Chapter 5

The Marketing of Copper

The demand for copper in the British and export markets grew through out the eighteenth and the first half of the nineteenth centuries. In the period covered by this thesis this demand was mainly satisfied by the output from the copper mines of Cornwall. From 1725 onwards copper ore was sold at public sales known as 'ticketings', except for a brief period between 1785 and 1792 when the sales were in the hands of a monopoly of Cornish mine adventurers. The quantity of ore sold at the ticketings was largely determined by demand for copper, but also by arrangement between the smelting companies. These arrangements amounted to collusion by the dominant companies of South Wales, and any competition from companies outside this region was fiercely opposed, and in many cases relatively short lived.

This chapter will examine the marketing of copper ore chronologically, addressing the issues as they arise. The period from 1760 to 1820 can be broadly divided into three epochs. The first is the years from 1760 to 1784 marked by the domination of the smelting companies of South Wales. In the fourth quarter of the eighteenth century, these companies were challenged by the power and influence of Thomas Williams, much to the detriment of the Cornish miners, who responded by forming their own marketing

organisation, the CMCo, this representing the second phase from 1785 to 1792. Thereafter the market reverted to much the same as it was prior to 1784, notwithstanding a brief period in which the smelting companies centred on Birmingham had a degree of influence. These 60 years were marked by collusion and monopoly, a result of the widely differing structures of the two industries, the smelting companies few in number, the mines significantly more numerous.

The demand for copper ore was largely dependent on demand for copper for manufacturing and export; whilst an investigation of this topic is not an integral part of the thesis, its context is felt to be sufficiently important for an overview of the market for copper to open this chapter. The chapter continues with an examination of the method of selling copper ore, the ticketings, its operation, strengths and weaknesses. This is followed by a discussion of the various factions into which the industry divided, the collusive activities of the smelting companies of South Wales, the monopoly of Thomas Williams and the cartel resulting from the formation of the CMCo, and a return to the status quo of the 1760s and 70s.

DEMAND

The demand for copper rose sharply in the years after 1760. Five major purchasers have been identified: the Admiralty; merchant shipbuilders; manufacturers of copper medals, tokens and coin; exporters, predominately the East India Company; and the manufacturers of consumer goods and general copper and brass hardware.[1] Demand had risen to approximately 9,000 tons per annum by the late 1790s.

The Admiralty.

In 1761 the hull of the 32 gun frigate HMS *Alarm* was covered, or sheathed, below the waterline with copper sheet to protect against weed growth and the boring worm, *teredos natalis*. The trial, and subsequent development, was deemed to be such a success that by 1780 copper sheathing had been applied to the majority of naval ships.[2] The impact on the consumption of copper was significant. Between the outbreak of war in 1793 and 1799 a total of 248 naval vessels were commissioned. The numbers built and copper consumed in each year is shown in Table 5.1.[3]

Table 5.1. Copper consumed by the Royal Navy, 1793 –1799 (tons)

	1793	1794	1795	1796	1797	1798	1799
Ship Construction:[4]	20	35	26	57	46	36	28
Copper Consumed:[5]	1,597	708	1,086	915	851	1,127	1,236

In addition, many of the 417 ships in ordinary would have been brought back into service, as well as the refitting of those in service.[6] Between 1793 and 1799 the Royal Navy consumed 7,520 tons of copper.

Merchant Shipbuilding

The merchant ship owners also recognised the advantages of copper sheathing. By 1780 an estimated 147 ships had been coppered, rising to 275 by 1786 out of a total fleet of 8,433 vessels, or 3.26 per cent. Thereafter progress was rapid. In 1796, 7.18 per cent, in 1806, 10.8 per cent and by 1816 the total had risen to 17.93 per cent, representing some 1,520 vessels out of approximately 8,500.[7] This represented a five fold increase in coppering over 30 years, but provides little guidance as to the amount of copper consumed.

The advantage of coppering was clearly demonstrated by Thomas Williams in his evidence to the 1799 Enquiry in which he stated:

> I know a vessel belonging to Liverpool of 350 tons, that was copper bolted and sheathed in April 1785, she has within the last fortnight[8] sailed from thence on her sixteenth voyage to Africa, the West Indies and home; all the repair expenses upon this vessel, I am well informed, have not exceeded £55 in the whole time, except for a few small repairs in her copper sheathing only, which her owner took no account of, and she is so perfectly sound and tight at this time, that she would sell for as much if not more money than the building and fitting out cost in 1785. An iron–fastened and wooden–sheathed ship of the same tonnage, never was known to make more than eleven, or at the most twelve of these voyages in the same time, and each of those voyages at an extra expense of £2,000 and upwards, beyond that of the coppered ship. A still more important saving is made by the use of copper on ships carrying slaves from Africa to the West Indies, in the number of lives saved by the shortness of the passage.[9]

Similar advantages were gained from coppering the hulls of the vessels serving the East India Company, enabling the Company to extend the number of voyages between surveys from five to six, resulting in lower maintenance, and reduced passage times.[10] Such advantages must have contributed to the spread of its application and an ever increasing demand for copper. Given the number of merchant vessels coppered by the end of the eighteenth century it is estimated that the demand for copper by the Royal and merchant navies must have been of the order of 2,000 tons per annum.

Coinage

There was an ever increasing demand for the distribution of a new copper coinage in the eighteenth century, which the Mint was reluctant to meet.[11] By 1755 the Mint estimated there was approximately 1,800 tons of genuine copper coins and upwards of 1,200 tons of counterfeit in circulation. By 1787 the genuine copper currency had fallen to roughly 1,500 tons.[12] In 1797 Boulton alleged that the Mines Royal Co was selling some 300 tons of copper to counterfeiters each year.[13] Some relief was afforded by the striking of tokens, mainly in copper, in considerable quantities. In excess of 400 different tokens were produced in the eighteenth century.[14] In 1787 Thomas Williams commenced issuing the

tokens of the Parys Mine Company, coining some 300 tons, and circulating them throughout North Wales and Lancashire.[15]

The Royal Mint received numerous proposals from private mints for the production of copper currency. Foremost amongst these, and the one with the greatest influence was Matthew Boulton. By 1786 he had built a number of coin presses powered by steam.[16] With no Government contract initially forthcoming Boulton was left to search for customers elsewhere. In 1787 he minted coins for the East India Co,[17] in 1788 copper cents for the new American government,[18] between 1791 and 1792 coins and medallions for the French[19], a penny coinage for Bermuda in 1791, as well as considerable quantities of copper tokens for British firms.[20] By 1791 Boulton had the capacity to coin 10,000 pounds avoirdupois per day with a guarantee of constant size and weight.[21]

Demand for a new copper coinage continued to intensify. In August 1797 the Government acquiesced, and agreed to '… giving Currency to a new Coinage of Copper Money of One Penny and Two Penny Pieces.'[22] Boulton was awarded the contract. From July 1797 to March 1799, Boulton consumed 1,200 tons of copper on this contract.[23] It was renewed regularly between 1797 and 1806 during which time he coined 4,200 tons of copper. Given this was in addition to his other contracts identifies the Soho Mint as a major consumer of copper. In the closing years of the eighteenth century Boulton alone was consuming some 500 tons of copper per annum. Boulton was supplied by the Government at £108 per ton, a value significantly above the Cornish standard in 1797, yet even at this price virtually unobtainable. In 1798 Banks noted the January price was between £96 and £100 per ton, and had risen to £109 to £120 by December.[24] This was a very significant rise over the price of £82 to £100 in 1792, the final year of Thomas Williams' monopoly. The strong demand throughout the country for a large coinage of a

low denominational copper currency must have had an influence on the rising price of the metal.

The East India Company and Other Exports

The East India Company purchased copper by annual tender, the price determined by the average copper price over the previous 12 months. It followed, therefore, that the price would invariably be below the current copper price in a rising market, leading to complaints of preferential treatment from the Birmingham merchants. The East India Company began exporting copper to India and the Far East in 1731. Between 1776 and 1782 the Company purchased 13,509 tons, an average of 1,900 tons per annum, at a cost of £300,375, and during the next ten years 1,310 tons per annum at an average cost of £79 per ton.[25] Only in the 1798/9 season was there any significant fall.[26] Whilst recognising the East India Company obtained copper at a preferential price, no surprise with annual purchases consistently of the order of 1,500 tons per annum, the Company could not be considered instrumental in inflating prices or greatly influencing demand (Figure 5.1).

In examining the exports of copper, the difficulty is the segregation of the data examined above and the export figures contained in the 1799 Enquiry Report. The source of the data also poses problems, for in addition to the statistics of unwrought copper, the statistics included brass and plated goods.[27]

Table 5.2: Total Copper Exported, tons

	1790	1791	1792	1793	1794	1795	1796	1797	1798
Brass[28] – Cu:	1,277	1,549	2,092	2,399	2,033	2,035	2,122	1,623	1,564
Wrought:	3,064	3,382	4,130	4,400	4,538	4,143	4,371	3,748	3,902
Total:	4,340	4,932	6,223	6,800	6,571	6,178	6,493	5,371	5,466

The annual totals in Table 5.2 must include the East India Company's purchases. The impact of the war of 1793 can be seen in the detail of the two appendices in the 1799 Report, although less obvious in Table 5.2 which indicates an overall upward trend, notwithstanding the decline in the final two years. Exports to Europe were badly hit, falling to zero in the case of France, Holland, Poland, and latterly Spain and Turkey. However much of this decline was offset by greatly increased exports to Germany. Exports remained strong amongst the Asian countries and the West Indies.

The Birmingham Hardware District and other Consumers

Birmingham was the major consumer of copper and brass in the late eighteenth century. Initially obtained from the Bristol companies, and the Cheadle company of Macclesfield, in the fourth quarter of the eighteenth century it was largely procured from the two Birmingham copper companies. Brass was also produced locally.[29] The two metals were consumed in the manufacture of 'sheet copper for sheathing ships' bottoms',[30] 'buckles, buttons, thimbles, locks, brass door furniture, and all kinds of small goods in copper and brass.'[31]

Data for the consumption of copper in the Birmingham hardware district is sparse, and that most readily available is found in the 1799 Report. In his evidence to the committee, Simcox estimated that the manufacturers of Birmingham at the commencement of the 1790s were consuming in the order of 1,500 to 2,000 tons of copper per annum.[32] This was confirmed by Boulton: 'About the years 1791 and 1792, the quantity of copper used was 100 to 200 tons less than 2,000 tons, at present it is not more than 1,000.'[33] It was not clear from this evidence whether Boulton's consumption of at approximately 500 tons per annum was included. If this is added to the above then there is

no great difference in annual consumption from the beginning to the end of the decade.

Williams in evidence to the 1799 Enquiry stated 'Exclusive of brass,… pure copper has been sold in London to the amount of about 1,000 tons per year to the manufactories, exclusive of sheathing for ships.'[34] In 1770, Bristol was producing in excess of 1,200 tons of copper, much of it consumed by the brass makers of the city. During the 1780s and 90s a proportion of this trade would have transferred to Birmingham. Liverpool would also have consumed copper in the shipbuilding trade and exports associated with the slave trade. Precise quantities are not known, but it would not be unreasonable to assume these three centres would together consume in the order of 1,000 tons per annum in the closing decades of the eighteenth century.

