DEL 5

Avslutning

11. The Global Context of the Scandinavian Copper Industry

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Introduction

This chapter deals with the broad global context within which the copper communities of Falun in Sweden and Røros in Norway operated. Falun and Røros were the most important centres of copper production in Scandinavia from the 14th to the 20th centuries. These communities can reasonably be described as remote, because they lie at considerable distances from not only the main cities in which their products were traded, such as Hamburg and Amsterdam, but even from their own capitals. Remoteness is not simply a matter of distance – Falun and Røros lie in areas where communications are difficult and weather conditions are harsh. Even so, they were linked to the dynamics of the wider copper industry and its products, both in Europe and globally. Copper was a key product not only of the early modern economy, but also of the Atlantic slave-sugar-cotton economies that were central to European industrialisation. The main point made in this chapter is that Scandinavian copper regions should be seen as integrated into these global patterns of trade and development: Falun and Røros should not be seen as peripheral regions, but rather as components of an evolving international system. What follows explores some main dimensions of this global environment, not only in terms of

links with Falun and Røros, but also in terms of its implications for our understanding of industrialisation.

Five key elements formed the global context of local developments in Scandinavia. These were, first, sustained growth of demand, and the expansion of copper output from the 14th to the 19th centuries from a range of sites in central Europe, Japan, the Urals and Yunnan in China; Falun and Røros were the main Scandinavian participants in this expansion. This growth happened on the basis of extensive networks in production, trade and finance. Second, there was an important technological transition in smelting in Britain, using coal as a fuel in reverberatory furnaces, beginning in the early 1700s and making major capacity expansion possible. Third, there was the growth of the Atlantic slave economy from the 16th century, based on exchange of manufactures, including copper products (high quality bars/rods and artefacts that were quasi-money), for slaves, and the extensive use of copper in process equipment in the plantation production of sugar. Central to the growth of the Atlantic economy, as well as Britain's rise to naval dominance, was the innovation of copper sheathing for ships. Fourth, there was a major transition in the 19th century in which smelting was separated from ore production sites, and Swansea in Wales became the major world smelting centre, with ores from Australia, Latin America and Africa coming into Wales as globally traded commodities (Evans & Saunders, 2015). Finally, there was substantial growth in manufacture of copper products, especially in London, but also distributed throughout Europe and elsewhere. A further major transition is not discussed here, but much later copper proved central to electricity, the most important radical innovation of the late 19th century. Copper's conductivity and ductility made it a core product in the electrical and telecommunications revolution.

Scandinavia copper production fitted, then, into a very dynamic complex of production and use of copper that has been a neglected element in global industrialisation. But there is more than that. When the copper complex is considered as a whole it provokes large questions about the roles of innovation and technology in modern economic transformations. There is a conventional wisdom, occasionally challenged but still dominant, that sees the transition to industrial modernity in terms of a

small number of so-called «critical technologies», such as steam power and textiles, developing in a leading economy or economies (notably the UK). In this approach, industrialisation begins in the 18th century with «critical technology» breakthroughs in a national context, and then spreads as key activities diffuse to follower and peripheral economies. We suggest that the timing, geographic dispersion and global-local interactions in copper more or less completely subvert such popular industrial revolution narratives.

The evidence from copper suggests that we need to rethink the technological transitions involved in modern economic growth. Narratives on industrialisation in economic history have over a long period been technologically too narrow and both geographically and temporally too constricted. We do not suggest that economic history needs to incorporate a new critical technology in the shape of copper. Rather we argue that the whole critical technologies approach is fundamentally flawed, conceptually and empirically. It should be replaced by a multi-technology, multi-sectoral, multi-regional understanding of change that is industrially complex and heterogeneous, geographically highly dispersed but economically integrated, and temporally long. From this perspective, products like copper, and regions like Falun and Røros are not peripheral but are integral components of a world technological system.

Basic elements in the economic history of copper

Specifically, the history of copper suggests that the following must be recognised within any history of industrial change:

1. Copper innovation begins in prehistory, and copper industrialisation began far earlier than allowed for in mainstream accounts of industrial transformations. Copper regions existed in Europe from the 14th century, expanded from the 16th century, and grew rapidly from the early 18th century. This growth included Scandinavia.
2. Copper industrialisation was a geographically widely dispersed process, but was globally integrated via trade, migration and knowledge flows. In fact it was global from very early, with trade and user networks across long distances.

