They in turn bought their

parts from a range of independent manufacturers - barrelmakers, lockmakers, sight stampers, triggermakers, ramrod forgers, gun furniture makers and bayonet forgers. These levels of division of labour and specialisation prevailed across the hardware and toy trades, but skills were also sufficiently flexible that workers could turn their skills in the use of file and lathe to other trades if need be. (Allen, 17) The 'flexibility' of small scale manufacturers in Birmingham, contracting and networking with a core of medium scale manufacturers and a few dominant large scale manufacturers, may be contrasted with the position of the small scale nail and chainmakers of the surrounding Black Country villages - here 40,000 sweated outworkers, substantial numbers of them women and children lived tied by poverty, debt and dependency to the nail factors of the region.

Fig. 6 Insured Assets of Metalworkers in Birmingham 1777-1787

In Sheffield, the cutlery trades had developed a division of labour going back to the seventeenth century based on both product and process. By the eighteenth century, the knife and scissormaking trades concentrated in the town were divided into forging and grinding. Forging was performed by one or two craftsmen in a small shop, while grinding was performed in separate departments of large works or in separate establishments. The actual building up or halfting of the knife was the craft of the cutler or individual artisan.

By the nineteenth century cost cutting and rationalisation brought a restructuring of this 'decentralised' sector, but the result was a one way road to concentration and large scale units.

The small producers remained, but subordinated now to a few large firms. In engineering there was indeed a trend after 1825 to larger more heavily capitalised firms; with this the focus of the industry shifted from London to South Lancashire. In the hardware trades industrial dualism emerged. In 1843 there were 4000 manufacturers in Birmingham and 1,344 cutlery warehouses in Sheffield. (Crouzet 1985: 36). The substantial artisan workshops and medium scale workshops gave way to a polarised production process. The size of the larger firms grew after the Napoleonic Wars, and large factories now dominated the industry; but there was also a proliferation of small garret masters, many of these subordinated to the large firms. (Behagg)

The post Napoleonic recession was also a time for the multiplication of small units in Sheffield - 'the little masters'. These were either factors using the labour of outworkers, or small cutlers renting a room in a factory. By this time they were subject to a local group of merchant capitalists who controlled the circulating capital of the trade and the distribution of the finished product; in reality they were little more than outworkers. (Lloyd, Smith)

The later stages of the industrial revolution were not marked by the market expansion and opportunities for entry of the first phases. They were marked by falling rates of profit, cost cutting, rationalisation and restructuring. The result for industrial organisation was a polarised structure between concentration on the one hand and dispersed sweating on the other. What effect did these phases of expansion and recession have on the giants of industry - the mines, the ironworks, the

large scale brewers, papermakers and glassmakers?

Centralised Industries

The centralised industries, especially mining and ironworking, while their processes required concentration of production at one site, were nevertheless characterised as were the textiles and metals manufactures by a few giants among pygmies. The pits on Tyneside and the Wear were truly large for their time - those of the 1690s employed 72-90 people turning out 18,000 tons, and 260-325 people in the 1710s turning out 65,000 tons, but this size declined by the late 1750s to 68-85 people turning out 17,000 tons. This size of pit compared to the more common small outcrop in Lancashire employing a few hewers. (Levine and Wrightson, p. 214). By 1830 the forty-one working collieries on Tyneside produced c. 3,000,000 tons a year, and the average colliery there produced 670-70,000 tons with an average workforce of 300. But even as late as 1850, the average coal mine was said to employ no more than "eighty men, women and boys under ground and above". (Clapham, p. 185) The comparable tin and copper mines were altogether larger affairs - the Cornish mines in 1838 employed an average of 170 workers per mine.

Mine management also revealed these contrasts. In some areas of the country a few major landowners controlled a number of large scale mines. In Scotland there were the Duke of Buccleuch and the Duke of Hamilton, in Lancashire, the Earls of Crawford and Balcarres and the Duke of Bridgewater. In Yorkshire the Wentworth estate of the Fitzwilliams had four collieries around Barnesley in 1795 and six in 1828, while the Duke of

Norfolk had several in the Sheffield area. The Lords Dudley had a number of pits in the Black Country. Some of these mines were leased, as in the case of the Duke of Norfolk's Sheffield colliery leased in 1820 to a group of partners including a landowner, a merchant a cutler and a collier. (Flinn 1984: 37-8). Other mining ventures were integrated with iron companies especially in Shropshire, Derbyshire, the Black Country and South Yorkshire. Whether owned or leased such large scale mines were directly managed by overlookers, overseers or managers.

Smaller collieries were, however, at least for the first half of the eighteenth century, frequently leased and run by working miners, as on the Derbyshire-Nottinghamshire border. Then there was the celebrated case of the Free Miners of the Forest of Dean, where even as late as the 1780s 99 mines were worked by 442 free miners and boys. (Flinn 1984: 42)

The contrast between the giant and the very small works was even more marked in iron working. In 1814, the Scottish Carron works employed 2000, but the average Scottish foundry employed 20. After the Napoleonic Wars, the industry underwent massive restructuring in face of over-capacity and technological change. The industry concentrated in South Wales which now produced 40 per cent of total output, and the Midlands. Works such as Samuel Walker and William Yates employed 700 men at one site. Average output per blast furnace grew in the early period from 300 tons in 1720 to 1500 in 1805 and 2600 in 1826. (Crouzet 1985: 34). In the 1830s and 1840s the introduction of the 'hot blast' process spread fastest in Scotland, and the industry was then spread equally across three major regions - Scotland, South Wales and

the Black Country, (Riden, 1986, p. 128).

Fig. 7 Initial Investment in Blast Furnaces - Costs per Typical (Modal) Unit

Dowlais in 1842 had 18 blast furnaces, dozens of puddling furnaces and 6000 employees. (Crouzet 1985: 34) Concentration in large scale units was also the norm in glassmaking; there were 116 'glass houses' in 1833 with one firm Isaac Cookson owning 9 of these. (Clapham, p. 190).

Table 2: Number of Persons in the Employment of the Dowlais Iron Company

Apart from those industries lending themselves to centralised production in large scale units, there were several others which managed to contain both a sector of large scale producers reaping economies of scale and exercising managerial innovation, within a much larger sector of very small scale producers producing for localised or specialised markets. Brewing is the obvious example; in 1822 there were 98 wholesale brewers in London - they were 6 per cent of the total number in England and Wales, but produced 43 per cent of strong beer. (Weir, p. 122).

Fig. 8 No. of Common Brewers and Brewing Victuallers in the Whole Kingdom with their Separate Annual Production 1700-1830

Josiah Wedgwood employed several hundreds at Etruria, but he was uncharacteristic of an industry populated by all manner of small earthenware manufacturers and 'china men' making ordinary chinaware. The itinerant papermakers of Kent held the stage in papermaking until the beginning of the nineteenth century when Fourdrinier invented his continuous paper

making machine.

Shipbuilding was another example - two shipbuilders on the Thames in 1825 employed 600 and 230 respectively. But the industry still one of wood and sail, and was otherwise dispersed through a large number of very small yards between the Thames and the Bristol Channel and over most other rivers, especially the Mersey, the Clyde and the Humber. (Slaven, p. 132) And while shipbuilding may have been concentrated in these yards, the production process was basically a building process, combining the independent crafts of a large range of wood and metalworking as well as shipwrighting trades. (Prothero 1979: 46-50, 163-71; Pollard and Robertson 1979).