It is readily accepted the figures derived above amount to gross estimates. Aggregating the contributions of the five consumers results in a total of the order of 10,000 tons approximately. This compares with a supply, derived from the ticketing data and Anglesey output of some 9,000 tons. To this can be added a matter of a few hundred tons from the mines of Ecton and Ireland, and an unknown quantity from private treaty sales in Cornwall. It is clear from this overview of demand that the market for copper was finely balanced, tending towards a shortfall in supply, leading to inflationary pressure on the price of copper.

Ticketing

Standard and Returning Charge

Prior to embarking on a description of the means by which Cornish copper ores were

sold, it is necessary to discuss two terms, the 'standard' and 'returning charge', which occur with great frequency in the history of the copper industry. Both have caused confusion, having changed their meaning over time. An anonymous writer in 1799 explained: 'A man may as well talk of buying grain by the acre, as copper by the standard.'[35] This indicated the confusion which had arisen in relation to the first of these two terms. The origin of the returning charge has received little attention in relation to the copper trade. It, however, was of some antiquity in the tin trade, its most likely source. Lewis writes:

> The chief of these (factors) is known as the tin standard. This is an amount paid by the smelter per hundredweight of metal contained in the ore, as calculated from the results of dry assay after deduction of one and one fourth for returning charges from the produce of every twenty.[36]

Whilst more obvious, it was the value of the returning charge which caused confusion. In relation to copper it was an allowance made to the smelter for the cost of smelting and transport.

Up to 1725 copper ore was sold by contract for a fixed term and price determined by the current price of one ton of cake copper, the standard, from which had been deducted the returning charge. From these two parameters, and the yield of the ore on offer, the value of the ore would be determined. It could be expressed mathematically thus:

$$p = S/y - R \quad \text{..... (1)}$$

where:
p: price per ton
S: standard, the prevailing price of one ton of cake copper on the open market.
y: yield
R: returning charge

This was the price the smelter was prepared to pay for one ton of 21 cwt to the vendors of the ore, the extra one hundredweight being an allowance for wastage in transit. Thus all

references to the quantity of ore raised in Cornwall refer to a ton of 21 cwt. As Percy writes: 'The sources of a smelter's profits were the care with which he got his ores transported from mine to his works,…'[37] The vital factor in this definition is that the price of ore was determined in the first instance by the smelter, based on the market price of cake copper. This may not have been his final price for there could well be commercial reasons for subsequent variation; to meet a contract, hoping to secure a parcel cheaply, stockpiling for the winter months when shipment was uncertain, or needing an ore of a particular yield to meet smelting requirements. Also, as will be seen later the operator of a smelter frequently adjusted his price in collusion with the other smelting companies. John Vivian's buying policy depended on the state of the market, where at times 'our purchases should be governed by the quantity we are likely to sell…', whilst on other occasions the selling price was determined by the price paid for ore,[38] no doubt a widely prevalent practice.

With the introduction of public sales of copper ore in 1725, these two terms took on additional significance. The standard was quoted more and more frequently as the benchmark for copper prices, but with a meaning at variance to that defined previously. Agents for the smelting companies would visit the mines which had ore on offer, usually a fortnight prior to the sale. The agents would sample the parcels, and ascertain its yield by assay. Then in consultation with the smelter the agent would determine the price he was permitted to submit at the ticketing for each parcel. The number of parcels on offer was not excessive, in the closing months of 1798 the number of parcels varied between ten and 26 from no more than ten mines, not all mines having ore available at every sale.[39]

On the day of the sale the chair would be taken by the representative of the mine offering the largest quantity of ore. In attendance would be the agents and adventures.

Parcels would be put forward for sale in descending order of weight, starting with the mine offering the greatest quantity. The agents would deliver their ticket, slips of paper, to the chairman on which he had written the price each was prepared to pay for the parcels on offer. The bids for each parcel would be read out, the highest accepted, and ownership transferred to the successful bidder. In the event of two or more equal bids, the parcel would be divided equally.[40] On completion of the sale all bids, successful or otherwise, would be published.[41] In the closing years of the eighteenth century, the quantity, the produce or yield, the returning charge, standard at which offered and at which sold, for each parcel were also included in the published ticketing particulars (Table 5.3), but early in the nineteenth century this had been reduced to include only quantity, produce, standard and bids for each parcel(Table 5.4). In the latter there was no need to include the returning charge, for by this date it had become fixed at £2 15s per ton of ore.

In the former the inclusion of a 'Standard offered at' was unusual, its purpose still unknown. It bore no relationship to similar parcels offered at previous ticketings, nor could it be a reserve, for all parcels were sold without reserve. Another peculiarity of the eighteenth century was the entry for quantity sold. It has generally been recognised that no parcel could be sold in part, yet it is clear from Table 5.3 this was not the case. Again no explanation was forthcoming.[42] Both Figure 5.3 and 5.4 also indicate no parcel was permitted to go unsold. The final major difference was the variable returning charge.

The 'Standard sold at' was calculated as follows:

$$S = (p+R)/y \quad \text{..... (2)}$$

where:
p: price per ton
S: standard
y: yield
R: returning charge

The standard resulting from the ticketings takes on a quite different meaning to that previously derived (eq 1). Both equations are algebraically equivalent, but in equation (2) the standard represents the value of the copper in that particular parcel, and allegedly bears little or no relationship to the market price. Newell pointed out: '…under the ticketing system the standard played no direct role in the pricing mechanism, it was simply an abstract measure of the value of one ton of copper based upon the price at which the ore was sold.'[43]

One further outcome of the sale was the calculation of an average standard:

$$\text{Average Standard} = \frac{\text{Average Price per ton of ore}}{\text{Average Produce}} + \frac{\text{Returning Charge}}{\text{Average Produce}}$$

This would have applied directly to the nineteenth century data, but for the eighteenth century data the average returning charge would also have been calculated. It is this average standard that was universally quoted at 'the standard' in the various sets of published copper statistics, and used to track the movement in copper ore prices at the fortnightly ticketings.

There remains one other factor not previously examined. From the mineral statistics in Lemon, the yield is not included until 1800, yet it is a simple computation, being the ratio of metal to ore.[44] This calculation was carried out and included in Table 2.6 of Appendix 2, where it was found that the yield was constant at 12 per cent from 1760 through to 1786. It has also been noted that in a costing undertaken in the 1730s the smelter employed '… ore that yields one ton of copper out of ten tons of ore.'[45] Furthermore this account makes no mention of either standard or returning charge. This emphasis on yield suggests that up to and including 1786 the value of copper was derived directly from the price of ore, in which it was assumed there was a fixed percentage of

copper. Thus where the standard was included in statistics prior to 1786 it was derived from yield. This conclusion is supported indirectly by Borlase[46] and Pryce,[47] both eighteenth century writers who describe the ticketings, but make no mention of the standard. Pryce even included an example of a ticketing return lacking all reference to the standard.

An important consideration regarding the yield is its long term impact on the standard. Over time the standard rose consistently, due in part to its inverse proportionality to yield. The yield fell as the mines developed ever deeper, producing lower yield ores, but the adventurers were also raising previously uneconomic ores of lower yield to meet demand.[48] Between 1785 and 1820 the yield fell by 4 per cent (A fall of one third. Figure 3.5) whilst the standard rose from £55 to £115 (Figure 3.4). Over the same period the price paid for a parcel of ore of similar yield rose by the order of 10 per cent. Figure 3.4 also indicates that the price of cake copper tended over time to track the standard. Thus the views expressed above by Newell, Thomas and Keates are difficult to accept on the basis of the statistics contained in this thesis.

As to the variation in the returning charge, if it is assumed the smelting cost remained constant, then the difference could be attributed to either or both the cost of transportation and seasonal variation. The main north coast ports were Hayle and Portreath, and on the south coast, ports on the River Fal, such as Truro and Devoran. With all the ore being shipped to Swansea, it would seem reasonable to expect costs from the Fal ports to be higher than the north coast, the former having to circumnavigate Land's End. The initial observation for the six months from 6 Sep 1798 to 21 Mar 1799 was that the returning charge remained constant for all lots offered by each mine at each weekly ticketing.[49] The location of these mines and ports, and distance between them was determined. It was assumed that mines shipped from the nearest port. The average

returning charge for the mines shipping from the nearest port was calculated, furnishing the following results:

Devoran:	51.68 shillings
Hayle:	51.22 shillings
Portreath:	51.18 shillings

This suggests that shipping costs based on distance were a possible contributor, with the Fal ports such as Devoran, charging an extra six pence per ton. A second factor may have been a seasonal differential. Computing and plotting the weekly average returning charge, suitably smoothed, (Figure 5.2) indicates an increase in returning charge during the winter of upwards of one shilling

Anomalies in the standard were also identified by Vivian in his calculation of profits. He argued that low yield ore was cheaper to smelt than high yield, given that an inexpensive low yield ore received a larger number of returning charges. Thus with ore at ten per cent, to produce a ton of copper the smelter would receive a hypothetical ten returning charges, or £27.5, whereas at five per cent, the smelter would receive twice the number, or £55. Yet it was not twice the cost to smelt the ore of the lesser yield, the bulk of the dross being removed in the early stages of smelting.[50]

The ticketing system was widely accepted by both sides of the copper industry. For the adventurers there was the certainty of a market, and the reliability of payment. This was an essential factor in the management of a cost–book company, which did not retain any reserve fund, but was required to balance its books at routine intervals. For the smelting companies the ticketings were no bar to collusion, with the opportunity always to secure ore at advantageous prices. Conversely they could find themselves with unwanted stocks during periods of overproduction.

It is apparent from this discussion that both the standard and returning charge had different meanings at different times, that the standard was possibly not the most appropriate determinant of the price of copper, notwithstanding its wide acceptance, nor the returning charge a fixed amount. Ticketing returns of the eighteenth century also did not conform to the criteria frequently quoted by writers, contemporary and later. What was more universally recognised were the problems raised by the shifting criteria. In 1867 Charles Thomas, manager of Dolcoath mine, scathingly remarked, that 'the standard and smelting charges are ... pure fictions and seem to have been introduced to amuse the miners.'[51] Six years earlier Keates, a Liverpool smelter, deemed the standard '…an everlasting stumbling–block of copper trade technicality'.[52] And, as will be seen in the next section, ticketing was not so perfect a means of selling ore as it may have appeared.

Collusion, Monopoly and Patent

Collusion is defined as an explicit or implicit agreement between existing firms to avoid competition one with another. This becomes a cartel when a formal legal agreement has been made.[53] Monopoly is collusion taken to the limit, whereby there is but a single source of supply of material goods or services. A patent is a means whereby an individual can obtain sole right to an invention for a specified number of years.[54] Where there is commercial benefit to be gained, then a patent is tantamount to making the holder a monopolist for its duration.

These were all defining features of the copper industry in the years under discussion in this thesis, the collusion of the South Wales smelting companies, the monopoly exercised by Thomas Williams, the cartel of the Cornish adventurers, the CMCo, and the monopoly exercised by Boulton and Watt resulting from Watt's engine patent. Whilst the early period from 1760 to 1785, dominated as it was by the South Wales companies, was comparatively

simple in its structure and operation, that from 1785 until the end of the century could not have afforded a greater contrast. Industrial interrelationships became a complex interplay between the CMCo, Williams' monopoly, that of Boulton and Watt and the entry into the industry of the Birmingham copper companies. Not until Williams' death in 1802 could the industry be considered stable, albeit with the re–emergence of the overriding influence of the South Wales smelting companies, bolstered by a number of new entrants who would ensure the region's future domination of the industry as the Associated Smelters had in the previous century.

