8 Economic Trends and the Consumption of Iron

The two preceding chapters have been concerned with the production of iron in England and with overseas trade. Those and various earlier chapters have described various technological, organisational, and other changes that affected the iron industry. This chapter will use the data described in the two preceding chapters to estimate consumption but only that of wrought (and bar) iron, as the data on the production of cast iron goods is not good enough to provide reliable conclusions. The chapter will alternate between this discussion of consumption and a summary of the major changes that took place in the iron trade during the three centuries of the early modern period.[1] Four different measures relating to consumption will be referred to. Firstly 'iron available in the English market' consists of the total of domestically produced and imported iron (see figures 8.1-8.2), but this is perhaps the least useful figure of the four. Secondly the amount of iron that was manufactured into finished ironware indicates the size of that industrial sector. This 'amount manufactured' is estimated as the amount available less bar iron re-exports and exports (see figure 8.3). Thirdly, the amount of iron sold to consumers, that is 'domestic consumption' is estimated as the amount manufactured less exports of manufactured ironware. Finally 'consumption per head' is estimated by dividing domestic consumption by population. However, the main concentration will be on the last two. A related figure, which will also be referred to is 'self-sufficiency', which is measured as the ratio of English production to the amount available in England. All four measures of consumption, together with English production, are shown together in figure 8.4. These are expressed in terms of a quantity of bar iron, but that will certainly be slightly more than the actual weight of the goods which consumers bought, due to a small proportion of the iron being lost as hammer scale in the course of manufacture. That was probably a relatively constant proportion. Accordingly, though the absolute figures may be slightly too high, the proportion between the estimates of a given measure of consumption at different dates and also their growth rates should not be affected.

In 1500 English iron was mostly made in bloomeries, but not in sufficient quantities to satisfy domestic consumption. Accordingly perhaps more than three quarters of home demand was met by iron imported mainly from the Biscay region of Spain. Neither English population nor English iron production at that period

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[1]. Because this chapter is mainly a summary of what has been said in earlier ones or calculated from data presented in the two preceding ones, references are only given in this chapter where a statement is derived directly from a particular source and for certain issues of European history that have not been discussed in detail previously.

Figure 8.1 Iron available in the English market

Consumption 1H bar/Available ch.

Figure 8.2 Iron available in England by source: smoothed as a 7 year running average

Consumption 1H bar/Smoothch

Figure 8.3 Iron manufactured in England

Consumption 2H manufacture/Chart2

Figure 8.4 Iron made and used in England

Consumption 5H/Chart2

is wholly certain, but English production may possibly have been 1000 tons per year in total and consumption 4 *lb.* or so per person per year. This situation began to be transformed shortly before 1500 when a new process for making iron was introduced into the Weald. This was brought by immigrant ironworkers from northern France. It consisted of an indirect process of making bar iron involving a furnace to make pig iron and a forge to convert that into bar iron. As a result, production increased, but there was little reduction in imports until the 1540s. It was only from that time that iron production in the Weald began to grow rapidly. Home production may have reached 2000 tons per year about 1540, possibly double that in 1500, but it increased eightfold over the following half century, representing an annual growth rate of 4.1%. In the same period imports decreased markedly, with the result that domestic consumption in 1590 at 17000 tons per year was almost three times that in 1540. With an increased population, the rise in annual consumption per head was less, but consumption of about 9 *lb.*, not much more than double the 4¼ *lb.* consumed in about 1540, which was in turn probably only slightly more than in 1500.

The 1590s mark the high point of the Wealden iron industry. For half a century it had dominated the market in the south and east of England. However the bar iron it made was not for the most part manufactured into consumer goods in the Weald, because there was no coal there. Its manufacture probably took place in London (using coal from Newcastle), and also in the hands of village blacksmiths throughout those areas.[2] However from the 1560s the new process with furnaces and forges had spread into other parts of England and Wales, and these became increasingly important areas both for iron production and manufacture. In 1590 57% of the 17000 tons of bar iron consumed in England was made in the Weald, compared with 58% of 8000 tons in around 1560, but this fell to 39% in 1620 and to a mere 6% in 1670. This change was probably brought about by the penetration into the London market of iron made and manufactured in the Midlands and to some extent in Yorkshire. The chronology of the growth of the Black Country (west of Birmingham) and of Sheffield as specialist manufacturing areas remains unclear, but the important role they were playing in that field by the 1620s is very clear. Midlands ironware was then being sold in London, and a market for it was provided in Leadenhall.[3] Both these regions had coalfields, but were too landlocked for their coal to be sold except in a quite limited area, which made coal cheap and encouraged its use in manufacturing ironware. On the other hand, the coalfields in Shropshire and around Newcastle had easy access to water-transport, which facilitated the sale of their coal at considerable distances from the pits where it was mined, and neither developed a significant manufacturing sector at an early date.[4]

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[2]. Wealden iron was for example reaching East Anglia during Elizabeth's reign and reached Nottingham in 1588: Williams 1988, 171; Cleere & Crossley 1995, 159-62 and 284.

[3]. Rowlands 1975, 11-13; Nicholl 1866, 194-7 from Guildhall Lib., ms. 16970, 38.

[4]. Szostak (1991, 114-6), whose views on the iron industry were severely criticised in chapter 1, was correct to follow M.W. Flinn (1984, ch. 5) in emphasising the importance of water transport for coal. Similarly, a failure to appreciate the importance of developing a market for coal, and the need for transport improvements to facilitate this explains a series of commercial failures in the exploitation of the Warwickshire Coalfield (between Nuneaton and Coventry) before 1730. Conversely, its successful exploitation in the late 18th century was closely connected with investment in turnpikes and canals: White 1970, 9-10 50 57-8.