Mechanical engineering, the industry responsible for the mechanisation of the rest of the industrial economy, was perhaps the most highly divided. In 1851 there were 677 engineering firms in the country, but two thirds of these employed fewer than 10 workers. Only 14 firms employed more than 350. The industrial structure of most of the industry was way out of line with that of a few leading firms. The largest textile engineering firm, Platts of Oldham employed 7000 in 1875, and even at the beginning of the Twentieth Century produced as much as the whole American textile machinery industry. (Saul ; Crouzet 1982: 249,50)

Across a wide range of British industry during the period of the industrial revolution, industrial organisation cannot be said to have been dominated either by concentration, centralisation and the factory system on the one hand, nor by small scale capitalism on the other. The 'success' of great

works was not so obvious that it drowned the efforts of smaller producers, but during the early nineteenth century production processes became increasingly polarised between concentration on the one hand and subcontracting, outworking and sweating on the other. If part of the definition of the industrial revolution lies with changing organisations of production, especially the rise of the factory system, where does this outcome leave the debate on the rise of the factory system?

The Industrial Revolution and the Rise of the Factory System

Smaller and medium scale manufacturers held the stage for much of the Industrial Revolution. Yet historians have given little weight to their experiences and practices. They have been more attracted to the few large factories with complex hierarchies and extended divisions of labour. For if these were not then the norm, they were gestures to the future domination of factory mass production.

It is not surprising then that manufacturing organisation has thus far been analysed in the main in terms of scale of production. Larger scale has been associated with greater efficiency, lower relative costs and greater ability to develop and use new technology. Larger scale firms were associated with the emergence of hierarchical forms of organisation, greater division of labour, and a divide between supervisory and unskilled workers. (Marglin). Hierarchy and economy of skill were the significant advantages identified by Charles Babbage in 1831 in his Babbage Principle: the division of labour allowed tasks to be subdivided according to skill requirements, so that only the requisite amount of skill was

allocated to the needs of each each task. Skilled as well as unskilled workers were thus arranged in a hierarchy, and masters could divide and rule them all.

Larger scale firms were also more amenable to the diffusion of mechanised and powered technologies. (Goldin and Sokoloff, 1984). In Landes' view, the factories and the machines went hand in hand. There was a factory bias to technological change because (1) that was where the money was; (2) the saving in labour costs was higher because factory wages were higher (3) the accumulation of small improvements was a function of the volume of investment - the new plant meant new and better equipment (4) the factory environment was a more favourable environment for the perception of improvements. 'The logic of technology was moving towards even wider mechanisation, toward doing more and faster, thereby enhancing the advantage of mass production and the factory system' (Landes 1986: 615)

The great technical innovation, the machine, had an internal logic pushing it in the direction of uniformity and standardisation (Landes 1987: 26) Scale economies associated with using certain types of machinery were greater than those due from the division of hand-performed tasks. (Sokoloff, 1984: 372) Indeed adoption of the factory was a prerequisite to reaping economies of scale from 'indivisible' new technologies such as the steam engine. (Von Tunzelman 1990: 26)

Fig. 9 Steam Power in British Industry 1800 and 1870

Large scale production entailing the machine and the factory have thus appeared historically inevitable, and it has been the prevailing convention at least since the nineteenth century to

put much of the progress of manufacture down to the economies of large scale production. Yet much of the early textile machinery was originally planned for use within cottage manufacture or larger workshops which formed part of the putting out system. And steam power had only limited uses in most manufacturing industry until the later years of the industrial revolution.

Recent work has drawn attention to the number and indeed efficiency of organisational forms other than the factory, as outlined above in this chapter. These forms have not only endured; they have revived in recent trends to 'flexible specialisation', and the Japanese model of 'network capitalism'. Piore and Sabel have pointed the disadvantages: the indivisibilities, inflexibilities and rigidities entailed in the bureaucratic structures of large scale production. Small scale production, on the other hand, offered economic advantages of creativity, nimbleness and easy entry. (Landes 1987). Small scale firms could develop 'flexible technologies', skill intensive processes, and interchangeability, providing a range of product choices for localised and regional tastes. (Sabel and Zeitlin). Furthermore, in Marshall's view, the lack of a fundamental divide between idea and execution had great advantages. 'The master's eye is everywhere; there is no shirking by his foremen or workmen, no divided responsibility, no sending half-understood messages backwards and forwards from one department to another'. (Marshall, p. 237) And the small scale manufacturer could take advantage of external economies, especially in the form of trade knowledge, and in regional concentrations of skills...'so great are the advantages which

people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously.' (Marshall, 237,225)

The 'efficiency' of organisation was not always at issue; managerial control frequently was. Marglin saw the key advantage of the factory system not in its technical efficiency, but in its success in eliciting greater intensity of labour, and in giving maximum control over the production process and the direct producers. The division of labour allowed the concentration of knowledge in the hands of proprietors and their managers; hierarchical structures created systems of control and discipline over the labour force. (Marglin 1974; Marglin 1991).

Industrial organisation provides the structures for control over the direct producers. It has also been seen as the means for controlling opportunistic behaviour by individuals and groups within and between firms. Thus it can be argued that various types of work organisation provide the ways of saving on transactions costs arising from unequal access to information or monitoring of performance as well as the costs arising from opportunistic behaviour. Saving on such transaction costs provides the key motivation for the emergence of managerial hierarchies, as well as various forms of work organisation including not just factories, but putting out systems, federated groups, and multidivisional and holding company forms. (Williamson 1985; Alchian and Woodward 1988: 68, 75).

Yet it was not just one or the other form of organisation which dictated the degree of control over labour. It was also the institutional setting of manufacture, notably the law. Masters had unequal advantage over labour before the law due to the existence of masters and servants legislation making workmen and women liable to imprisonment for breach of contract of service. This legislation went back to the Statute of Labourers of 1349, and its worst injustices were not removed from the Statute Book until the Master and Servant Act of 1867. (Webbs 1902: 232-5) The legislation notably became the weapon of smaller employers and explains the widespread practice of long contracts and bonds of service.

Conviction was usual in cases brought because employers in the same trade would often sit as magistrates, and in areas such as the Black Country an employer-magistrate culture could develop. (Haynes 1988: 245; Hay 1982: 152-8). Far more prosecutions were brought under this legislation than had ever been brought under the Combination Laws. A Parliamentary Return for 1863 showed that 10,337 cases of breach of contract of service came before the courts in a single year. (Webb 1902: 235).

Factories may have provided one way of controlling labour, but small producers and manufacturers using putting out systems exerted control through the law and through extensive credit and debt bondage. (Berg 1985: 280-2). Organisational innovation to increase efficiency, profitability or control over labour was thus available to manufacturers in many different forms.

The modern mechanised technologies of the large scale

factory hinged on a close dependency on 'traditional' artisan producers. Cotton manufacturers typically combined steam powered spinning in factories with extensive employment of dispersed domestic handloom weavers long after the availability of powered technology. This spread risks and deployed a cheap labour supply of women and children. The metal working trades of Birmingham and Sheffield had both large and small firms primarily concerned with metalworking diversifying into large scale metal processing ventures as a way of generating steady raw material supplies. The individual manufacturer might move simultaneously or in succession into 'large scale mechanised production' and 'small scale 'traditional' activities.