The Associated Smelters

Following the revival of the copper mining industry in Cornwall in the late seventeenth century, and the arrival of the Bristol smelting companies, the adventurers in the copper mines viewed the commercial activities of the outside companies with suspicion, a legacy of the earlier period.[55] Such suspicions dominated the trade following the establishment of the smelting industry in South Wales. As early as 1758 uncertainties as to the probity of the trade were being expressed. Initially, it was limited to little more than scepticism. Borlase in his comments on the ticketings was concerned:

> that they (the smelting companies) do not groundlessly suggest an exorbitant fall of the price of copper which the owner cannot contradict; provided also, that these agents do not combine to distress and reduce copper of a reluctant and too inquisitive miner. Such complaints are muttered, but with what grounds I pretend not to decide. If, besides this, the agents for the companies should combine, and refuse to admit the tickets of any person whatever, who had a mind to offer for any parcel of copper, it would justly increase and give weight to these suspicions…[56]

Although unwilling to take a stance in regard to collusion amongst the smelter's agents, Borlase does recognise two clear opportunities for such action by them, one the forcing down of the price of ore, and the other cutting the price of copper in an effort to minimise the chances of survival for new entrants to the industry. This was certainly the experience

of the Cornish Copper Company following its formation in 1758, 'which it must be owned had been frustrated through the confederacy of opposite interested companies.'[57]

By 1778 there was little doubt that collusion amongst the smelting companies was prevalent. Pryce noted:

> … the emulation natural to rival companies; but it is to be feared that principle has long ceased to operate: and as there is Copper Ore raised in the county sufficient for them all, they do not wish to push one another. On the contrary, the utmost harmony seems to subsist between them; and the talk of establishing a new company is sure to be followed by an association of the old ones, in order to defeat it.[58]

Here again he clearly identified the same two characteristics of collusive activity as Borlase did. Neither author provides any definitive evidence to support their contentions, and little is forthcoming elsewhere.

Toomey provided a useful benchmark by which to judge the extent of collusion in the industry prior to the entry of the Anglesey mines. In 1973 the Monopolies and Merger Commission stipulated the criterion of 25 per cent market share by a single firm or 50 per cent for the four leading firms as defining the existence of monopoly power.[59]

Between 1729 and 1785 at least 727,862 tons of ore were sold at the Cornish ticketings.[60] Fifty–four per cent was purchased by the four largest Welsh companies, Rd. Lockwood Esq. & Co, English Copper Co, Jos. Percevall & Co,[61] and Mines Royal Co. Only the Brass Warehouse Co of Bristol presented any competition, although its purchases were no more than 17 per cent of the total over the same period. Over this period the number of company agents at these sales increased from seven to 11. In the same period the number of Welsh smelting companies increased from three to seven, in which time their annual purchases were invariably in excess of 60 per cent of the total on offer.[62] In 1784, the year prior to the formation of CMCo, ore amounting to 37,290 tons was sold of

which 74 per cent was purchased by the seven Welsh companies. It is not surprising these companies located in South Wales earned for themselves the title of the Associated Smelters. They can with some certainty be said to have met the criteria for monopoly power as later defined by the Monopolies and Merger Commission.

Whilst the activities of the Associated Smelters were recognised by the Cornish adventurers, they were still able to market the ore to their satisfaction. Up to 1780 there was little or no difference between the price of cake copper and the standard. The market had all the appearances of being well balanced, the returning charge, and the additional hundredweight of ore in the ton furnishing the smelting companies with an adequate profit. This would have given the adventurers and miners of Cornwall some satisfaction and encouragement for the future, emerging as they were from a period of economic and social turbulence. The introduction of the improved Watt engine also enabled exploration to be extended to ever greater depths, with the promise of increased output. The fulfilment of this promise would have to wait for a further 20 years.

Thomas Williams

During the 1770s the impact of the output from the Anglesey mines began to be felt in the copper market. By the middle of the decade the copper produced from the Anglesey ore amounted to a few hundred tons per annum. By 1780 it had risen to close on 2,000 tons, and ten years later to 3,000 tons approximately. This considerable increase in the quantity of copper introduced a corresponding imbalance in the market. Bad as this was for the industry, it was made worse by the business organisation created by Williams who, within a very short period, had created a conglomerate of companies that encompassed all facets of the copper industry, from mining, through smelting, to manufacturing and marketing finished copper. Much of this resulted from the opposition of the Associated

Smelters who mounted their normal defence against all new entrants. They commenced cutting prices offered at the ticketings enabling them to reduce the price of copper. This, however, they could only take so far, as too great a reduction would result in the closure of mines rendered uneconomic. Thus ore supplies would fall, threatening their prosperity. This had little impact on the William's enterprise for his costs were low. Production of copper from Anglesey ore could be profitable with a standard as low as £50, whereas Cornwall could not operate much below £80.[63]

Thus, in his battle to counter the competition posed by the Welsh companies, and to a lesser extent the Cornish adventurers, Williams was also in danger of forcing the closure of the majority of the Cornish mines, an intolerable situation where ultimately all would become losers. It was important for Williams to secure the future of the Cornish industry, for the resources under his control could not meet the total demand for copper at home and abroad. The imbalance in competition was also recognised by Matthew Boulton, who was concerned for his company's receipts from engine dues in Cornwall. It became apparent to the Cornish adventurers that with the intensifying price war between Williams and the smelting companies of South Wales, they could not continue to dispose of their ore effectively at the ticketing sales. At these sales the agents of the Associated Smelters continued to depress prices as competition with Anglesey sharpened. In the early years of the 1780s attempts were made to resolve the situation, leading ultimately to the formation of the CMCo in 1785.

The Cornish Metal Company

In April 1785 Williams recommended the construction of three smelters, with a capacity to handle 30,000 tons of the ore raised annually by the Cornish mines. The cost would be offset by a realisation of much improved prices for the finished copper, it being

estimated that the price war was costing the mining industry £90,000 to £100,000 per annum.[64] Initially, the reception of the proposal by the Cornish interest was lukewarm. Yet as prices continued to fall some radical plan was required. With Matthew Boulton's interests as an engine builder, and mine adventurer, he recognised the inherent danger implicit in the manipulation of the market by the Associated Smelters, and actively canvassed for some form of copper cartel in Cornwall.[65] In this he was actively supported by John Vivian, mine agent and adventurer from Truro. In the first half of 1785 the market had reached such a low ebb that the adventurers had little alternative but to accept an arrangement hammered out between Boulton, Williams, and Vivian.

Their proposal was for the formation of a company to market copper produced from Cornish ore, the smelting of which would be undertaken by smelting companies under contract to this new company. Its success was predicated on an agreed division of the market with Williams, for the Cornish mines would still not be in a position to tolerate any competition. Even with the Associated Smelters sidelined, Williams would always be in a position to undercut the price of copper produced from ores raised anywhere in the country. Following an assurance of his cooperation, and a series of meetings, firstly amongst the Cornish adventurers, and subsequently with the merchants and smelting companies, it was agreed by the adventurers in the summer of 1785 that a company should be floated to purchase the Cornish ores, contract for their smelting, and market the copper produced.[66] Following the its flotation the ticketing sales would cease.

On 19 July 1785 the proposal was put to a meeting of mineral lords and adventurers in Truro.[67] The nominal capital of the company was set at £500,000, comprised of 5,000 shares, each of £100. The start–up capital was set at £26 per share, or £130,000. The initial enthusiasm for the company was such that within 15 minutes of the

announcement £65,000 had been subscribed. When the CMCo commenced business on 1 September 1785, the full £130,000 had been received, much of it from associates of Matthew Boulton, including one sum of £25,000 from the iron founder, John Wilkinson. Investors were guaranteed a return on their capital of eight per cent, secured by a sinking fund of £20,000. The voting rights of shareholders were one vote for the first £500 invested, with a further vote for each £1,000 subscribed up to a maximum of six votes. After some initial dispute relating to the duration of the company, and the rate of return on capital, it was agreed that in the first instance the company would operate for a period of seven years rather than eleven years proposed initially. The return to the shareholder would be kept at eight per cent, notwithstanding strong objections from the local land owner, mineral lord and mine adventurer, Sir Francis Bassett, who argued strongly that money could be obtained at lower rates in the money markets. The company would be overseen by a Governor, the first being Sir Francis Bassett, a Vice–Governor, John Vivian, and a board of directors elected annually, comprising 24 representing the interests of the adventurers who were not required to be shareholders, and 12 by the shareholders.[68] The directors representing the mining interest were to be elected annually on the basis of one vote for every £1,000 worth of ore sold in the preceding twelve months by each mining company associated with the CMCo[69]

The formation of the CMCo took no account of the arrangements required to be made between the Cornish adventurers and the smelting companies, or the mechanism for marketing the copper, each of which was the subject of a separate settlement between the relevant organisations. Negotiating authority was delegated by the board to a committee comprising a chairman and three directors: William Harris,[70] and R A Daniell, Thomas Kevill, Thomas Reed and John Vivian.[71]

The agreement between the participating mining companies and the CMCo relating to the sale of ore provided for the purchase by the company of all ores raised for a period of seven years from 1 September 1785, at prices negotiated by the adventurers and the board of the CMCo. In addition, the CMCo would distribute the annual net profit to the associated adventurers in proportion to the amount of ore purchased from each mining company, subject to the maintenance of a contingency fund of £20,000 established in the first year. The selling price of copper was set such as to secure the eight per cent dividend promised, and a minimum net divisible profit to the participating adventurers of £15,000 per annum.[72]

The agreement relating to the smelting of the ore provided for the sale of seven–eighths of the ore purchased by the CMCo to the contracting smelting companies in proportion to their capacity. Ore was sampled by these companies and by the CMCo, with the price for the ore based on the average assay of the samples. If the difference between the assays was greater than five shillings per ton, a further sample was assayed, and its outcome binding. The returning charge was set at £2 6s 4d. The copper standard was set by the negotiating committee, with the initial standard set at £72 10s. The smelting companies were guaranteed a minimum profit of eight per cent, ensuring that they would receive at least £78 6s per ton of copper. The CMCo was to pay them a price per ton for manufactured copper at the current standard plus £11, payable in London six months after delivery. The participating companies were required to deliver the finished metal to the CMCo's warehouses in London, Bristol, Liverpool, Plymouth and Falmouth at the company's discretion. The seven–eighths purchased by the smelting companies (with the proportion of ore allocated to each) who entered into this arrangement with the CMCo were:[73]

Lockwood, Morris & Co.....[7] 32
Sir Herbert Mackworth, Mowbray & Knoll (or Gnoll) Co.....[6] 32
John Freeman & Copper Co.....[5] 32
Mark Harford Brass Wire & Copper Co.....[6] 32
Michell, Edwards & Cornish Copper Co.....[4] 32

The marketing agreement drawn up between Thomas Williams, Edward Hughes and John Dawes, representing the Parys Mine Co, the Earl of Uxbridge and Thomas Williams, representing the Mona Mine Co, and the representatives of the CMCo provided for a division of the market for finished copper between the three companies, the major suppliers in the country, in proportion to their production.[74]

These agreements would, on the surface, appear to have eliminated the earlier difficulties experienced by the Cornish adventurers with the South Wales companies, and the low prices at which the Anglesey ore could be sold. They were assured a market for their ore, collusion amongst the Associated Smelters had been broken, the marketing of copper was in the joint hands of the two major producers, the Cornish and Anglesey mines and, perhaps most importantly, the standard had been raised to a level which would ensure a much greater likelihood of profit to the industry in Cornwall. Williams was well satisfied with the agreements. 'In the meantime,' he wrote to the Earl of Uxbridge, 'I only beg you may rest assured this Cornish connection cannot do any Injury to the Anglesey Miners, but may afford them very great advantages'.[75] How right Williams was will be seen later. Harris believed the four partners in the Anglesey mines, Lord Uxbridge, Edward Hughes, Thomas Williams and John Dawes, enjoyed gains equal to the whole achieved by those in Cornwall.[76] Boulton and Watt could also feel reasonably pleased with the outcome. With an apparently assured market for copper produced from Cornish ore, payment of the dues on their engines should no longer pose a problem to the adventurers. It would therefore appear that all parties had gained to some degree, although it has to be emphasised that not

all the mines, nor all the smelting companies, were prepared to participate in these arrangements.

