1 Introduction

The period, 1500-1815, constitutes a distinct era for the English iron industry, as these dates define the period during which iron was made from charcoal by a two-stage process involving a furnace and a forge. This technology succeeded the direct reduction of iron from its ore. It was in its turn replaced by new processes using mineral coal as fuel instead of charcoal. However neither change was instantaneous, the older process in each case continuing in use for many years. This thesis will address some of the outstanding problems concerning the economic history of the industry in the period. These were identified by J.R. Harris as being how much iron was made, why the industry failed to satisfy the home market for iron, why the cost of iron production was lower in Sweden and Russia than in England, and why it took so long after the time of the first Abraham Darby for most iron to be made with coke.[1] Each of these questions will be considered briefly in the following paragraphs. Answers will be provided in this thesis to the first and fourth questions. It will also be shown how home demand for iron was met and how large that demand was. However the answer to the second question to some degree depends on that to the third, and may also require a more detailed examination to be undertaken of the extent and management of English woodlands than will be done here.[2] The third question requires a major comparative study of the iron industry in Russia, Sweden, and England, which must be undertaken by some one fluent in the languages of all three. In addition this thesis will re-examine the technology of iron production, because that had a significant impact on the way the industry developed. It will also examine its macro-economic organisation, which underwent considerable changes over three centuries.

This thesis will also provide data of relevance to wider issues. In recent decades a major focus of research in economic history has been the compilation for the 18th century of quantitative data (such as industrial output and the consumption of goods), most especially for the period at its end commonly known as the Industrial Revolution. A particular difficulty for those investigating this subject has been the quality of the figures that are currently available, whether derived directly from contemporary sources or estimated by modern researchers. Having produced his own index of economic growth from 1730 to 1830, R.V. Jackson wrote,[3]

> 'The data are fragile, incomplete and relate only indirectly to the problem in hand ... The index itself ... rests on slight foundations ... Further manipulation [will not] improve matters ... until we know a great deal more about the production and prices of individual industries.'

The provision of more robust data for the iron trade for its period will be a major objective of this thesis. This will not only include estimates of the amount of iron produced (in chapter 6), but also of the amount manufactured into useful items for consumption and the amount of those reaching English consumers (in

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[1]. Harris 1988, 19-40. Several of these questions were first raised in Flinn 1958.
[2]. Both considerations of time and space have prevented this being done.
[3]. Jackson 1992, 21; Joel Mokyr (1987, 318-9) made a similar point.

chapter 8). However, the quality of these estimates after 1790 will be less good, because there remain considerable difficulties with the data for the output of bar iron from the industry after that date.[4]

The discussions surrounding the question of economic growth and the origins of the Industrial Revolution will be examined in chapter 2. However, before turning to the quantification of production and consumption, space will be given in chapters 3 to 5 for considering the technology and organisation of the iron industry. The remainder of this chapter will be devoted to discussions of the views of historians on the iron industry and of the various factors external to it that affected its development, including transport facilities and political events at home and abroad.

Iron

The account of the iron trade provided by this thesis begins slightly before what Joan Thirsk called the 'Age of Projects'. She claimed cannon production at Buxted in Sussex from around 1540 as one of the first of these 'projects'.[5] Cannon founding was certainly an important innovation, but still more important was the production of iron using blast furnaces and finery forges, and that began somewhat earlier, though also in the Weald.[6] This process and that preceding it (using bloomeries) produced bar iron, which at that period was the most important variety of iron made, because it could be forged into wrought iron goods, such as nails, knives, anchors, scythes, and door-locks, whereas cast iron from furnaces was only used to make a small range of products such as cannon, shot, and cooking pots.[7] Thus began the age which J.U. Nef proclaimed as 'an early industrial revolution'.[8] The period certainly saw an enormous expansion in coal mining, his own special subject, and particularly in coal shipment from Newcastle to London. It also saw much growth in the iron industry,[9] but in the woollen industry, the largest single manufacturing sector, there was no revolutionary change.[10] Nevertheless there were a considerable number of innovations in smaller sectors of the economy with new industries being established in the century up to 1640.[11] Many of the early projects were beneficial to the country in reducing the need for imports or in other ways, but 'projects' later acquired a bad name as they became a means for courtiers to line their pockets by obtaining the grant of monopoly and then creaming off the profits of other men's enterprise. Elizabeth had to recall a number of patents in the last years of her reign. Patents were ultimately regulated by the Statute of Monopolies of 1623, which confined patents to inventions and to a term of 14 years.[12] The period thus saw significant developments in the economy, enabling it to diversify considerably, but it was not one of revolutionary change.

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[4]. This difficulty concerns the numbers of puddling furnaces and the quantity of iron made using them.

[5]. Projects: Thirsk 1978; cannon founding: *ibid.*, 24-7 30; Awty 1987b; 1989.

[6]. Awty 1978; 1979; 1981; Cleere & Crossley 1995, 121-3; Combes & Whittick 2002.

[7]. Several of these goods will be discussed further in chapter 5.

[8]. Nef 1932, 165-9; 1934.

[9]. Nef 1932, 123-4 and ch.1; Dietz 1986; Levine & Wrightson 1991, 25-76; Hatcher 1991, 39-42 and ch.5.

[10]. Coleman 1956, 13-16; Clarkson 1970, 15; Clay 1984, ii, 65

[11]. Gough 1969; Thirsk 1978. New crops were also introduced in this period.

[12]. Macleod 1988, 10-19; Donald 1961, 196-200.

The new technology introduced into the iron industry in the early 16th century consisted of a two-stage process for making bar iron. First iron ore was reduced in a blast furnace using charcoal as fuel and cast into pigs of iron. These were then remelted and decarburised in the finery hearth of a forge and the resultant 'bloom' drawn out into a bar using a water-powered hammer, the bloom being reheated periodically in a chafery hearth. The bellows blowing the blast furnace and also those blowing finery and chafery hearths in the forge were also powered by water wheels, so that the process required prodigious amounts of water-power. This technology, which is reasonably well understood as a result of the work of H.R. Schubert and others,[13] will be described in more detail in chapter 3. The new process was first used in the Weald before 1500 and then from the 1550s spread to other parts of England and Wales, but was hardly adopted at all in Scotland until the late 18th century, which is why this thesis is principally concerned with England and Wales. As will appear in chapter 6, the rapid growth of the industry in the Elizabethan period came to an end in the early 17th century and was followed by a long period when there was a very slow decline in the output of the primary iron industry. However, the manufacture of iron into finished ironware continued to expand by making use of increasing amounts of imported iron, matters which will be considered in chapters 7 and 8.

