Production and Work in the British Iron Trade in the Eighteenth Century

A Swedish Perspective

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Forword

This text was written while being Visiting Fellow at the Department of History, University of Warwick. Many of my Swedish colleagues thought that I choose to spend a year at Warwick only because of its closeness to Birmingham, and in particular to Aston, as a way of satisfying my enormous apetite for English soccer, and the club of my heart, Aston Villa. I would not deny that this was a great bonus for me, in spite Villa playing poorly that season, but little did my colleagues know that Aston for me was more than soccer. Aston was also the place for a blast furnace in the Stour Partnership, the topic for this study, and Bromford forge, pictured in the study, lies just outside the borders of Aston. An even closer connection between my love for soccer and my interests in British iron industry is the Holte Family. They have given name to ‘Holte End’, the stand at Villa Park where the most devoted Villa Fans experience success and despair, as well as being the most important landowner in the area on whose land ironmaking took place. Yes Aston is important.

Many are the friends and colleagues who have helped me while writing this text. First I must mention Maxine Berg who invited me to stay a year at Warwick. Maxine not only arranged all the practical matters, but she, with her family, also ensured that I together with my family felt more at home in Britain. The late professor John Harris from Birmingham read the whole manuscript and not only made some valuable comments but also corrected my English. The latter task was completed by Lynn Karlsson, who also edited the text and helped me with all computer related problems. (In editing the text she was at one stage helped by her ‘editorial assistant’ Anna Rydén, my eleven year old daughter, who thought that her dad had ‘probably written an agreeable book’.) As always the text was read by Anders Floren and Inger Jonsson. Kersti Ullenhag also read the manuscript and made comments.

Lastly I want to mention my colleague from Wales, Chris Evans. Had it not been for his help and advice on all aspects of the British iron industry there would not have been any text at all. He has directed me to different source material, answered any question on details of the trade and has been a loyal listener to all my ideas. Chris is, however, not only a colleague. He is also a very good friend who makes my trips to Britain something more than just scientifically rewarding.
My research on British ironmaking has been made possible through generous grants from Rådet för Arbetslivsforskning, Stockholm, (Swedish Council for Work Life Research), earlier called Arbetsmiljöfonden, The Sasakawa Young Leaders’ Fellowship Fund Committee, Uppsala, and lastly Jan Wallanders och Tom Hedelius’ Stiftelse för Samhällsvetenskaplig forskning, Stockholm. It goes without saying that I am very grateful for their generous support.

When I was busy working on the final version of the text Richard and Danny Thompson released a CD called Industry. One of the songs was called Tall Chimneys, describing work in a blast furnace, had the line ‘pig iron, pig iron, making pig iron’. This text is written with that line in my head.

Uppsala, January 1998
Chapter 1:
A Swedish Perspective on the British Iron Industry

From the beginning of the nineteenth century it was obvious that the Swedish iron industry had lost ‘the battle’ of the British market. Powered by the coal using technology, and especially with the recent spreading of puddling and rolling, it became possible for British producers to gain, for the first time, supremacy on its own home market. This would also, in the near future, lead to a hegemonic position on the world market for iron. What the British ironmasters gained their Swedish counterparts lost. It became from the end of the Napoleonic wars clear to the latter that they stood at a crossroad and that they faced a grim future in which the survival of their industry was at stake.1

Early on representatives for the Swedish iron industry were well aware of the dramatic changes which swept the industry in Britain. Ever since the early eighteenth century, Swedish travellers, or perhaps rather industrial spies, had visited Britain to study both the industry and the market for iron.2 From the end of the century they sent home information about the gradual introduction of coal in the iron industry, and bar iron made according to puddling was described in Swedish as early as 1789, by Sven Rinman in his Bergverks lexicon.3

In 1802 and 1803 the Swedish metallurgist, and employee of the Swedish Ironmasters’ Association (Jernkontoret), Eric Th. Svedenstiema toured Britain. In the summary of his experiences, published 18 13 as Några underrättelser om Engelska Jernhandtering, he analysed the future of a Swedish presence on the British market for bar iron in light of the recent

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1 See Rydén 1997 for a treatment of the Swedish iron trade during this time.
2 For a treatment of one of these travellers, characterised as a ‘Pre-industrial spy’, see Florén and Rydén 1996.
development in iron producing technology. According to Svedenstiema it was possible to produce iron much cheaper in Britain after the introduction of coal in the blast furnaces, the advent of puddling and rolling, and lastly the use of steam power. The competitive situation for Swedish iron became harder and shares on the market were lost.4

This view of the development has, of course, since been affirmed by modern research. The very idea behind T.S. Ashton’s classic study, *Iron and Steel in the Industrial Revolution*, was to show that the iron industry went through a period of rapid change during the second half of the eighteenth century, an Industrial Revolution, and that this was promoted by far reaching changes in technology. It was the endeavours of men like Darby, Huntsman, Watt, Cort and others that made the difference.5

More recent research has challenged this view on a number of points, and especially the question of timing. Charles Hyde published a number of articles and a book in the 1970s that put forward a more gradual view of the development. It was no longer an industrial revolution but rather a more slow and gradual process in which the new technology was introduced in a rather patchy way. Puddling, for instance, was more slow to spread than earlier research had emphasised but this method was on the other hand preceded by a number of other coal using techniques in making bar iron from at least the 1760s. This means that we instead of seeing puddling as the breakthrough in the development rather should see it as the final achievement in a long and gradual process.6

The research on the British iron industry has to a large extent been directed to the matter of technological change, and partly also to the connected question of output.7 We have only been presented with the history of successful technological development and a subsequent rapid rise in production. The story we have been told is how the introduction of coal smelting, puddling, rolling, and the hot-blast changed the course of the industry, and how the iron industry due to a number of successful innovations turned importation of iron into an exportation. There have been few

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4 Svedenstiema 1813, pp. 16-28.
5 Ashton 1924. This view is largely supported by Birch 1967.
6 Hyde 1977.
7 Concerning the question of output see Riden 1979, and Davies & Pollard 1989, and the most recent study of Riden and Owen 1995.
attempts to investigate other areas of the iron trade. The fact is that very little is known even about the actual production of iron apart from the techniques and machines that were used.8

The industrial spies from Sweden noted, however, very important differences between the British way of making iron and the Swedish way, apart from differences in the way the iron was treated in the hearths or furnaces and under the hammers. In 1828 a young Swedish metallurgist, Gustaf Ekman, came to Britain for the first time. He was, as Svedenstierna before him, employed by the Swedish Ironmasters’ Association. His aim, as his predecessors had been, was to gain an ‘on-site’ experience of British iron making. In his case this was supplemented with the more urgent mission of finding new ideas for transforming the Swedish iron industry.9

Ekman achieved this by importing British technology to Sweden. Apart from visiting the gigantic ironworks in South Wales, totally dependent upon the new coal-using technology, Ekman also realised that the charcoal technology was still in use at a few minor works. He visited especially a forge in Ulverston, at that time still in Lancashire. The method they used to make bar iron differed, however, from what he was used to in Sweden. Instead of a chafery they used a coal-fired welding, or balling, furnace to weld the blooms from the charcoal furnaces.

According to the standard analysis of the Swedish iron industry during this time Ekman brought back to Sweden the idea of changing the prevailing method of making bar iron to this more elaborated charcoal method, and especially the welding furnaces and the possibility of rolling charcoal made iron. It proved very difficult to solve the problem of adapting the welding furnace to Swedish conditions but in the mid 1840s he succeeded, and what came to be known as the Lancashire method spread in Sweden at the expense of the older German method.

An older generation of Swedish historians, and metallurgists, have seen this development in a technical framework; the method could not spread before a suitable welding furnace was at hand. They have also foremost seen Ekman’s improvement as a technician’s solution to a technical prob-

8 The most notable exception to this pattern is Evans 1993, who has devoted his book to the study of the social history of work in Merthyr Tydfil around 1800.

9 For an introduction to Ekman and his importance to the development of the Swedish iron industry see Ekman 1944 or Boethius & Kromnow 1947-68, part III. pp.457-511. The next paragraphs are based on these studies.
lem. It is, however, clear that his contributions must be seen in a much broader framework. When we read the official reports written by Ekman on his return from Britain, and also his diaries from his journeys, it is obvious that he did not have only a welding furnace or rolling mills in mind. What he wanted was an overall change in the organisation of the Swedish iron industry in line with what he had seen in Britain.\(^{10}\)

According to Ekman an industrial way of organising the iron production prevailed in Britain as opposed to the more artisan- and craft-based production that existed in Sweden. It is not totally clear what he meant by ‘industrial production’ but a more integrated production, from the mines to the marketing of the ready-made iron, organised more as a continuous process seems to have been very important. What Ekman had found in Britain on his journeys was not only a lot of new machines and furnaces, but rather a different way of organising iron production. Of course the technological development was an important feature in all this, but it was none-the-less only one feature in a much bigger totality.

In the light of this information it seems very plausible to assume that it was not only the technology that had changed in the British iron industry. The development also included changes in the organisation of production. The British iron industry in the post-Napoleonic period was not only structured around an industrial technology, as has been highlighted by much research, but also around an industrial organisation of production. If this was the case, and there seems to be no reason to doubt this, we face the problem of its origins. An industrial organisation of the iron production existed in the 1820s, but when did the artisan craft production give way to this new form of organisation?

As I have already emphasised there are very few studies on the British iron industry not devoted to the technological perspective. The aim of this article is, however, to take a different starting point, and discuss the social organisation of iron production, and the matter of work. The purpose here is not, however, to study the changing forms of organisation throughout the whole process of industrialisation, the development of an ‘industrial organisation’, but rather to make a small contribution to such a study. In this article I will deal with the organisation of production and work in small British forges in the third quarter of the eighteenth century, at the

\(^{10}\) For an extensive treatment of Ekmans seen in this light see Rydén 1994.
onset of coal-using technology. The aim is, thus, to examine the situation out of which a new industrial organisation emerged.

Industrial organisation is a difficult notion to come to grips with, especially in periods of rapid change. It is for instance, as was said above, hard to detect what Gustaf Ekman really meant when he was using the term in the second quarter of the nineteenth century. Sweden lagged behind Britain and it might have been difficult for a Swede to pinpoint the exact nature of the difference. In any case the term implies some kind of connection between, on the one hand, production and work, and on the other, production and distribution. Without going into this matter in any length it shall here be stated that the organisation of work is at the centre of this article, but this feature cannot be studied in isolation. I will therefore first deal with the overall organisation of production, and its relation to the market, thereby creating a framework for the subsequent treatment of work in the forges.

The argument of this article is based on a study of an impressive set of business records from The Stour Partnership, one of the most important owners of ironworks in Britain in the eighteenth century. The archive material cover most of the eighteenth century and part of the next century. In this study I have used material covering the period from 1750 to 1785. The bulk of the records consists of the so-called General Accounts. These can be used in order to gain information about the overall organisation of production, but they do not tell us much about the nature of the work process in the workshops. This can, however, partly be dealt with by using the one single volume of weekly accounts that still exists. It covers two of the forges belonging to the partnership, Cookley and Wolverly, for the years 1763 to 1766.

For a Swedish readership, with a knowledge of the very excellent quality of the source material from the Swedish ironworks, it might be necessary to emphasise that the source material from the British iron industry is in a much inferior state, and especially so concerning the organisation of production and work. Partly this can be explained by the prevalence of in-
ternal subcontracting, by which the ironmasters delegated control and direct management to a few skilled artisans. The business records therefore only have entries dealing with the relationship between the masters and their artisans. The Weekly Accounts saved from Cookley and Wolverly forges do, however, give some details of ‘the Worlds of Labour’.

The Stour Partnership’s business records will be complemented primarily by information from an extensive diary written by one of those Swedish industrial spies mentioned earlier. Reinhold Angerstein, employed by the Board of Mines (Bergskollegiet), travelled around in Britain from 1753 to 1755. His still unpublished diary is filled with valuable information on most aspects on the British iron industry. Angerstein was a skilled ‘industrial spy’, more or less constantly travelling on foot throughout Europe in the 1750s, and the information given to us from his diary seems to be fairly accurate.

Another valuable source is the very short diary written by the British ironmaster Charles Wood on a short tour in the West Midlands in 1754. He visited among other places both Cookley and Wolverly.

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15 This diary was edited by Charles Hyde and published by West Midlands Studies in 1973. It will be quoted as Wood 1754.
Chapter 2:  
The Political Economy of Making Bar Iron

Ironmaking has always been a costly enterprise, and in the eighteenth century it was normally beyond the reach of individual producers to establish production on their own. They could hardly come up with a capital sufficient to erect blast furnaces, forges and slitting mills. This was done by a group of entrepreneurs, ironmasters, whose efforts are intimately connected with the rise of ironmaking from the Early Modern Period.16 This means that at least from this period we have a structure of the industry where there is an owning body, the ironmasters, and a group of producers, the ironworkers. We thus have the structure of a capitalist enterprise with ironmasters investing in heavy capitalised production units, mines, blast furnaces, forges, slitting mills, etc. in the hope of profit. The actual production: the smelting of ironstone and subsequently its refining into marketable iron of different forms, was left to the fillers and keepers in the furnaces, the forgemen in the forges, etc.17

Making profit out of the iron industry meant, however, involvement in a highly competitive iron market. One of the key issues of the British iron market from at least the sixteenth century was that home production of iron was insufficient to supply the demand. This problem got worse during the succeeding centuries as demand rose faster than home production. From the beginning Spanish iron penetrated the British market with great success, but from the seventeenth century a growing competitor was Sweden, whose iron production had risen significantly since the beginning of the century. Until the 1760s Sweden was the main supplier of bar iron to

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16 A somewhat different pattern prevailed in Sweden where pig iron production was in the hands of a group of ironmaking peasants. A co-operative form of enterprise existed in many mines as well as in furnaces in which the peasants were both owners and workers. See Rydén & Ågren 1992, for an introduction. There are also a few examples of forgemen owning or leasing their own forges in seventeenth century Sweden. See Florén 1994a, p. 28.