It soon became apparent that there were serious flaws in the constitution of the new company. The CMCo did not have the degree of control initially envisaged. With an increased purchase price guaranteed for their ore it did not take long for the output from the mines to rise, resulting in the CMCo becoming increasingly saddled with a stock of copper surplus to the market requirement. This was accompanied by a rapid fall in its capital, expended simply in purchasing unwanted copper from the smelters. Given that the CMCo's board was packed with adventurers, any change in the buying policy of ore was virtually impossible to achieve. Thus, as the situation in Cornwall deteriorated, the Anglesey mines thrived on the higher standard of which they were in receipt. Those Cornish mines and smelting companies who were not a party to the CMCo agreements carried on a parallel trade between themselves. This combined with an increase in the import of cheaper foreign ore by the independent smelting companies, did nothing to alleviate the problems facing the CMCo. It soon became apparent that the company completely lacked any ability to find buyers when compared to the aggressive marketing machine operated by Thomas Williams. Nor was there any real incentive to do so. That the CMCo's funds were haemorrhaging away in buying and stockpiling copper would not be a concern until the shareholders were called upon to make a further injection of capital. This should have come as no surprise given the structure of the CMCo's board, whose only marketing experience was arranging for ore to be offered at the fortnightly ticketings. With the current situation of assured sales at an advanced standard , the adventuring directors saw no reason for changing the *status quo*.

Within a comparatively short time the CMCo was burdened with large stocks of

unwanted copper, a result of overproduction due to the failure to include any quota in the initial constitution. In addition, the company was faced with high interest payments on loans entered into for the purchase of the finished copper from the contracting smelting companies. The outcome was that by 1787 Cornish mines were being forced to close or restrict production. By the end of the year four of the biggest mines in the county had suspended operations: Poldice, North Downs, United and Dolcoath.[77] The redundant miners were angry to the point of threatening to burn down John Vivian's house.[78] Similar threats were made against the agents of Boulton and Watt.[79] A reduction in the standard and the price of copper achieved little, and it was clear the original agreement was in crucial need of amendment.

Williams continued to enjoy high sales. With total control of production from mine to customer, and low production costs, he was not subjected to any of the difficulties experienced by the CMCo. By the closing years of the 1780s he was entering the peak years of his power. He had greatly increased his market share, opening new markets at home and abroad, particularly in the field of copper sheathing, selling to both British and foreign navies, as well as the builders of merchant vessels. Much of the increased sales was due to the introduction of the copper bolt for the fixing of the copper sheathing and other components, of which Williams was a major supplier. [80]

The CMCo had failed to achieve control of the Cornish industry, the purpose for which it was constituted. There was an inherent danger of a collapse in the price of copper, not only from competition of those producers outside the agreements, but also if the CMCo was forced to dump its large stocks onto the market, if the loans it had taken up were called in. Matters came to a head in the third quarter of 1787, when the CMCo failed to gain any share of the annual purchases made by the East India Company. Vivian was

attempting to arrange for a return to the pre–1785 position with the smelting companies, the larger mines were seeking an accommodation also. All the while the Anglesey firms continued to prosper, with rising sales in an expanding market. Williams, much to the anger of Matthew Boulton was attempting to break into the manufacture of buttons and copper coinage, core products in Boulton's business.[81] At the same time, covert discussions were taking place outside Cornwall, particularly between John Wilkinson, the iron founder, and Williams, for the latter to become the sole agent for copper in the country, marketing both Cornish and Anglesey copper. By now the CMCo, burdened by high interest charges, had a virtually unsaleable stockpile of some 6,500 tons of copper. Williams was in the ascendancy, and progressing towards the monopoly he was keen to obtain. Yet there remained one cause for concern, and that was the revival of the power of the Associated Smelters, an intolerable prospect for Williams. Nevertheless, this was his opportunity, for it was to neither producer's benefit to see the Associated Smelters back in a position to dictate the market.

In 1787 the Governor of the CMCo, Sir Francis Bassett was of a mind to call for the dissolution of the company.[82] Yet by November a new agreement was reached between Williams and the CMCo, whereby the Anglesey entrepreneur would be responsible for the marketing of all the Cornish output, subject to a strict quota.[83] Williams agreed to take 3,000 tons of copper produced in Cornwall, plus 1,300 tons of the CMCo's stock each year for the next five years, for which he would receive a commission of two per cent on sales. Initially, Cornwall would have two thirds of the sales and Anglesey the balance, but from the 1st January 1789 until the end of the current CMCo agreement in December 1792, sales were to be equally divided. Williams' victory was total, to the extent that Uxbridge's agent, writing to the Earl, remarked that:

> …the Cornish companies are all to agree and to be bound by every strong tie, that writing can effect, and if necessary by Act of Parliament, that every ounce of copper produced by Cornwall is to be sold by Mr. Williams for five years and no other man upon earth is to sell an atom of it… Anglesea triumphs, the command of the trade will be totally there.[84]

Williams had the control he had desired from the beginning, but it was now of even greater importance, for the Anglesey mines were on the threshold of exhaustion. Output had peaked at 3,000 tons per annum approximately in the mid–1780s, but by the end of the century was much closer to 1,000 tons per annum, and falling steadily. This was probably less than Williams required to meet existing contractual obligations, thus Cornish copper was essential to his needs. Notwithstanding the access Williams had to the Cornish output, shortages began to manifest themselves. With export contracts in excess of 4,000 tons, Williams was sending close on 60 per cent of total national output abroad, the majority supplied to the East India Company. At the same time he gradually increased the cost of finished copper, whilst keeping the price paid for ore reasonably constant. By this means he was able to meet the commitments of the CMCo in terms of loans and interest payments, at the same time causing annoyance to the manufacturers, particularly Boulton. Although the future for the CMCo seemed reasonably assured, receipts were still barely adequate, particularly for the deep mines where the greatest impact was felt from inflation, including significant rises in the price of consumables and labour,and depressed receipts on the sale of ore.[85]

The Birmingham manufacturers were far from happy with the turn of events, feeling both the effect of shortage and price rise.[86] Williams faced mounting opposition to his activities, it being alleged he was selling copper in the export market at up to £14 per ton below that in the home market. The manufacturers felt they were back to the days prior to the formation of the CMCo, when the Associated Smelters were the controlling

force. They had swapped what was effectively a cartel for a monopoly. Williams countered with two telling points. Firstly, with copper currently at £84 per ton, it was well below the previous 30 year average of £90.[87] Secondly, if copper was being sold at £70 abroad, then he suggested that the Birmingham merchants and manufacturers should buy it, for with duty at £2 per ton, it was significantly cheaper than in the home market, even allowing for the cost of transport.[88] With Cornish output limited to 3,000 tons per annum, mines continued to disassociate themselves from the CMCo. Such commercial opportunism was viewed by Vivian as potentially disastrous. Even with their stocks of copper reduced to something in the order of 5,500 tons, the release of this amount of metal onto the open market would be highly damaging to all concerned. Yet only by an increase in the standard could any relief be given to the industry and its work force. Vivian in an undated memorandum encapsulated the continuing problem of the Cornish mining industry:

> It will be admitted that the quantity of any Commodity brought to Market should exceed the Consumption of the Market; the only Means of preventing a great Depreciation in Value is to strike out some plan for raising a Fund to buy up and withhold the surplus Quantity from the Market — Let us look upon the Metal Co as a company that has bought that surplus…[89]

The CMCo was to become no more than the owner of a 'copper mountain'.

Whether or not Vivian's plan was ever published would seem very doubtful, but there is little doubt that the previous years of Williams' monopoly had not been entirely successful. On 9 July 1790, Williams wrote to Vivian offering revised terms, which in effect required that he controlled all sales,and stipulating all the Cornish mines were to be party to any new agreement. In return he would be prepared to smelt all the Cornish ore at a reduced returning charge, thus effectively raising the price received for the ore. Vivian communicated this to the Cornish miners in a letter of 20 July in which he emphasised the

danger inherent in the disintegration of the CMCo, the likely outcome if the sales by those outside the current agreement were to continue unabated. The potential benefits of the proposed arrangement were significant. Vivian estimated the standard would rise from its current level of £67 to £74, and this on an increased output in copper up from 3,000 tons to 4,000 tons per annum.[90] This increase, marketed through Williams, would again suggest that the reserves in the Anglesey mines were in decline. With Williams willing to take a further 1,000 tons of Cornish copper per annum, he was implicitly admitting that he needed the extra copper to meet contractual commitments. Even with the increased output, overcapacity remained an issue, and only by the closure of a number of mines could this problem be tackled, a matter of obvious concern to miner and mineral lord alike. In the event, agreement was finally reached late in 1790 between the miners, the smelting companies, the Anglesey interests, and the CMCo for Williams to retain his monopoly on the modified terms, and for a number of Cornish mines, including Dolcoath and North Downs, two of the largest in the county, to suspend operations in return for financial compensation.[91]

This arrangement was to hold for the remaining two years of the CMCo's existence. During these years demand rose and with it prices. The large stocks of metal held by the CMCo, were ultimately sold and by March 1792 the CMCo was able to meet its obligations to its shareholders, returning 40 per cent of their initial investment, with sufficient assets to meet the rest. Coupled with earlier payments, shareholders were in receipt of their initial investment plus interest over the life of the company equivalent to five per cent per annum. This had only been possible through the involvement of Thomas Williams. Left to others, particularly Sir Francis Basset, shareholders would have incurred considerable losses.

The CMCo was a flawed project, flaws which were significant and fundamental. Primarily was the lack of production quotas. Secondly, by not including all the adventurers and smelting companies in the agreement, a monopoly was unattainable. Thirdly, the CMCo had no marketing strategy, becoming no more than a copper stockholder. Fourthly, the directors of the CMCo failed to recognise that Thomas Williams needed the cooperation of the Cornish miners, as much as they needed him. Finally, and perhaps most importantly, the directors with their inability to control output or find buyers totally lacked all the means to compete with Thomas Williams, the only individual in the copper business during this period who recognised the worth of a fully vertically integrated industry.

Boulton and Watt

Until the development by Watt of the rotary engine in 1781, Boulton and Watt were to a large extent dependent for an income from the engine business on sales to the Cornish adventurers, and the protection afforded by their patent was vital to them. As was discussed above, the company's major source of income came from the dues imposed on the adventurers, an outcome of the improved economy resulting from the separate condenser. These routine payments would continue for the duration of the patent up to its expiry in 1800.