Innovation in organisational structures was also widespread within industries organised on a decentralised basis. New forms of putting out, wholesaling, retailing, credit and debt and 'artisan co-operation' were devised as ways of retaining the essentials of older structures in the face of a new more competitive and innovative environment. Customary practices, organisational forms and 'traditional' technologies were themselves transformed partly in order to combat the spectre of large scale factory production, and to find other ways of responding to the needs of more dynamic and market orientated production. Research on proto-industrialisation has identified the significance of innovation in organisation in the form of elaborate putting out networks, subcontracting and artisanal co-operative and share ventures, as well as in marketing techniques, credit arrangements, and product innovation. The

interdependencies of small scale and large scale technical innovation tend to undermine the notion of a sharp divide in the capacities for and types of innovation developed within the different organisational forms.

In fact as we have seen most industries contained concentrated and decentralised firms, but what is striking is that most of the concentrated firms they did contain were not large scale ventures at all. The leading factory industry, cotton, reveals an average primary processing firm in Manchester in 1840 of only 260 hands, with a quarter of all firms employing fewer than 100. The new cotton technologies were available at relatively low thresholds - small firms took advantage of small steam engines, and installed small numbers of spinning mules and power looms; they used traditional building methods and existing water power resources. (Chapman, 'Fixed Capital', Gatrell, 'Labour, Power and Size'). Even when numbers of these small firms succumbed in the early nineteenth century to falling profit rates, recession and restructuring, their place was not taken by the cotton lords, but by larger but still moderately sized enterprises ranging between 150 and 500 employees (Lloyd Jones and Le Roux 1980).

Fig. 10 Employment Structure of Manchester Cotton Firms

1815 and 1841

Other industries could reap the gains of moderate and 'small scale factories' for threshold sizes as low as six to fifteen employees. Even without mechanisation in these units, economies of scale could be derived from a division of hand performed tasks

within a firm, the use of simple tools, supervision and a more disciplined work regime. New organisation and the use of a new 'less skilled' or at least less restrictive workforce opened the way in the Northeast of the United States in the early nineteenth century to substantial productivity gains. Much of this new workforce was made up of women and children. (Goldin and Sokoloff 1981: 756; 1984: 480). These 'small scale factories' were, furthermore responsible for substantial inventive activity, prompted by the extension of the market with the growth of the canal economies and by the domestic competition which was ensured by the small scale of enterprise. (Sokoloff, 1988: 846; Sokoloff and Khan 1990: 377).

Evidence for the place of such 'small scale factories', their internal structures and efficiency gains is less systematic in Britain. Nevertheless, there is certainly a case to be made for an important place for this organisational form in British industry at a parallel stage of development, that is in the later eighteenth century and up to the end of the Napoleonic Wars. Market expansion, regional growth on the basis of the canal economies and a new departure in the use of child and female labour in textiles, potteries and the metal manufactures were parallel developments. After the 1820s as outlined for several industries above, the pressures of falling profit rates and mechanisation as a form of cost cutting brought trends to a polarisation of production processes into large scale units on the one hand, and very small scale dependent units on the other.

If the rise of the factory system was as much a question of regional, industrial and cyclical change, as of organisational

development, then there would appear to be no clear factors to identify it as a 'modern' organisational form. This is also the case within the factory sector itself. The modern trend to large scale organisation on the lines identified by Chandler include vertical and horizontal integration; economies of scale followed by economies of scope. Yet the British cotton industry remained vertically disintegrated throughout the nineteenth and into the twentieth centuries. The spinning and weaving sections of the industry remained separate, and marketing was controlled by separate groups of merchants. There is little in these factors as indicators of modern organisation when we recall the levels of vertical and indeed horizontal organisation achieved by the great concerns of some industrialists of the earlier years of the Industrial Revolution.

The one-way routes to economies of scale and scope and to saving transactions costs were crisscrossed many times by most eighteenth and early nineteenth century industries. They developed within a plurality of organisational forms suitable to region, market, and the economic cycle. Understanding the capacities within all these organisational forms for responding to market pressures and for using institutional environments should generate new analyses and measures of the performance of the industrial economy. Transformation, discontinuity and a rehabilitation of the Industrial Revolution may yet return to the historical agenda.

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February, 1991

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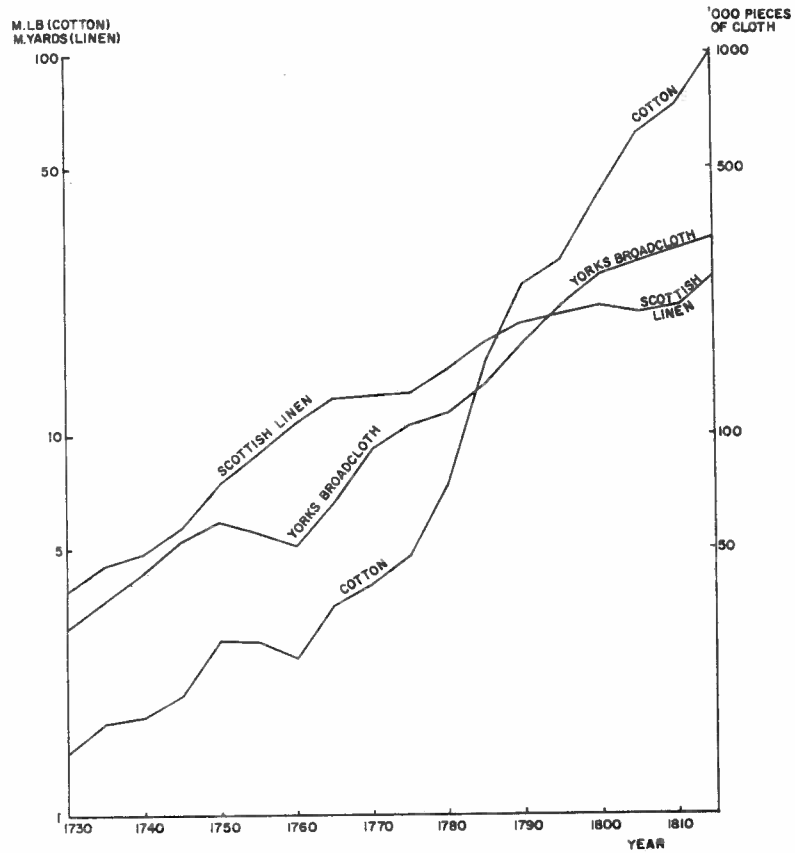
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Fig. 1 - The Growth of the Textile Industries



Source: E. Pawson, The Early Industrial Revolution Britain in the Eighteenth Century, (New York, 1979), p. 103.