17 I am not taking into account that most of the kommasters did not own the land on which they had their ironworks, but leased it from landlords. See for instance Raybold 1984.
Britain, and the annual imports of iron rose to close to 20,000 tons. From the middle of the eighteenth century Russian iron was sent to Britain in quantities similar to the Swedish tonnage, and during the second half of the century bar iron from the Urals overtook the role previously held by Swedish iron.18

Around mid-eighteenth century nearly to 30,000 tons of bar iron entered British ports annually, roughly half of it from Sweden and the rest from Russia. At the same time British producers themselves made close to 20,000 tons. This meant that on the British market for bar iron roughly 50,000 tons had to find a purchaser, and one would expect the competition to have been fierce. By 1780 the volumes of bar iron entering the British market had increased. The British producers made more than 23,000 tons while imports had risen to well over 40,000 tons. It is quite possible that the total amount of bar iron entering the British market annually came close to 70,000 tons.19

It is, however, doubtful if we should see the British market for bar iron as a ‘one market’ with all producers competing for the same consumer. It is more likely that we are dealing with a number of different, but closely connected markets, or layers of a market, each demanding bar iron of different quality and price. There may also have been a spatial division within Britain whereby foreign iron had more difficulties in penetrating regions further away from the ports.20 When it comes to quality British iron seems to have been softer than Swedish iron and therefore easier to work with for blacksmiths and other users. It was, however, often cold-short and therefore brittle when cold and only used for commodities where durability was not required. A large part of the British iron was used in the nailing trade. Swedish iron, on the other hand, was more difficult to work with but it would last longer. The iron was ‘tough’ and used, for examples, in making edgetools and anchors for the British navy. A special case was the high-quality bar iron made in eastern Sweden, the so-called ‘Öregrund iron’. It

18 Hildebrand 1958 and Hildebrand 1992, pp. 25-42. See also Thomas 1993, essay 1 and 3
20 This would mean that the West Midlands were on the edge of the reach for imported iron, and therefore a ‘fairly safe’ region for British made iron. The navigable Severn was, however, a very good way of transporting iron into the region. The Stour Partnership did in fact import Russian (and a little Swedish) iron themselves. In 1745, for instance, they bought 381 tons from Muller and Crowley in London, and 1750 26 ton of both Swedish and Russian iron was slit to rods at Park Mill. See the accounts in K.M. during the 1740s and 1750s. See also Kaplan 1995.
was the only material tough enough to be used in steelmaking. After the mid-eighteenth century the expanding steel industry in Sheffield demanded increasing quantities of Öregrund iron. The Russian iron (apart from types like the ‘Zobel iron’ which was suitable for steel making) was similar to the British iron and therefore more of a threat to British producers selling to the nailing trade.  

In spite of the emphasis in earlier research that the British iron industry was stagnating during the first half of the eighteenth century, mainly due to cost disadvantages, it is today clear that it was organised in way which allowed it to cope with ‘the enemy without’, that is imported iron from Sweden and Russia, to use a phrase originating from the pen of Chris Evans.  

During the later seventeenth century a number of large and powerful regional partnerships were created, each of them consisting of mines, coppice woods, blast furnaces, forges and slitting mills. A few of them were also involved in nail making, if not directly as suppliers of rods to the nailers, at least indirectly by selling rods to merchants who in turn dealt with the nailers. This means that the British iron industry even if limited in scope was well integrated, not only between different stages of production but also between production and markets.  

Coming back to the core of this article, production and work, we can clearly see that the British producers of bar iron, the forgemen, were integrated in a broader framework where their work was very much inordered in a structure where large integrated partnerships dominated the industry. The production of bar iron was one link of a production chain starting in the mines and ending at the market. Most of the British bar iron went to slitting mills to be turned into rod later used by the nailers. The structure of the market governed the production, and British forgemen did not produce for an unspecified market; they made bar iron for a clearly defined market, and most often the direction of the iron was towards nailing.


22 See Ashton 1924 and Court 1938. For the phrase see Evans 1994, p 45  

23 For a discussion of the regional partnerships see Johnson 1952, and for the connection between iron production and the metal trades see Rowlands 1975 and Hey 1972.
The Stour Partnership

The Stour Partnership, examined in this article, is an excellent example of one of these partnerships so typical of the organisation of the British iron industry during the eighteenth century. It originated from the first years of the century when Richard Knight took over some works in the Stour Valley from the most powerful partnership in the country, The Ironworks in Partnership controlled by the Foley family. Knight also became a member of this group. In 1710 he held three shares of a total of 25.24

The works taken over from the Foleys included the forges at Cookley and Whittington. With the formation of the Stour Partnership in the 1720s these forges were ‘united’, as Laurence Ince put it, with the blast furnace at Hales, and the objective seems to have been to form an integrated enterprise. The partnership expanded and in 1728 Wolverly forge was added. A few years later Lower Mitton forge was purchased and in the early 1740s the Upper Mitton forge was brought in. A last important addition came with the purchase of Aston furnace and Bromford forge in 1746, and the building of a slitting mill at Nechells Park. The last three units were located close to Birmingham.25

After some formative years the Stour Partnership can be said to have been completed towards the end of the 1740s. It was an integrated production organisation consisting of two blast furnaces: Hales and Aston, six forges: Wolverly, Cookley, Whittington, Upper and Lower Mitton and Bromford, and the slitting mill at Nechells Park. It was, however, not a perfectly balanced organisation as the production capacity of the forges exceeded that of both the furnaces and the slitting mill. As a result large quantities of pig iron had to be bought from other producers at the same time as large quantities of bar iron were slit to rods at independent slitting mills.26

24 The Stour Partnership has been the object of three earlier studies, Lewis 1949, Downes 1950 and Ince 1991. All of these studies have had a ‘Company approach and they therefore differ significantly from the aim of this study. The following paragraphs are, however, based on these studies.


26 Already by the beginning of the 1750s more than 2000 tons of pig iron were used in all forges although the furnaces produced perhaps half of that amount. Hales was also closed down in the early 1770s, enhancing this problem.
Concerning the slitting mills Lewis states that they are to be seen as an intermediate stage between the ‘iron industry’ and the metal trades, as ‘an invasion of machinery into the hand made nail trade’. The slitters had a normally independent position although they were really tied to the ironmasters, and gradually the latter began to take over older slitting mills or build new ones. When Whittington forge was closed down in the 1770s it was converted into a slitting mill, and Wolverly mill was bought from Moses Harper, an independent slitter, in 1792.27

However, it must be noted that this difference between the slitting mills and the forges and fumaces, and the fact that we are dealing with one large organisation doing some business with smaller independent production units, should not be exaggerated. The different workshops within the Partnership should be treated as more or less independent from each other but loosely connected by the purchases of raw material and the selling of the finished iron. According to Lewis this was due to the advance in the organisation of commerce compared to the organisation of production.28

The Knight family was always dominant in the Stour Partnership. There were, however, always other partners involved. From the beginning a large share was held by Sir Thomas Littleton, on whose land some of the works stood. When he withdrew, in 1736, his shares were taken over by Abraham Spooner, an ironmonger from Birmingham. A landowner was replaced by a merchant with good knowledge and aptitude in marketing. In 1742 the shares in the Stour Partnership were held by Richard Knight’s two sons, Edward with a half, and Ralph with a fifth. The remaining part, 3/10, was held by Abraham Spooner. In 1754 Ralph died leaving the Partnership in the hands of Edward Knight and Spooner.29

The Knight family was also involved in another iron business beside their involvement in the Stour Partnership. They owned a fumace at Charlcott and a complete ironworks at Bringewood, consisting of a furnace, a forge and a plate rolling mill.30

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27 Lewis 1949, pp. 97-100

28 Lewis 1949, p. 90.

29 Downs 1950 and Ince 1991, pp. 17-24. The Knight family was also involved in another partnership, the Bringewood Partnership, with two furnaces, a forge and a tinworks. See Ince 1991, pp. 7-15.

Leaving aside Charlcotte and Bringewood to concentrate on the Stour Partnership it is, to begin with, striking to see how remarkably stable the production of bar iron was during the thirty-five year period from 1750 studied in this article. It oscillated around 2,100 tons a year, with a mean production of 2,130 tons. There were, however, differences among the six forges, with two of them producing far more than the other four. Both forges at Mitton produced an annual mean of 470 tons while the others produced well below 400 tons; Bromford 365 tons, Wolverly and Cookley roughly 320 tons each and Whittington 285 tons.31

Figure 1: Bar iron production by the Stour Partnership, 1750-85.

Source: Knight Manuscripts, General Accounts 1750-1785

Almost the entire production of bar iron went to the slitting mills. Bar iron from Bromford was sold on the Birmingham market on a few occasions in smaller quantities, but the rest was slit to rods. As the partnership only possessed one slitting mill, it had, as was noted above, to use the services of independent mills. Iron from Bromford was slit at Park Mill, while the rest of the iron went elsewhere. In 1765, for instance, the iron from the forges at Mitton and Wolverly went to Wolverly Mill owned by Moses Harper, while Whittington iron was sent to Stourton Mill. Hyde Mill was also used by the Partnership during the period.32

31 Knight Manuscripts.
32 Knight Manuscripts, vol 154. See also Cooksley 1981
It is important to note that the partnership did not sell their bar iron to the independent slitters who then could sell the rods. Instead they paid the slitters to undertake this task on commission, meaning that the marketing of the iron remained within the partnership. Knight and Spooner thus sold rod iron, although they did not have the capacity to slit all of their own production. We could see this as a way of internalising a market relationship within the partnership.

After being turned into rods the iron was put on the market. Most of the rods were used, as was indicated above, in the nail trade. The West Midlands was the centre of nail production in Britain at the time, with as much as 9,000 tons of iron being consumed annually in nail making. *Aris’s Birmingham Gazette* stated in 1754 that ‘little less than one third part of all the iron that is made and imported into England is worked up within the compass of six miles of Dudley.’ If we add other metal trades to the nail trade, and at the same time deduct iron consumed in Scotland and Wales from the 50,000 tons mentioned as a figure for the total amount of iron annually passing through the British market, it is not unlikely that this area consumed a third of all the bar iron. The Stour Partnership were thus selling rod iron on a very large market indeed, probably the largest in the world at the time.

Marie Rowlands has studied this market, as she puts it, ‘before the industrial revolution,’ and she has used the sale of bars and rods from the Stour Partnership in the period 1750-60 as one example. The conclusion she draws from her study is that those who bought the iron were a ‘numerous body’ of different customers, ranging from ironmongers to other kinds of smaller customers such as ‘wholesale chapmen’, ‘petty chapmen’ and even some artisans. They differed quite significantly from each other, with a small number of purchasers buying large quantities while the majority bought very little. Not even the big customers, however, purchased iron in any large quantities. In 1765 the largest single purchase was 94 tons bought by Mr Francis Homfray. The picture Rowlands gives us is of a sellers’ market with a large number of customers but with a limited number of sellers. She emphasises very strongly that ‘Midland ironmongers and smiths were buying as much iron as the ironmasters could produce’. What she seems to mean is that there was always a demand for

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33 Quoted from Rowlands 1975, pp 54-55.
British produced iron, at least in the West Midlands where nailing and other metal trades were concentrated.34

Rowlands' idea of a constant demand for rod iron that was capable of consuming the entire production of iron does not really fit with the accounts from the Stour Partnership. Instead, there seems to be a slightly more complicated relationship between the market and the output of iron. The making of iron within the Partnership was fairly stable, oscillating around 2,100 tons a year, but the annual sale volumes varied more considerably. The annual mean sale for the period was 2,065 tons, 65 tons less than mean production, but the variation was much greater in the annual sale figures. In 1782 only 1,551 tons of iron was sold compared with the maximum sale of 2,580 tons in 1758. The standard deviation tells the same story, with 128 tons for annual production compared with 295 tons for the annual sales.

The difference between production and sales gives, according to plain arithmetic, the variance in the stock of bar and rod iron. The Stour Partnership made iron at a fairly constant level throughout the period with the intention to sell it. If that could not be achieved it was left in stock for later trade. The figures for annual sales and the pattern of stockpiling iron within the Partnership definitely undermine Rowlands' conclusion that the iron market in the West Midlands was an unproblematic sellers market. Instead, the evidence points towards a situation where Knight and Spooner had to adapt to the signals from the market and act accordingly. The production of bar iron and rods was structured to fit the constraints of supply and demand, and price changes were the signals to listen for. Producing for stock might partly offset this, but it cannot change the fact that we are dealing with a competitive market for iron.

Another way of establishing this situation is by examining the price movement over the period. The General Accounts of the Stour Partnership give us the possibility to create price series for the period. There is no information about prices for different qualities of iron, but we can make an annual average price for rod iron by relating the amount of rod sold and the total payments for this rod. As iron was sold from both Bromford/Park Mill in Birmingham and the Stour Works along the River Stour we end up

34Rowlands1975, pp. 58.62 and 68-71, quotation from p61. See also K.M. General Accounts 1765
with two different series. A third series can be based on the small amounts of bar iron that were sold from Bromford.35

Figure 2: The Stour Partnership sales of rod iron and the stock of iron, 1750-85

As figure 3 shows the prices of rod iron varied considerably over the period. Maximum was reached in 1761 when the rod was sold at more than £22 from both the Stour Works and Park Mill, while the ‘low tide’ occurred in the early 1780s when prices were less than £17. These figures confirm the conclusions drawn from the fluctuating volumes of sales and the practice of stock piling, that the market for iron in the West Midlands was very much structured within the constraints of supply and demand. It was a competitive market, and not the sellers market Rowlands stated.

Before leaving the market theme there are two more points which ought to be made. The first is that there is a connection, not surprisingly, between the sale of rods and the prices. With a high demand there is a rise in prices.

35 As the stock always was valued in money terms there is a possibility to see price changes there as well. It is interesting to note that the stock was valued at around £2 - £3 less than the market price.
Low demand means falling prices and larger stocks of iron. This does strengthen the conclusion of a competitive market. The second point which must be made is the gradual decline of iron sold from the Partnership over the period. The trend is clear, with a drop in annual sale from over 2,100 tons to below 2,000 tons. This is mirrored in the accumulated figures of stock piling. At mid-eighteenth century the normal stock of rod and bar iron was below 300 tons, while it approached 1,000 tons towards the end of our period. When it comes to the iron prices the trend is not that clear, with only a slight drop from close to £20 to around £19, but measured from the peak in the early 1760s it is clear that prices fell.

We can thus expand our conclusions, that this was a competitive market, by showing that the situation seems to have become tougher over the period, at least from the angle of Knight and Spooner. They sold more iron in mid-century than they did towards its end. This development is also reflected in the economic performance of the Partnership. The General Accounts show a long sequence of profitable years during the period, with losses made only in 1774 and 1779, and an annual mean profit of £3,705. Calculated on bar and rod iron making only, the annual mean profit falls to £2,974, and years with a loss rise to three.