In about 1620 the English iron industry seems to have reached a peak in output that was hardly surpassed until the 1750s. It is estimated that about 1620 18500 tons was made in England each year. This again represents about 9 *lb.* per head. English production (as in 1590) provided 93% of the quantity consumed, so that England was for a few decades nearly self-sufficient in iron. Spanish imports had been declining for many years, and amounted to little more than 500 tons per year around 1590, compared to more than 3000 tons around 1540. They recovered somewhat during the 17th century, but did not exceed 1500 tons per year again until after the Nine Years War at the end of the century. A very modest amount of iron (often a few hundred tons) was imported from the Baltic, but after 1610 this dropped to (usually) less than 100 tons. The peak in iron production coincides with the period when English textile industry experienced great difficulties exports, first due to the ill-conceived Cockayne Project, and then to currency manipulation in Poland and Germany.[5] Accordingly, it is likely that the subsequent decline in English iron production (and consumption) results from a general depression in the economy, which was in turn due to that in the clothing trade, for that was the largest economic sector of the economy, apart from agriculture.

By the second quarter of the 17th century, the iron industry in the rest of England had reached a state of relative maturity, but in the Weald it was in severe decline. However the speed and precise timing of the Wealden decline remain open to question. Elsewhere, there was no major change in the scale of the industry, which continued its very gradual growth; such changes as there were relate to its organisation. As early as the 1600s, the first signs of its organisation into large vertically-integrated regional businesses can be detected. This is most obvious in the west Midlands, where ironmasters (particularly Richard Parkes, Middleton Nye & Co., and Richard Foley successively and also their rivals Coleman and Chetwynd) each had five or more furnaces and an equal number of forges. The difficult economic environment of the 1620s ruined the Coleman and Middleton families, and caused a change in the personnel. Nevertheless, those ironmasters such as Thomas Chetwynd, Richard Foley and Humfrey Jennens, who remained in the industry, or entered it during this period, did very well out of it. Quite probably, this recovery was aided considerably by the building of slitting mills, which cut iron into rods for nailers.[6] However, the ironmasters' success was due to careful management of resources, particularly taking care not to overpay for wood. This was the strength of their vertically-integrated regional businesses. Charcoal, due both to its bulk and friability, was a commodity that was not normally transported over great distances. Accordingly, the local ironmasters were the only bulk buyers and, if there was only one ironmaster, he had an effective monopoly, enabling him to keep the price down.

In the same period, pig iron began to be transported over quite considerable distances. The beginnings of a trade in pig iron up the river Severn can be linked to the King's ironworks in the Forest of Dean, established in 1612. Within a few years, the farmers of those works were probably supplying pig iron to forges

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[5]. Supple 1959; Hinton 1959, 12-32.
[6]. King 1999a.

at Whittington (near Stourbridge) and Shelsley (Worcs.), and perhaps also to Coalbrookdale, where Sir Basil Brooke (at times one of the farmers) was converting iron into steel.[7] From the 1650s Humfrey Jennens began establishing ironworks in the east Midlands to supply the Birmingham area.[8] In the same way, long distance trade in pig iron up the river Severn was greatly expanded by Thomas Foley (Richard's son), who began acquiring furnaces in the Forest of Dean region in the 1650s. He supplied pig iron from there to his forges (including Whittington) in the lower Stour valley in north Worcestershire, a small area where a great expansion in forge production occurred. In the 18th century however, the Forest lost some of this importance, but the Severn trade in pig iron continued, much of the pig coming now from further afield, from Wales, Furness, Argyll and even Virginia, in the latter case ballasting tobacco.

By the 1670s, increasing imports of foreign iron were probably limiting the profits of English ironmasters, but this was sometimes aggravated by competition. The enormous Foley fortune seems to have been made in the 1650s and 1660s.[9] However after Thomas Foley retired, his youngest son Philip (who took over his Midland business) had a new local competitor in John Finch. In addition, he was in conflict with his elder brother Paul, who had taken over the works around the Forest. Various strategies were tried to resolve these conflicts. For a time there was a partnership between the brothers, then Philip handed over the works to certain managers, including John Wheeler and Richard Avenant who later leased Paul's works. Finally in 1692 both brothers entered into a partnership with the managers.[10] Their grandfather Richard Foley had probably been an ironmonger (that is an organiser of the manufacture and distribution of iron goods) before he became an ironmaster. He had probably divided this business between his sons, making Thomas an ironmaster and Robert an ironmonger. Thomas' attempt to split pig and bar iron production between Paul and Philip in a similar manner was however less successful, because the market in pig iron was not yet sufficiently free to enable Philip (by buying pig iron elsewhere) to escape the imposition by Paul of unreasonable terms of business. By the 18th century when the Foleys withdrew from owning forges in the Midlands, this problem disappeared.

Philip Foley's disposal in the mid 1670s of his interests to the north and east of the lower Stour valley was largely unrelated to the conflict with his brother. However competition from John Finch and the break up of Philip's Midland business put an end to its position as the monopoly buyer of local wood. New strategies had to be adopted to take account of this. The initial one was a series of bipartite agreements for sharing resources. Sometimes they involved a sale of pig iron, and they always set boundaries beyond which the respective ironmasters would not buy wood. Such agreements had to be renewed periodically. The last one known,

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[7]. King 2003 (where this is discussed at length). Brooke had iron and steelworks somewhere in Shropshire by 1622 (P.R.O., C 2/Chas.I/W2/47). He was described in relation to Gloucestershire as 'the great steelmaker in this county' (Fuller, *Worthies* (1965 edn) i, 547), but his only known steelworks was at Coalbrookdale and not in Gloucestershire. It is accordingly suggested there that his product was known as 'Gloucestershire steel', not because it was made in Gloucestershire, but because it was made from Gloucestershire iron that came ultimately from Forest of Dean haematite.