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Fig. 2 - Organisational Structure of the West of England and Yorkshire Woollen Industries

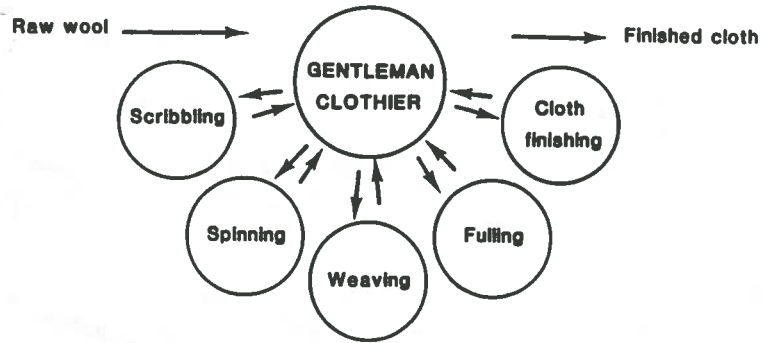


Figure 7.1 The organisational structure of the West of England woollen industry

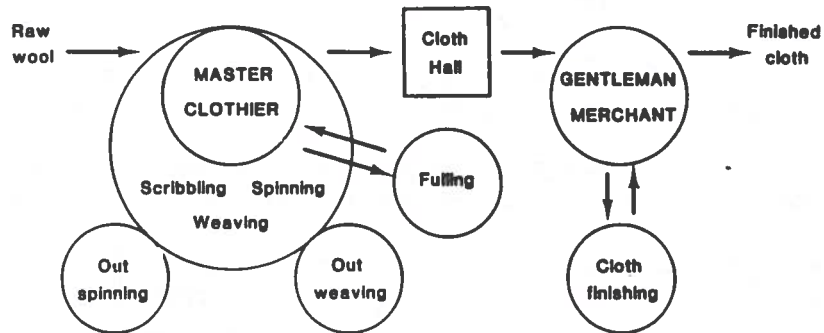
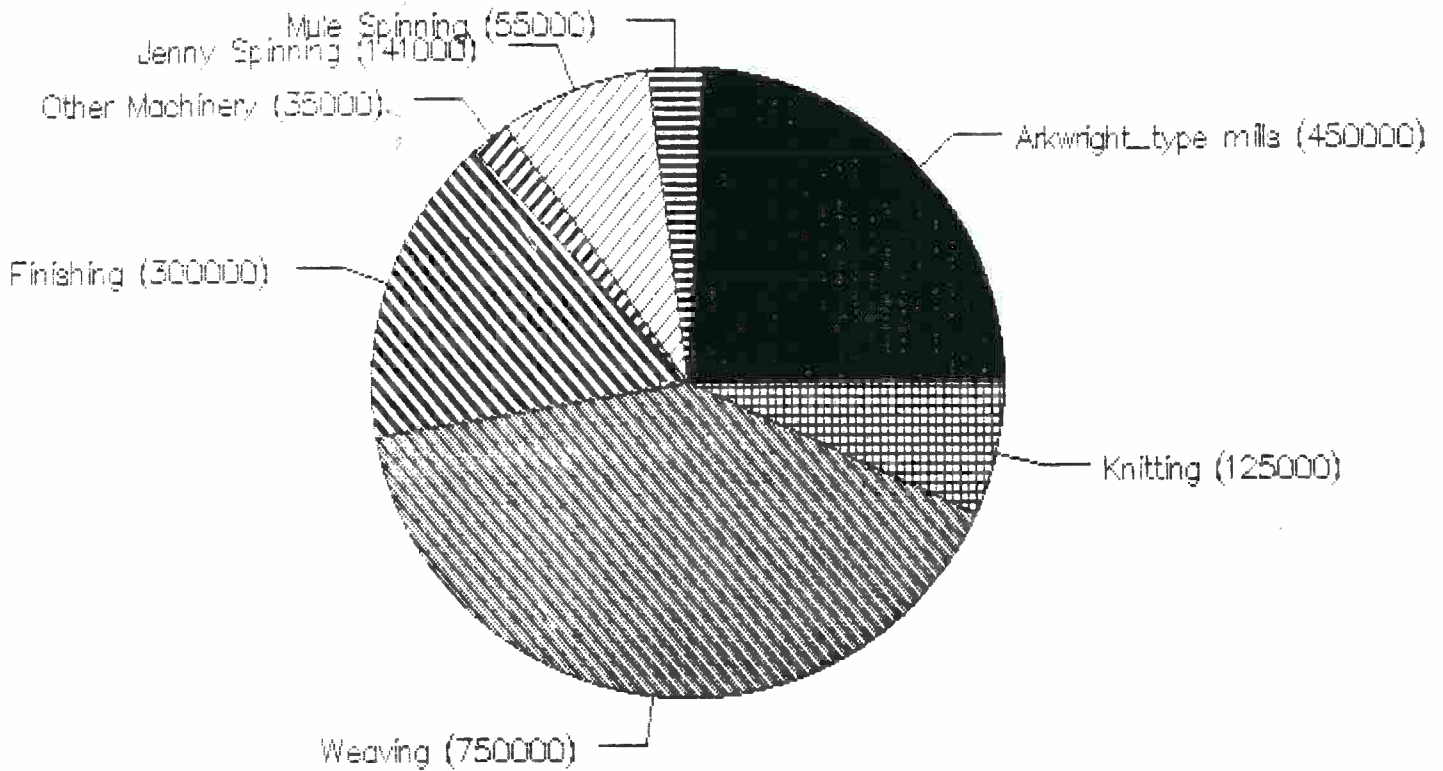


Figure 7.2 The organisational structure of the Yorkshire woollen industry

Source: A. J. Randall, 'Work, Culture and Resistance to Machinery in the West of England Woollen Industry', in P. Hudson, ed., Regions and Industries, (Cambridge, 1989), pp. 180-1.

Fig. 3

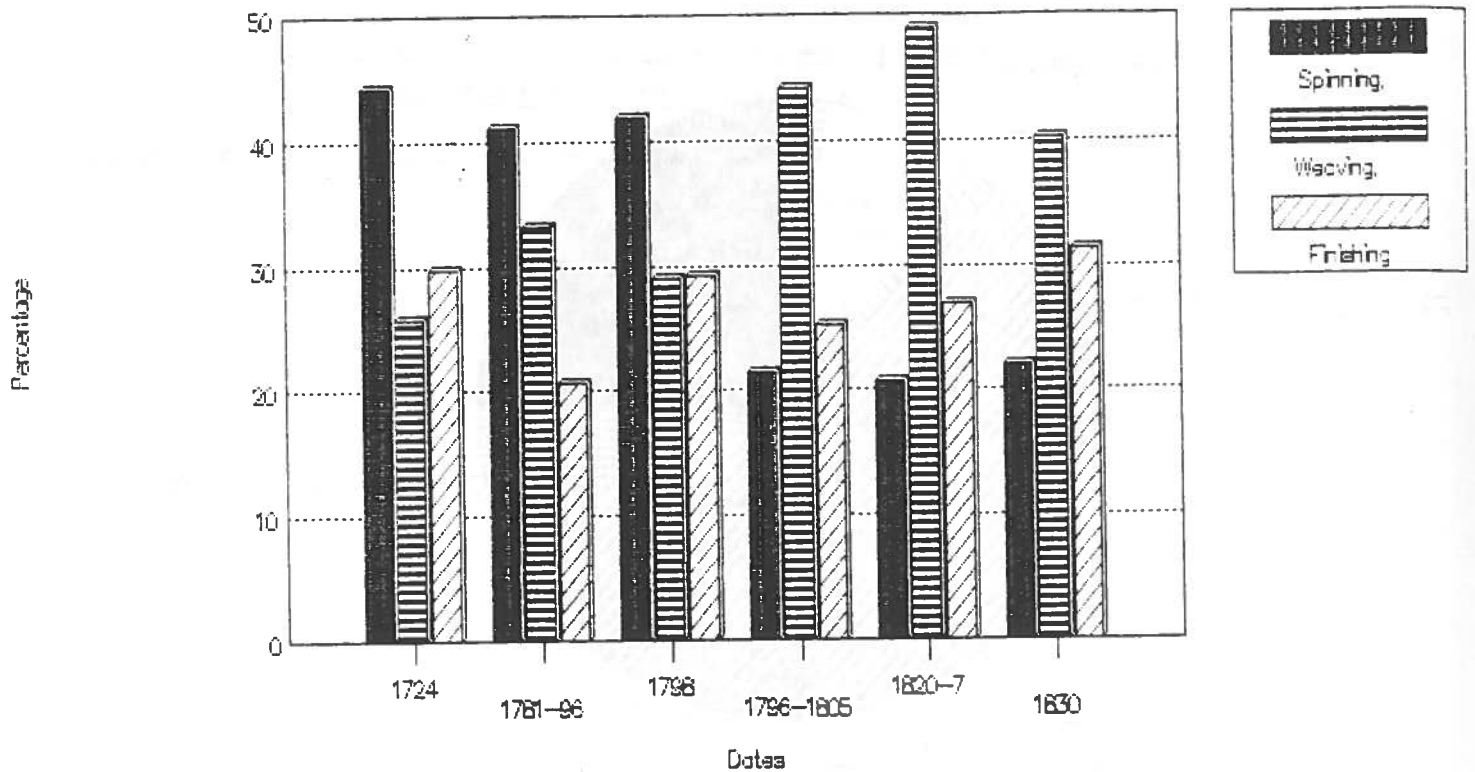
Capital Investment in the Cotton Industry, 1788