Thus Boulton and Watt had an implicit monopoly of the engine trade wherever the separate condenser was employed. This monopoly was challenged on many occasions by the local engine builders, who developed engines that were perceived not to violate the patent. Foremost amongst this new breed of engineers were the Hornblowers, father and sons, Edward Bull, and Richard Trevithick, jnr. The Hornblowers and Bull arrived in the county at much the same time as Boulton and Watt, they being engine erectors for the

company. Bull never attempted to patent his design. Jonathan Hornblower took out a patent for his design in 1781 which, when he attempted to renew it, was successfully opposed by Boulton and Watt, resulting in it being revoked by Parliament in 1792. Between 1791 and 1794, Hornblower erected ten engines in the county, and Bull erected eight.[92] As a result of this 'pirate' activity, Boulton and Watt were in significant danger from the loss of income for the non–payment of dues. The matter entered the courts, first against Bull, and subsequently Hornblower. Bull was found to be in contravention of the patent on the engine he had erected at Dolcoath, but no other. He, therefore felt free to continue his business on his return to Cornwall, but a year later an injunction was issued preventing him proceeding any further with the work in hand. This so infuriated his associate, Richard Trevithick jnr that he took over the work, completing the current engine installation at Ding Dong mine in West Cornwall in the same year. Boulton and Watt had to return to the courts to restrain Trevithick, which they succeeded in doing in 1795.[93] Boulton and Watt did not oppose the sale of such engines employing the separate condenser. They did, however, insist on where these engines had been installed the appropriate dues were paid by the mine owners, or otherwise be in breach of the terms of the patent.

By this time, Boulton and Watt were in grave danger of losing their monopoly. The industry was recovering rapidly, as Williams' Anglesey mines went into decline. Mines which had been neglected commenced development programmes, unwatering of abandoned levels being essential. In addition, two of Cornwall's most successful mines, Wheal Unity and Tincroft, were employing more efficient 'pirate' engines. Derogatory advertising campaigns initiated by Boulton and Watt were of no avail. Adventurers were calling in to question the validity of Watt's patent, again leading to court action. Whilst this was pending, dues were withheld leading to further litigation. Boulton and Watt

ultimately secured an injunction against Hornblower in 1796. This was too late, for by this time the engineer of choice in the county was Richard Trevithick, an intuitive innovator who would only cooperate with the Birmingham firm on sufferance. There was still the matter of the patent's validity, which was finally upheld by the court in January 1799. The feelings in the county towards Boulton and Watt were clearly expressed in the following:[94]

> Our meeting at Herland was fully attended by the Adventurers, and it was at last agreed to erect another Fire Engine (which makes three in that mine) but there is still a difficult obstacle to surmount which is Bolton and Watt's demand in consequence of their Patent. There has been a long Contest in the Courts of Law betwixt them and one Edward Bull, another engineer, respecting the validity of the former's patent – and after all – the judges in the Common Pleas during last term were divided in their judgement, two being for Bolton and Watt and two for Bull. So that the matter is still undecided which I fear is a fatal blow to Bull, as the Lord Chancellor issued his Injunction long ago against Bull's working any of his engines till the matter is decided – and it happens unfortunately for Herland that one of the engines there is Bull's erection. Bolton and Watt appear to be too much irritated against this county (out of which they have carried away £100,000 clear money) to hope for any mercy, other than their interest may induce them to show it. It was the opinion of most people that Bolton and Watt by receiving so much from this County only (exclusive of what they have received from many other parts of the Kingdom, and I might add from other Kingdoms) have been richly rewarded for their discovery – and finding in some instances they were not easily induced to relax their demands, most of the Gentlemen in the County seemed inclined to countenance Bull, and the other Engineers, by erecting their Engines in many Mines. But as Bolton and Watt have proved this to be infringements of their patent, and the others have not yet been able to set aside the validity of the patent, 'tis apprehended Bolton and Watt may servily revenge themselves on those they may be disposed to mark out for that purpose. Under this uncertainty Herland mine, for one, now stands – and if those Gentlemen insist on the payment of what they have hitherto demanded I fear for poor Herland after all. Ding Dong is in the same predicament – and is now a poor Mine.

The patent, and with it the engine monopoly, expired in 1800. Long before then, the engine business had ground to a virtual halt. Between 1777 and 1786, except for 1784, business in Cornwall amounted to between 28 per cent and 100 per cent of Boulton and

Watt's total business. Thereafter until the expiry of the patent in 1800, it never exceeded 50 per cent except during 1793, varying between zero per cent and a maximum of 17.9 per cent. Nevertheless, the Soho manufacturers had secured sufficient income to ensure their survival, as shown in Table 5.5.

Other than the introduction of the separate condenser, the steam jacket surrounding the cylinder, and improved quality of build, Watt did little to further improve the performance of the engine. Watt remained fiercely opposed to any move towards the introduction of high pressure steam and expansive working, an approach advocated by the engineers resident in Cornwall. In so doing it is argued he blocked the further development of steam power.

There was obvious relief in Cornwall at the termination of Watt's patent in 1800. Although many of the existing engines were in poor shape, there was no immediate rush of orders to replace obsolete equipment, the first decade of the new century was a period of stagnation in the engine business. If anything the engine performance deteriorated, a contributory factor being the exodus of skilled personnel following the departure of Boulton and Watt. The mines were able to return profits from the available reserves on the basis of a rising standard, coupled with increasing demand. The one engineer who could have influenced the improvement of pumping engines, Richard Trevithick, had shifted his interest to the development of the locomotive. Not until 1810 did he begin to take an interest again in mining matters. In this he was joined by another Cornish engineer, Arthur Wolfe.

Once again it was the need to search ever deeper that provided the stimulus. Further motivation resulted from the work of Joel Lean, who instigated the routine

publishing of the performance of individual engines. In 1811 the publication on a monthly basis of the duty figures for individual engines was instigated.[95] This provoked competition amongst the engineers on the mines, leading to significant improvements in engine design, and perhaps more importantly, maintenance. By 1814 thirty-five engines were submitting duty figures on a monthly basis. The average minimum duty for the year recorded was 10,800,000, and the maximum 32,600,000. In 1792 the Boulton and Watt engine at Wheal Butson returned a duty in excess of 28,000,000, clearly illustrating the decline in performance over those 22 years.[96] By 1821 Lean's routine reporting demonstrated clear benefits in engine performance from the reporting programme. For the 44 engines, the duty figures had risen such as to range between 17,800,000 and 43,900,000.[97] As long as this reporting continued so the competition it provoked ensured the continuance of engine development.

A New Generation of smelting companies

Williams was particularly successful in retaining a degree of control over the copper market after the loss of his monopoly following the cessation of trading by the CMCo in 1792. To meet his large commitments in exports and the sheathing markets he was forced to buy more and more ore at the Cornish ticketings, these having resumed following the closure of the CMCo. In this he faced competition from the new Birmingham companies, who had gained easy access as a result of the dislocation of the Welsh companies. In particular, the Rose Copper Co became a major buyer, to a large extent for the use of one of its principal shareholders, Matthew Boulton. His interests had shifted diametrically from mining to coinage, As such he had become a significant consumer, now more concerned with keeping prices low.

Yet as a result of competition amongst the smelting companies to satisfy a demand for which there was a barely adequate supply, the standard rose inexorably throughout the 1790s. Between 1790 and 1800 output fell by some seven per cent, accompanied by a rise in the standard of £56.13 to £133.15, with cake copper at £151 per ton on the London market.[98] It is little wonder that there was an outcry from the Birmingham manufactures in 1798, which led to the Parliamentary enquiry into the industry in 1799. In their petition to Parliament they called for a lifting of restrictions on imports of copper, and an embargo on exports when the standard exceeded a certain level. Simcox specifically called for:

> '… a bill to prohibit the exportation , and permit the importation of Copper, free of Duty, when it is above a certain price, as upon experience was found reasonable for the support of British mines, would have that effect, and be a means of preventing great flucuation complained of by the Manufacturers; …'[99]

Throughout the enquiry there was covert criticism of the role which Thomas Williams had played in elevating prices, failing to recognise that he was a major buyer. Neither was the buying policies of the Birmingham companies fully recognised. In the six months from September, 1798, 27,337 tons of ore were sold at the ticketings.[100] Ten agents attended the sales, with the following results:[101]

Purchaser	Totals Qty (tons)	Totals Cost (£)	Cost per ton
Birmingham	2,524	£25,402	£10.06
Bristol Wire	1,369	£14,986	£10.94
Cheadle	5,712	£42,722	£7.48
Cornish	1,327	£10,899	£8.22
English	1,670	£15,037	£9.01
Freeman	4,802	£36,457	£7.59
Lockwood	2,035	£15,446	£7.59
Mines Royal	1,920	£19,837	£10.33
Parys Mine	1,757	£14,250	£8.11
Rose	4,220	£37,080	£8.79

It would seem from these figures that Williams was not buying in significant quantities for his Parys Mine had only bought 1,757 tons. However, his agent in Cornwall, John Vivian, was also buying on his behalf in the name of the Cheadle company. His purchases therefore amounted to upwards of 7,479 tons. This large amount was unlikely to contribute to any significant increase in price for he paid the lowest for his ore of any of the other participants. Both the Bristol Wire and Mines Royal paid considerably more, although on lesser quantities. The two Birmingham companies can also be seen to be major buyers, the Rose Copper Co in particular, although it did not push the price up as much as the Birmingham Copper and Metal Co. The data indicates that there should have been no shortage of copper for the Birmingham trade, particularly when the shareholders of the Birmingham Copper and Metal Co had first call on the company's output. The Rose company on the other hand had no such restriction, and it was likely that much of this was being purchased by Matthew Boulton, who was a shareholder, perhaps as much as 50 per cent when examined in the context of his coinage contracts.[102]

The outcome of the Parliamentary Enquiry of 1799 was inconclusive. Various moves were made to control the import and export of copper, but with little impact on the trade. Relief came not from any artificial manipulation of prices, but from increased output. In 1800, the copper mines produced 55,981 tons of ore, realising 5,187 tons of copper. By 1820 these figures had risen to 91,473 tons and 7,508 respectively. Demand remained high for the first decade of the new century resulting in an increasing standard. In 1800 the standard was at £133.15; by 1805 it had risen to £169.80. It failed to maintain these high levels, falling sharply after 1810, and by 1816 had fallen to £98.65. It rallied in the next two years, but fell again in 1820 to £113.75. The early high prices reflected a demand which the mines were finding difficult to meet, but following the peace of 1815, demand dropped. A large proportion of this fall was due to the loss of sheathing sales to

the Royal Navy. With the end of hostilities the service became self–sufficient in copper through the recycling of scrap. Thus the trade had shifted from a deficit of copper to a surplus, and Cornish mining continued to experience difficulties for a number of years to come. As in the past the adventurers attempted to produce their way out of trouble by increasing output to compensate for the falling standard.

The Birmingham smelting companies were not the only new companies to be formed. The early years saw a marked increase in the number of smelters operating in the South Wales valleys. Amongst this new generation were a number of Cornishmen. The first of these were Pascoe Grenfell and his brother, William. Pascoe Grenfell was a close associate of Thomas Williams, and following the death of Williams in 1802, they entered into partnership with Williams' son, Owen, taking over the South Wales smelters at the Middle and Upper Bank Copper Works in 1803, conducting their business under the name of Williams, Grenfell & Co. In 1805 a copper works was established at Llanelli under the direction and management of R J Nevill of Swansea and Birmingham. The major partners, in addition to Nevill, were Savill of London, Guest of Birmingham, and R A Daniell a prominent merchant of Truro and adventurer in numerous Cornish mines. The company was known as Daniell & Co at the ticketings. Finally, following the move of John Vivian and his sons from Penclawdd in 1809, Vivian and Sons was founded in the same year, with a smelter built on the banks of the River Tawe at Hafod. These three companies, especially Williams, Grenfell & Co, became the foremost company in the early nineteenth century at a time when the industry was still in a fractured state.