In spite of this impressive row of profit making years it is beyond doubt that profit was falling over the period, exhibiting the same trend as sales of
iron. The peak was reached in 1761 when a profit of £10,617 was made. After that it was more or less downhill until the 1780s when profit rose to levels around £5,000. It might, however, be argued that the way the Stour Partnership calculated their profit is slightly misleading, and that it is not a good guide to their economic performance. Profit/loss is seen as the residual after the ‘charges for production’ had been deducted from the value of sales and stock. This means that the level of profit, shown in figure 4, include the value of the iron made but not sold from the Company. Even though this iron is not accounted at market value, it was still only an unconverted asset. This means that the level of profit for the 1780s does not indicate ‘economic performance’ as well as the levels for the early part of the period does. Less stock was included in the early figures. An alternative way of calculating economic performance rather than noted profit is to deduct the charges for production from the annual sale of rods. We then end up with a series with many more years with a ‘loss’; 1756, 1765-66, 1769-70, 1772-73, 1777, 1779, and 1782 were years when it cost more to make iron than was received from iron sold. With the exception of the first year it is quite clear that the Partnership had a tougher time during the last twenty years of the period than in the first fifteen. This development fits with British general economic development in the second half of the eighteenth century. As Ashton has shown this was not a
very stable period in economic terms. The economy fluctuated between crisis and prosperity, and according to him the years of 1752-55, 1762, 1765-69, 1773-74, 1778-81, and 1784 were characterised by depression.36 The Partnership records reveal, as shown above, a similar pattern with drops in the mid 1760s, mid 1770s and once again at the beginning of the 1780s.37

The aim of the preceding pages has been to discuss, from a general point of view, the market for rod iron from 1750 to 1785, and more specifically, the Stour Partnership in this market. It has been established, contrary to earlier research, that we are dealing with a competitive market. It has also been stated that the Partnership ought to have been an important actor in this market, supplying large volumes of rod, but that it underwent a slow but gradual decline during this period, and especially after the mid 1760s. This last point does not have a direct bearing on a more general discussion of the iron market, but indirectly it does. It has been shown that the trend in rod iron prices over the period was slowly falling, and there seems to be no reason to believe that this was not a part of a more general trend in the market.38 If this is the case it points towards a trade in difficulties. We must bear in mind that this period saw increasing volumes of Russian iron in Britain, at the same time as coal technology within bar iron making made its first impact with the ‘potting and stamping’ method. If prices were falling then production costs had to be reduced; otherwise the profits would wither away.

So far we have only been interested in establishing the structure of the market and the position of the Stour Partnership within this structure, but before entering into the forges and the discussion of work, we have to say something about how the Partnership acted on the market and how signals from the market were mediated into production on a more general level. I will briefly examine two different areas: attempts to control the market, and efforts to cut production costs. A capitalist producer wanting to either improve or secure a position in a competitive market, that is to make a

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37 Knight Manuscripts.
38 Unfortunately no other similar series exist, so it is not possible to make any comparisons.
profit, had either to control the transactions in the market and/or change production in order to make either cheaper or better commodities.39

Most research on the iron industry and the metal trades has emphasised that the only relationship that existed between the two was the market contacts; the former supplied the latter with the necessary materials in the form of bars, rods, sheets, etc. Marie Rowlands was quoted above emphasising this relationship, while Professor Johnson makes it clear that the Foleys left nailing before entering into primary iron production.40 The material from the Stour Partnership supports this view as most of the iron was sold to ironmongers in the West Midlands. I have argued that these transactions were undertaken in a competitive market, but there are signs of Knight and Spooner attempting to offset this ‘competitiveness’ and trying to control the transactions done on the market. In spite of not being directly involved in the nailing business themselves, they definitely tried to control this large and very important market by setting the prices for rods.

In 1754 the Swedish traveller Reinhold Angerstein, of whom we will hear more in the next section, visited the West Midlands. He saw iron-works as well as nailing shops, and he was interested in the organisation of both these trades. He wrote in his diary after visiting the vicinity of Stourbridge:

A Nailer uses rod iron of a hundredweight a week, on which he earns 1 shilling and 6 pence. The cost for this amount of iron was 22 shillings, or £22 per ton. The price has recently been increased by £1½ by Mr Knight and Spooner, who in this country can raise the price of iron as much as they want, even if the common people cannot get more from their work. As a result they have been very enraged and sent a note to Mr Knight in Wolverly with a threat of tearing down his newly built house, which cost £5000, if he does not lower his price to its earlier level. As a result of this threat Mr Knight had to put out guards, with loaded guns and cannon, to protect his house for more than 14 days until these feelings had cooled down. The price of the iron, though, remained the same.41

39 For a treatment of this see Magnusson 1991.

40 Rowlands, 1975, chapter IV; Johnson 1967, p. 115. Exceptions from this rule are found in Yorkshire. See Hey 1972, pp. 42-49.

41 Angerstein I, s. 368f. (A simply fixed translation, and the italics, by GR.)
This does not offset earlier observations that we are dealing with a competitive market for rod iron, with fluctuations in prices as well as in sales volumes and stock piling testifying to this, but it indicates that we ought to treat the Stour Partnership with care. Knight’s and Spooner’s powerful position in the market enabled them to impose, or at least to try to impose, their prices on the market as a whole. According to Angerstein they succeeded in this during the 1750s, but material presented above tells a slightly different story for the rest of the period studied.42

We do not have statistical information on the total supply of iron to the metal trades in the West Midlands during the second half of the eighteenth century, but we do know that the Stour Partnership was a major supplier of rod. As was noted above around 10,000 tons of rod were used for nailing in the area,43 and with up to 2,500 tons supplied by Knight and Spooner this made them a very large supplier indeed. With perhaps as much as a fourth of the market they were probably the largest and the most powerful of the ironmasters in the region, and they ought to have had an important impact in the market. It is not unlikely that they could impose their prices on the rest of the trade.44

This was facilitated by an important feature of the British iron trade in the eighteenth century: the tradition of price-fixing and market-sharing between the different partnerships. Ironmasters regularly met to discuss the trade and to exchange information, and an important part of this was to regulate the trade. A Swedish traveller in the 1720s, Henrik Kahlmeter, reported that ‘nearly all the iron-masters in the country’ (i.e. the region west of Birmingham) met at Stourbridge every fourth Friday ‘to confer on their business affairs and interests, and to agree upon the division of the market for their iron for the month.’45

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42 It is interesting to note that the average price for rod iron at both the Stour works and Bromford/Park Mill increased substantially from 1753 to 1755. At the first place it rose from £18.35 to £20.12 and at the second from £18.64 to £20.69. K.M. General Accounts 1753-55. These levels do not quite reach the levels noted by Angerstein, but he saw the prices in the nail shops while our prices are from the slitting mills. This probably explains the difference.


44 Important to note concerning this is the establishment of the so-called Quarter meetings of the ironmasters. All ironmasters in the district around Stourbridge met every fourth Friday in the town to discuss mutual affairs. Price regulations was one of the most important of these. See Evans 1997.

45 Kahlmeter quoted in Hildebrand 1958, p. 28. See also Evans 1997 for a lengthy treatment of the topic.
The Partnership was thus strong enough to impose their prices on the market, and this was probably most accentuated during the beginning of our period. Returning to the expanding volumes of iron stockpiled by the Partnership towards the end of the period we have another feature that could be interpreted as a strength. Despite their worsened economic performance over the period they kept on producing iron in fairly stable volumes. They were strong enough to be able to produce for stock and not shut down production as soon as the prices went down.

Turning now to efforts to cut production costs it is clear that you cannot remain in a dominant position within a trade simply by controlling the market. Knight and Spooner dominated the market for rod in the West Midlands, but they did not have a monopoly, and other works or combination of works would have increased their shares of the market if the Stour Partnership had not watched over their production costs. The competitiveness of the market meant that the aspects of production costs always remained an important issue.

The cost of making bar iron could be divided into three separate parts: around sixty percent was for the pig iron, either made inside the Partnership or purchased; around twenty percent was for the charcoal and the remaining twenty percent went to a variety of items like rents, the clerk’s salary, tools, the workmen’s wages, the costs of transporting material etc.

Table 1: The charge for making bar iron at Wolverly forge from Ladyday 1764 to Ladyday 1765

<table>
<thead>
<tr>
<th>Item</th>
<th>£</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rent of the forge</td>
<td>60</td>
</tr>
<tr>
<td>Clerk’s salary</td>
<td>35</td>
</tr>
<tr>
<td>Carpenter’s wages</td>
<td>24</td>
</tr>
<tr>
<td>Stocktaker’s wage</td>
<td>16</td>
</tr>
<tr>
<td>Common charges</td>
<td>225</td>
</tr>
<tr>
<td>Pig iron (from different fumaces)</td>
<td>2618</td>
</tr>
<tr>
<td>Charcoal</td>
<td>794</td>
</tr>
<tr>
<td>Pitcoal for drawing out bar iron</td>
<td>150</td>
</tr>
<tr>
<td>Wages for the forgemen</td>
<td>326</td>
</tr>
<tr>
<td>Assorted minor costs</td>
<td>63</td>
</tr>
</tbody>
</table>

Source: Knight Manuscripts vol 154, Stour Works General Account 1765

With this kind of cost structure it is fairly simple to guess where attempts were made to cut the costs. It was either to use less or cheaper pig iron.
and/or charcoal. Seen from the partnership as a whole this matter could be reduced to a matter of saving charcoal, as charcoal also made up a large part of making pig iron. Here we have, briefly, to enter into the much discussed theme of the substitution of coal for charcoal in the British iron industry. I will not discuss this question at length but only recapitulate the main arguments and relate this to the main outline of the development in the Stour Partnership.

As was indicated earlier it is today quite clear that the introduction of coal into the iron industry was a fairly slow and uneven process. Abraham Darby managed to smelt pig iron with coal for the first time 1709 in Coalbrookdale but it was only in the second half of the century that this novelty made any real impact upon the industry as a whole. The same thing happened with puddling. It was invented in 1784 but it was only in the first years of the next century before it made any impact. The ‘coal story’ is, however, more complicated because there were less known methods of using coal, such as the potting and stamping, and because coal had been used in some of the operations in bar and rod iron making from at least the late seventeenth century. Coal was used for heating the iron in the chaferies before it was drawn out to bars, and also in heating the bars before they were turned into rods in the slitting mills.

Two elements in these changes are important here. The first is the use of coal in the chaferies, and the second is the spread of coke smelting during the period under discussion. It is a bit strange that so little attention has been paid to the first of these matters. According to Hyde it was first tried around 1730 and was common during the 1760s. Johnson, however, states that it was tried as early as the 1660s, but only for bar iron of ordinary quality. In the forges belonging to the Stour Partnership coal was already used commonly in the chaferies before 1750. The change was not without its problems as the chaferies had to be rebuilt and the hammermen had to work in a slightly different way. The aspects of costs ought, how-

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46 Ince 1991, gives, as we shall see, some new insights into these questions based on material from the Stour Partnership.

47 See Harris 1988, pp. 30-40, for an introduction to the arguments in the debate of the technological changes.

48 Hyde 1977, p. 8

49 Johnson 1952, p. 33

50 Ince 1991, p. 34. See also the General Accounts, Knight Manuscript
ever, to have made all the difference as coal was much cheaper than charcoal.

When in 1924 Ashton first discussed the reasons for the slow diffusion of coke smelting he mentioned three: Darby managed to keep the invention secret, a special form of coal was used, and lastly the pig iron produced was of low quality and not suitable for bar iron making. According to Hyde, writing almost sixty years later, the last of these reasons was the most likely one, as most pig iron was turned into bar iron, but he nevertheless stated that all three of them were based on more or less false assumptions. He showed that bar iron was being made out of coke smelted pig in the Coalbrookdale forges by the 1730s. It might not have been of the best quality and not at the lowest price, but bar iron was made.

The basic problem with earlier analyses of the process, according to Hyde, is that all historians seem to have assumed that coke smelting produced a cheaper iron than charcoal smelting. This was, however, not the case, and Hyde calculated figures showing that it was not until after mid-eighteenth century that this was the case. The reason why ironmasters in Britain remained loyal to charcoal was not the quality of the pig iron but the cost of producing it.

Laurence Ince has, however, recently reopened the question of the diffusion of coke smelting by questioning Hyde's cost approach. He has done this on the basis of material from three forges belonging to the Stour Partnership: Wolverly, Cookley and Whittington. This is a very suitable 'testing-ground' for this question as it was at these forges that, according to Ince, 'the large scale conversion of coke iron into wrought iron was initiated'.

According to Hyde there was no change in the quality of pig iron from the beginning of the eighteenth century until the second half of the century. The example of Coalbrookdale shows that bar iron could be made

51 Ashton 1951, pp. 32-36.
52 Hyde 1977, chapter 2.
53 Hyde 1977, chapter 2 and 4
54 Ince 1991, pp. 37-41. This is the only point in which Ince, in this book, actually uses the large volume of material excerpted from the Knight Manuscript in order to challenge the present orthodoxy on the British iron industry. Most of the material presented in the many appendices remains unused by the author. On this point he does, however, make an important point directed to Hyde's view. The following paragraph is based on Ince.
from coke pig well before mid-century. What stopped other ironmasters from using this iron was the high price, and it was only after rising prices on charcoal pig and falling prices on coke pig that a change occurred. What Ince does is to start from this thesis and examine the accounts from the forges in the Stour Partnership from the time they started to buy pig iron from Coalbrookdale. He shows that the quality of the iron seems to have improved markedly. The most important point he raises is that the Coalbrookdale forgemen used more than three loads of charcoal to make one ton of bar iron out of coke pigs in the 1730s while their later counterparts in the Stour Valley only used half of that amount.

The conclusion is obvious which is that the coke iron used from 1754 at the Stour forges had completely different characteristics from the coke iron used at the Coalbrookdale Forge in the 1730s. There must have been a technical advantage at the Coalbrookdale Ironworks in the early 1750s which helped to make a coke iron which was far easier to convert into wrought iron.55

The argument I want to raise here is not directly connected to either of these views: whether the cost approach or the ‘quality theory’ should be seen as the sole explanation behind the slow diffusion of coke smelting. What is important for this article, and what I want to emphasize, is that the Stour Partnership was very well aware of the importance of reducing the costs of making bar iron, but without worsening the quality of the iron. If a cheaper coke smelted pig iron could be used after mid-eighteenth century without any negative effect on the quality of the bar iron it was a rational decision to change. I cannot see either Knight or Spooner making the distinction between cost and quality when they decided which pig iron to buy.