The two branches of the iron trade, production and manufacture, were largely distinct, each having its own entrepreneurs. The ironmaster 'owned' (or usually more strictly leased) furnaces and forges in order to produce iron. The ironmonger employed smiths, nailers, and more specialist artisans to manufacture it into iron goods suitable for its ultimate consumers. Throughout this thesis the words, 'production' and 'manufacture', are respectively reserved for these two distinct aspects of the iron trade. Iron production was capital intensive involving specialist plant (furnaces and forges) driven by artificial power and with a relatively small workforce. Its subsequent manufacture was labour intensive, the process mainly being manual involving relatively simple equipment, and was commonly carried on by the workmen at home. Nevertheless there were a few processes within the manufacturing phase for which mills were used, such as sharpening edged tools and boring musket barrels. These will be discussed in the latter part of chapter 3. A limited range of cast iron goods, such as cannon and cooking pots, were cast for ironmasters direct from blast furnaces and from the 18th century also at separate foundries, often in towns. This cast iron was a relatively brittle material, incapable of being forged.

While iron production was (as stated) gently declining for the long period from 1620, this was not a period of stagnation, as there were a series of developments in the organisation of iron production, which will be described in chapter 4. From the early 18th century new technology using mineral coal began to be introduced. Its development will be described in the second part of chapter 3, and the reasons for its very slow uptake will be considered in chapter 5. The following three chapters will then seek to quantify the production, import and use of iron and ironware. Considerations of space prevent detailed discussion of the organisation of iron manufacture and of the distribution of ironware.

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[13]. Schubert 1957; Tylecote 1991; 1992; Daff 1973; Morton 1963; den Ouden 1981; 1982: Jones & Harrison 1978.

Before the introduction of coke-smelting in the 18th century, the iron industry was using vast quantities of charcoal. Even when coke began to be used in blast furnaces, charcoal continued to be needed for fining the pig iron to make bar iron. Charcoal was usually made from cordwood from coppices, also the tops, lops and shreddings of timber. As such the iron industry was not directly in competition for wood with the users of timber. Timber (strictly defined) came from trees one foot square at the stub.[14] This was used by joiners, shipwrights, and cabinet makers.[15] Wood for making charcoal was generally sold by the cord, a stack of four foot long sticks (not less than 3 inches in girth), piled 4 foot high and 8 foot long, that is 128 cubic feet.[16] To make a ton of bar iron from its ore six to eight (wain) loads of charcoal were needed. Each load (a precise measure of volume) consisted of a dozen sacks each containing eight bushels.[17] To achieve this measure sacks were 2½ yards long and a yard wide and 'filled so that the coals are 4 foot 10 inches high'.[18] Sometimes, 'bannisters', small hampers that could be hung 'on either side of a horse ... made with a bottom to pull out for the convenience of emptying' were used instead of sacks.[19] It used to be suggested that the amount of iron produced in England declined as woods became exhausted (in the manner of mines),[20] but this is to misunderstand the nature of woods, since they are a renewable resource. Provided simple precautions are observed, particularly excluding grazing animals for a few years after cutting, a wood will regrow and provide a crop of cordwood ready to be cut and coaled after 14 years or so, though some ironmasters preferred slightly longer cycles.[21] The inclosure of woods after they were cut was regulated by a statute of 1540, made permanent in 1572.[22] Using data on furnaces collected by H.R. Schubert, M.W. Flinn argued that there was an expansion in the iron industry after 1660. This conclusion has been examined and refined over the last forty or so years, a great deal of research having been devoted (most recently by P. Riden) to determining the numbers and average outputs of

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[14]. This definition is derived from Statute 1 Eliz. c.15. Statute 35 Hen. viii c.17 s.1 specified ten inches square at three feet from the ground. The cropping and lopping of timber is mentioned in 1607: Staffs. R.O., D593/E/6/6. As to fuel for the iron industry generally note also Flinn 1959b; Hammersley 1973; Bayliss 1987; Jack 1997; Welch 2000.

[15]. While there was no direct conflict between growing cordwood and timber, an owner may have had a choice in managing his woods as to which to of them concentrate on.

[16]. Hammersley 1973, 603 605n.1; Jack 1997, 244. *Cf.* N.L.W., Tredegar 75/1. A dean cord was a few inches larger all round, 8 foot 4 inches long and 4 foot 3 inches wide and high (*e.g.* Ipswich R.O., HA49/II/1, also at Blackpool, Pembs.: N.L.W., Slebech 441) or 4 foot 6 inches by 8 foot by 4 foot: P.R.O., C 115/D24 no.2077. A Welsh cord was 9 foot long 4 foot 6 inches high and 4 foot in the billet or 18 foot by 4 foot 6 inches by 2 foot 2 inches: N.L.W., Tredegar 70/352; N.L.W., Penrice and Margam 5222; West Glamorgan R.O., D/D Yc 623.

[17]. Occasionally a load was made up of eight bags each containing twelve bushels. For example, Edward Knight & Co. at Hales Furnace worked in loads divided into 8 bags, rather than 12 sacks, but at their Aston Furnace, also in the Black Country region, the normal 12 sacks were used: SW a/c. In either case this make a load of 96 quarters, probably weighing a ton (or slightly less): Mott 1959a, 86; Jones & Harrison 1978, 802; SW a/c; Foley a/c; SIR a/c. The average charcoal consumption at Grange Furnace (Staffs.) around 1700 was calculated in l[oads], s[acks], b[ushels], and p[ecks]: E12/VI/KL/12. This makes it clear, contrary to the view of Hammersley (1973, 603), that a load was essentially a precise measure, though possibly less precise in its implementation.

[18]. National Library of Scotland, ms. 993, from contract with Earl of Breadalbane for Lorn Furnace. Despite this being a Scottish reference it is likely to reflect the practice in Furness, whence the ironmasters came.

[19]. Hey 2001, 66.

[20]. This view was expressed as recently as 1981 (Deane 1981, 107), despite the work of Hammersley (1973) and Flinn (1958) mentioned below. The idea may have arisen from the work of T.S. Ashton (1924, 14-15) who referred to 'hunger for fuel' forcing ironmasters to flee to 'the wilderness' and a 'centrifugal tendency' spreading the furnaces and forges into the Midlands and North. However this passage of his work seems to refer mainly to the late 16th century.

[21]. Schubert 1957, 218-21 430; Hammersley 1973, 603-6; Foley E12/VI/KC/81-3.

[22]. Statute 35 Hen. viii, c.17, s.6-11; continued by successive Parliaments including by 1 Eliz. c.18; made permanent by 13 Eliz. c.25. These statutes will be described further in chapter 3.

blast furnaces.[23] This matter will be further considered in chapter 6, where a new estimate of the production of bar iron, the principal product of the industry, will be presented. This estimate will be calculated from the production of forges, which should provide a more robust estimate of the capacity of the industry, because forges operated more continuously than furnaces. It will be based largely on my own unpublished research into the history, topography and output of individual ironworks, which is described in appendix 1. That estimate will also be used to provide a new estimate of furnace output. This estimate of domestic iron production will then be combined with data on overseas trade in chapter 8 to estimate the amount of ironware manufactured in England and the amount sold to consumers.

