

Proto-industrialisation and "Stages of Growth" in the Metal Mining Industries

Roger Burt

University of Exeter

Since Mendels first wrote of "proto-industrialisation" over twenty years ago, the international debate concerning the development and applicability of that model has been held to the exclusion of "big industry"¹. Milling, tanning, shipbuilding and, above all, mining and metallurgy, were all assumed to be exceptional cases, requiring relatively large fixed capital inputs, in a model which found "the first phase of industrialisation" in rural, domestic, low investment industry. Is this appropriate? The question is not asked in terms of whether or not "big industry" should be incorporated in the model, but whether these industries were in fact organised on a large-scale, capital-intensive basis. Arguably the unit size of many of these industries was exaggerated by early historians and we have failed to shake off this legacy and re-assess the true extent of small-scale, low-capitalised, "domestic" activity in this sector. Certainly there were examples of very large-scale organisation in these industries but the generality of activity in many, perhaps most, districts was very different and conformed more closely with the norm of small-scale enterprise. As D.C. Coleman noticed, "that deeper mines and larger iron works required capital beyond the range of the small man is obvious enough; but just as not every mining district was the same as Southern Germany or North Eastern England, so were these enterprises the product of exceptional

¹ F.F. Mendels, 'Proto-industrialisation: The First Phase of the Industrialisation Process' *Journal of Economic History* Vol. 32 (1972), pp.241-61.

men!"² This proposition can be well demonstrated by reference to the mining industries.

I - In the most recent, updated edition of his general textbook, *Before the Industrial Revolution*, Carlo Cipolla repeats the accepted orthodoxy that, "Mining and shipbuilding were the typical sectors in which 'bigness' prevailed at an early stage" and he produces an example of a large sixteenth-century mining operation in Poland to make his point.³ There is no doubt that large capital-intensive mines were found throughout Europe from the middle ages onwards. They were particularly associated with silver-rich lead and copper deposits where the crown or large land/mineral owners had a controlling interest. Extensive capital resources could be mustered to pursue lodes at depth and to maximise the output of precious metal that would contribute directly to the accumulation of wealth and power. In areas where ores were not argentiferous, however, and state power and capital was less directly concerned, the structure of the industry was very different. In England and Wales, for example, rich, silver-bearing deposits were uncommon and direct state enterprise and large-scale mining activity a rarity.⁴ In Continental Europe, from Poland, through Germany, to Spain, there were numerous examples of small-scale, part-time enterprise in the mining of metals and other minerals, either on marginal deposits or abandoned parts of once larger mines. Local mining laws made provision for such activity around the Medici silver mines in Tuscany in the early sixteen century, for example, and Molenda has shown how even in the advanced mining districts of Eastern Central Europe, the up-take of large-scale technologies before the seventeenth century was

² See J.U. Nef, 'The Progress of Technology and the Growth of Large Scale Industry in Great Britain, 1540-1640' *Economic History Review* Vol. V, No.1 (1934), pp.3-24 and D.C. Coleman, 'Technology and Economic History'. *Economic History Review*, XI, No.3 (1959), pp.506-14.

³ C.M. Cipolla, *Before the Industrial Revolution*, (3rd revised edition, 1993), pp.86, 95.

⁴ See R. Burt, *The British Lead Mining Industry* (Redruth, 1984), pp.219-23; R. Burt, 'The International Diffusion of Technology during the Early Modern Period: The case of the British Non-Ferrous Mining Industry' *Economic History Review* XLIV (May, 1991), pp. 249-271; P.F. Claughton, *The Combe Martin Mines*, (Combe Martin, 1992) J.B. Richardson, *Metal Mining*, (London, 1974), Ch. 2 and 3.

confined to a small minority of best practice "pilot centres" and small operations employing less than ten or twenty men remained common.⁵ It is regrettable that the concern of historians with the larger, and better documented mines, has prevented this section of the industry from being better researched.

The case for setting large parts of the mining industry - both metals and coal - within, rather than outside, of the proto-industrial model, is a strong one. The evidence has long been available in a range of articles dealing with industry in the countryside, specialist works on the mining industries and a range of original sources. It can be considered conveniently by looking in turn at the principal characteristics of the model. There are usually considered to be five main *descriptive* features of proto-industry and another five hypotheses about how *dynamic* elements within that type of industry propelled it forward into larger-scale, capitalistic enterprise.⁶

As a result of the lack of published material on small-scale continental mining, this discussion has been based primarily on British experience.

II - Firstly, the descriptive features.

1. *The regional basis of industrial organisation.* According to Mendels, 'The hypotheses relating to proto-industrialisation should stand or fall on the basis of regional and not national or international analysis and data collection'⁷ No other industry has a

⁵ See R. Morelli, 'The Medici Silver Mines 1542-1592' *Journal of European Economic History*, Vol. 5 No.1 Spring 1976, pp.121-39; D. Molenda, 'Technological Innovation in Central Europe between the XIVth and XVIIth centuries' *Journal of European Economic History* Vol. 17 No.1 (Spring 1988), pp.63-84; and D. Plaum and Witthoff, 'Das Seigerland. Ein historisches Profil' in Schulze (ed) *Industrial Regions in Transition*, (Essen, 1993), pp. 318-63.

