Economic History Working Papers No: 275/2018

Technologies of money in the Middle Ages: The 'Principles of Minting'

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LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE
DEPARTMENT OF ECONOMIC HISTORY
WORKING PAPERS
NO. 275 – FEBRUARY 2018

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The paper discusses which options medieval political authorities had to satisfy the demand for complex currencies. It distinguishes several models, each of which caused problems: A first one, where the basic unit was supplemented by a range of other denominations whose weight and purity where exactly proportional. While this did not take the proportionally larger labour costs involved in the production of small change into account, the second model did: here, small change had an over proportionally high content of base metal. In consequence, the stable numerical ratios between units of the same currency began to shift. The third option involved using gold for high purchasing power coins; a strategy that made currencies vulnerable to changes in the relative market prices of gold and silver. Again, the outcome was a that the numerical ratios between units of the same currency became instable. The paper discusses how political authorities chose between these options, how they supplied their mints with the necessary bullion and how minting was organised.

Keywords: Medieval monetary policies, mining, minting
JEL codes: E42, E52, N13

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I.

‘… the young White King very often visited his father’s mint and carefully inquired after all the principles of minting, because a mighty king and ruler needs to be acquainted with this art in particular…. Thus the young White King became most ingenious in minting, considering the use he himself might derive from it, and when he came to rule he ordered the very best coin to be minted, both in silver and gold, better than any other king, and due to his art and experience no other king was his equal in coinage. The same young king also abolished and eliminated all bad and foreign coins in his kingdoms and let new good money be minted in many places, which was to the particular benefit of his people and caused their wealth greatly to grow, as well as increasing his own income from his demesnes. … And having understood the experience and art of minting, he thought by himself that a king who failed to keep his realm’s mines in order did not draw much advantage from them; hence he diligently inquired

about each mine's nature and which regulations might maintain it best' (Schultz, 1888, p. 84, author's translation).

Fig. 1. The young White King learns the principles of minting. Woodcut by Leonhard Beck (c. 1480-1542)*; from Maximilian I's 'Weißkunig' ('White King').*

This is how Maximilian I (1459-1519), ruler of the Holy Roman Empire from 1486, described an essential part of his education and the resulting policies in his fictionalised autobiography, where he appeared as the 'White King'. The work was lavishly illustrated by leading renaissance artists; Fig. 1 reproduces the woodcut that shows the episode quoted at

the start of this chapter. Below, we will follow Maximilian in his inquiries: We will examine the 'principles of minting' about which he questioned his father's officials as a young man. On that occasion, he not only learned about the tools and implements used to produce coins, but also about fundamental questions of monetary policies. What currency units should a ruler issue? Which metals should his mint use? Should it produce coins that helped increase the ruler's wealth, or that of his subjects? And, last but not least, in what way should the mint be supplied with the raw material needed for coinage? Maximilian, 'the last knight', was learning how to answer these questions at the very end of the Middle Ages, when more than a millennium had passed since the fall of the ancient Roman Empire in the West. By his time, emperors, kings and other rulers as well as the many coin-issuing towns and city-states that chequered Europe's political landscape had come a long way, during which their own answers had changed and developed. To a large degree this had happened in response to the changing economic circumstances that affected the demand for money. Before turning to the 'principles of minting', we therefore need to examine these circumstances.

As money is not only a store of wealth and a measure of value, but also a medium of exchange, money demand was to a large degree a function of the importance of exchange. That barter was inconvenient was widely recognised in medieval Europe, as was the utility of money as a means of reducing this inconvenience or, in modern terms, the transaction costs involved in exchange (cf. e.g. Johnson, 1956, p. 4; Biel, 1930, pp. 19 f.). How often people engaged in markets and how important the purchase of commodities was relative to self-produced goods, influenced both the absolute size and the structure of their demand for means of payment: The questions were, how much money did society need? And how much of this was small change, useful in day-to-day transactions, and how much high-purchasing power money, needed for example in the wholesale trade? It is important to note at this point that causality was not one-directional: While a growth in trade triggered demand for a larger

quantity of money and a more differentiated monetary system, satisfying this demand might encourage a further increase in commerce.

