

A Brief History of Minting Technology

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The Medieval Technology

The technology for making coins involves three main steps after melting and refining the metal: preparing sheets of metal, cutting the sheets into blanks, and striking the blanks. From Greek and Roman times to the Renaissance, the technology employed in each step did not change.¹ The metal, once brought to the desired standard, was hammered into a sheet, and then cut into squares with shears. The weight of each square was adjusted and it was then beaten into a round shape. The resulting blanks were then blanched to remove tarnish. Finally, the blanks were struck.

The striking process itself was simple: the lower die or pile, whose other end was shaped like a spike, was driven into a wooden block. The worker placed the block between his legs, placed a blank on the pile, placed the upper die or trussel on top of the blank and struck the top of the trussel several times with a hammer.

In medieval times, the dies were made locally by the mint's engraver. The engraver prepared a collection of punches, each bearing in relief one of the elements of the coin's design. He then used the punches to engrave the dies (iron rods whose tip was covered with a sheet of soft steel) with the design. He usually engraved two or more trussels for each pile, since the trussel wore out more quickly.

The technology was not very costly, although it did require highly specialized labor: hammering, cutting, blanching and striking were each performed by different laborers, usually members of a privileged (and hereditary) corporation. The tools were simple, the plant was of limited size (furnaces were the largest piece of equipment), and minting could be carried out in a decentralized fashion. But the drawbacks of this simple technology were numerous. Since dies were produced locally, albeit on patterns provided or specified

¹ This account is based on Blanchet and Dieudonné (1916), Wendel (1960), Cooper (1981).

by the central government, there could be considerable variation in the style and quality of the imprints on the coins. The production process itself resulted in imperfect coins of varying size and weight, with a poorly centered imprint. The coins were thus subject to falsification,² because any engraver could make a coin with his everyday tools, and to clipping, because the irregular shape made it difficult to tell if a coin had been altered. The quality of the stock of coins in circulation could thus be rather low.

Production Costs (14th-15th centuries)

An fairly natural consequence of the production process is that small coins are relatively more expensive to produce than larger ones, since the same effort is required to strike a coin of any size, and not much less to prepare smaller blanks than larger blanks. As a percentage of face value, the smaller denominations are thus more costly to produce.

1 presents data on production costs from a variety of Western European countries in the Middle Ages.³ All mints (except that of Florence) were contracted out to private entrepreneurs who were usually allowed different charges for different denominations.⁴

In England, after 1351, a flat rate was allowed the mint-master for all coins of the same metal, resulting in strong incentives to make only the largest coins. Occasionally, the proportions of the various coins were specified in the contract, but the king could not force a competitive bidder to assume such costs in any event, and in 14612 the choice of the mix of denominations in production was left to the discretion of the comptroller, a government official, who should consult “the desire ease and content of the People.” Production remained strongly biased toward large coins until a complete scale of differential payments across denominations was adopted in 1770.⁵

² There are two kinds of counterfeit: coins that are not full-bodied, for instance plated or hollowed-out or made of a sub-legal alloy; and coins that are essentially identical to legal coins, but not produced by an official mint. In the second case, the only loss is incurred by the sovereign who loses seigniorage; but measures designed to prevent the first kind of counterfeit are bound to help prevent the second kind.

³ Sprenger (1991, 83) gives similar figures for Germany, 2% for Guldens, 7% for Schillings and 15% for Hellers.

⁴ See Appendices 1 and 2 for French and English minting institutions. Spufford (1988) confirms that similar arrangements prevailed in the Low Countries and elsewhere. Only Florence and Venice managed their mints directly.

⁵ Craig (1953, 75), Mayhew (1992, 168).