⁶ "These definitions and hypotheses together make up the essence of proto-industrialisation as a theory, viz. that a region experiencing proto-industrialisation will be propelled towards an industrial revolution by these mechanisms." See D.C. Coleman, 'Proto-industrialisation. A concept too many' *Economic History Review*, XXXVI (Aug.1983), pp. 435-48, pp. 436-7 and L.A. Clarkson, *Proto-industrialisation: The First Phase of Industrialisation?*, (London, 1985), pp.15, 28-9

⁷ F.F. Mendels, 'Proto-industrialisation: Theory and Reality'. General Report: 'A' Themes. Eighth International Economic History Congress, Budapest (1982). pp. 66-107.

better claim to regional analysis than mining. The process of mineralisation and fossil fuel deposition narrowly defines where the industry could be conducted, as well as the methods used and its economic and institutional structure. Mining history necessarily consists of regional studies and the broader issues can only be derived from comparative regional analysis.⁸ By its very nature, mining is the most regionally structured of all industries.

2. *Production was primarily for distant national and international markets, where it often had to compete with the output of other regions.* Again, this is a commonplace for mining. From the earliest origins of man, minerals have been traded over very long distances, and competitively marketed thousands of miles from their points of origin. In the sixteenth century, European mining was ruined by the sudden influx of cheap metals from South America. Ensuing centuries saw the rise and decline of numerous regional mining economies as their capacity to compete in distant urban markets waxed and waned.⁹ Throughout early and modern history, the prosperity of regional mining economies has been heavily influenced by changes in supply and demand in distant markets.¹⁰ What farmers came only to confront in the post-railway age, miners had grown accustomed to in the middle ages and earlier. Even in the primitive quarrying industry, part-time labour-intensive operations were often conducted to supply distant regional, if not international, markets, particularly where cheap water transportation facilitated delivery.

⁸ See R. Burt and P. Waite, *Bibliography of the History of British Metal Mining* (Exeter, 1988), p. VI; T. Greaves and W. Culver (eds.) *Miners and Mining in the Americas* (Manchester, 1985), p. 280; *Der Anschnitt, Zeitschrift für Kunst und Kultur im Bergbau. General register Jahrgänge 1 (1949) - 35 (1983)*.

⁹ See H.A. Miskimin, *The Economy of Late Renaissance Europe, 1460-1600* (Cambridge, 1977), p. 36; I. Blanchard, *Russia's Age of Silver: Precious Metal Production and Economic Growth in the Eighteenth Century*, (1989); E.S. Hedges, *Tin in Social and Economic History*, (1964).

¹⁰ See for example, I. Blanchard, 'English Lead and the International Bullion Crisis of the 1550s' in D.C. Coleman and A.H. John, (eds.) *Trade, Government and Economy in Pre-industrial England*, (1976), pp. 21-44.

3. *The industries were located in the countryside, and not the towns, and utilized "peasant" labour that combined their industrial activities with farming.* The model assumes that industrial activity was normally slotted into slack periods in the farming year and that domestic, proto-industry of this type was likely to be particularly attractive in poor agricultural areas which practised mainly pastoral farming. In other words the need for additional income was high, as was the time available for non-agricultural activity. In every case, the type of industrial activity favoured would be one that required minimal capital equipment and could be accommodated easily in or by the home. Again, there can be very few industries in the early modern period that better fit this model than metal mining, particularly in Britain. Most metal-mining districts were located in remote mountainous or hilly terrain where a living from agriculture was tenuous and sometimes made near impossible by local customs of partible inheritance.¹¹ Towns had often grown up near mines but for metal mining, if not coal mining, there can be very few examples, of mining in or under towns.

The essentially rural structure of the extractive industries has long been a matter of comment. In E. L. Jones's look at the "pastoral-industrial equation", he referred to mining as one of the options for regional specialisation in Europe. Elsewhere he noticed the effect of the decline of local mining and agriculture in the Erzgebirge, Thuringian Forest and Frankenwald and the reduced opportunities for domestic manufacturing.¹² Somewhat earlier, Joan Thirsk, whose work is so often referred to in the historiography of the proto-industrial concept, unhesitatingly included the extractive industries among those activities "which were carried on in conjunction with farming and which catered for a national rather than a local market". She noticed that in the mineral-yielding areas, "industry and

¹¹ J. Thirsk, 'Industries in the Countryside' in E.J. Fisher (ed.) *Essays in the Economic and Social History of Tudor and Stuart England*. (Cambridge, 1961), p.70. The Lordship of Dent is in the Yorkshire lead mining district.