Source: S. D. Chapman and J. Butt, 'The Cotton Industry, 1775-1856', in C. H. Feinstein and S. Pollard, Studies in Capital Formation in the U.K. 1750-1920, (Oxford, 1988), p. 109

Fig. 4

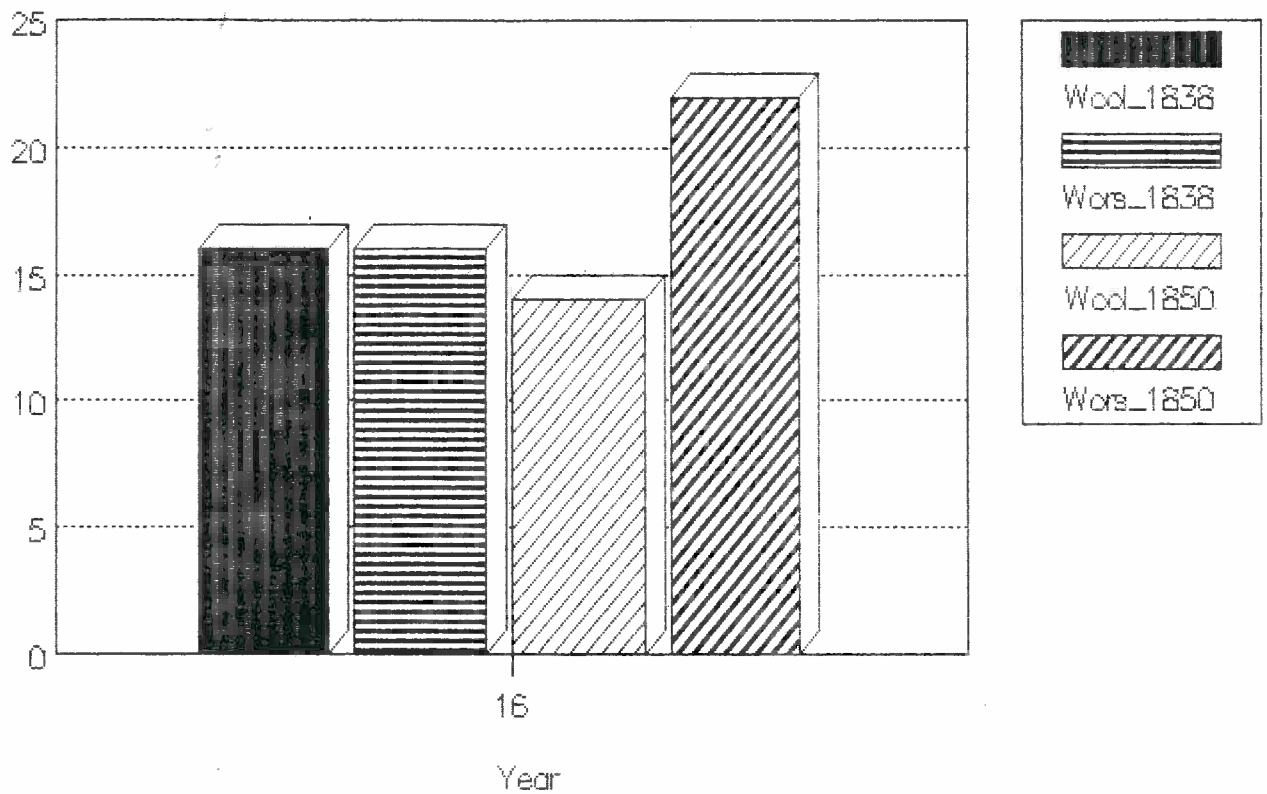
Percentage of Labour Costs of Woollens in Each Process



Source: Pat Hudson, The Genesis of Industrial Capital: A Study of the West Riding Wool Textile Industry c. 1750-1850 (Cambridge, 1986), p. 150