	<i>name of coin</i>	<i>legal value</i>	<i>silver/gold content (mg)</i>	<i>brassage (%)</i>
Florence, 1347	picciolo	1d	52	15.65
	quattrino	4d	217	6.22
	grosso	32d	1960	1.20
	<i>fiorino</i>	744d	3537	0.14
England, 1349	farthing	0.25d	283	3.64
	halfpence	0.5d	570	2.96
	penny	1.0d	1178	1.94
	<i>noble</i>	80.0d	8188	0.42
Flanders, 1389	double mite	0.08d	53	43.71
	gros	1d	1018	9.73
	<i>noble</i>	72d	7649	1.58
France, 1402	denier	1d	145	10.67
	blanc	10d	1448	6.46
	<i>écu</i>	270d	3948	0.72
Low Countries, 1433	double mite	0.08d	45	36.34
	gros	1d	814	4.51
	<i>philippus</i>	48d	3598	0.94
Milan, 1447	denaro	1d	37	20.50
	sesino	6d	272	8.56
	grosso	24d	1175	2.25
France, 1460	denier	1d	109	12.50
	blanc	10d	1086	4.94
	gros	30d	3258	2.32
	<i>écu</i>	300d	3321	0.56
England, 1467	penny	1d	707	3.11
	groat	4d	2828	3.11
	<i>ryal</i>	120d	7643	0.55
Castile, 1471	blanca	0.5mr	39	24.39
	real	31.0mr	3195	1.49
	<i>enrique</i>	420.0mr	4553	0.50

Table 1: Production costs (brassage) of coinage in late Medieval Europe. Gold coins are in italics. Legal values are in local pence (deniers, denari) or maravedis (in Spain).

Sources: Milan: Cipolla (1990, 111–23). Florence: Bernacchi (3, 33–44). Castile: Pérez Garcia (1990, 115). France: Saulcy (1879–92, 2:117, 3:226). England: Challis (1992, 703, 713). Low Countries: Munro (1972, 202–5) and Munro (1988, Table 5).

In Florence, whose mint was run directly by the city, the opposite tack was always taken, namely charging private agents for the cost. In 1347 (the period for which the figures in 1 apply), the seigniorage rate was 0.6% for the gold fiorino, 4.6% for the grosso,

6.6% for the quattrino and 17.8% for the picciolo (Bernocchi 1974, 3:38–40).

In France, the mint-master was allowed to deduct different production costs from gross seigniorage.⁶ This arrangement in effect pays for the different costs out of the king's seigniorage. Furthermore, the mix between gold and silver was often part of the contract, but only the aggregate value actually mattered, and quantities of small currency were never specified, leaving its determination to public demand and the mint-master's incentives. The mint-master was obligated to provide a minimal amount of total seigniorage during his lease. Since he could meet his obligation with any mix of coins, it was preferable for him to mint larger denomination silver coins. Indeed, minting of small denominations was apparently not adequate. Since the 1360s at least, the king regularly issued orders to his mints to produce set quantities of small coinage to relieve shortages and eliminate competing foreign currency. By the early 16th century, mintage of billon had ceased to be free, and was done only on government account.

Figure 1 shows the relation between intrinsic content q and production cost c to be roughly $c = c_0\sqrt{q}$. The cost is therefore not independent of the value (or intrinsic content) of the coin, but rises less than proportionately.

Medieval Canon Law and Minting Charges

The Canon (*Corpus juris canonici*) was the collection of Church Laws, based on collected decisions (decrees) of successive popes. One chapter of Canon law dealt with the alteration or falsification of money, namely Book 2, Title 24, Chapter 18. The original papal decision had to do with relieving a king from his oath to uphold a debased currency, but over time, a number of commentators expanded on the topic to consider money in general, its value, its debasement, and all questions of equity revolving around the use of money. The standpoint is always normative, obviously, and the reasoning is usually based on the notion of fairness or justice, so this cannot properly be called monetary theory. They are nevertheless indicative of the existing policy prescriptions in monetary matters.

⁶ The mint price for low-grade silver was usually lower, by as much as 10%; but the mint price does not seem to have depended on the coins in which it was paid.