[8]. King, *North*; from Leics R.O., DE 3541; Riden 1990; P.R.O., C 78/1030/2; Derbs. R.O., D 1404, various; and other sources.

[9]. Herefs. R.O., E12/VI/C/1 8; King 1999a.

[10]. Schafer 1971; King 2002b.

between Humfrey Jennens (with works in the Tame valley) and Zachary Downing (with works in the upper Stour valley), ended in acrimony around the turn of the century.

What replaced the bipartite agreements was a system of ironmasters' meetings, of which the most important took place quarterly in Stourbridge. These primarily regulated the sale price of iron, but that in turn limited the price that an ironmaster could afford to pay for wood. There were similar meetings in Bristol in January and July on the eve of the fairs there. Precisely when and how this procedure began remains obscure, but it was certainly in place by 1720. In areas where pig iron brought up the river Severn was readily available to forge owners, the new system removed the need for large businesses to control the resources of a whole region. Accordingly in the 18th century most forges in south Staffordshire and Shropshire belonged to businesses with a single forge or one furnace and two forges. Some used pig iron from Denbighshire and Cheshire, but they were not wholly dependent on a single supplier, as they could supplement locally made pig iron with that brought up the Severn. The one larger business in that area, that of the Knight family, was similarly not vertically integrated, in that it relied heavily on purchased pig iron.

Further north, however, large businesses persisted longer. The business that belonged successively to the Jennens, Vaughton, and Mander families (all of Birmingham) retained some integration between Derbyshire and the Black Country until the mid 1740s, after which the Derbyshire side of it continued in the hands of the Mather family for several more decades. In north Staffordshire, Cheshire and Lancashire, another business, which it is convenient to call the 'Cheshire Ironmasters', developed out of another Foley ironworks enterprise. This continued in being until the 1780s, the partners including members of the Hall, Cotton, and Kendall families.[11] The major difference here may be that the lack of water transport, which meant there was less opportunity to buy pig iron on the open market and goods had necessarily to be taken further by road (which was expensive). Thus integration, with goods moving towards their major market in the Black country, as they passed through successive stages of production, continued to have its advantages.

This discussion of organisation has been taken far ahead in time of that of production and consumption, which was left above at around 1620 when a peak in English production had been achieved. For the rest of the 17th century, there was a gradual overall decline in the quantity of iron produced, for the very sharp decline of the Weald was not quite counterbalanced by expansion elsewhere. Until the 1660s, iron consumption overall and also per head remained slightly below the levels estimated for 1620, averaging 8 *lb.* per head *p.a.* This period slightly precedes the century (from 1640), when the English population was relatively stable. This fall in consumption may be a real one that should be blamed on high taxes (which reduced the income available to be spent on non-essentials) and economic disruption due to the Civil War. However it could merely be an artefact of the methodology and of the quality of the data used in making the estimate of English production. In particular, the figures on Wealden production are built on very small samples, and it is possible that the decline

[11]. Jennens and successors: King, *North*; Cheshire ironmasters: Johnson 1954; Awty 1957.

in the Weald was slower and began earlier than estimated here. However, another factor, iron imported from northern Europe, now enters into the equation; this became increasingly important during the latter part of the 17th century and the one that followed. As a result, the amount of iron manufactured (and also that consumed) to continue to rise, in spite of the declining amount of iron made in England.

In the century up to 1730 most of the iron imported into England was made in Sweden. However for the origins of this, it is necessary to look further afield. As already mentioned, England had become largely self-sufficient in iron in the late 16th century, but by 1675 it was only about 50% self-sufficient. Sweden had long been a producer of iron, and members of the Eastland Company (who had a monopoly in Baltic trade) had for many years imported small amounts of it into England. However from the 1610s the Swedish iron industry underwent a considerable expansion, financed by Dutch capital. Investments by Louis de Geer and others, first at Finspång in 1615 and then in Uppland from 1624, were both followed by very sharp rises in the quantity of iron passing through the Sound out of the Baltic. Initially this had relatively little impact on the English market, as most was carried in Dutch vessels (probably bound for Holland). There was a lesser amount shipped in Scottish vessels, probably going to Scotland which had long imported iron from the Baltic.[12] The first investment may merely have been opportunistic, but the second is probably related to the Spanish blockade on the land borders of the Netherlands from 1625 to 1629 (or to the expectation of such).[13] From the Swedish point of view, it provided money to finance their involvement in their war, at that stage only with Poland, but subsequently in Germany as part of the Thirty Years War.[14] On the Dutch side, it freed the United Provinces from reliance on iron produced in the Liège region and the Rhineland, sources that were at best insecure and at worst denied to them by blockade. Nevertheless, it is not possible to determine whether these events are truly linked in terms of causation, or merely coincide in time.

The growth in English iron imports began around this time. Direct shipments of iron from Sweden began on a small scale in the late 1620s, but considerably greater quantities arrived in this country (probably as re-exports) from Holland, Hamburg, and even Norway, all places beyond the scope of the Eastland Company's monopoly.[15] Unfortunately, the relative dearth of English customs records from this period makes it difficult to assess the extent of this indirect trade, but it may have exceeded 2000 tons in 1633. However subsequently, the great growth in iron imports was in those coming directly from Sweden. They averaged under 150 tons annually in the 1630s, but probably rose during the 1650s from under 1000 tons to over 5000 tons annually. This great increase thus probably followed the Peace of Westphalia at the end of the Thirty Years War, which reopened Dutch trade with Liège and Germany, and so reduced their need for Swedish iron. This meant that Sweden needed a new market for iron, and that market was increasingly found in England. The growth of this trade was also facilitated by the Eastland Company's loss of its monopoly in the 1640s or 1650s. This had the

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[12]. See chapter 6.