3. Copper industrialisation was not simply dispersed but globally *interactive* with labour mobility and knowledge flows shaping such important regional manufacturing sites as London.
4. On a much larger scale there are links between copper products and the growth of important industries, in particular the Caribbean slave-sugar economies and the Atlantic economy more generally. Local producers in Scandinavia and eastern Europe were thus integrated into global dynamics.
5. Copper industrialisation was key to other industries and other fields of radical innovation in the second phase of industrialisation in the late 19th century.
6. Copper industrialisation (in both production and use) involved important issues of scale, and was closely linked to major changes in corporate organisation and control.

Copper through time

The first important point about copper is that it is (quite literally) an ancient technology: it undercuts any view that global industrialisation required radical technological breakthroughs into completely new technologies: «The technology of copper, the earliest useful metal, is far more important than that of gold or silver. All the important stages of metallurgy before the discovery of iron are outlined in its history.» (Forbes, 1954, p. 585). Copper artefacts dating to 8000 BCE have been found in Mesopotamia. The mummified body of the so-called iceman, Ötzi, found in the Austrian Alps and dated to approximately 3400 BCE was notable for the range of tools and equipment being carried: these included a copper-headed axe, made of almost pure copper. Ötzi's hair contained traces of arsenic, a by-product of copper smelting. At that time copper was already a well-established technology – Barry Cunliffe has shown that it was mined on a fairly large scale at Aibunar in North-West Bulgaria as early as 5100 BCE and was traded through complex exchange networks as far as Ukraine. At roughly the same time copper was being extracted in Spain, at Almeria, and by about 3000 BCE copper was being produced in the Cyclades (on the island of Kythnos). At about this time Cypriot copper was traded in

ingots as far as Sardinia. Cypriot copper remained extensively traded for at least four millennia and was central to bronze production in the Roman Empire. By 2400 BCE copper was produced in Ireland, manufactured as axe heads and tools, and traded across Britain. Bronze, an alloy of copper and tin, was produced in the Balkans by 3400 BCE, and widely traded (in part because copper ores and tin ores were rarely found in close proximity) (Cunliffe, 2008, pp. 154–155; 202–204).

Copper and bronze products were stable over quite long periods: these included weapons, especially armour and bladed weapons, but also (much later) firearms such as small cannons; jewellery and personal ornaments; household utensils; tools; and coins (from about 600 BCE). The technological history of copper extraction and processing through this long period is largely a story of incremental innovation. But from the 17th century onwards, major changes occurred, with movement towards much greater scale and capital intensity. In scale and organisation, copper became the focus of genuinely radical change.

The timing and geography of European copper industrialisation

From the medieval period and into the 16th century there were at least four significant copper production sites extending from western to eastern Europe (Tyrol, Mansfeld, Slovakia and Aix-la-Chapelle) producing around 4500 tons of copper per annum (Weber, 2018). Much of the capital for this came from the early finance house of Fugger, one of the most significant financial enterprises in early modern Europe. Fugger became famous (and still exists today) as a financial enterprise, but originated in the textiles and metals trades, beginning in the early 14th century. Fugger trading and finance operations had offices across Europe from the early 16th century. They supplied large quantities of copper to Portugal, from where it entered the West African slave and spice trades.[1] Several wrecks have been found in the North Sea and off Namibia with copper sheets and ingots

1 Retrieved 8 October 2020 from http://www.thehistoryblog.com/archives/54776 and http://news.bbc.co.uk/2/hi/africa/7634479.stm

bearing the Fugger insignia. «In a single contract the Fugger signed with the Portuguese crown in 1548, they agreed to purvey c. 30,000 brass pans and bowls and 7,500 hundredweights of brass bangles, all explicitly meant for the Guinea trade» (Weber, 2018, p. 2). Elsewhere, Venice was trading copper from central Europe and working it into products that were traded with the Levant from early times, but this accelerated strongly from the 14th century with the development of bronze cannon (Goody, 2012, p. 110).