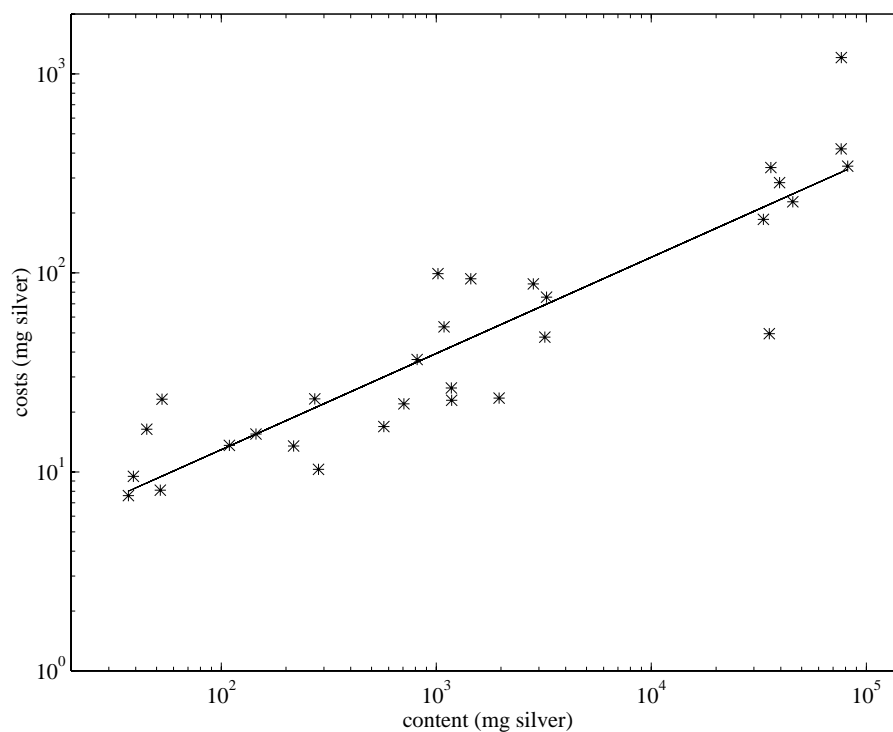


Figure 1: Cost of production per coin as a function of content of coin (log scale). The regression line has slope 0.48 with a standard error of 0.04. Source: 1.

Concerning the coinage, jurists were unanimous in considering that its intrinsic content ought to be as close as possible to its market value. Innocent IV, writing around 1250, considered that it was allowable to deduct production costs as a minting charge, and that the individual who provides the service of turning metal into coin should make neither a profit nor a loss. Considering that the sovereign's stamp added value to the metal it was imprinted on, he admitted that a small charge beyond minting costs could be withheld by the sovereign. This position was consistently adopted by successive jurists down to the late 15th century, with one notable exception: the Italian jurist Bartolo di Sassoferrato, in the mid-14th century, thought that the minting costs should be born by the general revenues, and not by the individuals bringing metal to the mint. None of the jurists seems to have considered the fact that smaller coins were more expensive to mint than larger ones.

Mechanization (16th–17th c.)

Mechanization of the minting process developed during the 16th and 17th centuries.⁷

The first innovations arose out of the art of medal-making, which began in Italy in the 1430s. Medals, often much larger than coins, were usually cast (and eventually chiselled), but around the turn of the 16th century the demand for high-quality medals had increased and ways to strike medals were sought.⁸ This required a better technology both to prepare the larger flanks and to strike them with sufficient force and accuracy. The innovations in minting arise in Germany and Switzerland around 1550, and quickly disseminated to the rest of Europe.⁹ Two methods of striking the coins developed: one using a screw-press, the other using two cylinders on which the dies were engraved, thus laminating and striking at the same time. The screw-press came to be adopted in France and England, while the cylinder-press was used in Austria, Germany, Spain, Italy and Sweden. In the 18th century, the screw-press overtook the cylinder-press as the main minting apparatus.

The Screw-Press

In 1547, the French king Henri II decided to reform the coinage of his realm. A first step was taken that same year, by appointing an engraver-general who produced all the punches for making dies in all mints, and thus bring greater uniformity to the realizations of the designs. He also asked his envoys in all countries to report on any new technology that could be put to use to produce better coinage. In 1550, he learned from his ambassador in Germany that an Augsburg goldsmith had perfected equipment to produce high-quality coins.¹⁰ The ambassador's brother was sent along with an engineer named Aubin Olivier to Germany: they negotiated the rights to the machines, and had them built in Augsburg and brought to Paris, along with one of Schwab's assistants. The machinery was set up in a

⁷ See mainly Cooper (1981) and Wendel (1960).

⁸ Some medals were cast and then struck over. This method was imported from Venice to produce groschen in Tirol in 1484 (Wendel 1960, 103).

⁹ Earlier developments in Italy by Bramante, Leonardo da Vinci and Benvenuto Cellini (who directed the Rome mint from 1529 to 1534) were not followed upon.