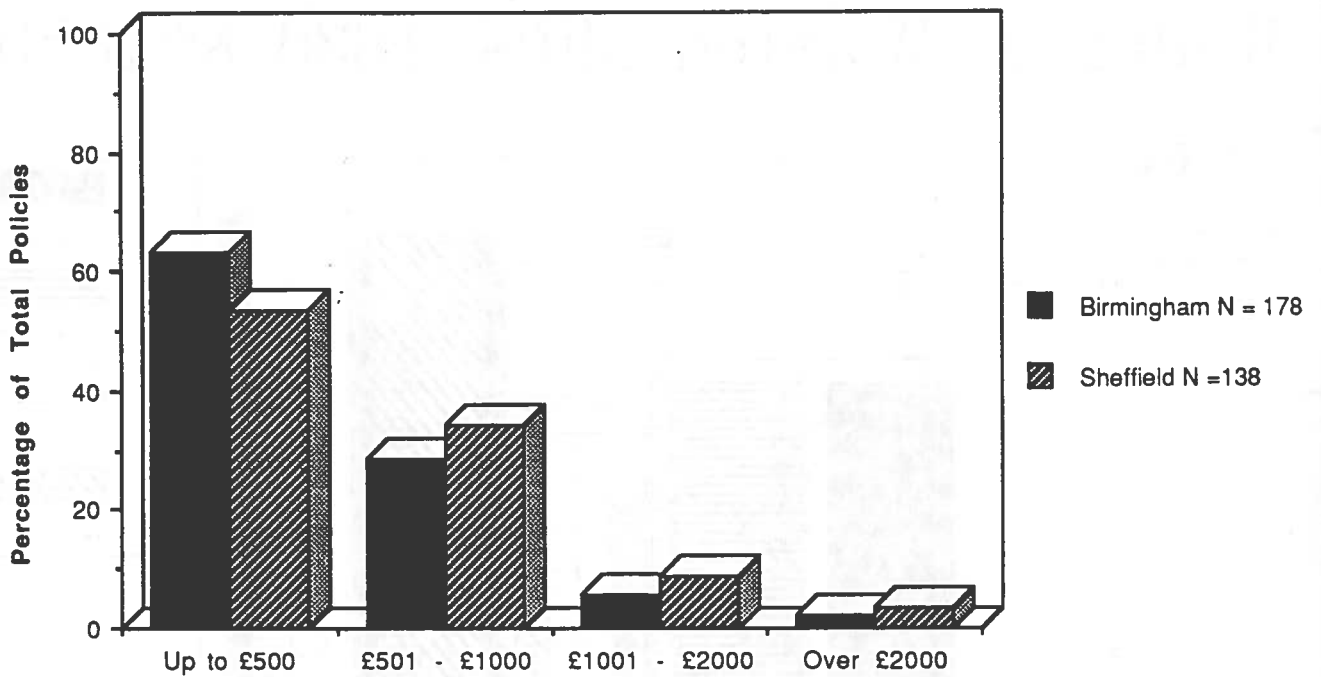
Fig. 5

Average Horse Power in Yorkshire Wollen & Worsted Mills, 1838 & 1850



Source: P. Hudson, The Genesis of Industrial Capital A Study of the West Riding Wool Textile Industry c. 1750-1850, (Cambridge, 1986), p. 40

Fig. 6 Birmingham and Sheffield Insurance Valuations 1777-1787



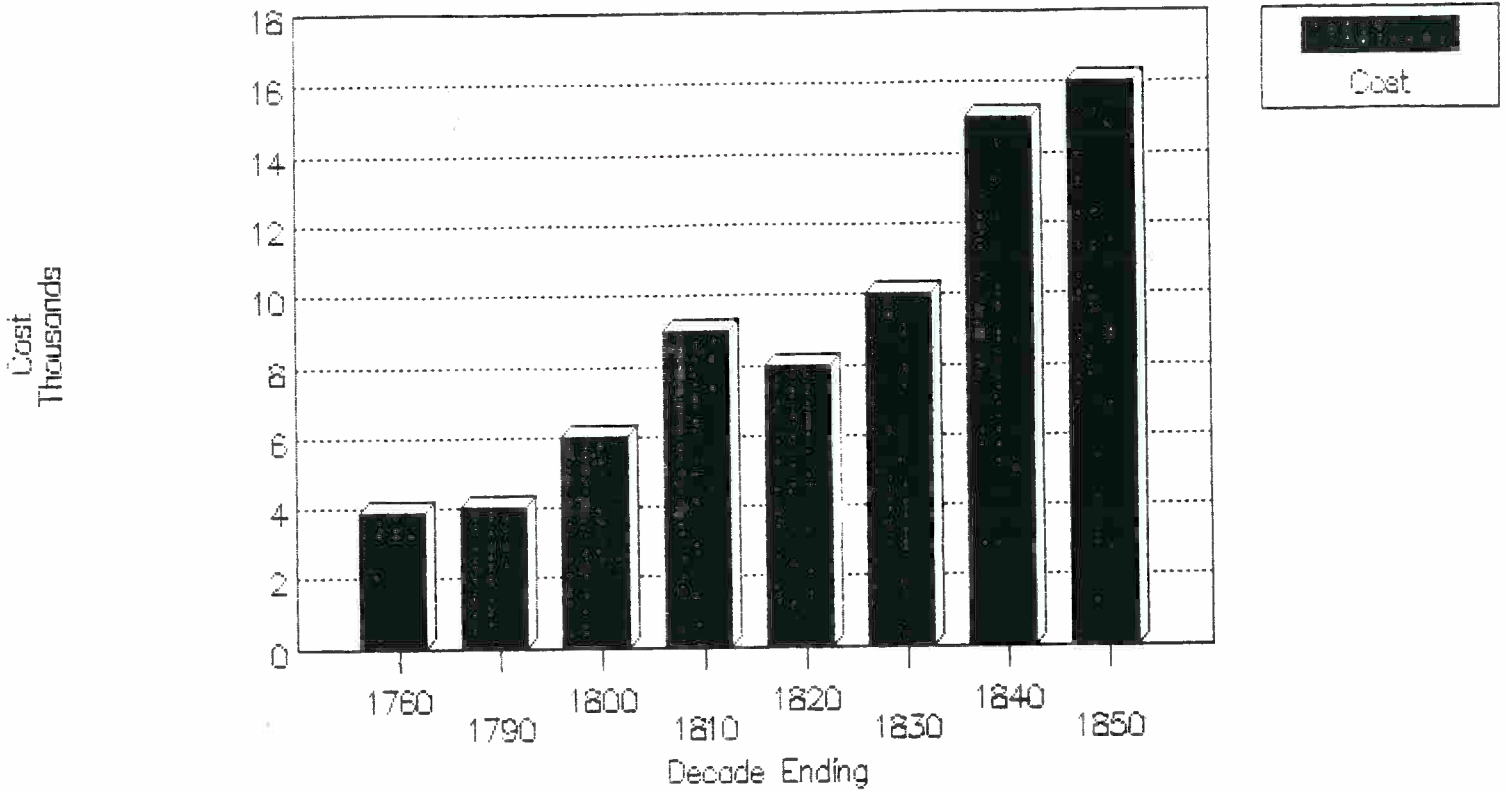
Source: Maxine Berg 'Commerce and Creativity in Eighteenth-Century Birmingham', In Maxine Berg, ed., Markets and Manufacture in Early Industrial Europe, (London, 1991), pp. 192-3.

Thousands

Fig. 7

Initial Investment in Blast Furnaces

Costs Per Typical (Modal) Unit



Source: R.S.W. Davies and Sydney Pollard, 'The Iron Industry, 1750-1850', in C.H. Feinstein and Sydney Pollard, Studies in Capital Formation, in the United Kingdom 1750-1920, (Oxford, 1988), p. 96

Table 1:

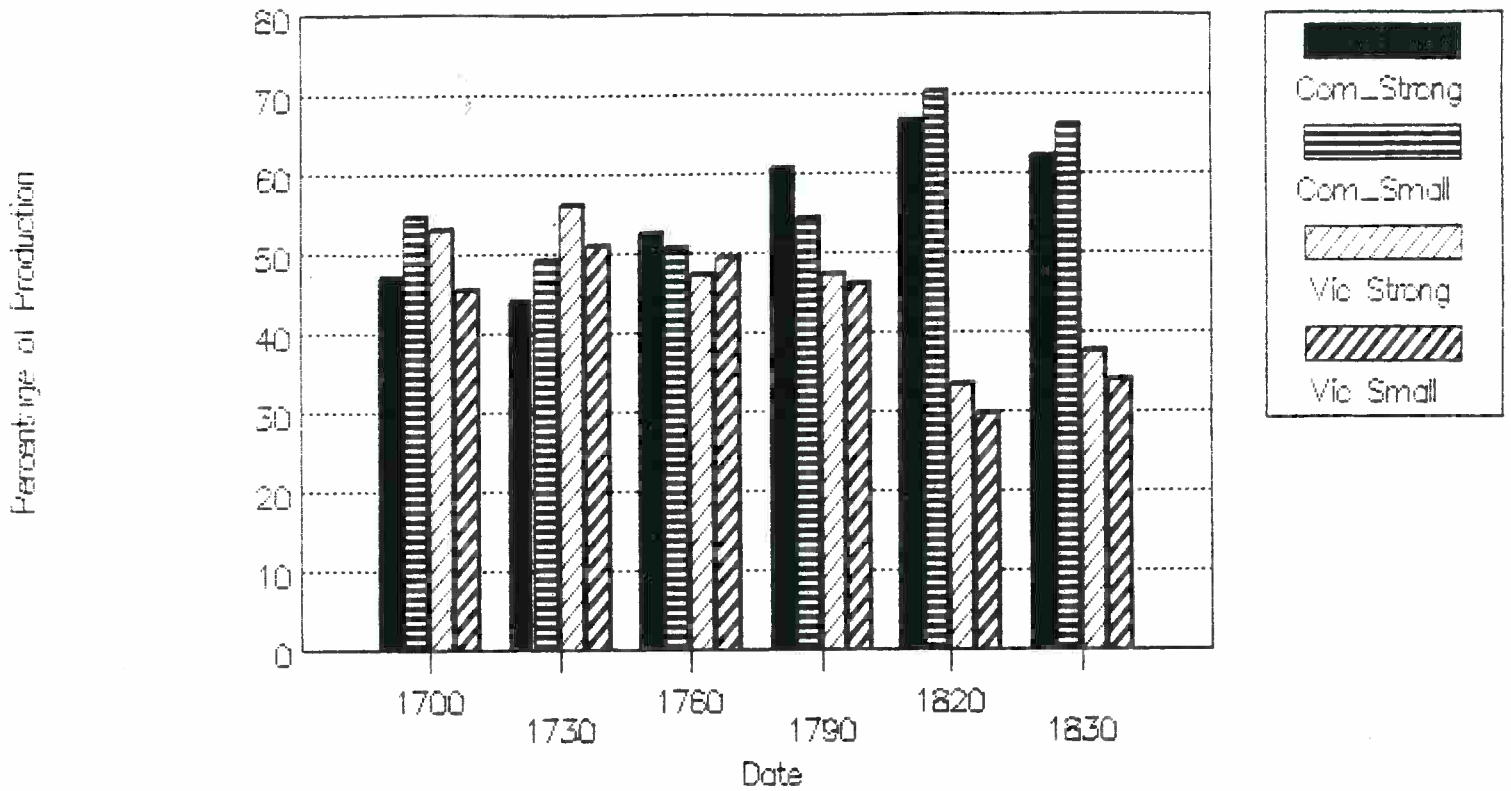
No. of Persons in The Employ of The Dowlais Iron Company 1 May 1866

| Iron Company | No. of Persons |
|---|----------------|
| Old Works, Forges and Mills | 1429 |
| Ifor Works | 775 |
| Furnaces | 802 |
| Steel Works | 44 |
| Fitting, Pattern & smelting shops, carpenters | 397 |
| Engines, Forge and Blast | 155 |
| Engines, Locomotive | 21 |
| Engines, Pits | 138 |
| Collieries | 2023 |
| Mine Works, Limestone Quarries | 1709 |
| Masons, Roadmen and Harries | 310 |
| Church Building | 31 |
| Farms | 32 |
| Stables | 84 |
| Railway Station | 4 |
| Washhouse | 4 |
| Traffic | 18 |
| Weighers, Croppers | 52 |
| Offices, Library | 48 |
| Schools | 55 |
| Cardiff Yard | 64 |
| Edge Hill Mines | 282 |
| London Houses | 23 |
| Total | 8500 |

(Source Alan Birch, 'The Economic History of the British Iron and Steel Industry 1784-1879, London 1967, p.255) (Frank Cass)

Fig. 8

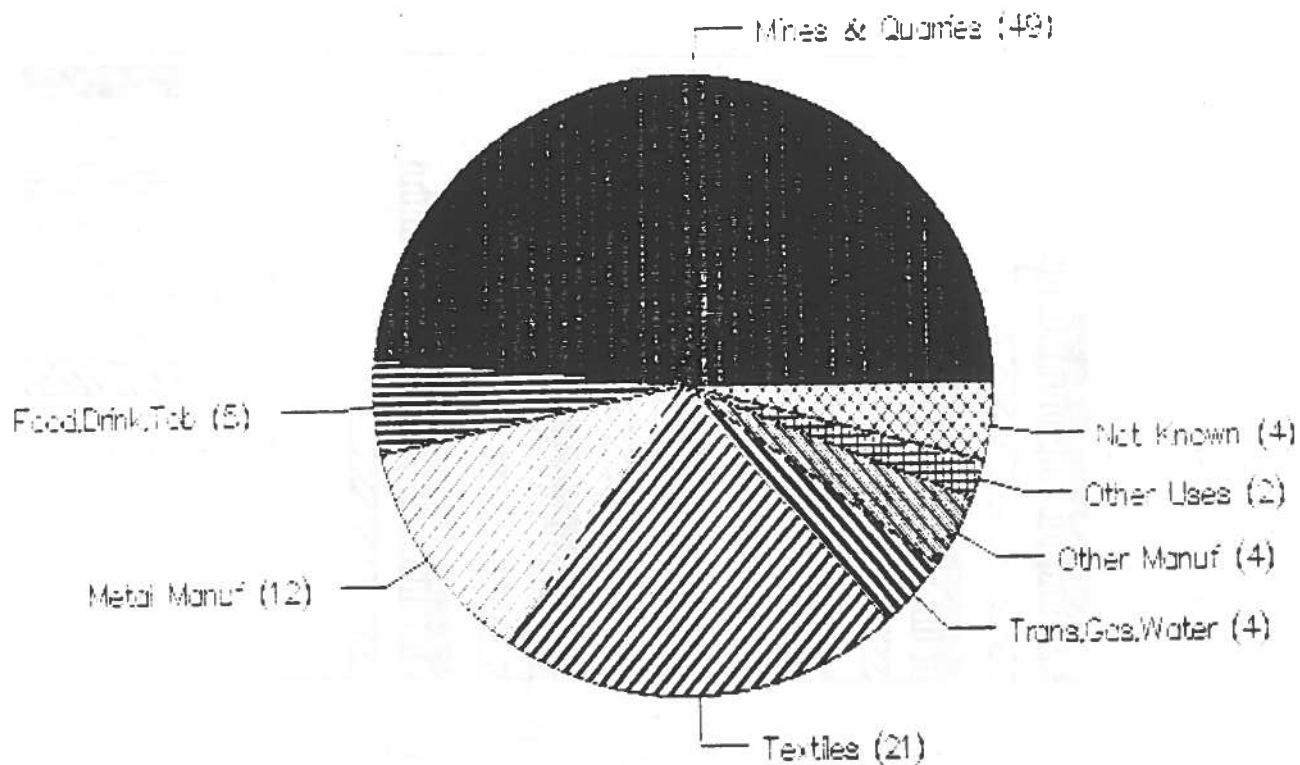
Annual Production of Common Brewers and Brewing Victuallers 1700-1830



Source: Peter Mathias, The Brewing Industry in England 1700-1830, (Cambridge, 1959), pp. 542-3