It is, however, important to note that Ince shows a gradual change with a steadily larger share of coke pigs. The first attempt to use coke pigs was in 1755, when six tons were purchased from the Coalbrookdale Company and tested at Wolverly. Ten years later more than half of the pig used at the forge was coke smelted, while the other forges also began to increase their share of coke smelted pig iron. The forges in Mitton, producing more quality iron, lagged behind, using only a fifth and a fourth respectively of coke pig in 1765.56 The obvious conclusion to be drawn from this is that

56 Ince 1991, pp. 39 and 49. For information on the Mitton forges see Knight Manuscript, vol 154
Knight and Spooner wanted first to try the new pig iron and see if the market would accept it before starting to purchase coke pig on a larger scale.  

British iron making in mid-eighteenth century was a capitalist enterprise working on a competitive market for bar and rod. 50,000 tons of imported and home produced bar iron were marketed and the competition must have been fierce. It is in this light we should analyse the development of the Stour Partnership, and the actions taken by the owners Edward Knight and Abraham Spooner. They owned six forges that together produced roughly 2,100 tons of bar iron annually for which they had to find customers in order to ensure a steady stream of profits. Knight and Spooner were important actors on the iron market, and they were successful as well. In a national perspective they produced less than five percent of the market but their share of the deliveries of rod to the nail trade in the West Midlands might have been as large as a quarter. The Partnership was an important actor on this market, and we have seen how they used this strength in order to impose their prices for bar and rod iron on the market as a whole.

We have also shown that they were well aware of the costs of making bar iron. The Partnership was constantly trying to cut the costs of production by being responsive to new technological development. They were among the first British ironmasters to use coke smelted pig iron on a large scale in their forges, and they also used coal in their chaferies earlier than most.

It is in this framework of the overall organisation of production and market responses that the question of work will be examined. The forge-men in the forges in the Stour Valley and in Bromford were placed at the very centre of Knight’s and Spooner’s activities. Their work was structured by a wish to make profit, and the performance on the market and the

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57 A word of caution might, however, be needed. Ince (1991) bases his whole argument on a few technical presumptions: The introduction of coke-smeald pig iron raises the amount of charcoal required in the finery and it also took more pig iron to make one ton of bar iron. No proof is shown to establish this relationship. It is likely that this might have been the case during an initial phase when the forge-men were not used to the material, but was this really the case later? It is beyond doubt that more charcoal was used after the change of pig iron, but other reasons might explain this rise in the use of charcoal in the fineries. It could perhaps be that in periods with high prices for charcoal there were attempts to reduce the amount used, but when charcoal was cheap no such restrictions were needed. At these times an extra ration of charcoal could perhaps be used in order to treat the iron in the finery more thoroughly in order to increase the quality. The figures shown by Ince, p. 94, point towards a slight correlation between the amount of charcoal used and its price.
costs of making iron governed their work. From an enterprise standpoint a high quality iron had to be made at low costs and sold at a high price, and from a technological standpoint this was to be achieved be using less input material, such as charcoal, coal and pig iron. In the end, however, all this was governed by work done by the forgemen in the forges. It was their responsibility to do all this; to make the good iron at a low cost, and it is to this work we now turn.
Chapter 3:
Making Bar Iron at Wolverly and Cookley Forges

As was indicated in the introduction very little research has been done on social aspects of the British iron industry, and it is no exaggeration to state that virtually no research has been undertaken on the history of work. This makes the following task very difficult as there are very few points on which to either lean upon for support or to dispute. As a way to partly compensate for this lack of research, comparative material from Sweden is brought into the analyses. This is of course a second-best alternative, but it has to make do. This also means that the analyse has to start from scratch dealing with fairly basic matters.

This second part of this article, dealing with the 1750s and the 1760s, starts by investigating matters like the forges and the forgemen, followed by a treatment of the actual work in the forge and the working time. A third and concluding section deals with the hierarchies within the workforce. All these sections are based upon a limited amount of empirical material left among the Knight Manuscripts, from which it has been possible to reconstruct the organisation of work in the forges. A subsequent part then follows from this foundation, dealing with the organisation of production of bar iron during the decades preceding the introduction of puddling in Britain. An attempt is made to pick up the theme from the previous part of the article, on the need to reduce production costs within the trade. The aim here is to reconstruct the organisation of work at mid-eighteenth century while the aim of the next part is to discuss whether there was a change in the organisation towards the end of the century.

58 Evans 1993a is, to my knowledge, the sole exception. Chris Evans is presently doing more research within the field. See also Evans and Rydén 1998.
Forges and Forgemen

During the eighteenth century bar iron in Europe was made according to two different principles. It was either produced with the so-talled direct process whereby iron ore was smelted and reduced to wrought iron in a bloomery, or with the so-talled indirect process where the production chain was divided into two distinct sub-processes; iron ore was smelted in a blast furnace into pig iron which was then refined into wrought iron. Apart from Spain and some parts of eastern Europe the former principle had by the eighteenth century given way to the more elaborated indirect process, and this was the case in Britain as well as in Sweden.59

The indirect process was however not a totally homogeneous technique of making first pig and then bar iron. There existed a wide variety of slightly different equipment and methods. The basic procedure was however the same. In bar iron making, which is discussed in this article, pig iron was melted and refined in a charcoal fired hearth supplied with air from water-powered bellows. The iron was then taken to a water powered hammer where cinder and other impurities were squeezed out of the iron. The bloom, as the iron then was called, was taken back to the hearth for reheating, before it was shaped to bars under the hammer.

One usually distinguishes between two different methods of making bar iron out of pig iron, or in reality between two different ‘families’ of forging methods, the German and the Walloon methods. The major difference between them was that two separate hearths were used in the Walloon method, the finery and the chafery, with a separation between the refining and the welding, while only one hearth was used for the whole process in the German methods. In the former method different hammers could also be used so that the shingling of the blooms was separated from the shaping of the bars.

In Sweden as well as in Russia, the main suppliers of bar iron to Britain during the eighteenth century, the German method of making bar iron dominated. It was only one-tenth of the Swedish production that was made with the Walloon method. In a few ironworks around the Dannemora mine in east-central Sweden the famous ‘Öregrund-iron’ was manufactured ac-

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59 See Harris 1988, p 11-18, for an introduction to the replacement of the direct process with the indirect.
cording to the Walloon method. In Britain, however, all bar iron was made with this latter method with a separation of the process into two different hearths; the finery and the chafery.60

In Sweden forges using either the German or the Walloon methods did not differ in layout. They were commonly furnished with two hearths and one hammer each. In the former cases it meant two ordinary German hearths while in the latter it meant one finery and one chafery. In Britain, however, there was slightly more variety. The standard seems to have been forges with two fineries and one chafery. The ironmaster Charles Wood denoted these forges ‘double works’. Other patterns were not uncommon, and Wood also visited ‘single works’ with only one finery and one chafery. The Swedish traveller Reinhold Angerstein also noted different forges during his stay in Britain. The forges in Mitton, belonging to the Stour Partnership, included for instance three fineries and one chafery. In Wood’s vocabulary they might have been called ‘treble works’. In Pontypool there was yet another structure and the making of bar iron was split into two distinctive forges; one with three fineries and one with two chaferies.61

The ‘double work’ was, however, the most common form and both Cookley forge and Wolverly forge were double works with two fineries, one chafery and one water-powered hammer. We cannot say anything for sure about the layout of these forges but it ought to be possible to give a fairly accurate estimate using an inventory from Wolverly from 1761 and some descriptions and pictures from other forges owned by the Stour Partnership included in Angerstein’s diary.

Bromford forge was like Wolverly a double work. According to Angerstein the building was a wooden construction. From a drawing included in the diary it is also possible to see that the building was rectangular with the three hearths placed close to three of the four corners. The hammer was placed in the fourth corner. This makes it likely that four water-wheels were placed along the two long sides of the building, two on each side. They gave power to the three bellows and to the hammer. It is not possible to detect which of the hearths was the chafery, but it seems likely that the hearth opposite the hammer was used for the re-heating, as the shaping of

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60 As will be shown below some ironworks might have used the German method in combination with wiremaking.

61 Wood 1754 and Angerstein, part I, pp. 313-314, 362, and passim, and Angerstein part II, passim
the bars ought to have been eased by a closer distance between the hammer and the chafery. This is also made likely as one of the forgemen on the picture seems to be carrying a welded anchony from this hearth to the hammer.62

The hearths in a British forge, the fineries and chaferies alike, were fairly simple constructions. Inside two brick walls and under a chimney, a cast iron ‘box’, the actual hearth, was placed. This box was fitted together by five iron plates that were placed differently according to whether it was a finery or a chafery, and which type of pig iron used, but also according to the wish of the forgemen. A twyer, supplying the hearth with air, was placed through one of the walls and directed into the hearth.63

The inventory from Wolverly does not include the actual building, there are no valuations of either the hearths or the hammer. Instead the most valuable items were the bellows. Two pairs of finery bellows and one pair of chafery bellows were valued to eighteen pounds together. The forgemen’s working tools were another valuable asset worth close to six pounds. The inventory also shows that a blacksmith’s shop was placed inside or adjacent to the forge. A smith’s bellows and two vices were noted at a value of close to three pounds. Apart from different tools and baskets for handling the charcoal and coal and a large stock of different material, it is worth mention that the forge also included scales.64

It is equally difficult to say anything for sure about the workers, or rather the forgemen, of the British iron industry as it is to know anything about the actual layout of the workplace. Once again this differs from the Swedish (and also the Russian) case where the actual numbers of forgemen in different forges at different times can be established with a fair rate of accuracy. The main reason for this is of course the much better source material available for Swedish historians, but also the fact that the organisation of the Swedish bar iron making was circumscribed by a lot more regulations enforced by the state. A sort of enforced guild system existed in the Swedish forges making the forge crews very homogeneous.65

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64 Knight Manuscript, vol 240.
65 See Florén & Rydén 1997 and Florén 1994b.
In the German forges in Sweden a crew of forgemen, (*hammarlag*), was attached to each hearth. It consisted of three persons, the master, the forge-hand and the apprentice. Six persons worked a normal sized German forge.66 The work force was slightly larger in the forges employing the Walloon method. The work in these forges was undertaken by a forge crew consisting of about ten persons, including one master riner, two riner hands, one master hammerman, three hammer hands and two ‘goujarer’ (boys fetching charcoal).67

There are very few references in British literature about the forgemen in eighteenth century forges, let alone the number of workers in *specific*
forges. Ashton, for instance, writes very inaccurately that ‘at each forge there were at least two men assisted by one boy’. He also discusses the feature of apprenticeship and concludes that it was essential in the industry, and that those becoming finers and hammermen had to serve at least three years as apprentices. The forge crew Ashton describes seems thus to consist of two skilled forgemen and one apprentice.\(^{68}\) Ince also has a note about the forgemen in his study of the Knight ironworks, but he is as imprecise as Ashton. According to him between two and four finers were employed at Wolverly forge, and he notes that four persons was the usual number.\(^{69}\)

Angerstein on the other hand is very clear when it comes to the number of workers in British forges. According to him the most common pattern was that three men formed a unit at each hearth, finery and chafery alike. At the ‘double work’ in Caerleon, for instance, there were nine forgemen, six finers at the two fineries and three at the only chafery. In Pontypool, to take another example, nine ‘iniers worked at the three fineries in one of the forges and six hammermen were employed at the two chaferies in the other forge.\(^{70}\) At a few places the Swedish traveller noted some slight alteration from this pattern; at Bromford forge he noted four hammermen at the chafery, while at Monmouth he observed that the two chaferies were worked by two hammermen each, but on the other hand that they only worked them during daytime.\(^{71}\)

The fact that Angerstein stressed that these last hammermen only worked during daytime implies that they worked round the clock at all other hearths, and that the size and structure of the forge crews were connected to the time spent in the forges. It is possible to tie this to information given by Charles Wood in his diary, pointing to some irregularities in the forge crews in the West Midlands. He has no information about the number of forgemen in the forges he visited, but he makes a distinction between hammermen ‘making [bar iron] double hand’ as in Cankwood or ‘singlehand’ as in Burgh and Sutton.\(^{72}\) It must be noted that the informa-

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\(^{68}\) Ashton 1924, p. 191.

\(^{69}\) Ince 1991, p. 34. We will come back to this information below.

\(^{70}\) Angerstein, part I, p. 294 and 313-314.

\(^{71}\) Angerstein, Part I, p. 14 and 329.

\(^{72}\) Wood 1754.
tion from both Angerstein and Wood only points to a ‘part-time’ utilisation of the chaferies and in the shaping of the bars. The fineries seems to have been used continuously. The information from Wood’s diary, whether it was a single or double work, if they worked singlehand or doublehand, together with information from other sources about weekly production and the outlay of the forges gives the following table.

Table 2: The structure of the forges visited by Charles Wood in 1754

<table>
<thead>
<tr>
<th>Forges</th>
<th>Fineries+Chaferies</th>
<th>Works</th>
<th>Working</th>
<th>Weekly prod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burgh</td>
<td></td>
<td></td>
<td>singlehand</td>
<td>4 ton</td>
</tr>
<tr>
<td>Cankwood</td>
<td></td>
<td>single</td>
<td>doublehand</td>
<td>3 ton</td>
</tr>
<tr>
<td>Heath</td>
<td></td>
<td>single</td>
<td></td>
<td>3-4 tons</td>
</tr>
<tr>
<td>Whittington</td>
<td>2+1</td>
<td>double</td>
<td></td>
<td>7-8 tons</td>
</tr>
<tr>
<td>Cookley</td>
<td>2+1</td>
<td>double</td>
<td></td>
<td>10 tons</td>
</tr>
<tr>
<td>Wolverly</td>
<td>2+1</td>
<td>double</td>
<td>double</td>
<td>7-8 tons</td>
</tr>
<tr>
<td>Sutton</td>
<td></td>
<td>double</td>
<td>single</td>
<td>2-2.5 tons*</td>
</tr>
</tbody>
</table>

Source: Wood 1754, Angerstein part 1, Ince 1991 and Knight Manuscript

Note: Although Sutton forge was described as a double work it is clear from Wood’s description that one of the fineries was used to make ‘Osbum Iron for Wire’ while the other was used to make Merchant iron. This implies that one finery and the chafery was used for the latter sort of iron, making 2-2.5 tons, while the other finery was used as a kind of German hearth used for both refining and welding, in the making of Osburn Iron. A Richard Jones who worked that hearth is called ‘the finer & hammerman’.