¹⁰ The details are in Vaissière (1892).

building on the Île de la Cité in Paris where, a water-mill had been installed in the 1530s for gem-polishing by the king's engraver, Matteo del Nassaro.¹¹ The Mill Mint (*Monnaie du Moulin des Étuves*) began producing gold coins in 1551, and Olivier became its director in 1556. The new machinery consisted in the following: a rolling mill (powered by the water-mill) created smooth strips of metal or fillets, a drawing bench brought them to the exact width, a hand-activated cutter or punch press perforated the strips into blanks, and a press struck the blanks on both sides. By 1555, Olivier had improved the press by adding a segmented collar to hold the blank in place: during the strike, the collar impressed on the edge of the coin a design or a motto (the collar had to be segmented to as to remove the coin after the strike). The new machines thus mechanized each step in coin-making, and also marked the edges to prevent clipping.

It is usually assumed that the stamping was originally done by a screw-press or fly-press, but there is evidence for its use in Paris only after 1600. It is rather unlikely that an Augsburg goldsmith would have had an operating screw-press in his workshop, and more plausibly some kind of drop-press was involved.¹² Which mint-master introduced the screw-press is unknown, and no connection with the earlier advances in Italy has ever been found. By the mid-17th century, the screw-press was well-developed: its first known depiction is on a painted window in the Constanz mint in 1624. It gained its force from the momentum of two large lead balls (weighing 40 to 150 lb each) at the extremities of a horizontal bar. At the time of its installation in London in 1662 it could strike 30 coins per minute. By the late 18th century, the removal of struck coins and feeding of new blanks had been made automatic; the Paris press took 16 men to operate and could produce 60 coins per minute.¹³

The new mint set up at the Moulin did not function long as coinage mint, however, in large part because of the high costs of operation, and perhaps some initial mismanagement. It was claimed that the wastage amounted to 30%, as opposed to 2% in the hammering process.¹⁴ In 1563, the Mill Mint was restricted by the Cour des Monnaies to medals and

¹¹ Hocking (1909), Mazerolle (1907, 26–31).

¹² Wendel (1960, 130) makes this case. A 1676 depiction of the Paris Mint machinery shows both a drop-press and a screw-press.

¹³ Cooper (1988, 59), Craig (1953, 164), Wendel (1960, 158).

¹⁴ Bodin (1578, 6:??). Cutting a circle out of a square wastes at least $1 - \pi/4$ or 21%.

tokens, although in 1575 its mandate was extended to pure copper coinage. It continued to function in that capacity, producing high quality medals until 1625.¹⁵ Historians usually attribute this failure to the resistance of entrenched interests among mint-workers and the Cour des Monnaies, although other problems, such as those which England encountered in the late 17th century, may have been foreseen at the time.

England became interested in the new process early on, and in 1554 some attempts were made at imitating the French press. In 1561, a former employee of the French mint named Eloi Mestrell came to England and was allowed to introduce the new technology at the Tower Mint. After 11 years, the machines were found to be ten times as slow as the hammering process and the experiment terminated.¹⁶

In 1630, an engraver from Liège named Jean Warin became director of the Mint-Mill (now called the Medal Mint and located in the Louvre Palace). On the occasion of a general overhaul of the French coinage in 1640, he was allowed to try again and use screw-presses for minting coins, and obtained in 1645 that the mechanized process be used in every French mint. It should be noted that the general recoinage had already been decided upon when the technology was adopted.

Once again, England followed the lead within a few years. In 1649, the Frenchman Pierre Blondeau was invited to England to bring with him the technology: his sample coins were approved in 1651, but the first coins produced with the new method appeared in 1658. The method was extended to the whole English coinage in 1662. The rolling mills were driven by horses. Samuel Pepys, in his diary for 1663, does note that the machinery made coinage more expensive for the king.¹⁷ In England, however, the coins produced for the next thirty years proved to be of such high quality that they were used more as bullion than as money, that is, they were hoarded, melted or exported. By the mid-1690s, the circulating medium was no better, and in fact much worse, than in 1662. It was decided that a general recoinage was needed, as a consequence of the new technology (as opposed to the French case). In distinction with France, the recoinage was carried out at government

¹⁵ Mazerolle (1907, 26–34), Blanchet and Dieudonné (1916, 192–5).

¹⁶ Craig (1953, 118–23). Mestrell himself was terminated in 1578 for counterfeiting.