The importance of exchange in the early Middle Ages has been debated. Points of view ranged from the hypothesis that markets were practically non-existent to the idea that exchange was flowering as early as the eighth and ninth centuries (cf. e.g. North and Thomas, 1971, p. 782; Verhulst, 2002, p. 113). The large monastic and noble estates of the Carolingian Empire certainly did sell their surplus, and on small weekly markets consumers could buy simple goods. There was also trade across the Empire's borders: with England, North Africa, Spain and Byzantium (Verhulst, 2002, pp. 97 ff.). In fact, according to modern research (McCormick, 2002, p. 778), commerce at this time was already expanding from its nadir in the seventh century. However, there is no doubt that its total volume was still very small and that compared to goods people produced for their own consumption those bought in markets played a minor role.

The 'Commercial Revolution' in the sense of the spectacular growth in local, regional and long-distance trade that Robert S. Lopez had in mind when he coined the term began to take off only in the tenth century (Lopez, 1976, pp. 56 ff.). First in Italy and then further north, merchants developed new ways to finance their endeavours (Hunt and Murray, 1999, p. 61). In consequence, the Baltic, Russia and the Middle East became for the first time firmly linked with Western and Southern Europe. At the same time increasing numbers of people moved from the countryside into the growing number of towns where they depended on buying the necessities of life. By 1400, the share of people living in places with more than 5,000 inhabitants had increased from practically nothing in the Carolingian age to almost 40 per cent in Belgium, 30 per cent in the Netherlands and more than 20 per cent in Italy. Even in England it reached 8 per cent (Allen, 2000, pp. 8 f.).

By that time, Europe was in the throes of the Plague that between its first appearance in 1347 and the end of the fourteenth century killed about half of the continent's population. How this affected the economy and specifically trade and exchange is another current debate. Robert S. Lopez and Harry Miskimin suggested that the late fourteenth and fifteenth centuries were a period of economic depression (Lopez and Miskimin, 1962); more recent research points to the growth of per capita output, the proliferation of regional fairs and the advances in market integration that took place at this time (Epstein, 1994, passim; Broadberry et al., 2015, p. 205; Chilosi and Volckart, 2011, p. 769).

There are no hard data, but neither is there any doubt that the absolute volume of trade in Europe was far larger at the end of the Middle Ages than at their beginning. What is more, while there certainly were pronounced regional variations, growth seems to have been almost uninterrupted between the eighth and the fourteenth century and seems to have continued at least in per capita terms even after the Plague. The wheels of exchange kept spinning faster between the seventh and the fifteenth centuries. To oil them, the European currencies did not only need to grow in volume; they also had to be increasingly complex and versatile.

II.

The currency of the Frankish kingdom of the early Middle Ages was initially that of the late Roman Empire, with the focus being on the issue of gold, in particular on so-called *trientes* or *tremisses* that equalled one-third of a Roman *solidus* (shilling). One of the first measures that caused the Frankish currency to depart from the Roman model was the decision to abandon this *triens* in the late seventh century. Instead, the mints in the Merovingian kingdom (as in some neighbouring regions such as Frisia) focused on the production of silver *denarii* (pennies) (Grierson and Blackburn, 1986, p. 91 ff.). From then on, *denarii* were the only monetary unit issued, with four equalling one old *triens* or twelve equalling one shilling

(Spufford, 1991, pp. 33 f.). We do not know what triggered the reform: There is no evidence for the principles of minting in the pre-Carolingian period. An outflow of gold to the Arab world and the discovery of silver ore deposits in Western France probably played a role, but there may have been at least one other motive: The lower value of the *denarius* implied that it was better suited to small transactions on local markets than the old *triens*; conceivably, this was taken into account when the gold units were discontinued (cf. Verhulst, 2002, p. 88). Until the eleventh century, *denarii* remained the only type of coin issued in Western and Northern Europe. However, the onset of the 'Commercial Revolution' presented rulers with a new challenge: how to meet the demand for complex currencies suited to the requirements of both local and long-distance trade. They had three options, which it is useful to consider systematically (cf. Redish, 2000, pp. 18 ff.).