It is probable at this stage in the evolution of the smelting industry, notwithstanding the presence of the Birmingham companies, now joined by the Crown Copper Co, that the earlier collusion amongst the Welsh smelting companies reappeared. As

yet only a relatively minor company in the industry, John Vivian was apparently initially against monopoly. In 1813 he wrote:[103]

> At a numerous and most respectable meeting of Persons interested in the trade to India held at Swansea in March 1812 I had the honour to propose the following Resolutions, which were unanimously approved and adopted –
> 1. That extensive and perpetual monopolies are unjust in their Principles and injurious in the effects.
> 2. That at this time when we are precluded from any trade with the Continent of Europe, it becomes essentially necessary that our Merchants and Manufacturers should look to new sources for a vent of their respective Commodities.
> 3. That no Country holds out such an extensive Market as India and the various other Regions now shut to us by the East India Charter, altho' foreign Nations in Amity with Great Britain are permitted to trade with them.
> 4. That the Copper Trade, that great source of the Prosperity of this Town of Swansea is likely to be particularly benefited by the Extension of Trade the Kingdom may acquire by an increase of the Exports to the Countries in Question.
> 5. That this town will assist by all Means within their Power in resisting a renewal of the East India Monopoly.
> 6. That there be a Committee to draw up a Petition to Parliament grounded on the basis of the foregoing Resolutions.

This letter indicates the importance of the East India Company trade, a feature of the industry from the eighteenth century, and a strong probability that the sale of copper to the Company had changed little from earlier times, namely an agreed division amongst the smelting companies. It further makes clear the East India Company was still a major buyer, the income being a 'great source of Prosperity to this Town of Swansea'. Vivian's opposition to monopoly seems somewhat ambivalent. Whilst opposing monopolies in the first resolution it would be unlikely that he would wish to accept any change in the prevailing arrangements for the sale of copper to the Company.

Neither would he want his bidding arrangements at the ticketings to be interfered with. A selection, not contiguous, of ticketing returns is to be found in the manuscript

collection of the National Library of Wales, almost certainly in the hand of one of the two sons of John Vivian (Table 5.6).[104] The returns would seem to indicate that for most of this period the Vivians were bidding on behalf of three companies, themselves, the Cheadle company between 13 April 1809 and 12 September 1811, and Williams & Grenfell until 17 Feb 1814. On no occasion did the Vivians bid in their own name, all tickets were submitted in the name of the Cheadle company. This was credible. During the years immediately following the Williams' monopoly, John Vivian would bid on Williams' behalf in the name of the Cheadle company.[105] Toomey argues that Williams and Grenfell sought to dominate the trade by driving out new entrants, including the Vivians and Daniell & Co, 'expanding their purchases from 17.5 per cent of the total in 1817 to 25.1 per cent in 1818.'[106] By this date they must have felt sufficiently well established to undertake this action, for in 1806 they were willing to collude with other firms.[107]

Notwithstanding Toomey's analysis of the dominant role of Williams and Grenfell, there would seem to be little doubt that by 1820 collusion had again resumed between the South Wales companies, or it was proposed that it should. Notes prepared by Vivian & Sons are unequivocal in their confirmation of collusion:[108]

> Suggestions for Regulating the Copper Trade – about July 1820
>
> The quantity of copper ore raised in Cornwall in the year ending 30 Jan 1820 was about 92,000 tons. By working of the considerable mines, it will probably be increased to 100,000 tons in the next year.
>
> It is suggested for the benefit of the trade, that the five principal Buyers should limit their purchases to nearly about the quantities they purchased in the last year.

	Bo^{t}. last year	To buy next year p week	p annum
	T(ons)	T	T
Williams & Grenfell	16,166	320	16,640

Rose Co.	9,328	180	9,360
Crown Co.	8,806	170	8,840
Daniels Co.	15,600	300	15,600
Vivians	19,801	400	20,800
	69,701	1,370	71,240

For the other companies there will remain more than they purchased in the last year:

English Co.	100	5,200
Birmingham (to buy in Cornwall)	100	5,200
Cheadle Co.	60	3,120
Freeman	60	3,120
Mines Royal	20	1,040
British	50	2,600
	1,760	91,520

By an understanding among the 5 principal Buyers, it should seem, that the standard and price of copper might always be regulated – There is ore enough for all, and probably more than enough – and, no doubt, there will be enough to enable the 5 companies to add 10 per cent more to their quantities if they wish it.

That is if the other Co's do not wish increase their quantities.

Once again the smelting companies of South Wales were in control of the industry, a feature of the trade in copper ore that had applied from 1760 onwards except for the years between 1785 and 1805. What is of note in the paper cited above three of the five biggest smelting companies, Williams & Grenfell, Daniels & Company and Vivians, had close ties with Cornwall, and yet no effort was made by them to integrate with the mines. There is no instance where the smelting companies in South Wales at this time held any shareholding in Cornish mines, or ownership of such mines. They had come to recognise where the greatest risks lay.

Throughout the period from 1760 to 1820, the smelting companies of South Wales were the major source of copper. Whilst they lost much of their domination during the term of the CMCo, they remained influential by their position as the principal location for the smelting industry. Their role as contractors to the CMCo, coupled with the parallel

activities of the independent companies ensured their survival. Whilst it cannot be denied there is strong evidence of collusion it does not follow that this action was taken solely for purely financial reasons. As discussed earlier smelting companies required a mix of ore for the satisfactory production of copper. It would therefore follow that the requirement for specific ores by individual companies would vary from ticketing to ticketing, a requirement which could also result in collusion.

Table 5.3

COPPER ORES sampled 21st and 22nd August, and sold 6th September 1798

MINES	Tons	Mines Royal (1) £	s	d	English (2) £	s	d	Birmingham (3) £	s	d	Cheadle (4) £	s	d	Lockwood (5) £	s	d	Freeman (6) £	s	d	Cornish (7) £	s	d	Roe (8) £	s	d	P. Mine (9) £	s	d	Birmingham Wire (10) £	s	d	Rose (11) £	s	d	Produce	Standard offered at £	Returning Charge s	Standard sold at £	Qty sold
Harland	164	6	19	6	7	14	0	7	11	0	7	4	6	7	17	0	7	17	6	7	17	6	7	0	0	7	0	0	8	1	0	7	19	0	10	104.00	49/-	105.00	3/4ths
Harland	144	11	1	0	12	12	6	12	2	6	11	17	0	12	8	6	12	5	0	12	10	0	11	10	0	11	11	0	12	16	0	12	14	6	14 7/8	102.00	49/-	102.00	
Harland	134	7	13	6	8	4	6	8	6	0	7	12	0	8	10	6	8	10	6	8	7	6	7	5	0	7	10	0	7	6	0	8	15	0	10 7/8	103.00	49/-	103.00	
Harland	131							1	8	6	1	6	6	1	15	6	1	14	0	1	3	0	1	5	0	1	8	6	1	3	0				3 1/2	103.00	49/-	120.00	
Harland	129	7	5	6	7	14	0	8	1	0	7	12	0	8	2	6	7	17	6	7	15	6	7	0	0	7	10	0	8	1	0	8	7	6	10 5/8	102.00	49/-	102.00	
Harland	38	3	2	6	3	9	6	3	13	6	3	15	0	3	13	6	3	12	0	3	10	0	3	0	0	3	10	0	3	6	0	3	14	6	6	103.00	49/-	103.50	
Cook's Kitchen	131	3	14	6	4	6	0	3	19	0	4	7	0	4	9	0	4	10	6				3	16	0	4	0	0	3	19	6	4	8	0	6 3/4	103.00	51/-	104.00	5/9ths
Cook's Kitchen	111	6	9	6	7	7	0	7	1	6	7	7	0	7	6	0	7	16	6				6	15	0	7	0	0	6	14	0	7	7	0	9 5/8	103.00	51/-	107.50	
Cook's Kitchen	96	4	4	6	4	7	6	4	12	0	4	9	6	4	16	6	4	13	0				3	16	0	4	4	0	3	19	6	5	1	0	7 3/8	103.00	51/-	103.00	
Cook's Kitchen	84	2	16	6	3	6	6	3	2	6	3	12	0	3	5	0	3	9	0				3	0	0	3	8	6	3	2	0	3	10	0	5 7/8	103.00	51/-	104.00	
Tin Croft	147	8	15	6	9	12	6	9	7	6	9	7	6	9	17	6	10	2	0	9	15	6	8	18	0	9	0	0	9	7	0	9	18	6	12 1/8	103.00	51/-	104.00	All
Tin Croft	135	9	19	6	11	8	6	10	14	6	10	17	6	11	4	0	11	0	0	11	6	0	10	8	0	10	10	0	11	15	6	11	12	0	13 3/4				
Tin Croft	116	8	6	0	9	12	6	8	18	6	9	5	0	8	14	0	9	16	0	9	17	0	8	11	0	9	0	0	9	13	6	9	11	6	11 3/4	103.00	51/-	105.50	
Outfield	91	8	18	6				11	1	6	10	3	6	10	11	6	9	17	6	9	15	0	9	11	0	9	15	0	10	3	0	10	17	0	13	103.00	51/-	104.00	5/9ths
Outfield	86	9	6	6				10	5	6	10	6	0	10	16	6	10	0	0	9	17	6	9	11	0	10	0	0	10	3	0	10	19	6	13 1/8	103.00	51/-	103.00	
Outfield	62	8	8	6				9	17	6	8	15	0	9	3	6	9	8	6	8	17	6	8	9	0	8	8	0	8	18	0	9	14	6	11 7/8	103.00	51/-	104.00	
Outfield	43	4	3	6				4	15	6	5	2	0	5	0	0	5	9	0	5	5	0	4	12	0	4	15	0	4	18	0	5	1	0	7 3/8	103.00	51/-	108.50	
Outfield	37	3	7	6				3	15	6	4	0	0	4	0	0	4	5	0	4	0	0	3	13	0	3	15	0	3	18	0	4	8	0	6 3/4	103.00	51/-	103.00	
Treskowe	79	7	7	6	8	7	0	9	3	6	8	3	6	9	0	0	8	9	6	8	7	6	7	12	0	7	17	6	7	11	0	8	9	0	11	100.00	51/-	106.50	3/4ths
Treskowe	59	10	10	6	11	15	0	12	17	6	11	17	0	12	11	0	11	12	0	11	10	0	11	7	0	11	11	0	11	3	6	12	6	6	14 7/8	100.00	51/-	103.50	
Prince George	84	11	0	6	12	12	6	12	0	0	11	19	6	12	11	6	12	0	0	12	10	0	11	7	0	11	11	0	12	3	6	12	3	6	14 5/8	100.00	49/-	103.00	50/64ths
Prince George	42	10	11	6	11	5	6	11	10	6	11	0	0	11	15	6	11	0	0	11	2	6	10	8	0	10	10	0	11	3	6	11	16	0	14 3/4	100.00	49/-	100.00	
Pednandrea	67	6	0	0	6	12	0	6	4	6	6	2	6	6	19	0	6	15	6	6	14	0	5	16	0	5	17	0	6	4	0	6	15	6	9	103.00	50/-	105.00	All
Wh. Providence	33	2	19	0				4	0	0	3	17	6	3	13	0	3	12	6	3	10	0	3	4	0	3	10	0	3	2	6	3	18	6	6 1/4	103.00	50/-	104.00	53/64ths
Boxprowell	24	8	7	6	9	10	0	9	9	6	9	7	6	9	16	6	9	2	6	9	5	0	8	13	0	9	0	0	9	4	0	9	9	0	12	100.00	51/-	103.00	All
New Redwore	21	8	6	6				9	8	6	9	0	0	9	3	6	8	17	0	8	19	6	8	13	0	8	12	0	8	17	6	9	4	0	11 3/4	100.00	51/-	102.00	9/10ths
	2289																																						