¹⁷ Pepys (1970, 4:147).

expense, and the worn and clipped coinage was exchanged one for one with the new milled coinage.¹⁸

The screw-press technology is also known to have been transferred to the small kingdom of Navarre (soon to be united to France), where a similar mint was set up by a former engraver of the Paris mint in 1556. Wendel (1960, 132) mentions that two German brothers obtained a patent for a screw-press to be used in minting from the king of Poland in 1578, but nothing further is known. Thus, it is only after its nearly simultaneous adoption in England and France that the screw-press took hold: it was adopted in Brandenburg soon after the peace of Westphalia in 1648, and by the Netherlands in 1671.¹⁹

The Cylinder-Press

At the same time as Henri II of France was actively searching for a new technology, the German Emperor and king of Spain Charles V was inspired to do the same. One of his advisers, count zu Solm-Lich, recommended mechanization to reduce minting costs; in 1551, he proposed the principle of a cylinder-press, similar to the rolling presses already in use by goldsmiths to produce flat strips of metal. The cylinders themselves would be engraved with the coin die; the coins would be cut out of the stamped strips afterwards. Horses or water-wheels were to provide power. The Emperor's brother Ferdinand, count of Tirol, showed interest and asked his mint officers in Hall to investigate the possibility. The first working cylinder-press, however, was set up in Zürich in the early 1550s, by Hans Vogler Jr and Rudolf von Rordorf.²⁰

The mechanism had the advantage of both laminating and stamping the metal at once. The disadvantage was that it was necessary to engrave oval dies (initially the cylinders were engraved, and later removable dies were employed). Also, the coins often came out slightly warped, which made serrating of the edges impossible. In spite of these flaws, the process proved very popular. The Swiss inventors set up a partnership to develop the new invention commercially and export it abroad; they obtained a patent for all of

¹⁸ Craig (1953, 184–97). See contemporary discussions by Lowndes and Locke.

¹⁹ Walther (1939).

²⁰ See Hahn (1915, 19) and Newald (1897) for the early development of the cylinder press.

Germany. Ferdinand bought it for Tirol and it was installed in Innsbruck in 1568. Austria would remain faithful to the cylinder-press until 1765.

The cylinder-press was soon adopted throughout Germany and beyond: Heidelberg in 1567, Cologne in 1568, Augsburg in 1572, Dresden in 1574, Danzig in 1577, Nyköping (Sweden) in 1580, Madgeburg in 1582, Hamburg in 1591, Saalfeldt in 1593, Rostock in 1594, Osnabrück in 1597, Münster in 1599. It reached Poland in the late 16th century, where the Göbel brothers secured a patent and exported it to Königsberg, Riga, Denmark. Before 1600 it had also reached Clausthal-Zellerfeld in Hannover near the mines of the Harz, Berlin and Strasbourg. Sweden began using cylinder-presses in 1625 in Kopparberg, near its large copper mines.²¹

From Germany, the new technology quickly spread to Southern Europe. Mechanization came to Florence in 1576. Machinery driven by a water-mill was installed in a new Zecca on the banks of the Arno, near Santa Croce. The machinery was imported from Germany, and operated by German engineers who proved to be excellent workers and great consumers of Chianti.²² Rome had similar equipment by 1581.²³

In 1581, Philip II of Spain asked his cousin the archduke Ferdinand, count of Tirol, to send him the a copy of the Innsbruck machines, and the archduke obliged by sending 6 German craftsmen from Hall to Madrid.²⁴ The Germans found a suitable location in Segovia and proceeded to build a new mint, called *el Ingenio*. The method of striking coins was the cylinder-press, and the machines were powered by water-mills. The first coins were issued in 1586, and initially only silver reales were made. But in 1596, it was decided that all billon (pure copper after 1602) coinage would henceforth be made at the Ingenio. The Segovia mint was to produce all copper coins, but in practice, although it did produce the bulk of the coinage, hammered coinage continued to be issued from other mints, resulting in an abundance of “thick billon.” A reform of the copper coinage in 1660 resulting in many counterfeits, it was decided in 1661 to extend the use of the cylinder-press to all

²¹ Walther (1939), Wendel (1960, 134).

²² Cipolla (1990, 233). Only silver coinage was produced in the new mint; gold was produced in the old Zecca. Cipolla does not specify the method used, but Wendel (1960, 134) states that it was a cylinder-press.