G. Hammersley examined the supply of wood in England and Wales, and argued that the area of woodland needed to sustain the probable output of the iron industry was considerably smaller than that then existing. However there was a limit to the distance that charcoal could economically be carried, so that only wood that was growing in ironmaking regions was available. Furthermore the profits from growing woodland were less than those from pasture and so provided little incentive for planting new coppices, save perhaps on marginal land.[24] However, the removal of many existing woods was (at least in theory) prohibited by statute.[25] The relatively short distance that charcoal was usually carried has often been attributed to its friability, but the primary reason for not taking it further was the cost of

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[23]. Hammersley 1973, 593-603; Hyde 1977, ch.3; Riden 1977; 1992c; 1993; 1994.

[24]. Hammersley 1973, 603-10; *cf.* Flinn 1959b, refuting Crow 1956; and Nef 1932 i, 161. Hammersley's view is sometimes said to be that the charcoal supply was not a limiting factor on the the output of British iron industry. This is a false caricature, oversimplifying his views. I have come across the caricature on a number of occasions in conversation, but have not actually found it in print. The views of Flinn and Hammersley have been criticised by Brinley Thomas (1986). He sought to argue that there had been an energy crisis in mid 17th century England. He supported his case by referring to the increasing import from Scandinavia of iron and timber. However the main thrust of his argument relates to a calculation in respect of the profitability of iron production, using price series for iron and charcoal, which he obtained from Beveridge 1939 and Thorold Rogers v, 504. Unfortunately the data on which this is based is fundamentally flawed. The iron series relates to the retail sale of wrought (*i.e.* manufactured) iron, priced in pence per *lb.*, not bar iron priced in pounds per ton or even shillings per *cwt.* The value of such finished goods necessarily not only reflects the value of the iron used but also the labour of the smith who made it, which judging by the prices, may often have doubled the value of the finished goods compared to the (wholesale) price of bar iron. Furthermore the iron prices (Thorold Rogers vi, 449-453) are based on a small sample of diverse articles. As Thomas himself recognised, the charcoal series are come from Westminster, Eton, Oxford, and Cambridge, where charcoal was being used as domestic fuel (in institutions). Indeed the first two are in the part of Thames valley where the erection of ironworks was expressly prohibited by statute (23 Eliz. c.5 s.1) to preserve wood as fuel for London, while Oxford lay only just outside it. As Hammersley pointed out (1973, 606; Thomas 1986, 125), charcoal was not usually carried more than a few miles by land. For a commodity, whose market was so intensively local, it cannot be proper to use the prices, which were paid in one place, in a hypothetical argument concerning others. Accordingly, Thomas' detailed case concerning the iron industry rests (at most) on such flimsy foundations that it is impossible to say whether or not his conclusions are correct. There are however other reasons why the charcoal price should have risen in the Thames valley in the mid 17th century. Firstly the population of London (and hence that city's need for fuel) was rising (Finlay & Shearer 1986, 49). Furthermore, the shipment of coal from Newcastle to London was stopped by the Royalist occupation of Newcastle during the Civil War. The price of wood in the Thames valley may not have returned to its former level subsequently. Thomas' work thus confirms that there was a fuel shortage in the London area, but not much more. However, that was already known from the work of Nef (1932) and others on the growth of the shipment of coal down the east coast.

[25]. Statutes, 35 Hen. viii c.17; renewed periodically; 1 Eliz. c.15 18; 13 Eliz. c.25; 25 Eliz. c.25; 27 Eliz. c.19.

its carriage to the ironworks.[26] Accordingly woods in Lincolnshire, Northamptonshire, East Anglia, and Devon, which were remote from any contemporary ironworks, were of no use to the industry.[27] Had there not been an alternative means of satisfying the demand for iron, it is likely that the price of iron would have risen to a level where it would have become economically viable to build forges in such areas to exploit their woods. However competitively priced iron could be (and was) imported in considerable quantities during much of the period under consideration, and in the 18th century much more iron came in from Sweden and Russia than was made here. These imports will be considered at length in chapter 7.

The Swedish economy was very different from the English. Sweden needed to import large quantities of grain from south of the Baltic, but had extensive woodlands. Her principal exports, which paid for grain and other imports, were forest products, such as pitch, tar, and deals, and most particularly iron.[28] Contemporaries believed that the reason Sweden could produce iron more cheaply than England was that wages were lower there.[29] Certainly there is evidence of subsistence wages being paid on Swedish estates.[30] However the lower agricultural productivity of its northerly climate may well have made the cultivation of trees for the production of iron more attractive from the point of view of profit than it was in England. Furthermore forestry provided winter work for Swedish farmers while the ground was frozen, when their English contemporaries were busy ploughing. Nevertheless there was also an organisational difference. In England from the early 17th century (and earlier in the Weald), most ironworks were run by professional ironmasters, who bought the raw materials (particularly wood), often partly from their landlords. In Sweden estate owners often maintained their ironworks to a considerable extent with their own wood.[31] Similarly in Russia ironmasters, such as Nikita Demidov and his descendants, were granted great tracts of virgin woodland in the Urals, where wood cost nothing but the cost of cutting it and carrying it (or charcoal) to the works.[32] As will appear in chapter 4, that was something like the situation in some areas of England and particularly Wales before the building of blast furnaces. However later ironmasters invariably had to pay for their wood, which represented their largest single cost. Nevertheless if woods had not been reasonably profitable to landowners, there can be little doubt that, despite the Tudor statutes for their preservation, they would have been grubbed up and the land converted to pasture.[33] Indeed that is probably what happened in the uplands of Glamorgan when the industry disappeared in the early 17th century.[34]

Hammersley suggested that 'if charcoal supplies were adequate and not too expensive the history of coke smelting may need revision'.[35] This issue had, when he wrote, in fact already been re-examined (though not then published) by C.K. Hyde. Using figures ultimately derived from accounts for Coalbrookdale, Hyde argued that in the early 18th century it was cheaper to make iron with charcoal

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[26]. Hammersley 1973, 606. The fragility of charcoal is for example mentioned by P. Dean (1979, 107).

[27]. There is in fact a belt of low grade ore running from Lincolnshire to Wiltshire, but this was not exploited (and probably not known) in the period under consideration.

[28]. Heckscher 1963, 92 100-1.

[29]. Flinn 1958, 149; Hammersley 1973, 612.

[30]. Hildebrand 1992, 100-8.

[31]. Hildebrand 1992, 85-95. The question of charcoal supply in Sweden is a complex one and cannot be discussed here: Hildebrand 1997, 21 27.

[32]. Hudson 1986, 40-54 59-64. In this case freedom from interference by local officials was more important than ownership as such.

[33]. There were periodically prosecutions for various offences under the statutes, for example against George Cotton and Thomas Kinge for converting woodland to pasture in Suffolk and of Sir Christopher Blunt and others for not leaving 12 standels (trees to grow into timber) per acre: P.R.O., E159/413, Tr. 140-2; Mich. 408.

[34]. This explanation seems to be my own: *cf.* Rees 1968, 247-64; *Glamorgan County History* v, 55.