[13]. Israel 1995, 496-8.

[14]. Roberts 1973, 62-77. This war probably only disrupted trade quite temporally, as revenue from customs dues on the south coast of the Baltic was a significant element in Swedish financing of the war there and later in Germany: *ibid.*, 122-5.

[15]. For the scope of the monopoly see Zins 1972, 114.

effect of removing a restriction on trade with Sweden, for English ships trading with the Baltic no longer had to land their outward cargoes at Danzig.[16] It was also no doubt facilitated by the development of a multilateral system of settling trade balances in northern Europe, using bills of exchange drawn on Amsterdam (and sometimes Hamburg). This settlement system was evidently established by Dutch merchants, and may have arisen in the 1650s, as a means of circumventing restriction on Dutch entrepôt trade imposed by the Navigation Ordnance of 1651. The Dutch entrepôt was thus replaced by a Dutch banking system that cleared trade balances multilaterally.[17]

After 1660, iron imports from Sweden continued rising: they passed 11000 tons in 1675, and averaged more than that for the rest of the century. In this period English self-sufficiency in iron dropped to below 50%. However a significant (though uncertain) quantity of iron began to be re-exported. In the same period, the amount reaching English manufacturers rose to an average of 27000 tons of bar iron, and domestic consumption to 26000 tons. This corresponds with consumption of 10 *lb.* per head. However, it is possible that re-exports have been underestimated in the late 1670s when England was the only neutral maritime power in northern Europe during a war in the Baltic (the Scanian War). If so, the consumption figures will be slight overestimates.

During the Great Northern War between Sweden and Russia (1700-20), Swedish iron exports seem to have declined slightly. This was matched by a slight increase in English production. However, events in the latter part of this war led to the most dramatic of all fluctuations in the whole period under consideration. George I intervened in the war as Elector of Hanover. England, though officially neutral, sent a naval squadron into the Baltic. In their desperation for money to continue financing their war with Russia, the Swedish government sought funds from the Catholic powers, under the pretence that they were intending to invade Britain in support of the Jacobite Pretender. When this became known in England in 1717, an embargo was imposed on trade with Sweden.[18] The embargo lasted two years, but proved largely ineffective as a measure against Sweden, because the Dutch did not also impose one.

Despite the failure of the embargo to damage Sweden materially, it had a dramatic effect on the iron trade in England. There was an immediate effect on the supply of iron as direct trade was cut off. This shortage evidently increased the price of iron, and therefore in the short term the profits of English ironmasters. For example, it encouraged William Rea (the managing partner of the Foleys' Forest Ironworks) to enter into a contract to buy wood at prices reflecting the current price of iron, and this contract ultimately proved financially disastrous for Rea. It also stimulated a wave of construction of new ironworks. Nevertheless, the embargo was taken off just as the new ironworks were beginning to come into production. Furthermore, even during the embargo, considerable amount of Swedish iron continued to enter England, as a re-export from

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[16]. Hinton 1959, 81-3 86-88.

[17]. *Cf.* Price 1962; 1996a; Roseveare 1987, 32-33. The suggestion as to the reason for the multilateral system is mine.

[18]. Chance 1909, 210-2; Ashton 1924, 110-2; Hatton 1978, 183-200; King 1996b, 30.

Prussia, Germany and Holland. This was no doubt at a higher price than previously reflecting the handling charges and profits of merchants in those countries. In any event, the lifting of the embargo almost certainly resulted in the market for iron being glutted, with a consequent adverse effect on profits. This led ultimately to a series of bankruptcies and ironworks closures towards the end of the 1720s, compounded by the first arrival of iron from a new source, Russia.

The effect of the Swedish embargo on the amount of iron produced in England was quite dramatic. This rose from about 13000 tons per year before the embargo, to 18000 in 1718, but dropped back to 12000 in 1735, after which growth resumed. On the other hand, the effect on consumption seems to have been quite modest. Around the embargo period, annual consumption per head increased from about 11 *lb.* per head to about 12 *lb.*, and this was the beginning of a long period of growth in overall iron consumption. The growth was both a reflection of a resumption in population growth and also of increasing consumption per head. However, detailed consideration of these matters must however be deferred until a technological change has been considered.

Throughout the 16th and 17th centuries, the normal fuel for making iron was charcoal, but the substitution of mineral coal ('pitcoal') for charcoal had been long sought after. Discussion of this in the 17th century usually focuses around Dud Dudley, who claimed to have made iron with pitcoal in the 1620s. He resumed his efforts in the 1660s with a unique horse-mill powered furnace at Dudley, and from this emerged the business of John Finch (already mentioned), who sought to rival Philip Foley. Coke-smelting at Dudley seems to have been abandoned,[19] but another partner in the business Sir Clement Clerke (and his son Talbot) went on in the 1680s successfully to employ pitcoal in smelting lead and copper, and then to apply the air furnace technology (developed for this) to remelting pig iron for foundry work at Vauxhall in Lambeth. The Company for Running Iron with Pitcoal, one of three chartered companies which Talbot Clerke promoted in the early 1690s, also built a furnace at Cleator in Cumberland to make pig iron with pitcoal, but this only operated for a few years.