The most straightforward solution was to produce several denominations made of the same metal and with the same fineness, but different weights. This was the option chosen by the kings of England. They retained the penny, but from the mid-fourteenth century onward supplemented it with a range of other units. The quarter-penny (farthing) had a quarter of the size, weight and content of pure silver as the penny, while the penny itself was equally carefully matched to its multiples, of which the four-pence piece, called groat, became most important (Challis, 1992, pp. 701 ff.). This may to some extent have addressed the problem of providing larger denominations useable in the wholesale trade, but small purchases still presented a problem. Thus, in the 1350s the average price of a tun (252 gallons) of cider was in the region of 12½ shillings (Rogers, 1866, p. 448), which implies that even the smallest piece of money, the quarter-penny, would buy almost half a gallon. Still smaller coins, however, were impracticable: The quarter-penny had a weight of 0.31 grams (Challis, 1992, p. 701) – less than a tenth of that of the physically smallest modern British coin, the five-pence piece. Anything still smaller would have been impossible to handle. How consumers

were able to buy small quantities of relatively cheap commodities is not entirely clear. There is some evidence that late Roman low-denomination coins were still circulating in the fourteenth and fifteenth centuries, as were privately produced jettons (Dyer, 1997, p. 40). However, the use of small scale credit was probably more important (cf. Nightingale, 2004, p. 51). We need to remember that even at its peak just before the Plague, the total population of England was only about half of that of London today (Broadberry et al., 2015, p. 20). Most people lived in communities where everyone knew everybody else. Under such conditions it was easy to buy small quantities on credit and to settle the balance once a sum had been reached that could be paid using a coin – which was the case for example after three or four pints of cider.

Another problem posed by the English way of structuring the currency was that producing a quarter-penny cost virtually the same amount of labour as minting a groat, whose value was 16 times larger. To save costs, it was tempting to focus on issuing large coins. Currencies based on the principle that all denominations should have a proportional bullion content therefore constantly tended to be plagued by a shortness of small change (Sargent and Velde, 2002, pp. 49 ff.) – if this term is appropriate for coins that had such a comparatively high purchasing power as the quarter-pennies.

The problem of the small size of the lower denominations could be solved by choosing the second and most common option, i.e. by minting them from an alloy of silver and a base metal such as copper, which was comparatively cheap. Nearly all European rulers and cities that issued currencies did this from the twelfth or thirteenth century onward. When, for example, Louis IX (1214-1270) – Saint Louis – of France introduced the *gros tournois* in 1266, whose nominal value was 12 *deniers*, the new coin was made of almost pure silver. The *denier* contained about one-twelfth of the amount of silver of the *gros*, but as it consisted

to more than two-thirds of copper, its total weight of 1.11 grams made it large enough to handle comfortably (Blanchet and Dieudonné, 1916, p. 225).

Fig. 2. Gros tournois *(4.22 grams total weight; 4.11 grams fine silver) and* denier *(1.11 grams total; 0.33 grams pure silver) of Louis IX.*

However, this option was problematic, too. For one thing, the costs of testing the bullion content of coins increased when the proportion of base metal of which they were made grew. Hence, issuing money with a high content of copper invited counterfeiting (Redish, 2000, pp. 21 f.). More importantly, using base alloys to mint small denominations did not address the issue of the proportionally higher costs their production involved. This problem could only be solved if the fine silver content of the smaller coins was reduced disproportionally. Doing this was dangerous, as Saint Louis' successors soon discovered. Once consumers noticed that the silver content of the *denier* had been lowered to less than one-twelfth of that of a *gros*, they began trading the larger unit at a premium. Already by the beginning of the fourteenth century, Philip the Fair (1268-1314) had to acknowledge this, issuing a *gros* whose official value was no longer 12 but rather 26¼ *deniers*. The wild fluctuations in the value of the larger silver coins must have made exchange extraordinarily cumbersome, defeating the purpose of issuing a complex currency. Moreover, governments who over-proportionally reduced the silver content of their small change, thereby driving up the value of their larger coins, could be drawn down a slippery slope. To depress the labour costs of producing the small units to a sustainable level, they had to keep reducing the proportion of silver in their smaller coins – with no end in sight. Most avoided this trap, but in extreme cases the policy

could end in episodes of rampant inflation (e.g. in Austria in the 1450s, Gaettens, 1957/82, pp. 40-51).