1799 Report, app 7a

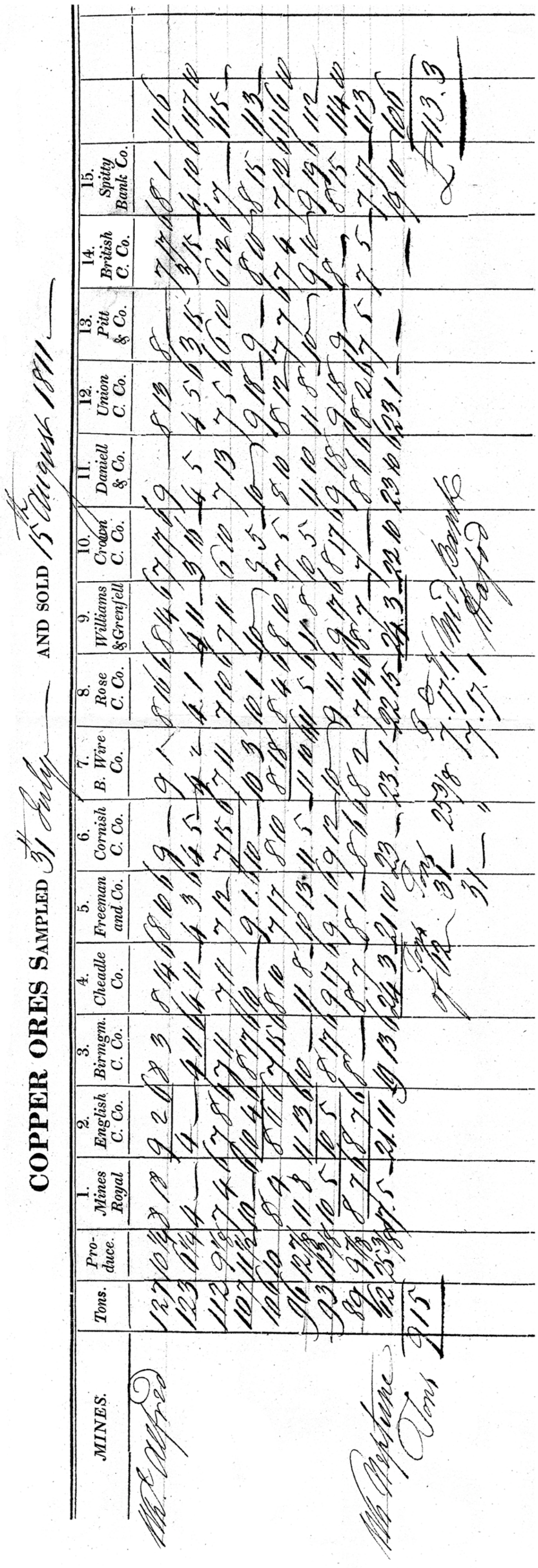


Table 5.4
NLW Vivian E68

Table 5.5: Premiums received by Boulton & Watt in Cornwall to end 1798.[109]

	£ s. d.
Whl. Virgin, St. Hillary	233 18 2
Ting Tang Dr.	509 3 0
Chacewater 63 Dr.	3,558 6 8
Whl. Union Adventurers	576 18 8
Hallamanin for 40 Inch	776 6 10
Hallamanin for 60 New Adventurers	187 6 0
Whl. Chance in Camborne	1,626 11 7
United Mines	15,701 15 11
Whl. Treasure 36 Inch	355 13 0
Whl. Gons 36 Inch	1,139 18 0
Dolcoath	4,587 1 9
Chacewater New Adventurers	3,666 13 4
Whl. Jewel Adventurers	425 5 0
Whl. Crenver 48 Inch	1,566 0 11
Godolphin	1,608 12 0
Polgooth	9,538 10 0
Whl. Reeth	21 0 0
North Downs	8,254 3 8
Cooks Kitchen	1,188 0 0
Hewas	168 0 0
Bog	150 0 0
W. Garland	238 10 0
Whl. Ramoth	175 0 0
Crane Adventurers	149 8 0
Scorrier Fenton & Co	667 1 6
Jno. Williams for Scorrier	200 0 0
Kestil Adit	839 4 0
Hallamanin for 60 Old Adventurers	318 8 0
Retallack 40 Inch	66 12 0
Poldice Adventurers	12,061 2 3
Tresavean	658 0 8
Whl. Treasure 40 Inch	59 0 0
Whl. Gons 63 Inch	2,750 0 0
Pool	174 8 11
Consolidated Mines	22,157 1 11
Whl. Carpenter	88 4 0
Whl. Crenver 60 Inch	2,935 17 7
Trevascus	435 15 4
Whl. Towan	31 10 0
Whl. Mount	21 0 0
Herland Adventurers 64 Inch	3,464 0 0
Mr. Gullet	170 0 0
Cardrew Downs	94 10 0
Neath Abbey Co.	426 0 0
Whl. Fortune	288 0 0
Whl. Unity	1,243 0 0
Ding Dong	122 8 10
	£106,208 7 6

Table 5.6: Ticketings – 1809 to 1814

	Purchases (tons)				
Date	Williams & Grenfell	Cheadle	Vivian	Total	Remarks
13 Apr 1809	–	–	–	–	No purchase
13 Jul 1809	187	67	–	254	–
30 Nov 1809	–	340	–	340	W & G bidding on their own behalf without success.
26 Jul 1810	44	–	190	234	W & G total found by difference between total and Vivian's portion
29 Nov 1810	–	–	–	975	Not divided
15 Aug 1811	31		31	62	Split parcel
22 Aug 1811	422	212	209	843	–
29 Aug 1811	53.5	–	38.5	92	–
5 Sep 1811	273	286	154	713	–
12 Sep 1811	207	339	131	677	–
26 Sep 1811	–	–	–	–	No purchase
3 Oct 1811	27		14	41	–
10 Feb 1814	–	–	–	–	No purchase
17 Feb 1814	43	–	325	368	Split parcel. W & G total found by difference between total and Vivian's portion
10 Mar 1814	16.5	–	8	24.5	W & G bidding on their own behalf
24 Mar 1814	413	–	75	488	W & G bidding on their own behalf
31 Nov 1814	198	–	–	198	W & G bidding on their own behalf

Figure 5.1. Copper prices per ton

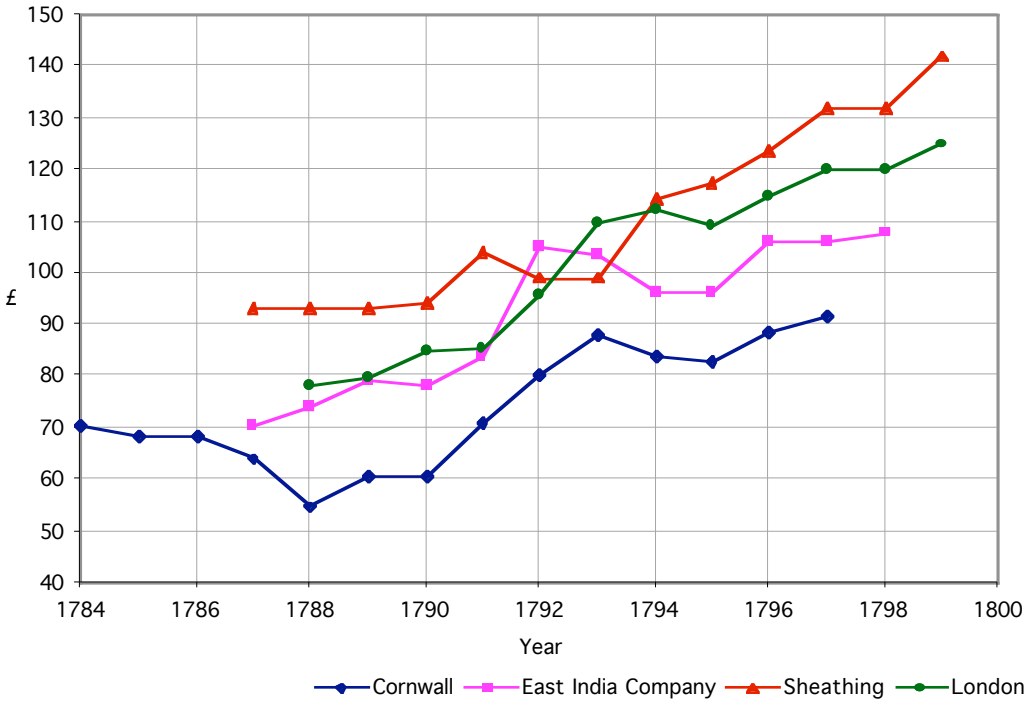
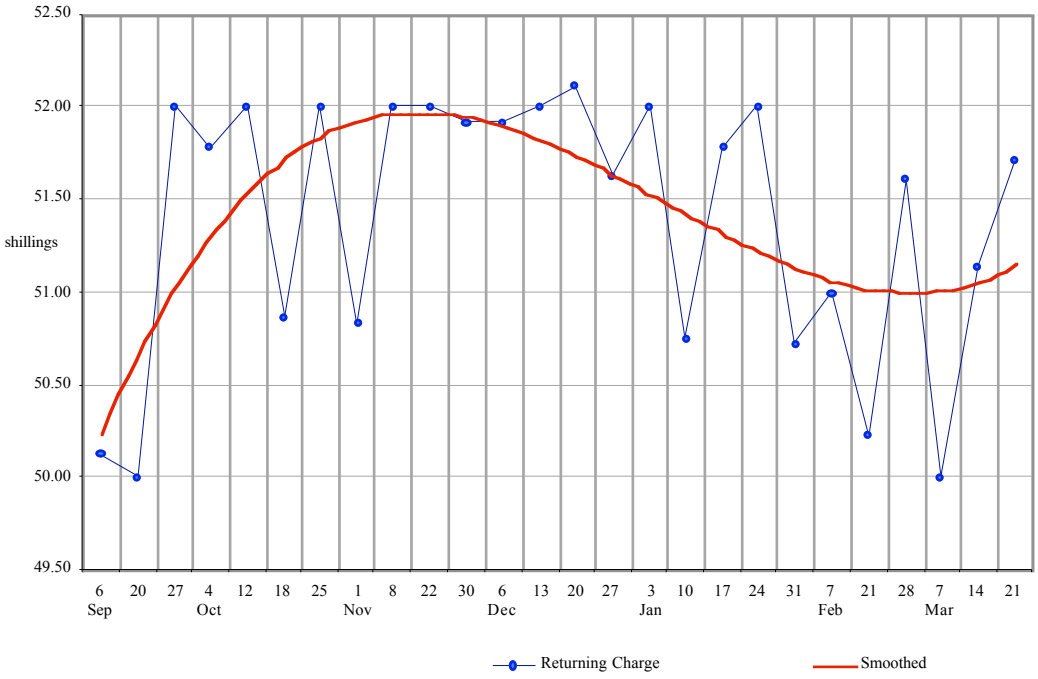