Far more important than Vauxhall or Cleator was the business carried on by Shadrach Fox at Coalbrookdale. He was the brother of Thomas Fox, who was the founder at the Company's foundry at Vauxhall. Initially as a subcontractor for the Company, and then in his own right, he cast grenado shells and shot for the Board of Ordnance at Coalbrookdale during the Nine Years War. He ultimately failed financially, and absconded to Russia in the early 1700s, after an explosion at the Coalbrookdale Furnace.[20] Shortly after this, Abraham Darby developed a method (patented in 1707) of casting pots thinner than hitherto, using reusable patterns and casting in 'green' sand. In 1709 he took over the derelict Coalbrookdale Furnace, and after certain teething troubles developed a successful business, smelting iron with coke to make cast iron goods, particularly

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[19]. King 2002b.
[20]. King 2002a, esp. 39-42.

Figure 8.5 Price of charcoal in the Stour valley and south Shropshire

Charcoal prices/Chart1

cooking pots. Nevertheless, the furnaces at Coalbrookdale were in the early 1720s consuming a very large amount of fuel in proportion to what they made. This did not matter unduly in the foundry trade where they had few competitors and could sell their products at a profit despite their relatively high costs. The problem with the fuel consumption in the furnace was gradually solved, probably by running the waterwheel of the furnace (and so the bellows) faster, thus increasing the blast and hence the operating temperature of the furnace. However this used up the water in the furnace pool too fast, and it was necessary in 1734 to install a horse pump, later replaced by a steam engine to refill the pool.

When it came to using coke pig iron to produce bar iron, the Coalbrookdale Company's forge at Coalbrookdale did not prove a success, but it seems to have been an inefficient little forge, which could hardly manage to make a profit, even when it only used charcoal pigs. Initially, despite a favourable trial before the forge was taken over, there seems to have been some difficulty with the use of coke pigs, leading to the reversion to the use of charcoal ones. However, by the late 1720s these metallurgical problems were apparently solved, but by then the price of iron had fallen, and the forge still made a loss. Nevertheless, the problem was now only an economic one and not a technological one.[21]

The economic difficulties of the English iron industry in the late 1720s and early 1730s arose partly from the expansion of iron production around the embargo period, but probably more important was the first arrival of significant amounts of Russian iron. Much of the Swedish iron was tough, and competed with the best kinds of English iron, such as that from the Forest of Dean. However, the main product of English ironworks was coldshort iron, which was made from ironstone from coalfields and had a significant phosphorus content, but was quite suitable (even desirable) for ordinary nails. Some of the Russian iron competed with this directly. Russian iron arrived in increasing quantities during the 1730s, but import growth was limited in the 1740s, perhaps due to the difficulty in English shipping bringing it to England in wartime. Nevertheless for much of the 1730s and 1740s, imports from Russia averaged 3700 tons, which was more than a quarter of home production in 1736. After the War of Austrian Succession, Russian imports grew steadily (though checked slightly during the Seven Years War) until the 1770s when over 25000 tons was imported annually, making Russia the largest single source of iron available in the English market. This level of imports was maintained until the early 1800s, after which there was a sudden and rapid collapse in this trade.

English iron production recovered from the doldrums into which it had fallen in the mid 1730s. By the early 1740s certain forges that had closed, such as Tortworth, were being reopened. It is however not clear exactly when the industry's difficulties ended, but if charcoal prices in north Worcestershire and south Shropshire are anything to go by, it may not have been until the late 1740s (see figure 8.5). From that time new ironworks began to be built, particularly forges in south Wales and furnaces in Furness and around the west coast of Britain. Some of this investment may be related to an expansion in tinplate production in south Wales in the

[21]. See chapter 5, which constitutes a significant reconsideration of the views expressed in Hyde 1977, particularly in the case of forges.

Figure 8.6 Swedish bar iron prices

Sweden Prices/Chart1

Figure 8.7 Iron sales prices

Iron price summary/Chart3

same period, but far more important was a rise in the price of iron. This is certainly not related to any decline in imports, for they continued to rise. Indeed English self-sufficiency in iron, which had been 48% for the half century up to 1725 and was still 42% in the 1740s (though lower in the intervening period), declined to 33% in the 1770s and early 1780s. This price rise is most evident in the Stockholm price of ordinary bar iron in Dutch riksdalers, a stable currency used for international trade (see figure 8.6).[22] It also appears in several English price series, though the rise was somewhat slower, and is least apparent in the series from ironworks at Sheffield (see figures 8.7).[23]

The reason for the price rise was attributed by E.F. Heckscher and other Swedish historians to the imposition of a limitation on the output of Swedish forges in 1747. This has already been alluded to several times, but must now be discussed in detail. Iron had by this time replaced copper as Sweden's prime export commodity, and therefore as its most important earner of the foreign exchange, to finance imports of grain from Prussia and of salt from Portugal.[24] The Swedish iron industry had long been subject to government regulation, by the *Bergskollegium* (Board of Mines) that was established in 1637.[25] Swedish iron prices were low in the early 1740s, and measures were taken with a view to supporting the industry. Jernkontoret (the Swedish Ironmasters' Association, literally the 'Iron Office') was founded in 1746, partly with the objective of providing ironmasters with a price support mechanism.[26] This was followed in 1747 by the imposition of a limitation on Swedish forge output based on a new taxation list, which was thereupon compiled. Ultimately in 1753, a prohibition was placed on the erection of additional forges, and even on applications for increases in the licensed output of existing ones.[27]

The reasons for these measures have become a matter of controversy. The view of E.F. Heckscher was that Sweden was exploiting a monopoly position in the international iron market, and was limiting production with a view to enhancing prices. More recent authors, such as K-G. Hildebrand, have emphasised the need to preserve wood, particularly to prevent excessive demand from the iron industry forcing up the price of its fuel. However P-A. Karlsson has suggested the limitation was a reaction by those who did not belong to the ironworks interest, and who wanted to promote the production of foodstuffs. Other historians are not convinced by this.[28] However it is only the effects of the restriction of production, not the reasons for it, which are in issue here.