Moreover, minting authorities that chose this option had to find the exactly right share of base metal in their coinage: It had to be high enough that low-value denominations could be handled with ease, but not so high that the difference between the coin's nominal value and its production costs became too large. Rulers issuing a currency made a profit – the seignorage – from this difference, and if they were pressed for money they tended to focus on minting those coins where it was largest.[1] Hence, if their small coins contained a too large proportion of base metal, they tended to flood the market with small change. Contrary to what two respected economists (Sargent and Velde, 2002) have claimed in a book highly esteemed by their colleagues for its analytical rigour, small change was by no means always scarce. Rather, late medieval Europe experienced periodic episodes of an oversupply of small change. From the 1420s to the 1440s, the Prussian estates repeatedly complained about this (Volckart, 1996, pp. 92, 99 f.). Further west, in Swabia, the analysis of coin finds suggests that in the fifteenth century up to 40 per cent of the total value of money in circulation was made up of ½-, 1- and 2-penny pieces (Schüttenhelm, 1987, pp. 429, 559). In late fifteenth-century Lübeck and Hamburg, conditions were similar (North, 1990, p. 84). A Hamburger who in 1487 wanted to buy a barrel (c. 47 litres) of wheat using pennies had to count almost 90 of these minute coins that weighed less than one-third of a gram (for the price see Koppmann, 1878, p. 521; for the currency Jesse, 1928, p. 209) – an example which shows that using small change in large purchases involved high transaction costs. Hence, an undersupply of large-denomination coins could seriously impede trade.

[1] As the former Minorite monk and metal expert Burkhard Waldis put it in a memorandum on monetary policies he compiled for the master of the Teutonic Order in Livonia in 1532: 'Whenever they may mint more than one type of coin, they mint that one most which allows them to make the best profit' Arbusow, L. (Ed.) (1910). *Akten und Recesse der livländischen Ständetage*, Vol. 3 (1494 - 1535). Riga: Deubner., p. 799

This does not imply that the consequences of flooding the market with small change were all negative. The late Middle Ages were the time when small scale commerce expanded rapidly. Hucksters, hawkers and pedlars plied their trade buying and selling cheap commodities that satisfied widespread demand: 'Poultry, eggs, cheese, fruit and other food of penny value', are listed in a slightly later Bavarian territorial police ordinance that sought to regulate this trade; an Austrian ordinance adds 'ironmongery, salt, woollens and linen' (1553, p. LXIX; Schwiedland, 1899, p. X). As these small merchants were itinerant (Fig. 3 shows one of them carrying all his commodities on his back), local credit arrangements that depended on buyers and sellers interacting regularly could hardly develop. Small scale trade would therefore have stagnated if consumers had not been supplied with low-value money that allowed them paying 'penny values'. The economic effects of this development can hardly be overrated. Hucksters reached places and people whom large merchants never visited, supplied consumers with goods that otherwise would have been impossible to buy, and thereby contributed to the shift from self-sufficiency to a market-based economy (cf. Braudel, 1979, pp. 58 f.).

Fig. 3. The pedlar (from Hans Holbein Junior's danse macabre, *1524-26).*

While in countries such as England even small silver coins had a fairly high purchasing power, satisfying the need of wholesale trade with silver alone was difficult, in particular as prices seem to have universally risen once the 'Commercial Revolution' began (Abel, 1986, p. 19). However, there was a third option that rulers and urban governments could choose and that offered a solution to this problem: They could supplement silver with coins made of gold. Both Genoa and Florence began doing this in 1252, and within decades cities and princes from all over Western and Central Europe followed suit (Lopez, 1956, pp. 223 f.). Many authorities tried to integrate the new gold units into their traditional silver currencies. The city of Florence, for example, gave its golden *florin* the value of one silver *lira*, Saint Louis his *écu d'or* that of half a *livre tournois*, and the city of Lübeck its *gulden* that of half a *mark* (Lopez, 1956, p. 223; Blanchet and Dieudonné, 1916, p. 225; Jesse, 1928, p. 214): they all introduced bimetallic currencies where the ratio between the value of gold and silver coins was legally fixed.