Figure 5.2: Weekly Copper Ticketings



NOTES

[1] Harris, J R. (1964), 115.
[2] (Paris, J A. 1831), 224 – 25. Harris, J R. 'Copper and Shipping in the Eighteenth Century', *Economic History Review*, vol 19 (1966), 554.
[3] 1799 Report, app 38. The data for 1799 in the Report is assumed to be for the first quarter only, with the total for the full year being four times this amount.
[4] James, W M. *The Naval History of Great Britain*, 6 vols. (Richard Bentley, London; 1837. Reprinted Conway Maritime Press; 2001),). vol 1, 407 – 413. vol 2. 398 – 403).
[5] 1799 Report, App 38
[6] Decommissioned. Not ready for active service, manned by a skeleton crew, and partially de–rigged.
[7] Rees, G. 'Copper Sheathing. An Example of the technological diffusion in the English merchant fleet', *Journal of Transport History*, 2nd series, vol 1, no 2 (1971), 85 – 94.
[8] in April 1799
[9] 1799 Report, 669 – 70
[10] Harris, J R. (1966), 566
[11] Whiting, J R S. *Trade Tokens, A Social and Economic History*, (David & Charles, Newton Abbott, 1971), 13 – 32.
[12] 'Sir Joseph Banks Papers', Series 84, State Library, New South Wales, www.slnsw.gov.au/. Sir Joseph Banks was a member of the Coin Committee of the Privy Council.
[13] www.slnsw.gov.au/
[14] Whiting, J R S. (1971), 77 – 144.
[15] Whiting, J R S. (1971), 90. Harris, J R.(1964), 152 – 53.
[16] Smiles,S. (1874), 312.
[17] www.geocities.com/
[18] www.nd.edu/
[19] Smiles,S. (1874), 316. This included a commemorative medal of Louis XIV for Monneron Bros of Paris, striking some 2,334,000 pieces consuming upwards of 70 tons of copper. www.napoleonicmedals.org/ coins/fr92–1.htm
[20] Smiles,S. (1874), 317.
[21] www.slnsw.gov.au/ 'The Birth of Modern Coinage', jquarter.members.beeb.net/
[22] *The London Gazette*, Saturday, August 12 to Tuesday, August 15, 1797.
[23] Boulton's evidence to the Enquiry. Report, 674.
[24] www.slnsw.gov.au/ 'The Birth of Modern Coinage', jquarter.members.beeb.net/
[25] 1799 Report. 666. From the evidence given by Thomas Williams.
[26] 1,054 tons.
[27] It is assumed that plated goods were silver plated onto brass. 1799 Report, apps 33 and 34.
[28] It is assumed that brass comprised a mixture of copper and zinc in the ratio of 2:1.
[29] Berg, M. (1985), 291. Berg, P and T. (trans). (2001), 39. Hutton, W. (1783), 329.
[30] Saint Fond, de F. 'A Journey through England and Scotland to the Hebrides in 1784' (1907), Horn, D B and Ransome, M. (eds), *English Historical Documents 1714 – 1783*. (Eyre and Spotiswoode,1957), 473,
[31] Hamilton, H. (1967), 292.
[32] 1799 Report, 655.
[33] 1799 Report, 659.
[34] 1799 Report, 670.
[35] Anonymous, *An Abridgement of the Evidence on the Copper–Trade*, Birmingham, May 1799.

[36] Lewis, G.R. *The Stannaries,* (Archibald Constable & Co, London; 1908), 224.
[37] Percy, J. (1861), 306.
[38] Toomey, R R. (1985), 62.
[39] 1799 Report, app 7.
[40] This has been universally accepted by contemporary writers and historians, yet Williams stated in evidence to the 1799 Enquiry: '… if it is below twenty tons, the last purchaser from the same Mine has the lot to himself.' 1799 Report, 672.
[41] NLW, Vivian, E71 to E80.
[42] Newell, E. (1988), 119. Rowe, J. (1953), 22.
[43] Newell provides a detailed discussion of this subject in Newell, E. 'Interpreting the Cornish Copper Standard', *Journal of the Trevithick Society,* (1986), 13, 36 – 45. It only, however, relates to the nineteenth century.
[44] Burt, R. (1969), 58 – 9.
[45] Jones, H. (1985), 23.
[46] Borlase, W. (1758).
[47] Pryce, W, (1778).
[48] 1799 Report, 678. Vivian in response to a question on yield, told the enquiry: 'Poorer Ores have certainly been brought to market in consequence of the high standard of Ores, but the Ores in general are poorer than they have usually been, independent of this circumstance.'
[49] 1799 Report, app 7.
[50] Toomey, R R. (1985), 56. It should also be remembered that underlying these considerations was the allowance of one hundredweight per ton of ore.
[51] Thomas, C. *Mining Fields of the West.* (London; 1867), 93.
[52] Percy, J. (1861). p.304.
[53] Begg, D, Fischer, S and Dornbusch, R. *Economics*, (McGraw–Hill Book Co; 1994), 162.
[54] Thompson, D. *Concise Oxford Dictionary*, (Clarendon Press, Oxford; 1998), 1000.
[55] See the extract from Carew quoted in Chapter 2.
[56] Borlase, W. (1758), 204.
[57] Pryce, W. (1778), 279.
[58] Pryce, W. (1778), 289.
[59] Toomey, R R. (1985), 350.
[60] This data originates from the National Library of Wales (MSS 15101 – 117), and correlates very closely with the data for copper ore sales presented by Lemon, see Chapter 3. There is no data in the NLW manuscripts for the years 1746 and 47, and between 1774 and 1778. Roberts, R. 'Copper and Economic Growth in Britain, 1729 – 1784', *Journal of the National Library of Wales*, 10,1, (1957), 65 – 74.
[61] From 1764 Freeman & Co.
[62] Except for 1748, 1765 and 1773.
[63] Hamilton, H. (1967), 166.
[64] Harris, J R. (1964), 56.
[65] Rowe, J. (1953), 82.
[66] Hamilton, H. (1967), 170. Harris, J R. (1964), 60. Rowe, J. (1953), 82.
[67] Harris, J R and Roberts, R O, 'Eighteenth Century Monopoly: The CMCo Agreements of 1785' *Business History*, 5, 2, (1963), 69 – 82. Pennington, R, 'The CMCo 1785 – 1792', *Trevithick Journa*l, 5, (1977), 76 – 88.

[68] The initial Board of Directors; representing the adventurers: Viscount Falmouth, Sir William Lemon , Sir Francis Bassett, later Lord de Dunstanville, Sir William Molesworth, Sir John St. Aubyn, Joseph Beauchamp, John Bevan , Matthew Boulton, R A Daniell, Thomas Daniell, John Edwards, George Fox, R W Fox, R L Gwatkyn, William Harris, Christopher Hawkins, Thomas Kevill, John Rapers, Phillip Rashleigh, Thomas Reed, Francis Rodd, Henry Hawkins Tremayne, John Vivian, John Williams, James Willyams Jun, and the shareholders: John Call, Lewis Charles Daubuz, John Gould, Silvanus Jenkins, John Martyn, William Paul, Joseph Tregelles, Robert Walker, Thomas Wilson, plus 3 others. The company's bankers were Elliot Praed, Basset & Praed and Messrs. Daniell, Willyams, Daniell & Co. J R Hams and R O Roberts. (1963), footnotes 22 and 23.
[69] Much of what follows concerning the CMCo is to be found in Hamilton, H. (1967), 169 – 202. Harris, J R. (1964), 54 – 69. Rowe, J. (1953), 81 – 88
[70] Independent arbitrator, London agent of the Cornish associated adventurers. Pennington, R, (1977), 80
[71] Hams, J R and Roberts, R O, (1963), footnote 20.
[72] Harris, J R and Roberts, R O, (1963), 69 – 82.
[73] Harris, J R. (1964), 65. Pennington, R, (1977), n 55, 87.
[74] Harris, J R and Roberts, R O, (1963), 69 – 82.
[75] Hunt, R, (1887), 106.
[76] Harris, J R, (1964), 68.
[77] Pennington, R, (1977), 78.
[78] Harris, J R, (1964), 73.
[79] Griffiths, J. *The Third Man*, (Andre Deutsch, London, 1992),172 – 73.
[80] Harris, J R. 'Copper and Shipping in the Eighteenth Century', *Economic History Review*, 19, (1966), 550 – 568. This significant change greatly reduced the galvanic action between the fixing bolt and the sheathing, the previous threat to the integrity of the hull below the waterline.
[81] Harris, J R, (1964), 73.
[82] Rowe, J. (1953), 85.
[83] Hamilton, H. (1967), 187. Harris, J R, (1964), 82.
[84] Harris, J R. (1964), 87.
[85] 1799 Report, app 8.
[86] 1799 Report, 654. Evidence of George Simcox.
[87] The average given by Schmitz between 1771 and 1779 was £87, a not unreasonable agreement with Williams's value of £90, and still substantiating his proposition. Schmitz, C J. (1979), 268 – 69.
[88] Harris J R. (1964), 94 – 95.
[89] Vivian J. 'A Plan on which the Metal Co. may approve of retiring from the Purchase of Ores', manuscript, (no date, circa 1790), Vivian B3, National Library of Wales.
[90] 1799 Report, app 1.
[91] Hamilton, H. (1967), 197 – 200. Harris, J R. (1964), 97 – 100.
[92] Tann, J. 'Riches from Copper: the Adoption of the Boulton and Watt Engine by Cornish Mine Adventurers', *Transactions of the Newcomen Society*, 67, (1995 – 96), 42.
[93] Griffiths, J. (1992), 182 – 83. Rowe, J. (1953), 106. Trevithick, F. (1872), 60.
[94] This engine was secondhand, purchased from Godolphin Great Work. From William Jenkin to George Hunt, Lanhydrock, written 30 May 1795. Jenkin was Hunt's agent. Jenkin, A K H. (1951), 35.
[95] Duty: A measure of the work done by a pumping engine. It is defined as the number of pounds of water which can be lifted one foot by a bushel of coal.
[96] Rowe, J. (1953), 99.
[97] Lean, T. *On the Steam Engines in Cornwall*, (Simpkin, Marshall & Co, London; 1839, reprinted in facsimile by D Bradford Barton; 1969), 13 – 55.
[98] Appendix 2, Mineral Statistics.
[99] 1799 Report, 656.
[100] 1799 Report, app 7.

[101] This table results from an analysis of Appendix 7 in the 1799 report.
[102] Hamilton, H. (1967), 236.
[103] Letter to Col Vivian at Knightsbridge Barracks, London, (17 March 1813), NLW, Vivian A44.
[104] NLW, Vivian E62 – E65, E67 – E74, E76 – E79.
[105] 1799 Report, 673.
[106] Toomey, R R. (1985), 318.
[107] Toomey, R R. (1958), 316.
[108] NLW, Vivian, E81.
[109] Fox, H. 'Boulton and Watt', *Annual Report of the Royal Cornwall Polytechnic Report*, New Series 1, 3, (1911), 538 – 39.