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[22]. Högberg 1969, 88-92; Hildebrand 1957, 354-5; Kent 1973, 71-2.

[23]. See last part of chapter 5.

[24]. Heckscher 1954, 194-5; Högberg 1969, ch. 6-7.

[25]. Hildebrand 1957, 80-1; 1995, 119.

[26]. Jernkontoret borrowed money from the Riksbank (the Swedish state bank) and lent it to ironmasters against iron awaiting export, enabling ironmasters to avoid having to sell their iron at once if they needed money when the price was low: Kent 1973, 35 71-2; Samuelsson 1951, 179-82; Roberts 1980, 127.

[27]. Heckscher 1932, 232-3; Samuelsson 1951, 179-82; Hildebrand 1957, 353-55; 1958, 13 21; Kent 1973, 35 71-2.

[28]. Heckscher 1932; Hildebrand 1997, 21; Floren & Ryden 1996, 261 (from Hildebrand 1957, 96). I have not seen the book that caused the recent controversy, P.-A. Karlsson, *Järnbruken och ståndssamhället: institionell och attitydmässig konflikt under Sveriges tidiga industrialisering 1700-1770 [Ironworks and Society: institutional and mass attitude conflict during Sweden's earlier industrialisation 1700-1770]* (1990).

Heckscher's suggestion of a Swedish monopoly cannot be quite right, since Russia had been exporting considerable amount of iron since the late 1720s. However much of the Russian iron was of less good kinds that only competed with the poorer varieties of English, particularly the coldshort iron made from the argillaceous ironstone of the coalfields that was mainly used to make nails. The best brand of Russian iron was 'Sable Siberia' (later known as 'Old Sable'), and seems to have been regarded as approximately equivalent to ordinary Swedish iron and to the best English iron (known as tough or 'tuff' or merchant iron).[29] The best Swedish iron had no English equivalent. It was known in England as oregrounds iron, and in Sweden as *vallonjärn* ('Walloon iron'). It was made mainly in Uppland, using ore from the Dannemora mine.[30] Oregrounds iron was the main raw material for conversion into blister steel, and was also bought (along with 'Stockholm iron' and small amounts of other sorts) for the British Navy.[31] Since oregrounds iron had no rival, its producers did hold a monopoly position, which they were able in some degree to exploit over a long period from the 1730s to the 1850s.[32] The position of ordinary Stockholm iron and other Swedish varieties is less clear, since they did have rivals, such as Sable and also English tough iron made from the haematite ores of the Forest of Dean and Furness.[33] In this market Sweden certainly had no monopoly, but by preventing Swedish ironmasters from responding to increased demand by increasing output, the Swedish government may nevertheless have succeeded in their supposed aim of enhancing the price. Certainly at home in Sweden, the policy appeared very successful as the price, measured in Swedish copper *dalers*, rose rapidly in the following years, but the copper *daler* was by then a depreciating paper currency. The price rise measured in the bullion-based currencies of international trade (as discussed above) was rather less.[34] The Swedish intention to enhance the price of iron was successful, but it is not possible to prove that this effect was directly caused by the Swedish limitation on production, rather than by increasing English demand.

What is clear is that the price did rise and that this stimulated an expansion in the English production of iron, as the high price offered the prospect of high profits. The profits of the ironworks of Edward Knight & Co. in the Stour valley and elsewhere commonly exceeded £5000 per year on an output of some 2200 tons in the 1750s and early 1760s, over £2 per ton, compared with £1 per ton or less in the late 1720s and early 1730s.[35] As already mentioned, this was a period when a considerable number of new furnaces, forges and tinplate works were built. This buoyant market for iron also provided the opportunity for a new product to be introduced to

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[29]. For a discussion of different kinds of English iron see chapter 3.

[30]. The English and Swedish terms strictly refer to different matters. The English one refers to the region from which the iron came and in effect to the source of the ore. Whereas the Swedish one refers to the process by which the iron was made. However they seem to be largely interchangeable. The English term comes from the small port of Öregrund, which was presumably fulfilling the function of a market town in the Swedish commercial system. Sweden had three systems of weights and measures for iron, *stapelstadsvikt* (staple town weight), *uppstadsvikt* (market town weight), and *bergsvikt* (mountain *i.e.* metal works weight). These had a fixed relationship to each other so that the metal's weight increased (so to speak), as it travelled towards the port of export. The apparent increase in weight was presumably a means of paying the carriers: see Barraclough 1990; King 2003; *European market*, 243 251; Högberg 1969, 34-6.

[31]. Barraclough 1990; King 2003; The Crowleys near Newcastle (but apparently not others) also converted some Sable, probably to provide their works with a lower quality steel: *Angerstein's diary*, 258-9.

[32]. King 2003.

[33]. *J.H.C.* 22, 851-2 (20 Apr. 1737); *cf.* Britannicus 1752. Iron made from Forest of Dean pig iron was referred to as 'tuf' in 1669: Schafer 1978, *passim*

[34]. Högberg 1969, 88-92; Hildebrand 1957, 354-5; Kent 1973, 71-2; *cf.* Roberts 1980, 250-7.