However, the price of gold and silver depended on supply and demand, and as both never moved entirely in step, the relative prices of the two metals were bound to fluctuate. It did not take long for this to cause problems. Monetary theory traditionally supposed that fluctuations in the price of gold expressed in silver or in that of silver in gold would result in coins made of the metal whose value was rising being withdrawn from circulation to be sold as bullion. Bimetallic currencies were therefore assumed to have a constant tendency to revert to monometallism. However, this outcome is likely to come about only if two conditions are met: First, as culling coins, melting them and selling the metal is not costless, people will engage in monetary arbitrage only if the difference between the legal and the market ratio of the value of gold and silver is large enough to cover the costs they have to bear (Flandreau, 2002, p. 492). Second, the local political authority needs to monitor market exchange closely enough to be able enforce the legal ratio between gold- and silver money. If this is not enforced, there is no incentive to withdraw those coins from circulation whose metal is appreciating on the market. Rather, they circulate at a premium (cf. Redish, 2000, p. 30). This is what happened in most late medieval polities. Florence, for example, proved unable to stabilise its *florin* as equivalent of the *lira*: On the market, the gold coin had a flexible exchange rate in Florentine silver money (Spufford, 1986, pp. 1-25), with both metals effectively constituting different and parallel currencies issued by the same authority. Likewise, Lübeck's repeated attempts to fix the value of its gold *gulden* in its silver *mark* failed (Jesse, 1928, p. 214). Using gold for large purchases still made sense, but the transaction costs savings were lost which a bimetallic currency with stable relationships between its denominations made of gold and silver had promised.

Many authors believe that the supply of high-purchasing power gold coins played a crucial role in the 'commercial revolution' (Vilar, 1984, p. 36), and to some extent this was certainly the case. A number of gold coins issued from the thirteenth century became popular all over

Western Europe, notably the *florin*, which was imitated by a large number of authorities (Berghaus, 1965, passim; Giard, 1967, passim). Venetian *ducats* and their Hungarian imitations played similar if more limited role in East-Central Europe (Volckart, 1996, pp. 47, 60, 212). Still, the commercial effect of gold should not be overrated. Peter Spufford (Spufford, 1991, 240) already suspected that the increasing quantity of money in the high Middle Ages helped trade more than the new forms in which it circulated. More recently, statistical analyses have found that trade links between the Hanseatic towns of the late fourteenth and fifteenth century benefited more from the use of the same silver currencies than from the availability of popular gold coins (Volckart, 2016, p. 26) – a finding that points to the overwhelming importance of local and regional small-scale exchange, which in total far outweighed large and generally better documented long-distance transactions.

In sum, medieval rulers who reacted to the growth in exchange by issuing currencies composed of several coin types faced a number of dilemmas. Using silver alone made it difficult to cover the whole range of denominations that consumers required; alloying it with copper invited counterfeiters, exposed the currency to the danger that the ratio between its denominations would become instable, and might provide incentives to focus on issuing small change, and minting both gold and silver amounted in most cases to issuing two parallel currencies that would circulate at flexible rates. In each case, consumers continued to face high transaction costs: less high, certainly, than if the early medieval one-denomination currencies had been retained, but higher than expected when complex currencies were first created.

On top of this, consumers had to cope with additional problems. Authorities did not always follow the lofty principles that Maximilian claimed to have learnt in his father's mint; rather, they often issued money to make a profit (the seignorage mentioned above). Secretly reducing the bullion content of the coinage – debasing it – allowed rulers to increase their

profit. When this happened, coins of the same nominal but diverging intrinsic values tended at least for some time to circulate side by side, creating uncertainty among consumers and increasing transaction costs. In practice, therefore, which types of coins consumers encountered depended only in part on the desire of political authorities to satisfy the increasingly heterogeneous demand for money: Its supply could always be affected by their wish to increase their revenues by debasing the coinage.

III.

How much seignorage rulers and governments received depended on how expensive producing coins was, and this, in turn, depended to a large extent on how much they had to pay for the coins principal component, i.e. for the gold or silver. Whereas they did have some choice when they had to decide whether and how to satisfy the demand for complex currencies, most of them faced far more restrictions when supplying their mints with bullion. In principle and with very few exceptions, which will be discussed below, there were only two possibilities: Either an authority controlled its own gold- or silver-mines whose output it turned into coins, or it had to use imported bullion. In the short term, an authority might experiment with various policies designed to increase the inflow of precious metal. In the long term, however, imports were only possible if the rulers' or governments' subjects produced sufficient goods for export in return for gold or silver, or if they provided services – e.g. in the transit trade – for which the subjects of other authorities were willing to pay.