¹² E.L. Jones, 'Environment Agriculture and Industrialisation in Europe' *Agricultural History*, 51 (July 1977), pp.491-502 and W.N. Parker & E.L. Jones (eds.) *European Peasants and Their Markets*, (Princeton, 1975). See also E.L. Jones, 'Agricultural Origins of Industry', *Past and Present*, 40 (July, 1968), pp.58-71. He makes no specific reference to mining, but his conclusions apply equally.

agriculture were ancient bedfellows, and in most places it is doubtful whether the beginnings of settled agriculture preceded or followed the mining of tin, lead, copper, iron, stone and chalk". She observed how the essentially pastoral nature of farming in the upland mining areas fitted well with the demands of mining and enabled the "mining-farming family" to make a success of "the two occupations".¹³

Similarly, Blanchard and Hatcher, writing around the same time as Mendels, debated the nature of the relationship between mining and farming in Derbyshire and Cornwall at the end of the middle ages. Blanchard took the view that in Derbyshire most miners were strongly dual occupational, fitting part-time work in their own neighbouring small and shallow mines into slack seasons in the agricultural year. The cash income from the sale of just a few tons of ore produced annually could be used as a useful supplement for an inadequate return from agriculture, to rent extra land, pay rents or simply acquire small luxuries.¹⁴ The position seems to have changed little by the mid-sixteenth century, with Kiernan calculating that "professional miners" made up less than ten percent of the Derbyshire lead mining labour force and that, "it was the miner/farmers who produced the bulk of the ore and were the backbone of the industry". A hundred years later, large-scale mining, financed by wealthy smelters and merchants, were beginning to have an impact in the district. However, a petition of Parliament in 1641 suggested that there were still around 20,000 people deriving some level of income from the industry which with an estimated value of ore output of £68,400 annually, represents an average of only just over £3 per head.¹⁵

In Cornwall, Hatcher saw a more important role for earnings from mining in family incomes as early as the fourteenth century but again he accepted the continued duality of activity. He wrote

¹³ Thirsk, 'Countryside', pp.72-3.

¹⁴ I. Blanchard, 'The Mines and the Agricultural Community in Late Medieval England' *Agricultural History Review*, 20, (1972) pp. 93-106 and 'Labour Productivity and Work Psychology in the English Mining Industry 1400-1600' *Economic History Review*, XXXI (Feb 1978), pp.1-24.

¹⁵ D. Kiernan, *The Derbyshire Lead Industry in the Sixteenth Century*, (Chesterfield, 1989), pp.35 and D. Kiernan, 'Twenty Thousand Miners Can't Be Wrong' *Bulletin of the Peak District Mines Historical Society*, vol. II, no. 5, (Summer 1992), pp. 249-53.

that, "a mass of evidence from the seventeenth century to the time when Maitland was writing and even beyond, attests the fact that the miner-cum-farmer and the farmer-cum-miner continued to be a major element in the mining communities, and that much of the labour force, particularly in the stannaries; continued to be casual in nature and composed of fishermen, women and children and the smallholders seeking to supplement the income from their farms"¹⁶ Similarly, in his analysis of the size of Cornish land holdings in the seventeenth century, Whetter concluded that over half were under 15 acres and that most people in the county had some interest in farming. "Although their main work may have been in some other sphere, they were usually part-time farmers as well"¹⁷

It was not just in metals that mining operations remained small scale. Stone joined Nef in emphasizing, "the intermittent and casual nature of mining employment" and concluded that the typical Elizabethan coal mine, "was the unmechanised, cheap unenterprising little concern". Similarly, Hatcher's recent review of the early modern industry has emphasised the prevalence of part-time and discontinuous working in many mines. He refers to the "part-time colliers and genuine collier-cottagers like the free miners of Kingwood Chase and the Forest of Dean" who often possessed small farms and observed that, "even specialist colliers in advanced mining regions were rarely without at least a garden plot".¹⁸ Clearly most market-orientated sectors of the coal industry had achieved a level of professionalisation and worker proletarianisation at an early date and fall beyond the scope of the proto-industrial model but there were some significant areas of dualistic activity worthy of notice.

In metal mining, the symbiotic relationship with agriculture and the rural environment continued well into the late eighteenth and nineteenth centuries. Raistrick and Jennings, Hunt, and Lewis have written at length about the part-time

¹⁶ J. Hatcher, 'Myths, Miners and the Agricultural Community' *Agricultural History Review*, 22 (1974), pp. 54-61.

¹⁷ J. Whetter, *Cornwall in the Seventeenth Century: An Economic History of Kernow*. (Padstow, 1974), pp.23,55; see also T.A.P. Greaves, 'The Good Life? The Westcountry Tinner AD c1500-c1700' *Journal of the Trevithick Society*, No. 20 (1993), p. 47.

¹⁸ J. Hatcher, *The History of the British Coal Industry Vol. 1: Before 1700: Towards the Age of Coal*, (Oxford, 1993), pp.387-8, 402-3.

agricultural activities of lead miners in the Pennines and Wales.¹⁹ They have shown how secondary employment, either on their own smallholdings or in other forms of domestic industry, provided a significant supplement to family incomes, even in the most advanced mining districts, and sustained an essentially rural, rather than town-based pattern of settlement. In Cornwall, a shortage of land and alternative domestic industrial employment, concentrated attention more strongly on mining incomes from an early date and town or village residence became more common. Nevertheless, part-time agricultural activity continued to be available to many. Rowe noticed, for example, how poor labourers "chiefly employed in mining" were heavily involved in the reclamation of the remaining Cornish wasteland at the end of the eighteenth century and Hamilton Jenkin and Rule have both written at length about miners' smallholding interests.²⁰ For those without access to land, the sea provided a long-established source of additional sustenance and/or income. Thus William Pryce observed in 1778, "Our county being altogether maritime, and the Mines being situated in the most narrow part of it, between the two channels, many of our adroit Tinnners are equally conversant with naval and subterranean affairs. So true is this, that in St. Ives and Lelant, during the fishing season, they are wholly employed upon the water, to the great hindrance of the adjacent mines."²¹ Everywhere wage dependence increased considerably during the late seventeenth and eighteenth centuries but rarely did it become complete before the early nineteenth century.