²³ It was observed by Montaigne during his visit (Pertile 1973).

²⁴ The story of the Segovia mint is told in Rivero (1918).

other mints. When Spain returned to making pure copper coinage at intrinsic value in 1680, hammering was adopted again. Only with the advent of the French Borbón dynasty were the hammers and the cylinder-press replaced with imported screw-presses in 1728.

A variant of the cylinder-press developed in the 17th century: instead of engraving a whole cylinder, a pair of mushroom-shaped pieces were engraved and inserted in slots of rotating axles. This design was known as *Taschenwerk*, and it required pre-cut oval-shaped blanks (their passage between the dies made them round). It was introduced in the early 17th century in France and England, but without taking root. A man named Nicolas Briot had begun his career as mint-master in Northern France and Lorraine, and traveled extensively to Germany, where he learned of the various techniques used there. He became director of the engraver of the mint in 1606, and in 1620 obtained the lease for the Paris mint. In 1617 a trial of his proposed minting device was carried out before French officials, but resulted in failure: wastage was high and the coins were not of good quality.²⁵ In 1625, he left for England where he became chief engraver of the mint. In 1629, he was allowed to experiment with machinery which he had been using to strike medals; he was also put in charge of producing pure copper coinage at the mint in Edinburgh, but neither attempt proved conclusive. In 1639, he tried again in Scotland with silver coinage: he used a *Taschnwerk* for large denominations and a screw-press for small denominations. The machinery was in part moved by horses. The costs were substantial, and the machines apparently remained experimental. Later, during the Civil War, Briot (who died in 1646) minted coins for the Royalists using cylinder-presses.²⁶

Technology and Fiat Money (late 16th and 17th centuries)

The 16th century saw the emergence of a technology for producing coins with high fixed costs and a large and standardized output. Aside from residual variations due to the imperfection of hand-produced dies, coins were round, sharply imprinted and nearly identical. These characteristics presented high barriers to counterfeiting.

As a result, it became possible for governments to envisage the production of coins

²⁵ See Poullain (1709) for the minutes of the trial.

²⁶ Craig (1953, 147–50), Mayhew (1992).

whose intrinsic content would be considerably lower than their face value. The recognition of this fact is explicit in the royal decree by which Philip II of Spain announced the production of pure copper coinage in the cylinder-presses of the Segovia mint, in 1596. He justified his decision by referring to the silver which was until then added to copper to produce billon coinage, and calling it a waste.

The subsequent story in Spain is interesting: although Philip II seemed to have had efficiency considerations in mind, his successors Philip III and Philip IV had revenue-raising objectives.²⁷ The weight of the copper coinage was soon reduced by half (1602), and colossal quantities of copper were issued, at a cost of 10-15% of face value, from 1602 to 1626, to the point that copper completely replaced silver as medium of exchange. Issues continued past the point where the demand for coinage was satiated, and inflation began in the early 1620s. Minting was halted in 1626; until 1660, the Spanish government used restampings to generate seigniorage, but ultimately the market value of the coinage fell to its copper content. A new experiment with billon containing 7% silver in 1660–4 proved only mildly successful and counterfeiting exploded in spite of the cylinder-press. Minting stopped in 1664, and in 1680 Spain returned to a pure copper coinage issued at its intrinsic value. Throughout this period gold and silver coinage remained almost unaltered.

In France, the notion that mechanized minting allowed to issue fiduciary coinage seems to have dawned at the same time. The mechanized mint had been set up in 1552; in 1575, it produced the first pure copper coins (the smaller denominations had until then been made in billon); the intrinsic content was worth about 45% of the face value. To quote Blanchet and Dieudonné (1916, 172): “The date of this reform is important: in distinction with medieval currency which, however alloyed, had never had value but for its content of fine metal, we see the birth of subsidiary fiduciary coinage, thanks to the progress in public credit, as well as to a sharper understanding of the relative roles of metals in circulation.” It is important to note that these copper coins were produced in the mechanized mint (*ibid.*, 337).

²⁷ See Carrera i Pujal (1943) and Gracie-Hutchinson (1977, 1992) for discussions of contemporary economic thought in Spain, as well as the advice that Philip II was given. See in particular Juan de Mariana’s 1609 Tract on Vellón Money, where he examines and weighs the advantages and disadvantages of a copper-based fiduciary system, well in advance of any inflation.