Putting the information in the table together it seems plausible to assume that a kind of technical relationship existed between the number of hearths and the way these were utilised. In Sutton, for instance, we can see that the arrangement of ‘one finery to one chafery making bars part-time’ produced up to two-and-half tons weekly. Heath forge was also a single work making between three and four tons weekly although we do not know anything about the work at the chafery there. But if we assume that they also worked a reduced time at their chafery, the production figure is roughly half of the make at the double works at Wolverly, Cookley and

73 As will be shown later working 'single' occurred at the fineries in Wolverly and Cookley. See for instance the overhead payment of eight shilling for working singlehand at the fineries at Wolverly the 19th of May 1754, K.M. Weekly accounts, vol 243.
Whittington. This makes it understandable why the configuration ‘two fineries to one chafery’ was the most common structure of forges in Britain at the time. A production from two fineries was required to enable a more or less constant production in the chafery.74

What kind of conclusion could then be drawn concerning the workforce of the British forges around mid-eighteenth century, and its technical organisation, from the information presented so far? The material from Angerstein seems to point towards an organisation of three workers per hearth if they worked round the clock, or doublehand as Wood put it. Angerstein has no information about these workers, their differences in age, skill or payment, apart from the fact that they formed some kind of work unit at the hearth. Neither has Wood, but the fact that he makes a distinction between singlehand and doublehand gives a clue to the ‘inner structure’ of the crew. Were Angerstein’s three-man crews at the chaferies in reality only two skilled hammermen and an apprentice, as it was called working double hand? When they worked singlehand, two men working a daytime shift, was it then one skilled hammermen with an apprentice?

If this conclusion is right can we then transplant these findings into the structure of the finery crews, and state that these consisted of two finers together with an apprentice? If so we are back to the information given by Ashton, with one important correction. He wrote that at least two men and a boy worked at each forge but he should have written that two men and a boy worked at each hearth.

From this more general discussion on forgemen in British forges during the eighteenth century we shall now concentrate on the forges at Wolverly and Cookley. Incé stated, as was noted above, that between two and four finers were employed at Wolverly, with four as the most common number. He also gives us the names of four finers.75 It is, however, possible to improve his analysis of the work organisation in these forges, by using the one volume of weekly accounts, stretching from 1763 until 1766. It seems as if this volume is the sole item saved by chance in a series of similar volumes. We could analyse this material in the light of recent research indicating that so-talled cost accountancy was not as poorly developed in Brit-

74 I have not at this stage discussed what impact the different quality of the bars would have on production time and organisation. This might be the explanation for the difference between weekly production at Wolverly and Whittington on the one hand and Cookley on the other.

75 Incé 1991, p. 34.
ain during the eighteenth century as earlier research has stated. These weekly accounts are a type of cost accountancy in its embryonic form.\textsuperscript{76} The weekly accounts from Cookley and Wolverly forges consist of a weekly summary of all cost elements in bar iron making. There are five entries that appear every week: payments for making blooms and drawing bars, based on the weekly production, the weekly wage for the stocktaker and the carpenters, and lastly the so-called 'common charges'. Complementing these entries there are others that occur more irregularly. Included in these are payments for transports of pig iron, coal and charcoal. Four weeks every year, ending a three month period, a number of other entries appear, entries that do cast some light on the organisation of work. It is to these we will now turn for an extended analysis of the organisation of production and work in Cookley and Wolverly forges.\textsuperscript{77}

The finers at Wolverly, like their colleagues in Cookley, were paid a so-called overhead every three months, before agreeing to work at the forge. As the weekly accounts cover a period from the end of 1763 to the beginning of 1767 it is possible to follow the payment of these overheads and from that uncover the number of working forgemen during each quarter.

This, however, easier said than done, as the payments do not occur on a regular basis. The forgemen seem mostly to have been paid 'the overhead' in advance but sometimes they may have been paid at the end of the period. It also happened that some finers were willing to enter into a longer relationship with the owners of the forge and were subsequently paid for a longer period than three months, while others remained tied to the payments every quarter. To draw any conclusions from these payments to the finers is therefore a very tricky business, but it is, in spite of the difficulties, possible to gain some insight into the forge crews at Wolverly and Cookley during these years.

The first striking feature which appears from the accounts is that the overhead payments seem to have been related to the guineas, and that two guineas were the most common amount, followed by one guinea. At Cookley, for instance, two finers, J Raybould and J. Scott, were both paid two guineas while two others, J. Dunn and J. Highley, were paid one guinea each on the 17th of March 1764. They were to work as finers for the

\textsuperscript{76} See Wilson 1995, p. 29f. for an introduction to the debate. It should not be forgotten, however, that compared to the Swedish source material from the time it is fairly poorly developed.

next three months. A second feature is the system whereby four finers were paid two guineas each and two finers were paid one guinea each. Using the above example it is clear that both T. Lea and J. Port had been paid overhead for the same quarter well in advance. Lea was evidently prepared to sign on as a finer for a whole year when he was paid eight guineas on the tenth of December 1763.

If these differences in overhead payments are to be seen as denoting differences in skill or status, it seems as if we have traced the same kind of forge crew in Cookley as was discussed above, with two finers and one apprentice forming a unit undertaking the work at one finery. The evidence for this structure is, however, not clear for the whole period. In Wolverly, for example, there seem to have been five finers, four with two guineas each and one with one guinea, for most of 1764. In any case it seems at least plausible to imagine that we frequently had forge crews of two finers and an apprentice at the fineries.

Table 3: *The payment of overhead, in guineas, to Cookley finers, 1763-66*

<table>
<thead>
<tr>
<th>Year</th>
<th>Dunn</th>
<th>Highley</th>
<th>Evans</th>
<th>Lea</th>
<th>Port</th>
<th>Raybold</th>
<th>Russell</th>
<th>Scott</th>
<th>Wilcox</th>
<th>Winton</th>
</tr>
</thead>
<tbody>
<tr>
<td>1763-IV</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1764-I</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1764-II</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1764-III</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1765-I</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1765-III</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1765-IV</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1766-I</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1766-III</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1766-IV</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1767-I</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

This interpretation of the tinery crews at Cookley and Wolverly having two finers and one apprentice at each hearth is supported by an other kind of overhead payments the finers received each week according to the level of output. Some weeks it is clear that they worked with crews below full strength, and for this they got an extra ‘bonus’. The entry in the accounts reads ‘Overh. Single hand Both f’s’. It seems thus as if one could work singlehand and doublehand at the fineries as well.

In relation to this it is interesting to note that the forgemen at the two fineries at each of the discussed forges were paid together. We have information neither about the production volumes nor the wage payments for each finery crew, but only the combined figures for the two. Two conclusions can be drawn from this. As their level of production and their wages are added together it seems logical that they worked the same amount of time every week. It is also likely that these two crews also co-operated in their work. The last idea is strengthened by the fact that the bonus money paid in relation to production level distinguished between working singlehand at one finery and at both tineries. It seems that work at the fineries at Cookley and Wolverly was undertaken by two finery crews, each normally consisting of two finers and one apprentice. In their work of making blooms these two crews were co-operating.

The odd thing about the weekly accounts from Wolverly and Cookley forges during these years is that there are no references at all to any hammermen. The finers had an overhead payment and they seem to have been tied to the forge for a time. The hammermen must have been tied to the forges in some other way. There is no doubt of them being present as bar iron was being made in both forges. We have the figures for production and also the entries in the weekly accounts that a certain amount of money was paid in accordance with this production, a wage to the hammermen. The only way to resolve this analysis of work in the two forges is to return to the information given by Angerstein, and the discussion above, indicating that the forge crews at the chaferies consisted of two hammermen and an apprentice. This ought to be possible without too much doubt as the

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78 See for instance the fineries at Wolverly on the 19th of May 1764, K.M. Weekly accounts, vol 243. See also Lewis 1949, pp. 120-122, for an analysis on this aspect. The weekly accounts does have two separate entries called ‘overhead’. The type of overhead discussed in this paragraph could be characterised as a kind of bonus, while the other type of overhead is more a kind of ‘Quartermoney’.

79 See the K.M. Weekly accounts, vol 243, and Lewis 1949, p. 122
discussion concerning the finer crews seems to be fairly accurately matched with the material from Wolverly and Cookley.

Work and Working Time

With information about both the forges and the forgemen we can now turn our attention to work and the actual making of bar iron from pig iron. As was indicated above there existed a number of different ways of making bar iron, but the overall principle was the same; pig iron was melted on a bed of charcoal and then refined at the bottom of the hearth. After a beating under the hammer the iron was taken back to the hearth for re-heating before it got its final shape under the hammer.

There are a few differing descriptions of the Walloon process in Britain from the late seventeenth and the eighteenth centuries. They differ in some respects, probably due to local differences or because forging was dependent upon skilled workers who changed their work with differences in charcoal, pig iron and the quality of the product they were making. One shift in the forge often differed from the next. It is, however, possible to make a detailed description of bar iron making in Britain using these sources. H.R. Schubert has already done this and the next paragraphs follow Schubert very closely.80

Production started with the finery being filled with charcoal and cinder, or slag, from an earlier shift. Then the pig iron was inserted into the hearth. According to Schubert pig iron in the form of a long piece, a ‘geuse’ to give its originally French name, was used, as in the Walloon region, France, and Sweden. The pig iron was put into the hearth through a hole in the wall of the hearth, with one end placed in the bed of charcoal in front of the twyer. The iron was forced forward into the hearth piece by piece over a set of wooden rollers. The charcoal was set on fire and the bellows were started.

80 Schubert 1952, p 67.70. He uses description made by John Ray from 1674 (included in Rees 1987, p. 357-58), Henry Powle from 1678, Robert Plot from 1686 (included in Ashton 1924, p. 233-34), Emanuel Swedenborg (see Swedenborg 1923, p. 191), Pashley from about 1760 (in appendix by Schubert 1952, p. 72.73) and extracts from an English Encyclopaedia of 1823. He does not use the description by Martin Lister from 1675 included in Percy 1864, p. 598f. See Schubert fora discussion on these sources. See also Ince1991, p 33f. See also Rydén 1991, pp. 76-98 for a discussion of the forging process in Sweden, and the literature referred to there.
The iron gradually melted and sank to the bottom of the hearth, which was then covered with cinder preventing the iron from getting stuck. At this moment the actual work was commenced by the finers, the so-called breaking up. This meant that the iron was lifted up from the bottom of the hearth in order to be more exposed to the air from the twyer. The finers did this by using a long iron bar. The aim of this procedure was to promote the decarburisation process, the chemical reaction between the coal content of the pig iron and the oxygen in the air from the twyer and in the cinder. This was the actual refining of the iron.

According to Schubert this procedure of melting the iron in front of the twyer down through the layer of charcoal was repeated three times, and every time the iron became more pure. After the third re-melting all the iron at the bottom of the finery was gathered and formed into a ball. This piece of iron was called a ‘bloom’ or after its French origin a ‘loop’.

At this stage the iron lump was taken from the hearth to the hammer, with the help of iron tongs, for a first treatment, the ‘shingling’. The purpose was to squeeze cinder and other impurities out of the iron. The blooms were also cut into two under the hammer, and two ‘half-blooms’ were created. (Pashley does not mention any cutting of the blooms into two, but he none-the-less talks of the iron in this state as ‘half-blooms’.)

These were taken back to the finery for a first reheating, whereby remaining cinder was ‘sweated’ out of the iron. At this stage the process also starts anew with more pig iron being melted down in the hearth. The half-blooms were then taken back to the hammer where they were shaped into anchonies. An anchony was a piece of rough iron formed into ‘a square barr in the middle and two square knobs at the ends one much less than the other, the smaller being called the Anthony end and the greater the Mocket head’, to use the words of Plot.

The anchonies were taken to the chafery for further treatment. At first the anchony end was welded for a while before this part of the iron was drawn out under the hammer, while the mocket head required two subsequent heatings interrupted by a treatment under the hammer. The making of bars out of anchonies thus required three heatings and three periods of hammering.

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81 Pashley’s description, appendix B in Schubert 1952, p. 72
82 Plot, in Ashton 1924, p. 234
From information in Angerstein’s diary it is possible both to challenge the above description on an important point and elaborate the discussion further. According to Schubert the pig iron used in British forges were the so-talled ‘geuses’, the very long and heavy sows of pig iron, but that does not lit with descriptions by Angerstein. According to him pig iron of smaller size were used. At one place he is very specific on that point. He describes the sows used in Caerleon, and made at Abercarne, as being up to 75 centimetres in length and 18 centimetres in width. He is also clear when describing how the pig iron is placed in the hearth. He implies that pigs of smaller size were used, and that these were put on top of the charcoal. Angerstein also mentions that pig iron was taken from fumaces to forges on horseback, a thing which also indicates that sows of smaller size were used.

This can be supported by information about the bar iron making at Wolverly and Cookley. At both these forges the weekly production at the fineries was always either in full tons or half tons. It would have been difficult to do this with long geuses gradually melted down in the hearths. If, on the other hand, smaller pigs were used it would be easier to regulate how much iron was made each week.

Two questions arise. The first one, which is practically impossible to answer, concerns timing. Was there a change in procedure over time in favour of using smaller pieces of pig iron? The second, related, question is if this had any implications.

It ought today be beyond doubt that the first half of the eighteenth century was not a stagnated ‘era’ for the British iron industry as Ashton and other have stated. Flinn and Hammersley have both shown that the industry was making a slight, but clearly visible, progress. According to the former this is evident in the number of new fumaces, forges and slitting mills. The industry was also expanding into new areas in Britain, Scotland, Cumbria and the Western coast of Wales. It was foremost fumaces that

83 Angerstein, part 1, p. 298. See also picture 158 where it shows that they intended to cast smaller pieces of pig iron.

84 Angerstein, part 1, p. 297. It is interesting to note that Pashley does not describe the form of the pig iron, nor the way of insetting it into the hearth.