[35]. Hammersley 1973, 610.

than with coke, a somewhat surprising conclusion since coke ought to have been a much cheaper fuel than charcoal, otherwise coal would not have become the usual fuel for domestic heating and many industrial purposes.[36] Hyde by this means sought to explain why the success of Abraham Darby at Coalbrookdale was not quickly followed by others, and why coke pig iron did not quickly replace that made with charcoal as the feedstock for finery forges. Hyde's view became 'the current orthodoxy',[37] but T. Rehder and L. Ince both have since shown that the disadvantages of using coke pig iron in forges were less than Hyde believed, so that Hyde's explanation is at best only partly correct for that stage.[38] Hyde argued that coke pig iron was more expensive to produce due to a high fuel cost, which was in turn the result of the enormous quantity of fuel used, compared with later periods. Accordingly the high fuel consumption counteracted the cheapness of the fuel. This issue will be addressed in chapter 5, using figures newly compiled from the Coalbrookdale accounts. It will be shown there that the fuel consumption was brought down in the early 1730s to a level where coke pig iron would have been competitive with charcoal pig, but that the economic conditions of the time, and the demand for coke pig iron from foundries, discouraged its use in forges until the mid 1750s. It was only in the 1760s that an effective method of producing bar iron from pig iron without charcoal was devised. Not until the mid 1780s were new processes widely adopted. As will appear in chapter 6, this enabled the output of the industry to expand rapidly, having been liberated from dependence for fuel on the speed of growth of trees. It will however not be possible to gauge the scale of this expansion precisely beyond its first few years, because too little is yet known as to when and how many melting fineries and puddling furnaces for the new processes were built at particular ironworks. The period covered by this thesis thus ends with this expansion of iron production during the Industrial Revolution, when most of the charcoal ironworks of the previous era either closed or were converted to use the new technology.

The transition from a renewable (organic) fuel resource to a non-renewable mineral one (*i.e.* coal) had been a long process. At the end of the medieval period blacksmiths used coal, but otherwise the normal fuel was wood (or charcoal), both for domestic and industrial purposes. By the early 17th century most trades that needed heat had gone over to coal. For example, glass making and steel conversion adopted the use of coal as a source of heat in the 1610s and maltsters began to use coke not long after. This only left certain metallurgical processes still using wood or charcoal. In these, the fuel not only provided heat, but was active chemically.[39] The abandonment of wood for the cheaper coal in other purposes (including domestic heating) made more wood available for those processes (particularly making iron) where it long remained indispensable. Coal was an important factor in the industrialisation of Britain. Indeed, J.R. Harris emphasised the skill of British workmen in managing coal fires as something distinguishing Britain in the 18th century, from Sweden (which made iron but had no coal) and from France.[40] The widespread adoption of the new coke-based technology (particularly puddling) during the Industrial Revolution resulted in an extremely rapid expansion of iron production in Britain. How this happened and the debates surrounding this will be examined in chapter 3.

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[36]. Harris 1992, 2-11; Hatcher 1993, ch.12; see also the next paragraph. The cost and loss in quantity in coking was not significant. In 1719 at Coalbrookdale the royalty of big coal was 3*s.* 9*d.* per stack (over a ton), 2*s.* was paid to carriers, and 10*d.* for coking it (making 6*s.* *7d.* in all). Charcoal commonly cost 28*s.* per load (about a ton): calculated from Coalbrookdale a/c.

[37]. Harris 1988, 31-3; Hyde 1973, ch.2; Deane 1981, 108; Rule 1992, 116-7.

[38]. Rehder 1987; Ince 1991a.

[39]. Hatcher 1993, ch.12. In the case of steel, the coal only provided the heat. Charcoal continued to be the carburising agent as long as the cementation process continued to be used to make it.

[40]. Harris 1976.

The economic progress of the early modern iron industry was set out in general terms long ago by T.S. Ashton,[41] many (but not all) of whose conclusions have stood the test of time. A great deal of material on the histories of individual ironworks and iron-producing regions has been published in a large number of regional and local studies by such people as B.G. Awty, D. Cranstone, A.S. Davies, I. Edwards, M.C.S. Evans, A. Fell, M.W. Flinn, C. Hart, G.G. Hopkinson, L. Ince, B.L.C. Johnson, P. Lead, R.A. Mott, A. Raistrick, P. Riden, E. Straker, B. Trinder, J.T. Turley, and R.F. Tylecote.[42] Some of these merely describe a particular ironworks or a region, but others have details of wider application. However there is a problem inherent in regional studies in that they are necessarily limited to a region. Their authors are thus generally unable to set their region in the wider context of the industry nationally, by showing how their region differs from others.[43] Furthermore the coverage of regional studies is necessarily patchy. Some regions are only covered for a limited period, others hardly at all. This applies to the charcoal iron industry in Shropshire, where the main focus of research has been on the coke industry, of which it was a cradle.[44] To make good such deficiencies I spent several years, before starting work on this thesis, using a very wide range of archives to determine the dates, ownership, and output, as far as possible of every charcoal furnace and forge in England and Wales (excluding most of those in the Weald). This has provided the data for making the new estimate of iron production already referred to.[45] This research and the methods employed are described in detail in the first appendix.

The myopic nature of regional studies is illustrated by the way in which early ones (such as E. Straker's on the Weald and W. Llewellin's on Glamorgan) seemed to support the old view that the output of iron declined as a whole, for in both these areas it certainly did decline long before the end of the charcoal era.[46] That view also appeared to be supported by the observation that many of the charcoal furnaces that remained in use in 1788 were scattered in remote areas around the coast.[47] This pattern is actually related to the distribution by coastal shipping of redmine, the haematite ore of Furness, the furnaces in question all being close to navigable water. Moreover substantial numbers of charcoal forges continued in use in inland areas.[48] In fact, the decline in output in the Weald, and also Glamorgan, was almost balanced by growth elsewhere, so that the overall decline was only slight. The Weald was a distinct region, a long distance from any other significant area of iron production, and its iron industry had its own distinctive character, different from that in the rest of England. Since the Weald has recently been the subject of a major study,[49] the main emphasis of this thesis

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[41]. Ashton 1924.

[42]. These authors are named in alphabetic order and the list is not exhaustive. The works referred to will be found in the bibliography.

[43]. This thesis inevitably suffers from a similar failing in that its region is England and Wales, so that it cannot provide adequate comparison with other parts of Europe.

[44]. Some aspects are dealt with in Chaplin 1963; 1969; 1970; others in Trinder 1973 (which is less focused on the coalfield than the 2000 edition); in volumes of *V.C.H. Shropshire*; and briefly in Trinder 1996, 13-17.

[45]. I hope to publish this material in a series of books, probably entitled *Iron in the North*, *Iron in the Midlands*, and *Iron in the West*. The data is summarised in appendices 12 and 15.

[46]. Straker 1931; Llewellin 1863a.

[47]. Scrivenor 1841, 86; Deane 1981, 107. It is perhaps unfortunate that the distribution of charcoal forges in 1788 (Mushet 1840, 44) is much less well known.

[48]. See chapter 4; Mushet 1840, 44.