The minting of pure copper coins continued on a rather limited basis. In 1596, it was decided that all pure copper coinage would be made in the Mill Mint exclusively. France did not immediately follow Spain. When, however, mechanized minting was extended to all mints in 1640, new emissions of pure copper soon followed, in 1642–3 and in 1653–8. The minting was subcontracted to private entrepreneurs, Mathieu and Blondin, who established presses in small towns with water-mills. Large quantities of copper coinage were thus issued, at a time of extreme political crisis.

As noted above, the cylinder-press technology was adopted fairly rapidly across Germany in the late 16th and early 17th century. In 1618 began the Thirty Years War, a costly and destructive conflict which devastated Germany; many states were involved in the fighting and needed large resources. The ensuing period, from 1619 to 1623, is known as the *Kipper und Wipper Zeit*, which means “the clipping and culling times.” The phrase actually refers to a flood of copper coinage throughout Germany and ensuing high rates of inflation.²⁸

Finally, let us note that mechanization came to Sweden in 1625. The following year, Spain stopped minting copper, and the demand for Swedish copper (the biggest producer in Europe) collapsed, as Spain had been consuming the equivalent of half of Sweden’s copper output. Within a few years Sweden had moved to a copper standard, which it retained until the mid-18th century when it went to a paper currency. The Swedish experience differed in that the coins were full-bodied rather than fiduciary, since the aim was to enhance the demand for copper (Heckscher 1954, 88–91; see the price series in Wolontis).

Coincidences? *I don't think so.*

England and Copper Coinage

Prim and proper England, as always, provides an interesting contrast. It did not use mechanized minting until 1662. Prior to that date, the Royal mint refused to issue copper coinage.²⁹ Under the first Stuart kings James I and Charles I, small coinage was

²⁸ See Kindleberger (1991). The article is not very good, but it is full of references to track down.

²⁹ Historians traditionally ascribe this to the notion that the royal image could not be placed on so base metal as copper. There’s got to be some author who sees through this ludicrous argument.

issued by private individuals to whom royal patents had been granted. It appears that the scarcity of small change was used as a means for the king to provide monopoly privileges to his cronies, and that these patents were not guided by any public policy considerations. As a consequence of the acute shortage of small change in the 17th century, “trade tokens” made their appearance in large quantities.³⁰ Between 1648 and 1679, over 12,700 different types of tokens are known to have been issued in 1700 different localities. In London alone, over 3500 types are known.

The question of small coinage was repeatedly raised during the Commonwealth and in the first years of the Restoration. Quote by Slingsby, Mint-master (1662-80).

In 1672, after the adoption of mechanization, provisions were finally made for regal copper coinage, but the government insisted on minting only full-weight copper coinage: the proclamation of August 1672 insisted that the coins were ‘to contain as much copper as shall be of the true intrinsic value of each less the charges only of coining and uttering.’ As Craig notes: ‘The amount of this part of coinage was, however, no longer automatically regulated by the flow of raw material to the Mint; controlling authority had henceforth to guess how much should be provided’ (Craig 1953, 175).³¹ It seems that British policy-makers had little interest in this guessing game. Moreover, the price of copper relative to silver remained very volatile (much more than the gold-silver ratio; see prices in Posthumus), in particular during wars, since the resulting demand for cannons and other military equipment never failed to drive up the price of copper, and lead to massive melting of the petty currency. The shortage of small change thus persisted and trade tokens remained common until the early 19th century. The United States followed an identical policy in the early 19th century, with the same consequences, notably with the rise in international copper prices during the Napoleonic Wars.³²

The Industrial Revolution

During the 18th century, the only substantive change was the marking of edges with

³⁰ Trade tokens have been studied and catalogued by numismatists; references.

³¹ The cost of the copper accounted for 66% of the face value, and production costs for 18%.

³² Carothers (1930). I don’t know if there was token coinage in the US; probably not, given the expense of importing the copper blanks and striking them.