85 A regulated production is seen below in figure 5.

86 Ashton 1924, p. 13.

were being erected in these newly ‘conquered’ regions, while the lion’s share of bar iron production still took place in central Britain. It is therefore plausible to argue that the importance of transportation increased for the industry during this period, and with this also the smaller size of the pig iron used.88

Another important feature having bearing on this discussion concerns the quality aspect. Most British bar iron was cold-short, as it was called, meaning that it was brittle in a cold condition and therefore not suitable for many purposes. It was, however, possible partly to overcome this deficiency, and this could be achieved in two ways: to work the iron more thoroughly in the tinery and to mix pig irons of different quality. Johnson notes three different grades of bar iron; Merchant Bar, Best Mill Bar and lastly Ordinary Mill Bar. The first sort was made only with high quality, tough, pig iron while the latter was made only with cold-short pigs. Best Mill Bars were made with a combination of these. (Johnson also notes that charcoal was used throughout the process of making Merchant Bar, but that coal was used in the chaferies for the other two grades.)89 According to another writer, R.A. Pelham, it was possible to distinguish between four different grades of bar iron, Best-tough, Ordinary-tough, Blend and Cold-short, with the highest grading based on pig iron made from high-quality ironstone from Walsall.90

The result of this long diversion from the main argument is to support the information given by Angerstein on the use of smaller pieces of pig iron in the hearths from at least mid-eighteenth century. They were easier to transport and it also made it easier for the finers to blend pig iron of different qualities. The last point has a bearing on the discussion earlier about an increased competition on the British bar iron market in the second half of the eighteenth century.

If we use Angerstein’s evidence together with the description given by Schubert, we can conclude that between 25 kilograms and 60 kilograms were inserted into the tinery at each shift and it took between one and two hours to make the bloom and shingle it into half-blooms. At Bromford

88 Se for instance Johnsson 1951 for a discussion about this.
89 Johnson 1950, p. 42-43. Mixing, or blending, pig iron meant that two, or perhaps more, types of pig iron was melted at the same time.
90 Pelham 1950, p. 151.
roughly 60 kilograms were inserted and the blooms were made in two hours, while at Caerleon they used half as much pig iron and also half the time to refine it. With a production round the clock the weekly production at one finery ought to have been somewhere between three and three-and-a-half tons. This corresponds very well with the figures presented above, in table 2, and also with Angerstein’s information about weekly production.91

The work at the chaferies went on at a different pace. Schubert mentions that the reheating of the anchony end took a single heating of fifteen minutes, while the mocket head required two periods of reheating. He does not indicate how much time was required for this, but we could perhaps assume that the whole of the anchony was heated in the chafery for less than an hour. As one anchony could be drawn out under the hammer while others were re-heated the production could have been at least an anchony an hour. It is not possible to transform this into tons as we do not know if the blooms were divided into half-blooms and therefore not how much the anchony weighed, and we do not know anything about the length of the bars. It might have taken longer time to draw out a quantity of bars of smaller dimensions than bars of larger dimensions if they had the same weight.92 At Bromford they made seven tons of bar a week compared to six tons at Caerleon. If we assume that they did not split the blooms into two at either place this would make the total number of bars at Bromford to 144 and at Caerleon to 240. Each bar was of course heavier at Bromford, but ought to have taken longer time to make.93

Is it possible to use this general information about bar iron making in Britain to say something about work in Cookley and Wolverly? An easy solution would be to state that bar iron production at these two forges ought to have been undertaken in roughly the same way as the general descriptions disclose, but by using information from Wood’s diary and material from both the General Accounts and the Weekly Account from both these works in combination with the material presented above it is possible to be more precise as to what happened in Cookley and Wolverly.

92 For a discussion of this based on Swedish material see Rydén 1991, pp. 84, 99ff. and 128-131.
93 Angerstein, part I, ss. 14, 294, 313, 346 och 362. These figures are calculations based on information from Angerstein.
According to Wood the two fineries at Cookley were capable of making between seven and eight tons a week using English pig iron. At Wolverly they produced two different qualities of bar iron. At one hearth they used ‘Tubal & Cardiff pigs’ to make Mill iron, and at the other they used ‘Bush River pig’ to make Mill best Tough iron, ‘which they say makes the best Iron in England’. Of the first sort they made three-and-a-half tons weekly, and of the latter only three tons. Wood also noticed that: ‘Their Blooms or anchonies go at 20 to the ton’.94

Many of these conditions seem to have been the same in the mid 1760s. At Wolverly they had, however, switched production to iron of ordinary quality at both ‘rineries and they made at most seven tons a week. This level was not reached every week, but the average production of blooms in both forges during 148 weeks between 1763 and 1766 was 5,1 tons, meaning roughly 2,5 tons per finery per week. We can, however, assume that maximum production per finery was somewhere in the region of three-and-a-half tons, and that weeks with less production were weeks when they for some reason did not work every day.

If we assume, for a start, that seven tons was the maximum production per week, three-and-a-half tons per finery, we can use the information from Wood to take a closer look at work at Wolverly forge. According to him their blooms and anchonies were twenty to the ton. That implies two things: The first is that they did not divide their blooms into two, as the blooms and anchonies had the same weight, and secondly that they could produce 140 anchonies per week at the two fineries, that is 70 anchonies per finery. If they worked for twenty-four hours, as we have already stated, six days a week at both fineries that means that the forge was going for 144 hours, and that it took roughly two hours to finish a bloom, or anchony.

From figure 5 we can detect that work at Wolverly was regulated in some way, as the accounts always show a weekly production given either full or half tons. As it was suggested above that work at the two fineries was divided equally it is possible to recalculate production by the numbers of anchonies made per finery per week. If seven tons of blooms were produced it meant 70 anchonies made at each finery every week, while four

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94 Wood 1754, p. 40. Ince 1991, p. states that the information from Wood is partly misleading as they mostly used coke pigs and obviously made bar iron of ordinary quality.
Figure 5: Weekly production at Cookley and Wolverly Forges 1764

A) Wolverly Forge

B) Cookley Forge

Source: Knight Manuscript, Weekly Accounts, vol. 243
tons of blooms give 40 anchonies, an so on. This can also be recalculated into the likely number of shifts made every week, on basis that every anchony took two hours to make and that they seem to have made five anchonies per shift.

On basis of the information from figure 5 it is possible to state that the finers at Wolverly worked in shifts of roughly ten hours, making five anchonies during this period. At most they worked 28 shifts during a week, making seventy anchonies weighing about three-and-a-half tons. This information can be formalised as in table 4 below.

Table 4: The likely shift system at the fineries at Wolverly Forge 1764

<table>
<thead>
<tr>
<th>Weekly production in the Forge</th>
<th>Weekly production/finery</th>
<th>No of Shifts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons</td>
<td>Anchonies</td>
<td>Anchonies/finery</td>
</tr>
<tr>
<td>4.0</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>4.5</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>5.0</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>5.5</td>
<td>110</td>
<td>55</td>
</tr>
<tr>
<td>6.0</td>
<td>120</td>
<td>60</td>
</tr>
<tr>
<td>6.5</td>
<td>130</td>
<td>65</td>
</tr>
<tr>
<td>7.0</td>
<td>140</td>
<td>70</td>
</tr>
</tbody>
</table>

Source: See Figure 5

With a production organised round the clock, with the finers supposed to make bar iron 24 hours a day, there had to be some trade off for the forgemen between work on one side and rest and sleep on the other. Charles Wood noted that the forgemen at Sutton forge did not have ‘more than 3 hours sleep in the 24’.95 This sounds quite unendurable as the work went on throughout the year. No worker could sustain the hard work of making bar iron in a forge with only three hours sleep per night, day in and day out. Swedish forgemen slept longer although they too worked very long hours. The way work was organised in Swedish forges was by splitting the responsibilities between the two senior members of the forge crew. In German forging the master forgeman and his forgehand worked independ-

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95 Wood 1754, p. 40.
ently of each other. One of them undertook all work during one shift of between ten and twelve hours before resting the next shift, while the other forgeman did the reverse. They were both helped by the apprentice during the first half of their shift. This means that the master and the forge hand worked ten to twelve hours and then had a rest for an equally long period while the apprentice worked and rested five-six hours at the time.\textsuperscript{96}

We have no information about any shift system in British forges at this period, as there is no information at all on how the forgemen organised their work and time, but as the discussion above indicated there was some kind of shift system whereby work was split into segments of time in each of which five anchonies were made. This was interpreted as signs of ten hours shifts. Nothing can, however, be said about the way the finer crews divided their work internally, but a division along the same lines as in Sweden is quite plausible. The distinction between working singlehand and doublehand is a sign of this, and it is also interesting to note that the number of shifts made per week is always divisible by two indicating that they worked the same number of shifts. We must not, however, forget the fact that the two crews also seem to have co-operated in their work, giving the finers a more elaborated flexibility.

Returning to Bromford forge we get some support for this interpretation. We can see that six forgemen were present on the picture, although Angerstein stated that ten persons were responsible for seeing the work done, with four workers at the chafery. The missing four were perhaps taking a rest, before their work started.

Turning to another matter we can also note on figure 5 that there was little or no connection between the work at the iniers and that of the chaferies. Weeks with high production at the iniers correspond with low production at the chafery, at both Cookley and Wolverly forges, and vice versa. This implies that the hot anchonies were not always taken directly from the hammer to the chafery; rather they were left to cool down before being re-heated. In Pontypool, where the process was divided between two different forges, it is obvious that the blooms were left to cool. This implies that the welding took longer time than it need have done, and that a source of productivity gain was not used. If hot anchonies had been used in the chaferies both fuel and time could have been saved.\textsuperscript{97}

\textsuperscript{96} Rydén 1991, p. 88.

\textsuperscript{97} For information on Pontypool see Angerstein, part I, pp. 313-314
It is also clear from the table that the production capacity of the chaferies at both Cookley and Wolverly was higher than the capacity of the two fineries. Weekly production of blooms/anchonies in both these forges could reach seven tons, but it was possible to make as much as ten tons of bar per week. This is also evident in the yearly production, with 287 tons of blooms/anchonies in Wolverly in 1765 as opposed to 299 tons of bar. Additional blooms were taken from the nearby Mitton forges.

Wages, Salaries and Hierarchies within the Forges

So far this part of the article has only dealt with the forgemen, mostly at Cookley and Wolverly, but bar iron making also included other persons in and around the forges. Of utmost importance in our example were of course Edward Knight and Abraham Spooner, but they did not take a day-to-day interest in what was going on at the forges. Their primary concern was with trading, as treated earlier, and their links to the production process were made through a staff of employed clerks. At all five forges belonging to the Partnership in the Stour valley a clerk was employed, with an annual salary of £35.98 According to R.A. Lewis it was their duty to go to the forges once a week to pay all the expenses, including foremost the wages to the forgemen and the other workers.99

These payments were recorded in special books, of which one has survived—the weekly accounts. We can follow the clerks to the forges as they sorted out the financial matters. Most weeks the clerk only paid the workers their wage, but, as was noted above, every three months the payments were larger, including as they did also overhead money to the finers, substantial sums to different persons for carrying different goods, and also payments for coal and charcoal. It is clear that some kind of ‘balancing of the books’ was done every three months.100

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98 At Bromford it says only ‘Salary £20’, but it is likely that it means a clerk’s salary. There is also a salary paid to Abraham Spooner of £9. See K.M vol 154 This may indicate a more active role for Spooner at Bromford compared with Knight in the Stour valley?

99 Lewis 1949, p. 41.

As the payments recorded in these weekly accounts show, bar iron making involved more than paying the forgemen a wage. The production at the forges was arranged in the larger structure of the Partnership, and a steady supply of raw material was as essential as good forgemen. It is difficult to say how this was organised within the Stour Partnership, but within their other enterprise, the Bringewood Partnership, the Knight family employed one person responsible for mining and collieries and two persons who took care of charcoal supplies, as well as the clerk who was responsible for all ironmaking.¹⁰¹

It seems thus very likely that Knight and Spooner also had a small staff of clerks who managed the production within the Stour Partnership. These clerks made sure that raw material was extracted or acquired, they had raw material or ready made iron sent to the right destination, and they paid all the different categories of workers their wages. It is, however, important to note that these clerks, the ‘link’ between the partners and the sphere of production, only administered the production. The clerk responsible for bar iron making only came to the forges once a week, and during the rest of the time the workers were left on their own. During his tour of the Midlands Charles Wood noted that: ‘There is not any Clerk at any of these forges. The stocktaker keeps an Account and delivers it once a week to one of Mr. Knight’s sons.’¹⁰²

A stocktaker was employed at all the forges belonging to the partnership, and apart from keeping the accounts his tasks included taking care of all the materials within the forges, tools as well as raw materials and the finished bar iron. He seems thus to have had a supervisory position within the forge, as a kind of assistant to the clerk. For this he received a weekly wage of six shillings, or an annual wage of just below £16, less than half of what the clerk received.¹⁰³

It is, however, far from clear that the stocktaker should be seen as only a supervisor, and that he was the only person within the forge given supervisory tasks. Some forgemen also got responsibility for keeping the accounts. Michael Raybold, a finer, was for example paid fourteen shillings

¹⁰¹ K.M. Brindgwood & Charlotte General Accounts 1742-1755, vol. 245. See also Lewis 1949, pp. 28-44.

¹⁰² Wood 1754, p. 40

¹⁰³ Lewis 1949, p. 36, writes that ‘The clerks had no staff under them except possibly the a stocktaker.’