[49]. Cleere & Crossley 1995.

will be on the rest of the country, though without wholly ignoring the Weald. However the rest of England and Wales cannot satisfactorily be studied save as a whole, certainly not after the improvement of the river Trent above Nottingham from the mid 17th century linked the west Midlands with Yorkshire and the east Midlands, ending their relative isolation from each other.[50] Nevertheless this thesis is also a regional study, its region being the whole of England and Wales. Accordingly, issues concerning the development of the industry in Europe as a whole cannot be addressed here. This is why the question of the comparative costs of ironmaking in England, Sweden, and Russia cannot be answered here.

The iron trade in its wider context

Developments in England

The iron industry did not exist in isolation, unaffected by events taking place around it. However, the outside events that did affect it significantly were relatively few in number and were often ones that do not figure largely in historical textbooks, such as the crisis in relations with Sweden in the late 1710s. Politically England was a stable country with all the economic benefits that brought with it. Except for the Civil War, there was no internal conflict that adversely affected the industry. On the other hand wars abroad, such as the Thirty Years War, sometimes did great economic damage, and prize-taking frequently disrupted maritime trade, rendering convoys necessary and increasing insurance premiums, but usually not for long enough to damage commerce permanently.[51] Furthermore the English government generally refrained from meddling in commercial affairs. This is in marked contrast with modern times, and also with Russia where the State had its own ironworks, and with Sweden where the iron industry (as the producer of the most important export commodity) was heavily regulated.[52] In England the government's attitude was essentially one of *laissez-faire*. Its only interest in commerce concerned the taxes it collected, and it did not succeed in taxing English iron significantly. Charles I tried during his personal rule,[53] and plans to tax the industry were considered in 1797 and 1806, but not implemented.[54] Only during the Interregnum was English iron subject to excise.[55]

The English currency was a stable bullion-based one, except during a period in the mid 16th century when the currency was for a time debased,[56] and also from 1797 to 1821 when the Bank of England had to stop payments in specie.[57] In contrast with the 20th century, price inflation was not significant. The cost of

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[50]. This is a failing in P. Riden's otherwise excellent study of the industry in the East Midlands: Riden 1990.

[51]. As to the economic effects of war, see Bowen 1988; Jones (D. W.) 1988; Deane 1975; John 1955.

[52]. Kahan 1985, 109-14; Hudson 1986; Hildebrand 1957; 1994; Nisser 1987, 114-6.

[53]. See chapter 4.

[54]. Attempts were made to impose a tax on iron production in 1797 and on coal used in ironmaking in 1806, but both were abandoned as impracticable: Smith 1978; Evans 1994; Riden & Owen 1995, xi-xii; note also John Winwood, *A letter to Lord Sheffield* P.R.O., PRO 30/8 301, 73-77.

[55]. See chapter 4.

[56]. Challis 1971; 1978, 83-128.

[57]. Clapham 1944, i, 271-2; ii, 1n 62-76.

Figure 1.1

Phelps Brown Hopkins index/Chart3

living, measured by the Hopkins and Phelps Brown ('PBH') index of prices (see figs. 1.1 to 1.3), rose until the late 1630s and then remained relatively stable until the late 1750s, though with considerable short-term fluctuations according to the size of the harvest. After that, prices increased considerably, peaking in the 1800s at two and a half times the 1750 level. Industrial prices on the other hand hardly rose until the late 1790s, when the gold standard was abandoned, and they peaked at 60% above their 1750s level.[58] Attempts have been made to correlate changes in the cost of living and in population and this will be discussed in the next chapter. Though the shapes of the graphs of the PBH index and of population are until 1780 similar, it is by no means clear whether this is more than coincidence.

The price of iron (see figs. 1.2-1.3) was under £5 per ton between 1460 and 1520 and only slightly more in the next quarter century, but underwent a sharp rise to more than double that in the 1550s. The price then settled down to £12 or so per ton for more than half a century.[59] In the late 1620s there seems to have been another significant rise, with about £16.5*s.* was being paid in 1629 for merchant iron at Bewdley and £15 for colshear iron, compared to £13 in Staffordshire in 1623.[60] After that prices usually fluctuated within a relatively small range, generally between £15 and £17 throughout the century and more of stable food prices, before rising somewhat from the end of the 1740s (see also fig. 8.5).[61] The price for good bar iron was usually between Û18 and £20 during the rest of the century and about £22 during the Napoleonic War. In the 1800s there seems to have been a divergence between the price of good iron (such as that made by Knight & Co. in the Stour valley) and that of less good varieties, whose price was more like that in the early 18th century. Thus the price fixed by the ironmasters at the Newport quarter-day declined from £16 in 1807 to £12 in 1815 and £8 in 1816, while good iron (probably 'best best') as produced by John Knight & Co. in the Stour valley was bought for the Navy at £24, rather more than was being paid for ordinary Swedish, but £37. 10*s.* was asked for the Swedish oregrounds iron in 1808.[62] Iron prices were not so high again for many years. They recovered somewhat at the end of the 1810s, and then rose and fell cyclically, reaching in the 1830s a low level not seen since the mid 16th century, but that fall was the result of increased energy efficiency due to the introduction of hot blast in furnaces. However the quantity made rose and rose.[63]

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[58]. Phelps Brown & Hopkins 1971. O'Brien 1985, 791-8. Certain of O'Brien's index numbers are plotted in fig. 1.1. The index excluding metals there is calculated from his figures excluding his metals index, inflated by dividing it by 0.78 to allow for the absence of the 0.22 weight he gave to the metals index. The PBH index, plotted in figs. 1.1-1.2 against iron prices, has been smoothed by averaging over 21 years and rebased by dividing the average of their numbers by 40, to provide figures that are similar in size to the price of bar iron in pounds per ton.

[59]. Thorold Rogers iv, 398 404 410; v, 478-80; vi, 449-53. These prices, taken from the accounts of various institutions, are often for quite small quantities being sold retail. In many cases the variety of iron is unclear, particularly the extent to which it may have been manufactured before sale. Note also prices listed in Cleere & Crossley 1995, 284-5.

[60]. P.R.O., C 2/Chas.I/J5/12; King 1999a, 66.

[61]. The beginning of price rise, about 1748-50, was quite sharp, and will be discussed at the end of chapter 5 and again in chapter 8.

[62]. Scrivenor 1841, 405-10; SW a/c; P.R.O., ADM 106/2670, 17 Mar 1807; ADM 106/2671, 8 Apr. 1808. The Newport price (of £13 to £14 per ton in 1807 and 1808) was probably for iron from ores in the Welsh coalfield by puddling, which would be coldshort. At the same time (ordinary) Swedish bar iron was priced at £19. 10*s.* to £20. 10*s.* and Russian at £14. 10*s.* to £19. 10*s.* Iron purchases for the Navy at this time were dealt with by the Contracts Office, whose records have not survived.

[63]. Scrivenor 1841, 407-9; Hyde 1977, ch. ix.