Central and Eastern European deposits went into decline in the 16th century but were replaced by immense deposits in Sweden – at the Stora Kopparberg site in Falun – which became the largest producer in Europe. Falun later declined also, set in train by a big cave-in in 1687, but the Scandinavian copper industry was supplemented by production from Røros in Norway from the late 17th century. This was of course not a new development, but a continuation and development of growth trends that has been in existence in the 15th and 16th centuries. Copper and its alloys were also produced in Lapland, along the Torne River valley by the Reenstierna brothers, entrepreneur-migrants from Germany (Nordin, 2020, p. 110). What was happening in copper in this early period was connected to growth in markets via Hamburg and Amsterdam, a development, we can note, that undercuts the diffusionist interpretation of Britain-Europe relations in industrialisation. A key point from Scandinavian copper research has been the incredibly intricate relationships of production, trade and finance across western and central Europe. Røros, Falun, Lapland and other European sites were part of an integrated process of European development in which Britain was a component but not necessarily a leader. As Hutchison has shown (see chapter 6), much of the Røros gahr copper (semi processed copper slabs) shipped to Amsterdam was sent on to Stolberg in south-west Germany, some of which returned to Amsterdam, and even to Norway, in different (reworked) forms. Ranestad (2017) shows that Norwegian gahr copper was traded via Copenhagen into global markets, through networks of producers, merchants, coppersmiths and copper industrialists. Olofsson has shown in chapter 7 that Sweden, Europe's largest copper supplier, exported copper to more than sixty European destinations. Similarly, Weber showed that throughout the 18th century Hamburg traded copper on a large scale, copper being Hamburg's second-largest export item

(after linen). Between Hamburg and the Baltic, in the small Duchy of Stormarn, there were at least thirty copper mills, using ore and gahr that was traded over long distances. There were no copper deposits in the region. This evidence suggests that all dimensions of the copper industry were active across Europe, with complex networks of labour, trade, product development and finance in existence from the 16th century, but coming into prominence for the 18th. Labour mobility was important in this, with Dutch and German immigrants playing significant roles in technical and organizational innovation (see Berg, 1998; Sprauten, 2008; Bull, 2002). The specific influence of Germany on early mining laws, organization, and technology is discussed in chapter 2, «Statlige reformer ved Røros kobberverk: arbeidere, formenn, partisipanter og stat» by Ranestad and Olofsson and chapter 3 «Bergmesteren i det nordafjelske Norge 1656–1699» by Anne Signe Enget.

There are issues around the extent to which these changes were sponsored by Cameralist and Mercantilist policies, but it is certainly the case that emerging princely states were central to the new production sites, and copper revenues buttressed the new distribution of state power, feeding into the growth of fiscal-military states (O'Brien, 2011).

The big transition: «Copperopolis» and the emergence of global production chains

Perhaps the most important organisational and technological revolution of modernity in copper emerged from around 1720 at Swansea in South Wales (Evans and Saunders 2015, on which this section draws). Swansea had a number of locational advantages for copper smelting, notably a good port and proximity to high-quality coal. But Louise Miskell has shown that these advantages were at best necessary conditions. What was perhaps more important was an extended learning process through which Swansea firms focused on quality improvements and connections with markets (Miskell, 2017).

Copper innovation in Swansea had two primary dimensions. On the one hand there was a decisive break with the historical system in which smelting and refining occurred in close proximity to ores, because ores

were so cumbersome to transport. Swansea entrepreneurs exploited new shipping possibilities, and Swansea's port, to import ores from all over the world. Using South Wales coal, they reversed the copper process that had existed since the ancient world: instead of bringing fuel to the ore, they brought the ore to the fuel. Ore was shipped from Southern Africa, from the Maghreb, from Central and South America, from Spain, from Australia and New Zealand, from the US and from Newfoundland. Evans and Saunders rightly point out that this must modify global history perspectives that focus mainly on Asia – «…it was properly global; that is to say, it embraced every continent» (2015, p. 4).

The second dimension of Swansea's development was a new technological basis, namely coal-fired smelting in reverberatory furnaces, a technique which was in use in South Wales by the late 17th century, with location being determined by the relative costs of shipping ores and coal. Production expanded steadily from the 1750s and grew dramatically later in the century – output increased 75% between 1775 and 1783. There were 310 reverberatory furnaces in Swansea by 1780 (Evans, 2017, p. 2). Hammersley points out that from the early 17th century there had in fact been a range of innovations in copper production, such as underground railways, and new modes of water power, driving bellows and hammers. These points should lead us both to rethink the role of copper in early industrial technological change, but also its timing, with copper expansion occurring well before the British industrial revolution as conventionally understood. But there was also a dramatic change in the scale of operations, involving new capital-intensive production methods, and therefore large-scale capital mobilisation. Such developments in Swansea did not diffuse (for example, to Scandinavia) but gave rise to further innovations later in the 19th century (such as the increases in scale and new furnace techniques in the US).