54
on October 4 1764 for keeping the accounts at Wolverly for fourteen weeks. John Raybold had the same task at Cookley two years later.104

It is perhaps better to see the stocktaker as a person responsible for the auxiliary tasks connected to bar iron making. Such tasks were also undertaken by smiths and carpenters. Lewis wrote that ‘The nature of the stocktakers’ duties is indicated by their close association with the smith’. In the 1760s there was a smith employed at all the forges belonging to the Stour Partnership. They were paid annual wages of anything from seven pounds to ten pounds. There may have been a connection between the volume of the iron production and the smiths’ wages as they were paid ten pounds at the two large forges at Mitton, while they were paid less at Cookley, Wolverly and Whittington. The connection between the stocktaker and the smith is also indicated by the fact that the latter was subcontracted by the former in the first half of the eighteenth century.105

Another category of workers that should be included in this group of auxiliary workers was the carpenters. We do not know anything about them or their work, except from the fact that they were paid an annual wage and that more than one carpenter was employed at each forge. In 1765 they were paid high annual wages in the region of £25.106

We can now turn our attention back to the forgemen, and the matter of hierarchies and wages. Starting with the finers, we have already seen that they were paid an overhead in advance every three months. For their actual work they were paid a piece rate and an overhead (a bonus) in relation to the amount of blooms produced per week. At Cookley and Wolverly in the 1760s the finers were paid nine shillings and six pence per ton made, and on top of this the overhead was added. As was mentioned in the last section this overhead was dependent upon whether the crews were working doublehand or singlehand. If both crews were at full strength an extra three shillings was paid if weekly production reached five tons. This rose to double that amount if six tons were made. Six and a half tons gave an extra seven shillings and six pence, while a weekly production of seven tons increased the overhead to eight shillings and six pence. If any of the crews were working singlehand the overhead payment were higher than if they

105 Lewis 1949, p. 117.
were at full strength. A third ‘extra payment’ was a bonus received for making blooms from coke melted pigs.107

If we assume that the finer crews consisted of two finers and an apprentice each, and that their payment was divided in accordance with the differences seen in the overhead payments, with the finers paid twice as much as the apprentice, it is possible to calculate the annual individual wage. In the year ending at Ladyday 1765, the finers at Wolverly were paid £136.06.6 for ‘making Iron out of Pigs’, £13.09.06 for ‘Overhead’ and £35.12.0 for working coke smelted pigs. Together this makes £185.8.0, and if we add the Quarter Money for the year, 20 guineas, or £21, we end up with a round sum of £206. If this is split between the members of the two crews the finers received an annual wage of slightly more than forty pounds, while the apprentices got half of that sum.108

The hammermen, making bar iron from the blooms, are, as was indicated before, sadly missing from the accounts. We know, however, that they received a wage for their work, and it can also be established how the payments of bar iron making were structured. The hammermen were also paid a piece rate and an ‘overyield’ every quarter. Lewis states that the piece rate was nine shilling per ton, but that was not the case. Rather there was a slightly increasing scale. A production of three and a half tons was paid only 8.7 shillings while eight tons commanded close to 8.9 shillings. The hammermen were also paid an overyield every three month. According to Lewis this yield was tied to the production volume but that cannot be established for the 1760s.109

Summarising the hammermen’s wages in the same fashion as for the finers, and dividing the amount among the individual members of the hammer crews, consisting of two hammermen and one apprentice, we end up with the following figures. In 1765 132 pounds were paid for ‘Drawing’, that is making bar iron, and eight pounds in ‘Overyield’. This

107 All this is based on my own calculations from K.M. vol. 154, General Acco, Ladyday 1765, and K.M. Weekly accounts, vol 243. See also Lewis 1949, pp. 119-123.

108 This calculation suffers of course from a number of different uncertainties, mentioned above, and it was therefore decided that the figures given are only round numbers. They do, however, give an idea of the amount of money received by the finers.

109 All this is based on my own calculations from Stour Works General Acco, Ladyday 1765, and K.M. Weekly accounts, vol 243. See also Lewis 1949, p. 123.
gives the sum of £140, which gives an annual wage for the hammermen of 56 pounds each and 28 pounds for the apprentice.\footnote{110}

We are now in a position of creating a hierarchy of the persons involved in bar iron making at Wolverly (and Cookley), based on the annual wage paid to the different categories of workers. The hammermen seem to have been better paid than the rest, followed by the finers. The apprentices at both the chafery and the tineries came next in line followed by the stocktaker. We do not know anything about the number of carpenters and cannot say anything about their individual wage, but omitting them the smith was the lowest paid worker at the forge. It is interesting to note that the clerk was paid less than the forgemen, but on the other hand this was only what they received from one specific forge, and it is likely that they supervised more than one production unit within the partnership.

What can we detect from this structure? Could anything be said about the social organisation of bar iron making from the material presented in this section? It is of course difficult to state anything for certain about the social structure and the distribution of power on the basis of such a shaky material on wage payments, but some points can be made, especially if we relate this discussion on wages with the preceding sections, and also make some comparison with Swedish ironmaking. The first point that needs to be emphasised concerns the division of labour. It is quite clear that the division of labour was much more elaborate in these British forges than in that of the majority of Swedish forges. This depends mostly upon the fact that Walloon forging was a divided process between the tineries and the chaferies, with each having their own personnel. Walloon forges in Sweden also had this clear demarcation, but the division of labour in Cookley and Wolverly was even more elaborate than in Swedish Walloon forges. In Sweden all forgemen were responsible for making and repairing their own tools and equipment. In Britain the smith seems to have had this responsibility, giving the forgemen the possibility of concentrating on the work at the hearth and hammer. The stocktaker might have done the same by ensuring that raw material, iron, charcoal and coal, was within reach for the

\footnote{110 For these calculations, as for those connected to the finers, a number of uncertainties exist. We can, however, compare them with the figures from Bromford, where Angerstein noted that four persons were included in the crew at the chafery. They produced more bar iron, but in spite of being four persons also received a slightly larger individual wage.}
forgemen, and giving them the opportunity to concentrate on their main tasks.

Leaving the horizontal division of labour for vertical relationships, it is interesting to note the important position given by Lewis to the stocktaker. According to him the stocktaker was ‘in charge of the day to day working of each forge’, and he was together with his assistants and the smiths, seen as a ‘managerial group’. For this the stocktaker received ‘little more than the other workmen’ in money, but as was seen above both the finers and the hammermen were better paid. From the material presented here the stocktaker should only be seen as an ordinary worker; rather the forgemen being the masters within the forges owned by the Stour Partnership\textsuperscript{111}

In comparison with the Swedish iron industry there are two more points which ought to be mentioned. These are the presence of payments by results and the differences in wages between the finers and the hammermen. Starting with the first of these it must be noted that the wage system for Swedish forgemen was structured in a totally different fashion. Their wage consisted of three different parts: a piece-rate, sometimes adjusted for iron of finer dimensions, extra pay if they used less pig iron than stipulated, and lastly extra pay if they used less charcoal than stipulated. One can say that the system was aimed at a fixed production volume while at the same time saving pig iron and charcoal\textsuperscript{112}

The British system differed substantially from the Swedish system, aiming more towards increasing the volumes of production. Evidently this was done without any monetary incentives to make savings in pig iron or charcoal. It is interesting to speculate why the wage system in the two countries differed, with one supporting a rising production while the other supported an efficient use of pig iron and charcoal. The attitudes towards the production levels seem reasonable. I have argued that the iron industry in the West Midlands was not the sellers market earlier researchers have emphasised, but it was non-the-less situated much closer to the consumers of iron and had to adapt to signals from the market. There may, therefore, have been an advantage if the ironmasters had some kind of incentive system in order to be able to raise production very fast when needed. Payment

\textsuperscript{111}Quotations from Lewis 1949, pp. 116 and 118

\textsuperscript{112}See Montelius 1959, pp. 56-77, for an introduction to the wage system within Swedish bar iron making. It must be emphasised that this system was uniform for the whole country as it was stipulated by decrees from the state.
by results was an essential part of such a system. In Sweden a regulated production policy had been inaugurated by the Swedish state in mid-eighteenth century, and no ironworks were allowed to make more than a certain quota every year. Therefore no reason existed to promote a rising production.\textsuperscript{113}

It is much more difficult to see any logic in the fact that Swedish forge- men had every incentive to save both pig iron and charcoal, while no such system prevailed within the Stour Partnership.\textsuperscript{114} It ought to have been the other way round, as Sweden was a country with larger resources for making charcoal. In spite of the fact that charcoal prices in Britain were not rising as steeply in the eighteenth century as during the preceding one the country nevertheless experienced a relative scarcity of charcoal. It has been argued that there was enough charcoal to keep production of bar iron at a certain level, but not for any further rise.\textsuperscript{115}

If this was so, why were not British forgemen given any economic incentive to save charcoal and/or pig iron? There may be two different explanation for this. One could be that the ironmasters thought that bar iron of high quality should be made, and that this was to be achieved by using as much pig iron as necessary. The other might be that no such regulation could be enforced as the forgemen were the masters of their forges and in total control over the production process.\textsuperscript{116}

On basis of the above argument the last explanation seems the most likely one. The forgemen were in control of their work. Concerning the quality aspects it has already been stated that the British iron industry made a fairly ordinary, i.e. cold-short, bar iron suitable for nail making. This was certainly the case with the Stour Partnership in the 1760s, and there was no need to make any attempt to improve the quality of the bar iron by using more pig iron.

The second point in the comparison with Swedish ironmaking is also connected to the quality aspect. As was shown above it is likely that the

\textsuperscript{113} For a discussion on the regulation system see Hildebrand 1992, pp. II 1-120

\textsuperscript{114} One can actually talk of saving only charcoal as the costs for making pig iron consisted mostly of expenses for charcoal.

\textsuperscript{115} For figures on prices on charcoal see Hammersley 1973, p. 609, and Thomas 1993, p. 66. For the argument that the British production had reached a production plateau from which it could not rise on the basis of its charcoal resources see Evans & Rydén 1995.

\textsuperscript{116} For a discussion of the latter alternative see Evans & Rydén 1998.
Hammermen in Wolverly were paid better than the finers. It seems also likely that this was the case for all the forges belonging to the Partnership. This was not the case in Swedish forges using the Walloon method, where the master finer was better paid than the master hammerman. The piece-rate was paid as one large sum to the entire forge crew, which included the workers at the finery as well as at the chafery. This wage was then divided between the individual workers. At Forsmarks ironworks the master at the finery received sixteen Daler Kopparmynt for every Skeppund made by the crew, while the master at the chafery only got twelve and a quarter Daler Kopparmynt in the 1760s.\footnote{Forsmarks Bruksarkiv, Avräkningsböcker 1765-67, GIIa:3, Uppsala Landsarkiv.}

The reason why the finers in Sweden were better paid was that this part of the work was seen as essential to the quality of the iron. According to the Swedish historical metallurgist Wilhelm Ekman one of the most important characters of this iron was its purity. The finers had to make an iron with as little slag content as possible, ‘a sound iron’, and this demanded skill.\footnote{Ekman 1987, pp. 129-140.} The hammermen on the other side had an easier task. They were to weld the anchonies and then to shape them into bars, but Walloon forgemen did not have to be as accurate with the measurements as the forgemen using the German method.\footnote{Hildebrand 1992, p. 57. It must in this respect be mentioned that extra payments for ‘saved’ pig iron and charcoal was not introduced into the Walloon forging in Sweden untilearly nineteenth century. During the eighteenth century they could use as much of this material as possible as long as the iron were of high quality. See Utterström 1959, p. 315.}

The question is, does the opposite pattern in British forges, with the hammermen being better paid, say anything about bar iron making in Britain? Could it, for instance, mean that in making bar iron at Cookley or Wolverly more significance was attached to the shaping of the bars than to the ‘inner structure’ of the blooms? This could very well have been the case. Throughout this article it has been emphasised that bar iron made within the Stour Partnership was destined for the nail trade, and that this iron did not have to be of high quality. It seems therefore logical to assume that not too much energy was invested in raising the quality of the iron. The hammermen had, on the other hand, the responsibility of shaping the bars in order for them to be further worked in the slitting mills. Could it perhaps be that the bars then had to be of a very specific shape, and within
specific measurements? If so this says something about the distribution of skill, and maybe also of power, within British forges during mid-eighteenth century.

Conclusion

The organisation of production and the pattern of work in British forges has been discussed on two levels; from a more general stand-point and from a specific one dealing with the situation in Cookley and Wolverly forges. The materials used are not ideal, especially if compared with Swedish ironworks archives, and the results are therefore tentative. Summarising the findings as far we can, with a full knowledge of the problems with the sources, the following points are suggested:

Bar iron in Britain was produced according to the Walloon method, with its division between the fineries and the chaferies. In the former pig iron was melted and refined while the latter was used for reheating the iron. The British forges were small industrial undertakings, commonly consisting of two fineries, one chafery and one water-powered hammer.

The organisation of bar iron production was centred around the forge crew. One crew was assigned to each hearth, fineries as well as chaferies, and they consisted of three persons. There is scanty evidence of the inner organisation of these crews but it is likely that two skilled forgemen were working together with another worker with less skill, here called an apprentice. These crews worked at their hearths and on their hammer round the clock for six days a week, altogether for more than 140 hours a week. Evidence from Wolverly forge points in the direction of a shift system with each shift lasting about ten hours. There is no information about the time different forgemen spent in the forge, but it is obvious that there had to be some trade-off between work and rest. One such shift system discussed was the one used in Swedish forges where the two skilled forgemen in the crew divided the work into one shift of making wrought iron and one shift resting. This might have been the case in Britain, but evidence also shows that the two crews making blooms did co-operate with each other, creating a much more flexible organisation.

Concerning the social organisation within these forges it has been established, on basis of an analysis of the salaries and the wages paid to
clerks and workers, that a marked hierarchy, and an elaborated division of labour existed within the forges. The stocktaker, the smith and the carpenters undertook a number of auxiliary tasks, thereby making it possible for the forgemen to concentrate upon the work at hearth and hammer. The stocktaker also had the duty of keeping the accounts, and thereby giving information to the clerk about what was going on in the forges. It must, however, be made clear that the stocktaker did not fulfil any ‘managerial’ duty, and that he has to be seen as a worker. The power in the forges was in the hands of the forgemen, and it seems likely that the hammermen were more powerful than the finers as they were better paid.
Chapter 4:  
Towards the End of the Century – Efforts to Reform

In the introduction it was stated that very few studies on the British iron industry have dealt with the social organisation of production. The majority have only discussed the technological change within the trade, and especially the developments leading to the supremacy of the coal-using technology involving coke-smelting, puddling and rolling. Swedish travellers did note, however, that not only the technology was changing, but also the organisation. They emphasised that an industrial organisation was linked to the advent of an industrial technology.

The aim of this article was not, however, to deal with the development of this industrial organisation; such an aim is far too large for an article. The more limited plan was instead to give a starting point to such a discussion by giving an outline of the social organisation of production and work around mid-eighteenth century. No other such study exists. In this last part I will go beyond the initial aim, and touch upon a few of the themes in the development of industrial organisation in the second half of the century.

We have so far mostly been dealing with the organisation of iron production during the 1760s within one of the most important ironworks partnerships in Britain at the time. We have, so to speak, built a platform in time twenty years before Henry Cort invented puddling and rolling. What happened within the British iron industry during these two decades? We have seen that consumption of iron rose in Britain, and we have also stated, on basis on material from the Stour Partnership, that the competition on the iron market ought to have become more fierce. This was seen in declining rod iron prices and falling levels of profits. Ironmasters had to cut production costs in order to remain profitable, and new ways of making iron were also slowly gaining ground. Coke smelted pig iron was used in the fineries, and coal replaced charcoal in the chaferies. The Stour Partnership was active in both these processes, indicating that they responded to signals from the markets.
I will now briefly discuss two features of the last decades of the eighteenth century, based on the development of the Stour Partnership: whether they used an efficient production organisation and how they introduced new technology in their forges in the 1790s.