Figure 1.2

Iron price summary/Chart1

Figure 1.3

Iron price summary/Chart2

Transport improvements

Other economic factors influencing the iron trade were mostly not peculiar to it. Some relate to goods in general, others specifically to manufactured products. Among these is the transport infrastructure used to bring raw materials to manufacturers and to take finished products to market. The attitude of the State to transport improvements was just as benign as with commerce generally. Its role was primarily as a facilitater, by providing the powers necessary for individuals, trusts, or companies to carry out improvements. Before the Civil War this was usually done by letters patent, but subsequently by private Act of Parliament. Such improvements in communications transformed England, by making it easier (and presumably cheaper) to dispatch goods for sale in distant markets. This in turn transformed England from having a series of local economies (with an element of subsistence) to having a national one. This applies to agriculture as well as industry,[64] and in the case of industry it encouraged specialist manufacturing regions to develop. This process is closely related to proto-industrialisation, which will be discussed in chapter 2.

The choice of the mode of transport to be used depended to a considerable extent on the value-to-weight ratio of the goods and to some extent the risk of damage in transit (as with fish and pottery). Textiles had a high value compared to their weight and could economically be taken long distances by road, whereas it might cost as much as they were worth at the start to carry heavy low value goods (such as coal and grain). Unless the value of the latter increased in proportion to the distance carried, it was not worth sending the latter beyond a certain distance.[65] This is why charcoal was generally not carried more than a few miles.[66] Iron lies between the cheap bulky goods and the light valuable ones, and was taken by water whenever possible, but was also carried considerable distances by road. This subject will be explored at various points in the course of the thesis, and it will be shown that on occasions the need to use road carriage had a significant effect on the organisation of the industry. R. Szostak (as part of a study of transport in England and France during the Industrial Revolution) sought to argue, but failed to prove, that transport costs had a major impact on the adoption of coke as the fuel for iron production. He correctly pointed out that transport improvements significantly reduced the cost of coal in areas outside coalfields,[67] but failed to appreciate that until about 1850 coke-fired ironworks were almost invariably located very close to the mines that supplied them with both coal and ironstone, so that transport costs between the mine and the furnace were not significant. This was particularly the case from the 1780s when steam-power became the usual means of blowing furnaces and working forges and rolling mills. Before that it had been necessary to carry materials to where there was water-power.[68] Szostak's work furthermore ignored important recent work and contains a number of other errors,[69] probably due to the extent to which it is built on a review of published works with a very scanty examination of original documents.[70]

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[64]. Overton 1996, 136-47.
[65]. Willan 1976, 1-4 11.
[66]. Hammersley 1973, 606;
[67]. Szostak 1991, ch.3.
[68]. See the latter part of chapter 4.
[69]. Szostak (1991) not only failed to refer to Cox 1989 (which may have appeared between his book being completed as a thesis and published), but also the whole of K.C. Barraclough's work on the steel industry (Barraclough 1985(1), 1985(2), and many earlier articles), as a result of which most of what he says about steel is at best misleading. At p.108 Szostak refers to iron plate being produced by hand before the rolling mill, ignoring the existence of plating forges. He seems to have believed (pp.125-6) that coke pig iron could not be used to make bar iron until the introduction of Cort's puddling and rolling process, whereas B. Trinder (1973, 81; 2000, 30-1) showed that it was supplied to a number of charcoal forges in large quantities in the 1760s and 1770s. Szostak suggested (p.113) that there was a change in the way iron was distributed during the 18th century with direct sales from forges to metal workers becoming more common, but this is the reverse of the truth and ignores the role of the manufacturing ironmonger, which was described in detail by M.B. Rowlands (1975). It may be that direct contacts between retail ironmongers and their suppliers became more frequent during the period,

The greatest rivers, the Thames, Severn, Trent, and Yorkshire Ouse, have been navigable at least since medieval times, and coastal shipping was always a possibility. However in the 17th and 18th centuries a number of initiatives were undertaken to extend navigation further upstream and to make lesser rivers navigable too. In this respect the improvement of the river Trent, from Nottingham to Wilden Ferry (probably shortly after the Restoration) and then up to Burton in the 1710s, was particularly significant for the Birmingham iron trade, in that it made available to it iron imported through Hull and also that produced in the East Midlands.[71] The improvement of the river Don up to Tinsley (just below Sheffield) was similarly important to the Sheffield cutlery trade, whose river port had previously been Bawtry.[72] The river Severn was extensively used by the West Midland iron industry, but did not need much improvement.[73] Evidence concerning the transport of iron clearly shows that river transport was much cheaper than road transport. Pig iron could be carried some 50 miles from Broad Oak (below Gloucester) to Bewdley for 5*s.* freight per ton, the same sum as was paid for the carriage of bar iron a mere 7½ miles by land from Brewood Forge to Hampton [*i.e.* Wolverhampton] and of pig iron about the same distance from Wombridge Furnace to Wroxeter.[74] These sums do not seem enormous, but high road transport costs could make a significant difference in the profitability of a forge. It cost Mr Barker of Lizard Forge 10*s.* per ton for carriage from the forge to the slitting

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but that is not what he said. The fallacy may arise from a remark by Hutton (1783, 69-70; 1806 edn, 98), which was dismissed by D.E.C. Eversley as inaccurate (*V.C.H. Warws.* vii, 91). Hutton may have (wrongly) thought that the commercial system he found in Birmingham was new, because it was quite different from where he grew up. Szostak went on (p.113) also to discuss the division of labour in manufacturing processes and the use of large workshops, suggesting this enabled manufacturers to place large orders with ironmasters. In doing so he again ignores the role of the ironmonger and of the domestic system of manufacture (involving putting out). In any event, most of the 18th century evidence for large workshops in the metal trades only relates to the Birmingham toy trades.

[70]. Though a small number of manuscript sources are listed in Szostak's bibliography, his citations of them are so sparse that he can only have spent a very short time studying each of them. As a result, the quality of his work differs greatly from that of C.K. Hyde, who spent a considerable time in England. Szostak placed considerable reliance on 18th century pamphleteers (who are tendentious and liable to exaggerate or guess), on 19th century historians and encyclopaedists (who often had to rely on unreliable hearsay in dealing with periods before their informants' time), and older economic historians (whose knowledge was often incomplete). The sources for such works ought (wherever possible) to be checked or corroborated. Szostak's difficulty was ultimately that of conducting detailed research, while based in North America, on industry in England and France.

[71]. Owen 1968; 1978, 13-17.

[72]. Willan 1965; Hey 1991, 9 147 162-7; King 1995a. Bawtry was not entirely a satisfactory port in that goods had to be transshipped at Stockwith, being (as John Watts the manager of Carburton Forge put it in 1715) 'taken out of the keels and put into Bawtry Boats' which were small enough to negotiate the river Idle: Watts l/b, 2 Apr. 1715; Hey 2001, 98. Hey describes John Watts as of Kirkstall Forge, which was correct later but probably not at this time.

[73]. Willan 1938, 68-9. The river was certainly navigable up to Montford Bridge (above Shrewsbury) by the 1630s, when iron was dispatched down river from a warehouse there: Edwards 1958, 191 198-201. Later it was navigable up to Pool Quay about four miles below Welshpool; for the use of the river generally see *Gloucester portbooks database*; Schafer 1978. This subject will be examined further in chapter 4.