¹⁹ See A. Raistrick and B. Jennings, *A History of Lead Mining in the Pennines*, (1965) Ch. 14; C.J. Hunt, *The Lead Miners of the Northern Pennines in the Eighteenth and Nineteenth Centuries*, (Manchester, 1970), Ch. VII; W.J. Lewis, *Lead Mining in Wales*, (Cardiff, 1967), Ch. XI.

²⁰ J. Rowe, *Cornwall in the Age of the Industrial Revolution*, (2nd edition, St. Austell, 1993), p. 225; A.K. Hamilton Jenkin, *Cornwall and its People*, (1932), Ch. III; J.G. Rule, 'Some Social Aspects of the Cornish Industrial Revolution', in R. Burt (ed.), *Industry and Society in the South West*, (Exeter papers in Economic History, University of Exeter, 1970), pp. 71-106; J. Rule, 'The Labouring Mines in Cornwall c. 1740-1870: A study in Social History', (Warwick PhD, 1971).

²¹ W. Pryce, *Mineralogia Cornubiensis*, (1778), p.35.

4. *Rural industrial activity stimulated adjacent commercial agriculture because it created a market for food.* The problem of the sources of supply of food and other materials to mining districts, is one that has received comparatively little attention. There are, however, some indications of the proto-industrial model at work. Hatcher has shown, for example, how as early as the fourteenth and fifteenth centuries, periods of intensified tin-mining activity in West Cornwall and West Devon produced boom conditions in the intervening agricultural area of east Cornwall, forcing up rents in that district and encouraging colonisation.²² Similarly, Thirsk explained how the expansion of lead mining and other industrial activity in the Derbyshire peak in the early-seventeenth century had caused demand to outstrip the supply of food from local agriculture. The miners were becoming dependent on additional supplies imported from the fertile lowlands of south Derbyshire and east Staffordshire, as well as Danzig rye brought from Hull via the Trent.²³

A hundred years later, with the emergence of large-scale capitalist mining now firmly established, the dependence of mining communities on additional imported food supplies was unmistakable. In the North East during the second quarter of the eighteenth century, for example, corn (mainly rye) was regularly purchased in Newcastle to be sold to the lead miners in Weardale. Around the same time, lead miners, colliers and other industrial workers in North East Wales rioted over the increase in food prices caused by the export of grain from local parts.²⁴ In 1758, Borlase noticed that the eastern part of Cornwall was no longer able to compensate for the provisioning shortfalls of the western mining districts and that in years of bad harvest, the county was heavily dependent on food imports.²⁵ There is little doubt that this increasing dependency was largely occasioned by the rising

²² J. Hatcher, 'A Diversified Economy: Later Medieval Cornwall' *Economic History Review*, XXII, (Aug 1969) pp. 208-227.

²³ See Thirsk, 'Industries' p. 73 and D. Hey, 'The North West Midlands' in J. Thirsk (ed) *The Agrarian History of England and Wales VI 1640-1750: Regional Farming Systems*, (Cambridge, 1984), p.140, pp. 393-428.

²⁴ P. Brassley, 'Northumberland and Durham' and F. Emery, 'Wales' in Thirsk (ed) *Agrarian History*, pp. 30-58, 393-428, 31, 405.

²⁵ W. Borlase, *Natural History of Cornwall*, (1758), pp.89-90. See also A.K. Hamilton Jenkin, *The Cornish Miner*, (1948 ed.), pp.143-5.

population of the mining districts and the neglect of agriculture, but it should also be remembered that the pollution associated with mining, and particularly smelting, also undoubtedly reduced the capacity of the mining districts to produce food, even if they had been minded to do so.²⁶

The influence of the mining districts on neighbouring agriculture was not confined to the market demand for food alone. From the beginning of the sixteenth century, for example, the Derbyshire lead smelters were buying timber fuel from a wide surrounding area, creating important sources of secondary income for small landowners.²⁷ The need to move food and fuel into the mining districts, shift ore around internally, and take finished metal out, created a large and increasing demand for transport services. These were customarily purchased from farmers and when the mines were growing and booming, many neglected agriculture to maximise their profits. Thus Whetter noticed the heavy investment in horses by Cornish farmers during the seventeenth century, particular in the western mining districts of the county, and Lewis observed that in Flintshire in 1773 little cheese or butter was made because the grass was consumed by the horses which the farmers used to carry lead and coal.²⁸ These influences widened the commercialising impact on mining district development over a larger agricultural area.