Global copper and the slave/sugar Atlantic economy

Copper was a globally-trade product. Portuguese traders sold ingots of central European copper in India in the 16th century. Japanese copper was traded in Amsterdam in the 17th century, «inaugurating a genuinely global market» (Rydén, 2017).

But the most consequential international development was the growth of the Atlantic slave-based economy. Klaus Weber argues that while the development of the Atlantic economy has mainly been studied in terms of the maritime colonial powers, it is necessary also to consider the key role of the «European hinterlands» as both suppliers of traded goods (especially textiles and copper goods), and as markets for colonial products. The small, distant, sometimes remote areas produced copper and copper or bronze products that fed directly into the growing slave trade, especially to the Caribbean. Swedish copper was used extensively in more than 100 slave voyages of the Dutch Middelburgse Commercie Compagnie – this was Swedish copper, from Falun, obtained via a Rotterdam merchant, who also processed it (de Kok, 2017).

The African slave trade to Latin America, the Caribbean and the United States began in the early 15th century and continued until 1866. There were in total roughly 54,000 slave voyages, and about eleven million enslaved people were transported. Of these, roughly five million were employed in sugar plantations (Thomas, 1997, pp. 805–806). This new slave/sugar economy of the Caribbean was closely linked to, even dependent upon, copper production and copper products of increasingly high specification.

In the first place, copper artefacts were used in the trading of slaves directly, in the sense that slaves were actually exchanged for copper or copper-based products. Copper «rods», which were lengths of copper bar, acted as a currency in the purchase of slaves, and in addition there were weapons, utensils, jewellery and adornments. «Manillas», copper bracelets of specified weight and purity, made in Scandinavia among other places, were used as currency in slave trading (Nordin, 2020, p. 111). Slaves were bought not with trinkets, but with high-quality copper products. Evans and Rydén make a very important point here:

> The merest glance at the invoice of a slave ship – the detailed listing of the articles that were to be bartered for captives on the Guinea coast – puts paid to the notion that European traders were able to obtain slaves by offering a few trashy gewgaws to their African counterparts. The typical invoice, which extended over many pages, itemised an enormous variety of goods, few of them cheap. Indeed, slave merchants in European ports took great pains to source goods that would command a high price on the African coast. They knew that African consumers

> were discerning; only articles that matched African tastes and met local quality standards would find a market. Europeans also knew that African demand was dynamic (Evans & Rydén, 2015, p. 1).

Equally important were two key new products that transformed slave shipping and then sugar production itself. The first was copper sheathing for ships, which prevented hull fouling and rot. Ships at that time were highly vulnerable to wood-boring molluscs, especially in the tropics, which if not expensively and frequently treated could significantly reduce the life of a ship. The solution was sheathing the hulls with thin plates of copper that were fixed with copper nails and bolts. This was a major technical accomplishment, which took time to master. But by the late 18th century, Evans has estimated, «it may be that the naval market accounted for as much as a third of the copper produced in Britain at that time» (Evans, 2017, p. 11). This innovation led to a significant expansion of rolling mills around London. The new technology was of course vitally important not only to slave ships operating along the West African coast and in the Caribbean, but also the British navy. For the Royal Navy, copper sheathing, for the first time, made extended global operations possible.

The second development was increasingly large-scale copper equipment such as boilers, pipes and vessels for sugar refining. In the slave economies of the Caribbean it was copper boilers and clarifiers that drove the production process; copper-based techniques were critical to the slave-based economies of the Caribbean. Sugar processing was based on heating in copper boilers, as well as the use of other copper processing equipment: the sugar-slave economy was copper-intensive (Zahedieh, 2010).

These products were produced all over Europe. But they transformed London in particular into a major site of copper manufacture in the 18th century. This has important global dimensions:

> The mills on London's periphery were the gateway through which advanced processing techniques entered Britain. Temple Mills in Buckinghamshire was famed for its Dutch workforce. And when the Swede Kalmeter visited Ember Mills in Surrey at the start of the 1720s he found the senior workman to be a German called Matthias Thiller (Evans, 2017, pp. 13–14).