[35]. SW a/c; Ince 1991b, 111-2.

the trade. That product was coke-smelted forge pig iron. Apart from the commercially unsuccessful efforts at Coalbrookdale in the 1720s and 1730s, the first regular use of coke pig iron in forges followed a trial carried out by Edward Knight & Co. on Coalbrookdale pig iron in 1755. This proved a success, and from the latter part of that decade forge pig iron became a major product of several new coke furnaces, built mainly in Shropshire.

The price rise noted above both for Swedish and English iron and the expansion in home production were only sustainable because there was a growth in the demand for iron. Annual iron consumption per head climbed fairly steadily from 12 *lb.* in the early 1720s to around 15½ *lb.* from the early 1760s until the early 1780s, and then to more than 20 *lb.* around 1805, that is if the contemporary estimate of bar iron production in that year is to be believed.[36] This level of consumption per head was rather higher than that in the West Indies until 1750, though lower in the next two decades (see figure 7.21). The growth rate of English consumption per head from 1715 to 1806 was 0.6% per year, but this period was nevertheless not a period of continuous steady growth. From 1715 to 1744 growth averaged about 0.5%, but this was followed by more rapid growth at 1.1% *p.a.* until 1770, a decline of 0.4% until the end of the American War of Independence, and then very rapid growth of 1.4% *p.a.* from then until 1805.

With a growing population, the figures for the total manufactured and that consumed show an even more rapid increase. In the early 1710s, immediately before the embargo, some 30600 tons were sold in England each year. After allowing for re-exports, 28600 tons reached manufacturers and 26800 English consumers. By the late 1780s these had risen to 74500, 70700, and 57300 tons respectively, and in the mid 1800s they were 123,900, 110,800, and 91000 tons respectively. This represents an annual growth from 1715 to 1805 of 1.4% in the amount manufactured and of 1.2% in domestic consumption. This period was nevertheless not one of uninterrupted growth, as there was a significant recession in the late 1770s. The amount of iron manufactured is estimated to have fallen from 62700 tons in 1773 to 58400 in 1777-80, while domestic consumption stood still at slightly less than 50000 tons in the early 1770s. This results from reductions both in home production and in Swedish imports, though Russian imports continued to grow. This recession coincides with the American War of Independence. It is obviously related to the reduction in the level of exports during the war. This reduction not only resulted from the virtual cessation of the export of manufactured goods to continental America, but also from severe hardship in the West Indies, much of whose food normally came from the northern colonies. The demand for slaves was reduced, both in the colonies in rebellion and also (because of the difficulty in feeding them) in the West Indies. This in turn reduced the level of trade to Guinea.[37]

An alternative possible cause of the recession might be the banking crisis of 1772 and 1773. In that year there was a severe crisis in commercial credit due to the collapse of the Ayr Bank and of Fordyce & Co. in

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[36]. The estimate was apparently calculated from pig iron production shown in the 1806 list, rather than being compiled by means of a separate survey. The pig iron estimate of that year is certainly reliable, but that for bar iron is not necessarily so.

[37]. Perry *et al.* 1987, 115-19; Pares 1950, 91. For the levels of trade see Schumpeter 1960 (see figs. 7.19 and 7.20).

London.[38] The same speculative bubble led to the collapse of certain Amsterdam merchant and banking houses, causing difficulties in Anglo-Swedish trade.[39] However the crisis preceded the observed recession by some years. Such financial crises are no doubt an interesting subject, but they were relatively short-term phenomena. Certainly neither the effect of the 1772-3 banking crisis, nor for that matter the earlier one of 1763 when the de Neufville house in Amsterdam failed,[40] can be detected in my estimates of iron production and consumption. The economy was evidently too strong for it to be upset more than temporarily by such events.

As mentioned in chapter 1, historical economists have sought to use statistics to estimate growth in the British economy in the 18th century. They have generally identified a point when the British economy took off into sustained growth around 1780. Earlier researchers, such as Deane and Cole, identified that as the beginning of the Industrial Revolution.[41] More recent ones, particularly Crafts and Harley, have suggested that the effect was not as great as previously believed, the earlier estimates having overemphasised the importance of certain leading sectors of the economy, including cotton and woollen textiles.[42] Iron was also one of the leading sectors of the Industrial Revolution, with a growth rate of over 6½% *p.a.* in production from the late 1780s to about 1810. However, the present study suggests that the period immediately preceding it was one of recession (at least in the iron trade), and that the recession was primarily due to the American War of Independence. Accordingly, the take-off around 1780 may be seen partly as a resumption of growth after a period of recession (or at best of stagnation).

Most of the estimates of output by historical economists have compared sample periods. This does not however apply to the most recent, which contains an index of industrial production. This index (rebased) has been included in figure 8.4, and will be observed to show a similar growth pattern to total iron consumption in England. When these are plotted against each other (see figure 8.5), there is an obvious correlation between the index and iron consumption throughout the 18th century. This suggests that growth in iron consumption was merely a reflection of the growth that was taking place in the economy generally. The index shows a period of lower output in the late 1770s, corresponding with the pause in the growth of consumption identified here, but this is a somewhat less dramatic effect than for iron consumption.[43] A general decline in exports has been noted,[44] but the effect of this on particular industries, and the economy as a whole, requires further study.[45]

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[38]. Wilson 1941, 167-82; Hamilton 1956; Ashton 1959, 125-9; Hoppitt 1986, 52-4.
[39]. Wilson 1941, 187; Samuelsson 1951, 23 25 40-1 etc.
[40]. Wilson 1941, 167-8.
[41]. Deane & Cole 1972.
[42]. Harley 1982; Crafts 1985; Jackson 1992; Crafts & Harley 1992.
[43]. Crafts & Harley 1992, 725-7. I have not sought to adjust the index (as ideally I should have) to take account of the fact that the output of the iron industry (based on estimates of pig iron production in Riden 1977) is a constituent of the index.
[44]. Crouzet 1980, 52-3 60.
[45]. S.D. Smith (1995, 54-5) has noted a decline in the export of woollen textiles, but continuing growth in their output. I have not seen his thesis.