Similarly, the rapid expansion of mining in remote mountainous districts often amounted almost to a process of "frontier colonisation" and denuded neighbouring agricultural areas of their male population. Thus, Brassley has argued that in Northumberland and Durham, many farming districts were largely dependent on female labour for the harvest and some female day labourers were employed throughout the year. Such labour shortages, together with high market prices for their products, may well have particularly concentrated farmers' minds on adopting the new

²⁶ Lewis, *Wales*, p.283.

²⁷ Kiernan, *Derbyshire*, p.63.

²⁸ Whetter, *Cornwall*, p.35 and Lewis, *Wales*, p.281. For a detailed view of lead haulage in the early eighteenth century and the numbers of horses that could be employed, see A. Blackburn, 'Life on the Lead Ways' in B. Chambers (ed.), *Men, Mines and Minerals of the North Pennines*, (Killhope, 1992), pp.58-70.

crops, breeding techniques and methods evolving in agriculture during the period. Brassley concludes that, as a result of the rigid expansion of mining and industry of all types in the north east after 1650, "its agriculture began the rise to the pre-eminence which it attained in the nineteenth century".²⁹

5. *Towns in proto-industrialisation zones began to expand as centres of trade and commerce.* As has been seen, the progress of early mining increasingly concentrated attention on the sale and exchange of goods: viz the sale of ore to smelters; the purchase of fuel and food; the collection and marketing of finished metal to distant consumers. These functions, together with the merchants who increasingly came to finance the industry from the mid-seventeenth century, were centred on local towns and regional distribution points, and they prospered and grew accordingly.³⁰ Thus the stannary towns of Devon and Cornwall were among the most prosperous in the south west while in the Derbyshire Peak, towns like Wirksworth, Matlock, Ashover and Eyam emerged as important smelting and trading centres from the early sixteenth century.³¹ From Chewton in the Somerset Mendips to Grassington in North Yorkshire, the towns of the lead districts expanded along with the mining industry.³²

The effect, however, was not confined only to the mining districts alone. Many of the merchants who controlled the metal trades based themselves in larger neighbouring centres, astride the main distribution routes. The rapidly expanding lead output of Derbyshire in the seventeenth century, for example, was distributed to national and international markets via the rivers Don and Trent. Towns along the various routes from the Peak, such as Sheffield,

²⁹ Brassley, 'Northumberland and Durham', p.58.

³⁰ For the expansion of merchant finance in the industry, see Whetter, *Cornwall*, pp.67-71, Blanchard, *Age of Silver*, p.46 and Kiernan, *Derbyshire*, Ch.6.

³¹ The medieval and early-modern stannary coinage towns, where all tin output was recorded and duties paid, were (Cornwall) Lostwithiel, Bodmin, Helston, Truro, Liskeard and (Devon) Tavistock, Chagford, Ashburton and Plymouth. See G.R. Lewis, *The Stannaries*. (Truro, 1965 reprint), p.45. For Derbyshire towns, see Kiernan, *Derbyshire*, p.55.

³² See J.W. Gough, *Mines of Mendip*, (Newton Abbot, 1967 reprint) and M.C. Gill, *The Grassington Mines*, (British Mining No. 46, Keighley, 1993).

Chesterfield, Derby, Bawtry, Stockwill and Hull, all saw a major increase in a range of handling and manufacturing activities and increased their size and wealth.³³ To the north, York, Stockton and Newcastle became centres of the lead trade, while in Wales, Aberystwyth became the focal point for the mines of Cardiganshire and Montgomeryshire and Chester emerged as the seat of the merchants controlling the output of Flintshire and Derbyshire.³⁴ In terms of the proto-industrial model, there is no doubt that the commercial and managerial skills developed by the merchants living and working from these towns, together with the accumulation of wealth from the profits of the lead trade, created the entrepreneurial, organisational and financial basis for future transformation of the industry to large-scale, capital intensive organisation.³⁵

III -When we come to the *dynamic* aspects of the proto-industrial model, the ease of its application to mining becomes more difficult. The problem, however, is not an insoluble one and with some fine-tuning to take account of the particular circumstances of mining, it appears even more convincing than for most other industries.

In the traditional model: (1) The success and growth of proto-industry will begin to encounter diminishing returns as wage rates are increased to encourage more labour into production and the dispersal of production creates difficulties in the organisation and collection of output. With a declining range of profitable opportunities for investment, proto-industrial merchants will be encouraged to collect production together and to pursue new technologies to reduce costs and improve productivity. (2) The higher family incomes created by proto-industry, and the increase in the population consequent upon them, will be reduced by many of the new, essentially labour-saving, technologies that were

³³ Kiernan, *Derbyshire*, p.55.

³⁴ See Raistrick and Jennings, *North Pennines* p.267 and Lewis, *Wales*, p.29.