Fig. 9

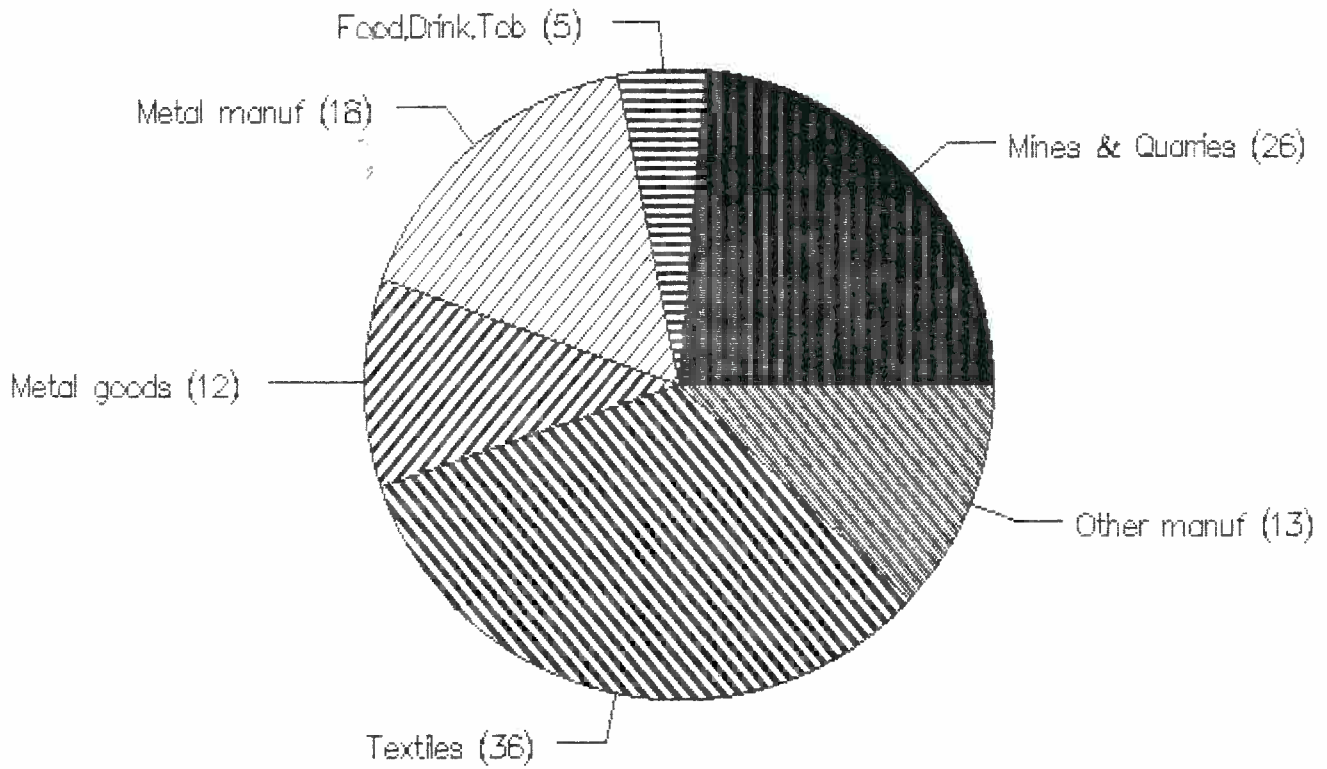
Percentages of Steam Power in British Industry, 1800



Source: G. N. von Tunzelmann, 'Coal and Steam Power', in J. Langton and R. J. Morris, Atlas of Industrializing Britain, 1780-1914, (London, 1986), p. 78

Fig. 9

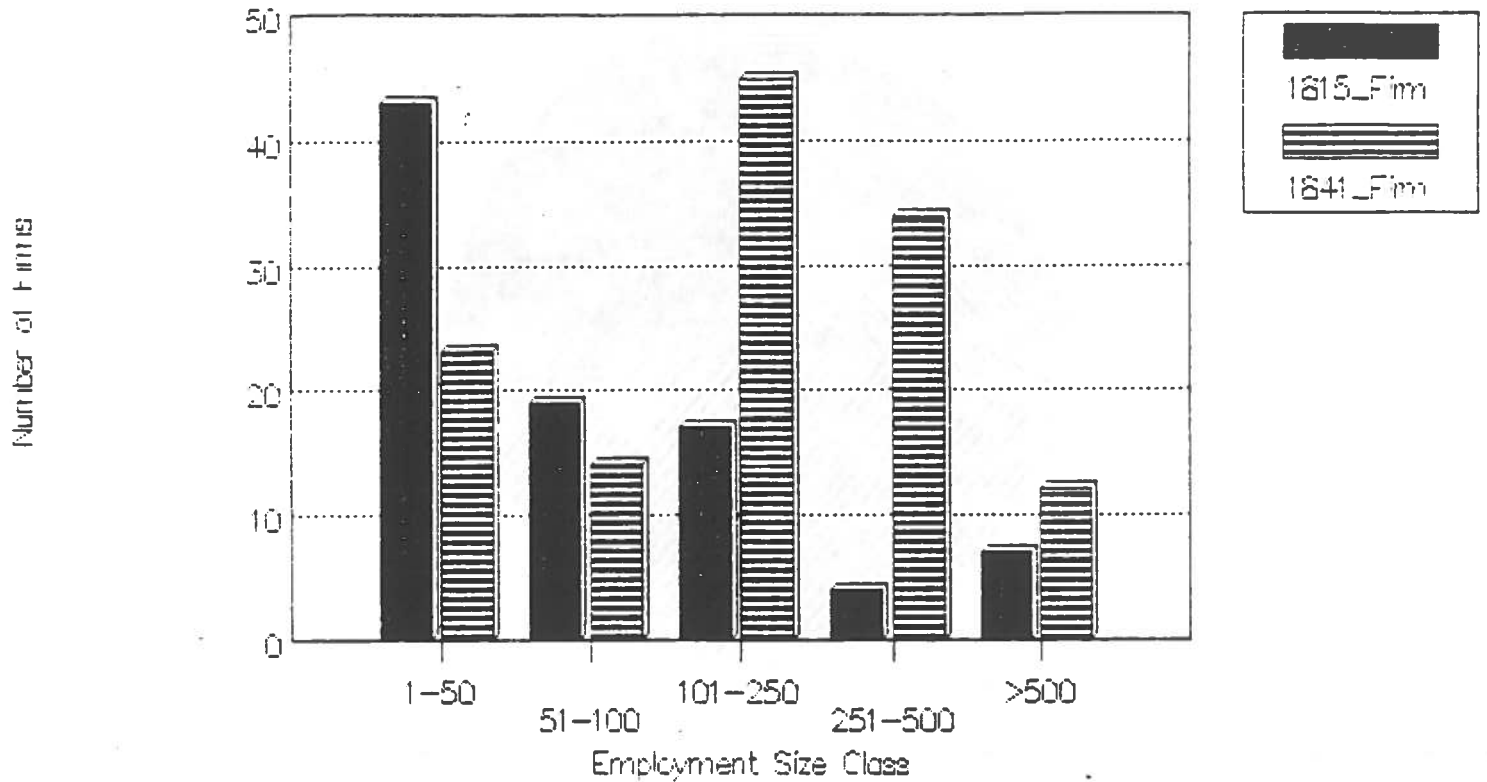
Percentages of Steam Power in British Industry, 1870 (000 h.p.)



Source: G. N. von Tunzelmann, 'Coal and Steam Power', in J. Langton and R. J. Morris, Atlas of Industrializing Britain, 1780-1914, (London 1986), p. 78

Fig. 10

Employment Structure of Manchester Cotton Firms in 1815 and 1841



Source: R. Lloyd-Jones and A. A. Le Roux, 'The Size of Firms in the Cotton Industry: Manchester, 1815-41', Economic History Review, 33 (1980), p. 75