The identification of iron as a leading sector in the Industrial Revolution is nevertheless no mistake, but its importance consists mainly in an expansion of production, rather than of consumption. English iron production underwent a prodigious expansion during the 1790s and 1800s. This began very precisely in a short period after 1785 when the production of bar iron by the new potting and stamping process began to be widely adopted. It also coincides with means being devised to apply steam power to operate hammers, but that was probably not the decisive factor, since it would have been possible in principle to build more water-powered forges. The advantage of the potting and stamping process, and of the puddling process that succeeded it, was that iron was made using mineral coal alone (without the use of any charcoal at all). This released the iron industry from dependence on the speed at which trees grew. It also removed the need for forges to be scattered across the countryside, so as to be near their fuel supply, for the fuel was the most bulky (and so least transportable) of the resources needed. This allowed the iron industry to be concentrated in coalfields, which provided both coal and ironstone, thus cutting transport costs.

An estimate dated 1788 indicates that 16400 tons of iron were made in England by the traditional process and perhaps another 15600 tons in melting fineries (using the potting and stamping process). This figure may be excessive, as it is difficult to reconcile it with an estimate of the same date for pig iron production.[46] The cause of this discrepancy is not clear, but results from the building of significant numbers of new furnaces not beginning until after 1788. From this time frequent surveys were made of pig iron production and furnace numbers. As a result, a great deal is known about the numbers and output of furnaces, but very little about the numbers of melting fineries and puddling furnaces. Accordingly after 1790, estimates of bar iron production have to be derived from those for pig iron. A new series of figures for both has been presented in chapter 6, but the figures for bar iron remain unsatisfactory. The difficulty is in estimating the proportions of the pig iron output that were on the one hand used to produce bar iron and on the other in foundries to make cast iron goods. Difficulties of this kind are no doubt the cause of the wild fluctuations in my estimates of consumption per head after 1805. No satisfactory solution has so far been found to this problem.

As far as can be determined on the basis of the rather unsatisfactory data available after 1790, bar iron production increased extremely rapidly from the mid 1780s, increasing at 2.6% per year from 1783 to 1805. In the same period, overall home consumption increased at 2.5% *p.a.* and iron imports reached their highest level at more than 50000 tons in the early 1790s. They sometimes still exceeded 40000 tons as late as 1802, but after that time there was a very sharp decline. For the next few years, the annual average imported from Sweden and Russia still exceeded 10000 tons each, but total imports did not exceed 5000 tons in 1811 and 1812. The counterpart to this is that English self-sufficiency in iron increased rapidly from a low of about 33% in the early 1780s to more than 90% in the early 1810s. One cause of the decline in imports was undoubtedly increases in import duties, imposed so as to finance the Napoleonic Wars. As there was no similar duty

[46]. See chapter 6. The pig iron required for the production of this bar iron together with the likely requirement of pig iron by foundries seems to come to rather more than the estimated pig iron production for 1788.

charged on English iron, the latter gained a competitive advantage. However the expansion of English production outstripped demand, and the industry went through a severe recession in the latter years of the war and immediately after it. It is possible that this was merely a cyclical downturn, because production had expanded to exceed demand. However, demand was also reduced by American non-importation measures imposed from 1807, in response to the effect on American trade of the British Orders in Council, which were in turn a reaction to the Napoleonic Continental System.[47] This embargo led ultimately to the War of 1812-15. Unfortunately the trade statistics are incomplete for this significant period.[48] However a number of ironworks suffered bankruptcies or closed in this period, including Wilsonstown and Balgonie (in Scotland), Abernant (in south Wales), Hasland and Stone Gravels (near Chesterfield), Birkenshaw, Calder, Fieldhead, Royds, and Swallow Hill in West Yorkshire (all coke ironworks).[49] Elsewhere the depression appears most clearly from the large number of furnaces out of blast.[50] In the course of this depression many of the surviving charcoal ironworks closed, for example the Bringewood works, and Burton and Hints Forges.[51] This series of closures marks the effective end of the charcoal iron industry in Britain, and with it that of the period covered by this study. A small number of furnaces continued using charcoal for many years, in one case until 1918. Some forges may have continued using the traditional finery process for a decade or two after 1815, but they represented an insignificant proportion of a very substantial industry.

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[47]. Heaton 1941; Frankel 1982.

[48]. Some of them were destroyed in the Customs House fire of 1814.

[49]. Wilsonstown: Ritchie 1939; Donnachie & Butt 1964; 1967; Abernant: Tann 1996; Hasland: Jenkins 1991, 43-61 88-90; Stone Gravels: Stephens 1980, 111 121; King, *North*; West Yorkshire generally see Firth 1990; King *North*; Goodchild iron notes; for Calder and Royds: Wakefield Deeds Registry, various; Swallow Hill: Yorks. Arch. Soc. (Leeds), DD/70/84; DD/70/137.

[50]. Trinder 2000, 112-4; Birch 1967, 52-6; Butler 1954, 250-1.

[51]. The closure dates are often indicated by Land Tax Assessments. In the case of Bringewood, this coincides with the expiry of a lease: Ince 1991b, 14; Riden 1993, 56; Burton: Lloyd 1975, 210-3