³⁵ J.W. Gough, *The Rise of the Entrepreneur*, (1969) Ch. 6 and 7; Burt, *Lead Mining*, pp.58-63 and L. Willies, 'The Baker Family and Wyatt Lead Mining Business, 1730-1875' *Bulletin of the Peak District Mines Historical Society* Vol. 18 (Winter 1983), pp.331-68 and 'Prosperity and Decline in Derbyshire Lead Mining', *BPDMHS*, Vol. 9 (Summer 1986), pp.251-82.

introduced in the processes of production, and wages and living standards will be driven down. (3) As a result of the earlier success of proto-industry, merchants will have acquired the capital to finance the new large-scale industry. (4) They will have developed the managerial and entrepreneurial skills (e.g. financial control, large-scale marketing, labour organisation) successfully to run them. (5) Because of the earlier contiguous development of regions of proto-industry and commercial agriculture, the basic infrastructure for the supply of food to a more fully proletarianised labour force is already in place.

It is easy to identify (3), (4) and (5) as important aspects of the evolution of modern large-scale mining. Much of the evidence has been presented already. It is more difficult to analyse (2) the effect of proto-mining on demographic structures. This is because of large "colonising" inflows of migrants to often remote mining districts during periods of rapid development. However, Hammersley's estimates of the changing costs of mining during the eighteenth century suggest that wages and standards of mining may have been suppressed by rising populations and evidence of immiseration is there for those who wish to find it.³⁶ The demonstration of (1) - diminishing returns to proto-industrial merchants from rising wages and the dispersal of production - has to be cast in the special circumstances relating to mining. It is clear that there was no significant increase in miners' incomes immediately prior to the period of transition to large-scale capitalist organisation but there was undoubtedly the threat of a major escalation in total labour costs. All of the major British metal mining districts were beginning to encounter a "drainage crisis".

From the early seventeenth century traditionally widely dispersed, small-scale, shallow surface deposits were approaching exhaustion and exploitation of lodes at greater depths was essential if the industry was to survive. However, working lodes well below the water table, using primitive proto-industrial technology, would have required a massive increase in the numbers employed as

³⁶ G. Hammersley, 'The Effect of Technical Change in The British Copper Industry Between the Sixteenth and Eighteenth Centuries' *Journal of European Economic History* Vol. 20, No. 1 (Spring 1991), pp.155-73.

additional workers were recruited to bail or hand-pump the mines. The limits of human muscle power for operating simple water drawing hand windlasses is reached at about 15 metres depth and unless very large numbers of workers were to be employed in working multiple lifts, the introduction of improved mechanical devices was essential.³⁷ Everyone connected with the industry increasingly came to accept that there would have to be a re-organisation of production to assemble the capital necessary for full scale mechanisation. This meant the introduction not only of the water-powered pumping technology that had long been in use in the deep precious metal mines of Central Europe,³⁸ but also the exploitation of new techniques that were becoming available during the period, such as gunpowder blasting for driving long, deep drainage adits and, slightly later, the atmospheric pumping engine. The smelters, metal merchants, mineral owners, farmers and other men of capital in the mining districts were encouraged to invest in the industry, and effectively to substitute capital for labour, by the buoyant demand and high prices for lead and copper during the period. The miners were left with little alternative than to seek regular employment in the new enterprises.³⁹

It is important to note, however, that the nature of the labour contract that evolved in the larger-scale enterprises, and which remained a feature of the industry through to the mid-nineteenth century, strongly reflected the independent origins of the speculating free miner, binding together the family unit - men below ground; women and children on the surface dressing floors - in the

³⁷ See P. Braunstein, 'Innovation in Mining and Metal Production in Europe in the Late Middle Ages' *Journal of European Economic History* Vol. 12, No.3 (Winter 1983), pp.573-591. Braunstein shows how the unwatering of the Falkenstein mine in the Tyrol *before mechanisation*, required 600 men in a continuous human chain working four hour shifts night and day. Mechanised pumping was substitute by a once-and- for all investment equal to the recurrent annual wage bill of these men.

³⁸ See Hammersley 'Technical Change', pp.168-71. Molenda has shown how innovative activity in mine engineering was concentrated on devices for the vertical haulage and removal of water between the fourteenth and seventeenth centuries. This was seen as the greatest single obstacle to continuous deep-mining operations. 'Technical Innovation', p.66.

³⁹ See Raistrick and Jennings, *Pennines*, pp.296-7; Lewis, *Wales*, p.265; Blanchard, *Age of Silver*, pp.36-7, 45-8. Tin production was also favoured by expanding demand from the early eighteenth century. See Jenkins, *Cornish Miner*; p.128.

calculation of total earnings.⁴⁰ There can be few other industries where the original proto-industrial family economic unit survived so well in the transition to proletarianisation. The general point, however, is that in the metal mining sector, just as in many other industries, the threat of escalating labour costs was a major factor in propelling its development from small- to large-scale organisation.

While the development of the metal-mining industry in the pre-industrial period can clearly be accommodated within the proto-industrial model, this discussion of the forces shaping its development raises issues that go far beyond that model alone. It can be argued that the institutional structure of the mining industry, is a direct function of the depth, value and physical difficulties of working proven ores and the technology available for their exploitation.⁴¹ The progression from proto- to large-scale organisation is just one point or stage in a much larger developmental sequence that can be identified in most mining districts at different times from the ancient world to the twentieth century. Indeed, mining districts world wide appear to have seen a clearly structured "stages of growth" process shared by very few other industries.