[74]. Schafer 1978, 45-6 98-99. This works out at 8*d.* per ton-mile, which is within the range quoted by Willan (1976, 5-8) for road transport in the late 16th century.

mill in 1759, among total costs being £15. 9*s.* at a time when iron was selling at £18. However, ten or so years before the sale price had been under £16.[75]

Many main roads, which were not adequately being maintained by the parishes through which they passed, were improved from the early 18th century by turnpike trusts. These were authorised under private Acts of Parliament to borrow money for this purpose, to be repaid by tolls levied on passing traffic.[76] From the 1760s the availability of water transport was further extended by the building of still-water canals, linking the great river-systems of England across the Midlands. These joined the Trent to the Mersey, that canal to the Severn (both completed in the 1770s) and later the Midlands to the Thames by the 1790s. These canals required the investment of much larger amounts of money, and most of them were financed through companies that issued shares to those providing the capital, entitling them to dividends paid out of the profits of the navigation.[77] Canals also reduced costs. For example, it usually cost 5*s.* 8*d.* to carry pig iron from the Severn at Bewdley to Cookley Forge in the late 1760s, but only about 2*s.* 3½*d.* for freight from Stourmouth (*i.e.* Stourport) by canal from 1771.[78] The ability of Midland metal manufacturers to export goods through Liverpool must have been greatly enhanced by the availability of canals, and transport costs to London were no doubt similarly reduced.[79] The development of long distance railways, which eventually replaced canals, lies beyond the period covered by this thesis, but shorter horse-drawn waggonways were built in a number of coalfields to link mines with rivers, canals or ironworks.[80]

Events abroad and customs duties

In the late 17th and the 18th centuries with a large proportion of the iron used in Britain being imported, its price was sometimes affected by factors external to Britain, but the only strictly political event to have a significant impact on the iron trade is one that hardly features in most textbooks of English history. Having succeeded to the English throne, George I as Elector of Hanover intervened in the Great Northern War between Sweden and Russia against the former by occupying the neighbouring duchies of Bremen and Verden, which had been acquired by the Swedish crown during the Thirty Years War. Desperate for money to continue the war, the Swedish government entered into negotiations with the Catholic powers, feigning to be planning to

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[75]. Staffs. R.O., D 641/3/E/5/32.

[76]. This subject is dealt with at length in Pawson 1977 and Albert 1983. There were a handful of earlier examples, but the period of greatest growth was in the 25 years from 1750: Albert 1983, 32-44.

[77]. Duckham 1983; Pawson 1979, 146-9; Barker & Savage 1974, 38-40.

[78]. The equivalent figures to Wolverley Old Forge were 4*s.* and just over 1*s.* 8*d.* These are not a reflection of the difference in distance, as carriage from Stourmouth (where iron was usually landed for the Mitton Forges) in the early 1760s was only marginally more dear than from Bewdley. The road carriage price had risen by 9*d.* per ton to Wolverley and 15*d.* to Cookley during the 1760s, possibly reflecting the imposition of turnpike tolls. In addition wharfage of 6*d.* per ton was payable at Bewdley and 3*d.* at Stourmouth, rising to 4*d.* after the canal opened: SW a/c.

[79]. *P.P.* 1812 iii (210), 7 29 indicate that Liverpool's export trade had become a major customer for the Birmingham metal trades. Liverpool's growth was also enhanced by the relative protection its shipping enjoyed from French privateers during the war: Hyde 1971, 26. J. Langton (1983) failed to identify any products from further afield than the Potteries among those passing through Liverpool at the end of the 18th century, but (p.11) attributed all the ironware exported from Liverpool to the minor iron manufacturing area around Wigan. While I have not investigated his sources, I do wonder whether he is incorrect in his identification of the source of at least some of this ironware. Could it not have almost as easily come from the Black country by canal?

[80]. Barker & Harris 1974, 56-70; Lewis 1970. Railways and waggonways were particularly significant in mountainous country such as south Wales and for delivering coal to the river Tyne: Baxter 1966; Rattenbury 1972; 1988; Baber 1973; Van Laun 1977; Levine & Wrightson 1991, 44-76.

invade Britain in support of the Jacobite Pretender. When they discovered this, the British government (ignoring his diplomatic privilege) arrested the Swedish envoy, Count Gyllenborg, and seized his papers. Understanding from his papers Sweden's dependence on imported grain, the British government imposed an embargo on trade with Sweden in March 1717, which remained in force until the end of the war about two years later. However, this embargo failed in its objectives, because the Dutch (with their control of so much shipping) declined to conform with British policy, and continued shipping grain. Nevertheless the embargo starved British manufacturers of imported iron, and before long Swedish iron was again being imported, but as a re-export from Holland and Germany and at an enhanced price reflecting the handling costs and profits of the middlemen.[81] These increased prices stimulated the erection of a considerable number of ironworks in England. T.S. Ashton drew attention to these events, particularly the disruption of the import trade, but data was not then available to show the very marked effect on domestic iron production in England, which rose from 13,300 tons in *c.*1716 to 19,485 tons in 1718 or 1720.[82] Nevertheless this expansion was unsustainable when the iron price fell back again, leading to a series of bankruptcies and closures about a decade later.[83] This will be explored further in later chapters.

Difficulties in export markets could depress the English economy, and affect the trade in iron. This happened several times in the early modern period. The first was in the latter part of the reign of James I. At that time English overseas trade was mainly concerned with the export of cloth, principally to Holland and Germany and to a lesser extent other markets, including the Baltic. This trade was severely disrupted from 1615 by the ill-conceived Cockayne Project, which sought to replace exports of unfinished white cloth with those of dyed and dressed cloth. However the new entrepreneurs of the Project lacked sufficient capital and expertise, and within a few years the old monopoly of the Merchant Venturers had to be restored. However this was followed by difficulties in selling cloth in the German and Polish markets, which seem to have been caused by currency debasement in these regions. This meant that the exporters had to increase their prices (in local debased currency) to receive the same value in hard currency, and also by the time they had paid the currency had often depreciated further, thus reducing (or extinguishing) their profits. All this caused a severe depression in the clothing trade and cloth making regions and thus on the English economy generally.[84]

A century and a half later the export of manufactured goods to English colonies underwent a severe recession when trade to America ceased during the American War of Independence.[85] This came shortly after the banking crises of 1772. The

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[81]. Chance 1909, esp. 210-2; Ashton 1924, 110-3; Hatton 1978, 183-200.

[82]. Ashton 1924, 110-3; King 1996b, 30 and tables 1 & 3. The *c.*1716 ironworks list was only discovered after Ashton's publication: Hulme 1928.

[83]. King 1996b, 30-1 and app. C. Unfortunately most of the price series in fig.1.3 used are broken during the embargo period, so that details of actual prices in this period are somewhat obscure.

[84]. Supple 1959; Hinton 1959, 12-32.