**An Efficient Organisation?**

The production of bar iron at both Cookley and Wolverly in the 1760s was not very efficient. We saw above that the utilisation of the forges was well below the production capacity. The maximum production per week, seen in the weekly accounts, and mentioned by both Angerstein and Wood, was achieved only a few times every year, with a mean production per week around 25 percent below maximum possible production. Another implicit feature was the lack of co-operation and co-ordination between the crews at the fineries and the hammermen at the chaferies. On one hand the production capacity in the chaferies was well above the potential of the two fineries at both forges. At Cookley ten tons of bar were drawn out in certain weeks, while bar iron making at Wolverly reached nine tons on a few occasions. On the other hand the anchonies were not taken to the chaferies while still hot, and a possibility to save fuel was lost.

From the viewpoint of this article it is useful to make a distinction between these features. We have in the first place not fully utilised forges and in the second place an organisation of production not yet transformed into a more continuous process, with a more integrated organisation, as discussed in the introduction. Perhaps we might term the second kind of ‘inefficiency’ as a failing to take advantage of an economy of scale rather than an inefficiency in utilising the workshops.

From what was said about the Stour Partnership earlier, it seems unlikely that Edward Knight and Abraham Spooner were unaware that their forges were poorly utilised. If Wood could be informed that maximum production at both Cookley and Wolverly was roughly seven tons of blooms a week, why should not Knight and Spooner be able to calculate that the same forges ought to be able to produce as much as 350 tons annually, and realise that they did not reach that level. The Partnership tried to cut production costs by using coal instead of charcoal in their chaferies from the early eighteenth century and they were among the pioneers of
using coke smelted pig iron. It would therefore be very odd if they did not try to do something about the problem of the inefficient working of their forges.

That is of course if they thought of it as a problem, or if it was in their power to do something about it. On the first point, whether it was considered as a problem, I would like to argue that it ought to have been. In spite of the minor share of production costs comprised by the wages of the forgemen, the capital outlay for the forges was still a heavy burden for the ironmasters. It should therefore have been an advantage for the ironmasters if production could have been concentrated on fewer units. It is also possible to argue that the overhead and control costs would have been reduced with a diminished number of workshops.  

It is possible to gain some insight into the question whether Knight and Spooner were aware of the situation in their forges, and how they handled the matter, by analysing the only major change in the overall organisation of the Partnership during the period discussed. In the beginning of the 1770s it was decided to close down both the furnace at Hales and the forge in Whittington. Evidently the former had been run with losses during most of the 1760s and it stood idle for many years during the decade. Pig iron was blown there for the last time in 1772. Bar iron was made at Whittington for the last time the year before. From the end of the 1760s the sale of rods from the Partnership had started to decline and so had the level of profits. In the light of this a closure of one of the furnaces and one of the forges seems to have been a logical step to handle a difficult situation.  

Ince has very briefly discussed this development. He does not say why Hales furnace was blown out, although his appendix shows losses during seven years in the 1760s, but he states that Whittington forge was closed down as it was mainly operated with pigs from Hales. ‘Whittington was’, according to Ince, ‘the partnership’s forge which was most difficult to supply with pig iron’.  

This does not really fit with the information derived from the Stour Partnership’s Accounts. The most obvious reason for this is that the forge

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120 See Davies and Pollard 1988, for the costs of building forges and furnaces, and Magnusson 1991 for a discussion on the transaction costs, and the need to control production.


122 Ince 1991, p. 21, and appendix 5 and 16, pp. 87-88 and 111-113.
was closed down before the furnace. It can also be established that Whittington took pigs from other furnaces as well, especially as Hales did not produce much pig iron during the 1760s. A third reason for arguing that Ince is wrong is that when pig iron was made at Hales the output was distributed to the other forges in the Partnership as well. In 176.5, for instance, when 425 tons were made only 34 of these were delivered to Whittington while 74 tons went to Cookley and 113 tons went to Wolverly. 123

There must, thus, have been other motives for closing down Whittington in 1771. The most obvious explanation is that the forge either made the most expensive bar iron of the Partnership or made iron of worse quality. It is impossible to say anything about the quality matter as the sales records from the Partnership are massed together in two great lumps, one for Bromford and one for the rest, but when it comes to the costs of producing iron we end up with a surprise. Iron from Whittington was not the most expensive. On average the charge of making one ton of bar iron during the 1760s at Whittington was 14.6 pounds as compared with Wolverly 14.2, Cookley 14.3, Upper Mitton 16.8, Lower Mitton 16.2 and lastly with Bromford 14.9.124

These figures do, however, conceal the fact that the bars made at the forges in Mitton were of higher quality, at least according to Ince,125 so, apart from Bromford situated on its own in the vicinity of Birmingham, Whittington made a slightly more expensive bar iron than Wolverly and Cookley. So if one forge should go it had to be Whittington, but the main motive for its closure was probably not its slightly higher costs but rather an attempt from Knight and Spooner to impose a more efficient production. This becomes visible as soon as the annual production of the Partnership is analysed. As has already been stated the total production of all the forges remained fairly stable throughout the period under discussion, oscillating around 2,100 tons. This remained so even after the closure of Whittington, with Wolverly and Cookley taking on a larger share. The production in these two forges expanded radically, as figure 6 shows, from the beginning of the 1770s. In 1772 both forges reached the 300 tons barrier for the first time in more than a decade, and after that production of

123 K.M. vol 154, General Accounts, 1765.
124 Own calculation based on the Accounts, K.M
blooms, except for 1774, exceeded 300 tons. At Wolverly as much as 350 tons were made in the 1780s.

It seems thus that a more efficient organisation of production was established in the 1770s. The Partnership achieved a more or less stable production volume in spite of closing Whittington forge down. If we assume that no technological or organisational changes were undertaken during the period, and that maximum weekly production remained close to seven tons, an annual production of 350 tons of blooms meant that the forgemen were occupied in their forges for longer periods than they had been earlier. Unfortunately we have no weekly accounts for this period to prove this, but it seems likely that Knight and Spooner tried to cut costs not only by using coke smelted pigs and coal in their chaferies. They were raising efficiency in their forges as well.

Figure 6: The Production of Blooms at Wolverly, Cookley and Whittington, 1750-1785

Sources: Knight Manuscript, General Accounts.

**Technological Change?**

The last section started with the assumption that two types of inefficiency prevailed within bar iron making in the forges belonging to the Stour Partnership during the 1760s. On the one hand production took place at a level well below maximum, and on the other hand there existed a discrepancy
between the production capacity of the ‘bloom department’ and the ‘re-
heating department’. It was established that the Partnership solved the first
of these problems by closing down one forge while at the same time in-
creasing output at other units. This was assumed under the condition that
no technological change had occurred affecting maximum production per
week during the 1770s or 1780s.

The hypothesis of a stable technological development within the forges
of the Partnership means that nothing could be done concerning the dis-
crepancy between bloom making and bar making, unless the forges were
reconstructed. A maximum production at a finery remained at three-and-a-
half tons a week while nine-ten tons could be reached in the chaferies.

No major technological development did take place within the forges we
have dealt with in this article. This is evident from a statistical survey of
the British iron industry made in 1794.126 Both Cookley and Wolverly
were at that time still furnished with two fineries and one chafer each
while the Mitton units had three fineries each. Another two years passed
before anything happened, but by then the whole production organisation
was ready for a total reshaping. At Ladyday 1796 John Knight Jnr., grand-
son to Edward Knight, drew up his plans for the future organisation of bar
ironmaking in the units in the Stour Valley. Stamping and potting was go-
ing to be introduced. This started in 1797 at Upper Mitton forge and one
year later in the ‘siste? forge at Lower Mitton. A couple of years later
puddling was also introduced within the enterprise, and after the tum of the
century the old charcoal based method was surpassed by the new coal-fired
technology. At the same time there was a development to better integrate
the different units with each other. Coke smelted pig iron was still bought
from other producers. This was taken to Lower Mitton where it was retined
before distribution to the other forges where it was puddled into wrought
iron. Cookley was rebuilt into a welding and finishing forge, where the
puddled bar was turned into merchant bar. Most of this was transferred to
the slitting mills at Whittington and Wolverly mill where it was turned into
rod.127

126 Birmingham Central Library, Archives Division, Boulton & Watt MSS, MII/5/10, ‘List of the different Iron Works in England, Wales, Scotland, Ireland to the year 1794’. Quoted as the 1794 list.

Technological development took off within the Stour Partnership in the late 1790s, and within a couple of years the old technology was superseded. Stamping and potting first, and puddling later, became the way to make bar iron. The statistical survey from 1794 and another one of 1788 make it clear, however, that the Stour works were late in transforming their technology. In the latter survey it is shown that 32,000 tons of bar iron were made annually in Britain, and that only slightly more than half of this amount was made according to the old Walloon method. 208 fineries, and subsequent re-heating and drawing of bar, made 16,400 tons of bar iron compared to 15,600 tons made in 60 melting fineries, according to stamping and potting.128

The survey of 1788, which only includes the total production of each county and gives no figures for individual units, shows very clearly that the average annual production per finery was much higher for Worcestershire, where the Stour Valley was situated, than for any other county in the rest of Britain. The figure was 130 tons per finery and year. It is, however, very clear that the future lay within the new technology, as each of the new melting refineries made five tons a week, or more than 250 tons annually.129

A quick look at the list from 1794, with information about individual units and their technical standard, reveals that the new technology was introduced, not in the traditional regions for charcoal-iron, but on the coal fields. 50 melting furnaces for stamping and potting were recorded in the list of 1794. Fourteen of these were in Shropshire, nineteen in Staffordshire and eleven in South Wales. Of the 59 balling furnaces, used for re-heating blooms, as many as 27 were found in Staffordshire.130

This very short treatment of the technological development during the last decades of the eighteenth century shows that Worcestershire, with the Stour Valley, must have been in the forefront of technological development within the old Walloon method. The high average production per finery in 1788 is a sign of this, and so is the important development discussed earlier in which the Stour Partnership started to use coke smelted pig iron.

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128 Science Museum, Weale MSS, MS 371/1, f. 89, ‘List of the Charcoal Works or Furnaces in Great Britain, 1788’. See Evans 1993b, for an introduction to the statistical surveys done on the British iron industry around 1800.

129 The list of 1788.

130 The list of 1794.
in their fineries around mid-century and to substitute charcoal for coal in their chaferies. The Partnership is also seen as an active agent in the transformation of bar iron making in their attempt to create a more efficient organisation in the forges in the 1770s when production remained stable even though they closed down a forge.

It is, however, clear from the national surveys of 1788 and 1794 that the technological initiative had passed the Stour Valley in the last decades of the century. It was ironmasters in the coal-fields of Shropshire, Staffordshire and South Wales who developed the new technology. The Stour Partnership adopted these new technologies, but not before anyone else as they had done in mid-century, but rather a decade after. The Partnership was dissolved during the Napoleonic wars, but iron was still made at Cookley and Wolverly well into the second half of the nineteenth century.
Chapter 5:  
Concluding Remarks

The aim of this article was to set an agenda for future research on the British iron industry. In the introduction it was stated that very few studies have touched upon the social aspects of this industry. Martin Daunton has emphasised the same problem in his recent book *Progress and Poverty*. According to him it is very strange that so little research has been directed to such an important industry.131 Here I have stressed the fact that most studies have neglected the theme of work and organisation of production for fairly narrow studies on technological change.

T.S. Ashton set the trend in the 1920s, in his classical study of the iron industry during the Industrial Revolution, by analysing ironmaking primarily from the entrepreneurs’ perspective. ‘The application of coke to the series of processes and the widespread use of the steam-engine brought other momentous changes’, in his own words.132 Other researchers followed his lead, with Birch and Hyde as the most important. They differed from each other in many respects, but it was technological change that they studied.

Swedish contemporary industrial spies testified that the momentous changes occurring within British ironmaking from the second half of the eighteenth century included other aspects than this ‘pure’ technological change highlighted by modern research. The division of labour was described by Reinhold Angerstein, and Gustaf Ekman stated that British workers did their tasks with more speed than Swedish iron workers. Taken together they imply that something that we might term ‘industrial organisation’ prevailed within the British iron industry. This was taken as the starting point for this article; if a new way to organise iron production was initiated in Britain during the Industrial Revolution, complementary to the advent of a new technology, this deserves more attention than hitherto.

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131 Daunton 1995, see especially chapter 8
132 Ashton 1924, p. 99.
The scope of the article was, however, much more limited than to study the introduction of an industrial organisation within British ironmaking. As has already been remarked, such a scope is far to wide for an article. The aim was instead restricted to two aspects of this process. To reconstruct the organisation of production around mid-eighteenth century, as a kind of starting point for a treatment of the development later in the century, and to insert this organisation in a wider economic framework of British ironmaking. A last part has also briefly touched upon a few points of the development in the later eighteenth century.

As late as the 1760s bar iron in Britain was still made in small forges furnished with two tineries, one chafery and one water-powered hammer, and employing nine forges. The annual production at each such forge was around 250 tons to 300 tons. The organisation of production was centred around the skills of the forges. They were very much in control over most things affecting their work. Pig iron and charcoal was delivered to the forges and bar iron was sent away, but in between these events the forges were their own masters.

The organisation of bar iron making in Britain at the time remained in a few respects fairly inefficient. In this article it has been established that the forges might have been lying idle for long periods. Weekly production was on average twenty five percent below maximum production. There was also a discrepancy between the capacity of making blooms and bar iron making.

It was also established that the second half of the eighteenth century was a difficult period for British ironmasters, at any rate ironmasters in the West Midlands. In spite of a growing demand for iron, supplied by British producers as well as increasing volumes of Russian iron, the prices fell. The level of profits also declined. The Stour Partnership is in this respect an interesting case study as they must have been among the most important iron partnerships within the country.

In order to stay in the market cutting production costs was the only solution, and the period also show signs of a gradually accelerating technological change. The Stour Partnership was among the first to try coke-smelted pig iron on a broad scale, in the 1760s this was the norm, and coal was used in the chaferies already during the first half of the century. The period studied also reveals that attempts were made to come to grips with the inefficiency that prevailed in the forges. The Stour Partnership closed one of their six forges in the 1770s without reducing production volumes.
No further attempts were made to change the organisation of bar iron making until the late 1790s, when the coal-using technology was introduced; first stamping and potting, but puddling furnaces were soon built. When this happened it was, however, already obvious that the Stour Partnership, and other ironmasters in that region, were lagging behind. Bar iron was still made in the Stour Valley during the nineteenth century, and the slitting mills along the Stour still supplied the nailing trade in the Black Country with rods, but the new technology expanded foremost in the coalfields. The technological development of the late eighteenth century and the nineteenth century did not only affect the traditional regions for iron-making in Britain, it also conquered new regions.
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