IV - The sequential evolution of mining districts may be illustrated by reference to European experience in the later medieval and early modern period. Initially, the discovery of stream-washed "placer" deposits or surface outcropping ores, often in remote areas, lead to an influx of independent miners, who worked alongside the indigenous population in exploiting the deposits with simple, labour-intensive technology. In most European mining districts, this first stage of development was well established before the Roman period but similar movements can still be identified *within* established mining districts, as new lodes

⁴⁰ See R. Burt (ed.), *Cornwall's Mines and Miners*, (Truro 1972) and L.L.F.R. Price, 'West Barbary; or Notes on the System of Work and Wages in the Cornish Mines' in R. Burt (ed.) *Cornish Mining: Essays on Cornish Mines and the Cornish Mining Economy* (Truro 1969), pp.121-206.

⁴¹ This argument has been developed for a later period by C.J. Schmitz, 'The Rise of Big Business in the World Copper Industry, 1870-1930' *Economic History Review*, XXXIX, (August 1986), pp.392-410.

were discovered, well into the middle ages and later.⁴² For the individual miner, life was little different in principle from that experienced two thousand years later by the Klondike 'stampeder' or the Amazon 'garimpeiros' - they would certainly have recognised each other's daily problems.⁴³ Where the deposits contained precious metals and the prospect of rich rewards, the activity was intensive and mono-occupational, with essential food and raw materials being 'bought in', whatever the difficulties. The ores were pursued quickly to the water table and where they appeared to continue at depth, entrepreneurs came forward, usually in the form of the government or their agents, to organise the miners into a paid workforce and invest in the best available technology. For such operations, medieval Europe produced the first multinational corporations and consultancies, stretched the limits of available technology, and created a structure for the international transfer of best practice unparalleled by any other major industry. Herein lies the explanation of the historians long-established view of the 'bigness' of mining enterprise.

Where only base ores were found, however, it was more difficult to make a living from their exploitation alone and the miners needed additional means of subsistence. Mining was accordingly less intensive and, until metal prices and transportation improved, essentially a part-time activity. There was less opportunity for external entrepreneurial activity and investment, the technology remained crude and labour intensive, and the exhaustion of shallow deposits slower to be achieved. This large part of the overall European mining industry was ignored by the contemporary practitioners of advanced "big mining" and left few traces for historians to uncover.

At the beginning of the sixteenth century, both the proto-industrial and large-scale forms of mining existed side-by-side. In central Europe, Sweden and even parts of south-west England, large, deep integrated operations of the type alluded to by Cipolla

⁴² See R. Slack, *Lands and Lead Miners: A History of Brassington in Derbyshire*, (Chesterfield, 1991).

⁴³ See Jenkin, *Cornish Miner*, D. Wharton, *The Alaska Gold Rush*, (Bloomington, 1972); D. Cleary, *Anatomy of the Amazon Gold Rush*, (Oxford, 1990).

were common.⁴⁴ Meanwhile, non-auriferous and non-argentiferous deposits commonly remained in the hands of independent free farmer-miners, supported in their small and shallow workings by an as yet small group of wage-dependent workers. Clearly there were important exceptions in both sectors of the industry but they serve only to prove the general rule. At this point, however, the influx of precious metals from South America seriously undermined European prices. The profits and output of the larger mines slumped. With a consequent reduction in their base metal output, this created the opportunity for a rapid expansion of the British proto-mining industries and in the late sixteenth and early seventeenth centuries lead output increased rapidly. There were also attempts to establish copper mining in England, which after a series of false starts finally took off from the third quarter of the seventeenth century.⁴⁵ The result of this increased level of activity, after centuries of earlier working, was that by the mid-seventeenth century, the proto-miners in the great centres of production, such as Cornwall, the Somerset Mendips and the Derbyshire Peak, were in crisis as their shallow ores approached exhaustion. In some areas, such as the Mendips, where the ores did not continue at depth, this signalled the end of the industry as a major producer, and gradual "de-industrialisation" set in.⁴⁶ In others, the only way forward was to adopt the same forms of large-scale organisation pioneered centuries earlier by the precious metal producers.⁴⁷

Although the process of transition was a rapid one - with most British production of tin, lead, and eventually copper, firmly in the hands of capitalist entrepreneurs and large companies by the mid-eighteenth century - it was far from a straight-forward and simple one. Firstly, the entrepreneurial initiative had to come from the private

⁴⁴ See above p. and J.U. Nef, 'Mining and Metallurgy in Medieval Civilisation' in M. Postan and E.E. Rich (eds) *The Cambridge Economic History of Europe*, Vol. II, (Cambridge, 1952), pp.429-492.

⁴⁵ See G. Hammersley, 'Technique or Economy? The Rise and Decline of the Early English Copper Industry' *Business History*, Vol. XV Pt. 1 (1973) pp.1-27 and J. Day 'Copper, Zinc and Brass Production' in J. Day and R.F. Tylecote (eds.), *The Industrial Revolution in Metals* (London 1991), pp.131-99.