[85]. Schumpeter 1957, table V. See also chapters 7 and 8. Most works on overseas trade or on economic growth are based on sample years or sample short periods. Thus R. Davis' works on overseas trade examine the periods 1700-74 and 1784-1856, apparently without comparing 1774 and 1784 (possibly because the one work relates to England and the other to Great Britain) and thus misses short term trends: Davis 1962; 1979. Many of the works on economic growth (such as Harley 1982; Crafts 1985; and Jackson 1992) also look at sample periods, though this is not true of Crafts & Harley 1992, which provides an index of industrial production. This shows a decline from 1772 to 1774.

banking crisis in Britain followed and may have been aggravated by the glutting of the American market with European goods in 1771. However the subsequent cessation of trade was due to the American Revolution, not to a short-term crisis in financial confidence.[86] Something similar happened again from the late 1800s when America passed laws prohibiting the import of English goods as a reaction to the restriction placed on their trade with continental Europe by the British Orders in Council, which were in turn a response to Napoleon's Continental System. This ultimately led to the War of 1812 with the United States.[87] The causes of the recession in the latter part of the Napoleonic War probably also have other causes, and need investigation in a wider context than just the iron industry. There may, for example, have been a cyclical downturn at the end of a quarter century of rapid growth, as supply outran demand, but high wartime taxation and bad harvests no doubt played their part too.[88]

Other factors external to the English iron trade were also liable to affect the price of iron. Firstly prices were often high in wartime, probably due more to increased insurance costs and the inefficiencies of the convoy system, than to increased demand from the government for munitions. Such rises occurred during the Nine Years War and the wars of the mid 18th century.[89] Anecdotal evidence can be provided that the three Dutch Wars and a war in the Baltic in the late 1650s also encouraged home production, but this may be at least as much due to difficulties with importing iron as to any increased demand.[90] Secondly the import duty on iron was progressively raised. In 1690 at the beginning of the Nine Years War an additional import duty of 23*s.* per ton was imposed on imported iron in 1690, making a total of £2. 1*s.* 6*d.*, with 10*s.* more if it was brought in foreign vessels. This increased the price of iron (and charcoal) in England, leading to difficulties for one Midland ironmaster, who had a fixed price contract to supply pig iron.[91] By 1782 this import duty had risen to £2. 6*s.* 2*d.* and it was increased by stages to £3. 15*s.* 5*d.* in 1798 and £5. 9*s.* 10*d.* in 1809.[92] Thirdly measures were taken by the Swedish crown in the middle of the 18th century to enhance the price of iron. Jernkontoret ('the Iron Office'), the Swedish ironmasters' association, was established in 1747. Amongst other things, this made loans to ironmasters, thereby reducing their reliance on *förlag* loans from the iron exporting houses in Stockholm, who in turn needed loans from foreign financiers and English importers. Its establishment was followed shortly afterwards by Swedish measures to restrict their production, a subject that will be discussed more fully in chapter 8.[93] The reasons for these moves are controversial.[94] What is clear

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[86]. Hoppitt 1986, 52-4.

[87]. Heaton 1941; Frankel 1982.

[88]. Hudson 1992, 58-60; Deane & Cole 1967, 14-16 96 226.

[89]. Late 17th and 18th century prices are taken from Foley a/c; SW a/c; SIR Y a/c; Navy Board contracts in P.R.O., ADM 106/3590-3621; ADM 49/32; N.M.M., POR/A/2-21; Scrivenor 1841, 405-6 410.

[90]. Lists of ironworks in Sussex of 1653 to 1664 specify ironworks 'discontinued before 1664 ... ruined, but repaired and stocked upon account of the war and ... future encouragement': Parsons 1882, 21. A list of his land purchases among the Foley papers indicates that Thomas Foley assembled the bulk of his vast landed estate, mainly in Worcestershire, in the 1650s and 1660s: Herefs. R.O., E12/VI/C/1 & 8. This presumably points to the profitability of the industry in this period. War in the Baltic: Rying 1980, 159-63; Andersson 1970, 200-4.

[91]. P.R.O., E 112/880/41. This will be discussed further in chapter 4.

[92]. Statute 2 W. & M. sess. 2, c.4; 7 & 8 W. & M., c.17; Ashton 1924, 105; Scrivenor 1841, 405-6. A rise in duty had been suggested in 1668, but not enacted: King 1996b, 24.

[93]. Roberts 1980, 127; Kent 1973, 35 71-2; Samuelsson 1951, 179-82; Hildebrand 1957, 353-55; 1958, 13 21; Söderlund 1960, 53; *cf.* Ashton 1924, 120. See also chapter 5. For Swedish history in this period generally see Roberts 1986.

[94]. The controversy arises from work of P.-A. Karlsson, *Järnbruken och ståndssamhället: Institionell och attiytmässif konflikt under Sveriges tidiga industrialisering 1700-1770* [Ironworks and the state of society: institutional and mass-attitude conflict during Sweden's earlier industrialisation 1700-70]

(1990), which I have not seen. This is discussed in Floren & Ryden 1996, 259-63; Hildebrand 1997, 21; and in chapter 8 below.

however is that there was a sharp jump in the price paid by the Navy Board for Stockholm iron between 1747 and 1752 (see fig. 8.5).[95] This price rise seems to have stimulated the erection of new charcoal ironworks, particularly forges in south Wales and furnaces around the west coast of Britain, and also of coke-fired blast furnaces, principally in Shropshire. This expansion, unlike that around 1720, proved to be sustainable, as the price of iron stayed high.[96] However this expansion also coincides (both in time and geographically) with the erection of a number of tinplate works, mostly in south Wales. It also coincides with the first significant use of coke pig iron by forges. The increases in duty in the 1790s certainly coincide with the great expansion of iron production in Britain, but a far more important factor in that expansion was the invention in the 1770s and 1780s of new methods of fining pig iron to make bar iron without using any charcoal. However the increases in duty certainly improved the competitive position of British iron compared to imported, and greatly decreased imports. These matters will be considered further in later chapters, but the next one will consider various issues concerning the English economy more generally, but particularly its demand side.

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[95]. N.M.M., POR/A/15, 20 Mar. 1746/7 (£13.15*s.* for second oregrounds and £12.15*s.* for Stockholm) and Mar. 1747/8 (£14 for second oregrounds, no Stockholm iron ordered); POR/A/16, 4 Mar. 1752 (£19.10*s.* for second oregrounds and £18.10*s.* for Stockholm). No contracts were apparently made in the intervening period. There was a similar increase in the prices paid by the East India Company between 1747/8 (£12) and 1748/9 (£14.14s.). However the price in 1749/50 (from Puller & Co., not a regular supplier of iron) was £12.13s. 6*d.* and in 1750/1 and subsequent years again over £14. The identities of the merchants suggests the iron was Swedish, but the prices are consistently low, suggesting that the East India Company was not choosy about the quality of the iron, no doubt reflecting market conditions in India.

[96]. King 1996b, 37 45-6. See also chapter 4 below.