The role of London in British industrialisation is often neglected, but it was a very large production centre for a wide range of products. Among these, metal foundries and copper products were central to this (Barnett, 1998, pp. 74–79).

Global history is the most important recent development in historical interpretation, and is transforming economic historiography. However, much global history is written around large countries and regions, and this is something that will need revision. Copper production was genuinely global, being integrated into complex transnational networks with cross-border networks of production and distribution. But it often involved small and remote regions. Ranestad, Rydén and Martens (2019) have shown that the links between Scandinavia traders and the Caribbean slave economy extended globally, since Danish merchants were trading Indian textiles, Northern European metal goods, and silver for slaves. They did this via trading networks and financial systems that were so complex that they defy, at least for the moment, a full analysis. Klaus Weber (2017) has extended this into showing the complexity of the trading patters across Northern Europe especially. Bronze cannons were distributed globally. So, this process of early integrated European development was connected to much wider developments, involving copper as a key component. This gives some important perspectives on the meaning of the global in global history.

The creation of industrial enterprises

In early industrialisation, the enterprise was not pre-existing in terms of organisational forms, internal control, accounting methods etc. Industrial enterprises had to be created and built, and this involved quite long processes of learning, struggle and conflict. In *The Genesis of Modern Management*, Sidney Pollard (1965) argued that early industrial enterprises had serious problems of management, and that the evolution of control and calculation were slow. A big problem was simply assembling and managing the workforce. There are at least three critical dimensions to the enterprise creation process: building management structures (i.e., executive capabilities, accounting techniques, etc.), securing workforce

control and managing the flow of inputs. Historically, all this took a long time. Some parts of the copper industry were among the first large-scale enterprises, both in the mining of copper, its transport, smelting processes, and the use of copper in complex technologies in sea transport. The refining of sugar was a very early example of large-scale production and gave rise to companies and managements that were global in their production, and fully national in terms of product distribution networks (Bruland, 2004). Evans and Saunders (2015) show the exceptional efforts required by Swansea firms in overall corporate control throughout the production chain, with British investors heavily involved in financing and running ore producers in South America and Cuba. Similar direct management was undertaken in South Australia, and this included the assembly of a labour force from Britain. In the Scandinavian copper industry the resolution of management problems and labour conflicts frequently depended on active state involvement (Ranestad, 2020). As we noted earlier, the capital intensity of early modern copper production led to the involvement of such key financiers as the Fugger (Weber, 2018).

The copper sector and the historiography of industrialisation

Evans has remarked rightly that the copper transition «is as dramatic a story as the Industrial Revolution has to tell» (Evan, 2017, p. 3). Some years ago, Roger Burt (1991) argued that there was a «well-established» view that «the emergence of large-scale technologically sophisticated industry in Britain took an important step forward from the late sixteenth century in a few areas». He went on to argue that this could not be seen as an early industrial revolution, but then points out that in fact the developments in metals, glass mining, shipbuilding etc. all required centralised enterprises with financial requirements that transcended the capabilities of small producers (Burt, 1991).

The implications of copper development, as well as the other industries mentioned by Burt, need to be revisited. Our view is that we should not seek to replace a traditional view of British industrialisation (based on the allegedly critical technologies of steam and textiles and located in

the UK) with a different technological perspective and a wider geography. Industrialisation is a far more heterogeneous, diverse and complex process than standard accounts of the «industrial revolution» recognise. From such a perspective, copper throws light on an industrialisation process that is technologically innovative and significant, but also earlier, and far more geographically dispersed, than the later industrial revolution. The geographical complexity of copper seems to seriously disrupt any centre-periphery model of industrialisation, with its associated concepts of leaders and followers.

Can the kinds of reflections prompted by the copper industry and its technology, be prompted also by other products and their technologies of production and use? We would answer yes – if we drop the idea of exemplary technologies and industries, we can find industry after industry in which surprising changes occur over similar time periods, and on global scales. Many of these, like copper, involve the development, transport and processing of natural resources, and tertiary production or final consumption based on them. This in turn suggests that copper pushes us towards a different conception of transition, in which a slow but deep transformation of the global economy, based on sustained trade and investment interactions, and changing forms of governance, was reshaping many connected regions and polities, including Falun and Røros. If it was this global coevolution that was the impulse to the manifold technological changes of modernity, then we might have the basis for a far more satisfactory theory of industrial change.

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