⁴⁶ See Gough, *Mendip*, Ch. VI.

⁴⁷ The process of transition in Derbyshire is discussed in I. Blanchard, *Age of Silver*, Ch. 2.

rather than the public sector. The state treasury, which had long been interested in securing a domestic supply of precious metals, had little similar interest in base metals and the government put no great effort into fostering the industry. It happens that in Britain, the success of proto-mining had created a merchant class anxious and able to undertake that role. But in other countries, such groups often had not emerged and mining fell into decline at this stage until foreign entrepreneurs (frequently British) arrived on the scene, perhaps centuries later⁴⁸

Secondly, the exploitation of base-metal ores at depth was a costly process. It could be conducted profitably only if there was a major increase in metal prices, or working costs were reduced by new more efficient mining machinery and methods. An increase in prices could be achieved only if production was restricted and this might well have resulted in offsetting decline in demand. It was not a practical prospect for late seventeenth-century mining entrepreneurs. New, cheaper methods of drainage and rock breaking had to be found if lead mines were to go as deep as silver mines. Fortunately, this new technology was at hand, conjured as much by the needs of the hour as fortuitous coincidence. Thomas Newcomen, the Devon hardware supplier, developed his early atmospheric engine to meet the increased pumping requirements of neighbouring mines; Derbyshire miners eagerly adopted gunpowder blasting techniques for driving long-drainage tunnels; Smeaton and others improved the efficiency of large water-wheels to power deeper pumps; improved smelting furnaces and techniques reduced final ore processing charges.⁴⁹ It was an entirely new order of technology that was not substitutable by increased man-power alone. It was the nexus of a true industrial revolution in mining that was fundamentally different from what had gone before. It did not simply enable the base-metal

⁴⁸ See for example, S.G. Checkland, *The Mines of Tharsis*, (London, 1967); R.W. Randall, *Real del Monte: A British Mining Venture in Mexico*, (Texas 1972); M.C. Eakin, *British Enterprise in Brazil*, (Durham, 1989); C. Harvey and P. Taylor, 'Mineral Wealth and Economic Development: Foreign Direct Investment in Spain, 1851-1913' *Economic History Review*, XL (May, 1987), pp.185-207.

⁴⁹ See R. Burt, *A Short History of British Metal Mining Technology in the Eighteenth and Nineteenth Centuries*, (Lelielaan 1982) and 'The transformation of the non-ferrous metals industries in the seventeenth and eighteenth centuries' *Economic History Review* Feb 1995.

sector to catch up with the precious metal mines, but helped to transform methods and organisational structures in that sector as well. In the most highly-capitalised mining districts, such as Cornwall, backward and forward linkages with advanced engineering supply and processing industries created the 'critical mass' seen by Pollard as necessary for sustained growth and the emergence of the region as a leading industrial centre.⁵⁰

Once started, technological change continued rapidly, affecting all aspects of mining and ore processing. It meant that there was no once-and-for-all organisational transition for mining – from small-scale, proto-industrial forms to large-scale capitalist enterprise – but a continuous increase in depths and scale of operations. The big enterprises of the mid-eighteenth century were dwarfed by those of the mid-nineteenth century and they in their turn were amalgamated into larger and larger productive units until they reached the vast tonnages and financial complexities of today's great multinational operations. It must be stressed, however, that this was not one continuous process affecting all mining areas globally at the same time. As has already been shown, each mining district went through its own stages of evolution independently. Some, such as the gold-rush areas of western American and Australia were still firmly in the initial, labour-intensive stage when most European mining fields were well on the way to new universal large-scale capitalist organisation.

V -The purpose of this article has been two-fold. Firstly to suggest that not all mining was "big mining" before the industrial revolution and that large sections of the industry can be included conceptually within the proto-industrial part-time, regional rural industrial model. This argument has been pursued not to elaborate further on the model itself but to draw attention to the multifaceted structure of the early-modern mining industry and to engender interest in some important but much neglected areas. It has been

⁵⁰ See S. Pollard, *Peaceful Conquest: The Industrialisation of Europe 1760-1970*, (Oxford, 1981), p.106 and P. Hudson, ed. *Regions and Industries*, (Cambridge, 1989), pp.28-30 and C.J. Schmitz, 'Capital Formation and Technological Change in South West England Metal Mining in the Nineteenth Century' in W.E. Minchinton (ed.), *Capital Formation in South West England*, (Exeter, 1978), pp.25-54.

based heavily on British experience largely because no one has yet written much about small-scale mining in Continental Europe - but hopefully it will promote such research. Secondly, it has indicated that while the "stages of growth" view of industrial development now receives little support in terms of manufacturing, it certainly still has an attraction for mining historians. Probably there is no industry where the proto-industrial progression to large-scale capitalistic organisation can be shown with greater clarity, and with greater predictability than metal mining. At the end of the day, however, it will have served a useful purpose if the student of early-modern economic history remembers that Snow White's "Seven Dwarfs", raising their own food and operating their own independent shallow mine in the middle of the forest, are as representative of one important part of the European mining industry as Carlo Cipolla's giant Polish lead mine was of another.