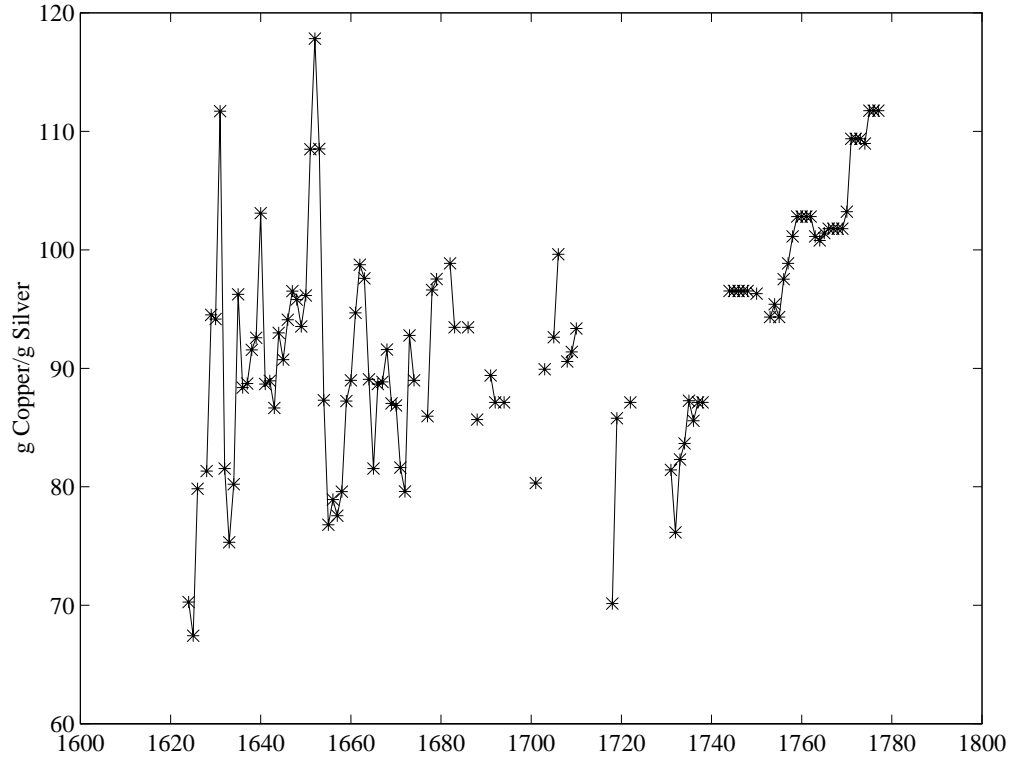


Figure 2: Price of Swedish copper in Amsterdam. Source: Posthumus.

the Castaing machine (invented in England and adopted in France in 1685), a process by which a coin was rolled on a horizontal surface between two steel bars, one of which bearing the motto or serrated design in relief.

Several innovations occurred in the late 18th and early 19th century. The portrait lathe and hubbing were invented by the Swiss J-P Droz around 1780: this finally permitted coin dies to be identically reproduced, and eliminated one of the last sources of variation from one coin to the next; it was adopted by Dupré, engraver of the French mint, in 1791. Also, in 1788, Boulton of Birmingham introduced steam-driven machines, which he used for private coinage until they were adopted by the London Mint in 1810; the output was 70 to 80 coins per minute. Steam engines, however, were not easily adapted to the old screw-press, and technical problems were found in accomodating the rotation and recoil of the screw. In 1817, D. Uhlhorn, a German engineer in Grevenbroich near Cologne, invented a

lever-press which could more easily be driven by steam. His machine could strike 30 to 60 coins per minute, depending on the size of the coin. By 1840, Uhlhorn had built presses for mints in Düsseldorf, Berlin, Utrecht, Vienna, Munich, Karlsruhe, Schwerin, Stockholm, Wiesbaden and Naples.³³ The method was adapted by Thonnelier in France in 1834, and the Thonnelier press, striking 40 coins per minute, came in use in Paris in 1845.³⁴ By the late 19th century, when the Thonnelier press was in use throughout Europe, it could strike 60 to 120 coins per minute.³⁵

Soon after, the first principles of subsidiary coinage issue are laid down. See Carothers (1930) for the details of how England finally uncovered these principles. Chronicle their adoption in various countries (France followed fairly late, in 1864; the US in the 1850s).

³³ *Meyers Conversationslexicon* (1840).

³⁴ Blanchet (1890).

³⁵ *Encyclopaedia Britannica*, 9th ed.