The link between access to bullion mines and minting was close from early on: The importance of the silver ore discovered in Western France for the development of the silver penny was already mentioned. Since the 960s, silver deposits newly discovered in the Harz Mountains gained particular importance (Hillebrand, 1967, p. 109), and two hundred years later the Saxon Ore Mountains and Kutná Hora/Kuttenberg in Bohemia became the centres of

European silver production (Schwabenicky, 1994, passim; Steuer, 2004, pp. 133-136; Castelin, 1973, pp. 1 ff.). Production figures do not exist, but the general impression is that until the fifteenth century, all other mines remained comparatively unimportant. The fourteenth century saw a decline in output of at least some mining districts (Bartels, 2000, p. 166), the fifteenth the discovery of new deposits and the opening of new mines, which resulted in the silver mining boom of the decades between 1460 and 1550 (Munro, 2003, p. 8). Gold, by contrast, was nowhere in Europe produced in large quantities: From the twelfth century onward, there were mines in the Alps, Silesia and Hungary, but most of the metal was imported from Africa and Asia (Vilar, 1984, pp. 33 f., 47).

We do not know which ways the bullion took from mine to mint before the late Middle Ages. However, from the twelfth century onward mineral resources were everywhere counted among the rulers' 'regalian rights' that were supposed to generate revenues (Thieme, 1942; Hägermann, 1999/2003). Mining itself was entrusted to organisations called *gewerken* whose members initially may have worked below ground themselves but later engaged primarily in finance, selling for example shares that by the fifteenth century were freely traded (Ermisch, 1887, p. XCI ff.). The *gewerken* sold a fixed percentage of the bullion they produced at a fixed price to the ruler, whose mint then had to buy it at a similarly fixed but higher price (Schirmer, 2006, p. 92; Wolfstrigl-Wolfskron, 1903, p. 65).

Given the uneven distribution of deposits of gold or silver ore, few governments could rely on mining to supply their mints: In the late Middle Ages, the kings of Hungary, the Habsburg rulers of the Tyrol and some other German princes, e.g. the dukes and electors of Saxony and the counts of Mansfeld, were important in this field. All other rulers depended on the import of bullion, and this normally required a positive balance of trade. The supply of bullion to the English mints, for example, always depended on England producing enough goods for export: This is why the wool and textiles trade with the Netherlands played such a crucial role

in English politics. The kings of England sought to improve the situation by pursuing what have been called ‘bullionist’ policies: Not only did they prohibit the export of gold and silver but they also tried to attract as much precious metal as possible. For example, a statute first published in 1340 required merchants to bring 1⅓ pound of silver plate to the London mint for every sack of wool they shipped (Munro, 1972, p. 36). A more subtle way to reach the same aim was manipulating the exchange rate: If gold was to be issued, the mint would offer higher rates (in silver) for foreign gold coins and raw metal; if it planned to intensify the production of silver coins, it offered more gold in return for that metal (Munro, 1972, p. 29).

Other rulers pursued similar policies, though generally with less success. Thus, the Teutonic Order in Prussia was well aware of how Western European rulers supplied their mints. In the 1420s, the Order imitated such measures, trying to safeguard the gold supply by setting the rate its official exchange offered to above the market rate. However, while by the late Middle Ages the kings of England were able to enforce their policies, the Teutonic knights failed: Their rudimentary bureaucracy was incapable of making sure that enough gold reached the mint (Volckart, 1996, pp. 144 f.). In any case, most medieval lordships were far too disorganised to even consider pursuing policies as sophisticated as the kings of England, whose mint published the price at which it would buy precious metals and then waited for members of the public to supply it with bullion. Most mints were left to their own devices, with their head officials, the mint masters, trying to persuade merchants to sell gold and silver at the best possible rate. Occasionally, for example in early fifteenth-century Prussia, the mint master would even engage in commerce himself, using the profits to subsidise minting (Volckart, 1996, p. 147). As he could of course not buy silver whose market value was higher than the nominal value of the coins he intended to produce, such practices had at best a limited effect: They could help cover the labour costs of minting, but not much else.

There were some further approaches. In the first place, any ruler would be able to increase the supply of bullion by debasing his currency. As long as the public did not become aware of the reduced bullion content of his coins, his mint would be able to offer a higher nominal price for the gold and silver it bought. Even when experienced merchants and money changers did notice that the coins they received from the mint had been debased, they might still accept them: If they expected to be able to pass them on to other consumers, whose ignorance or weak bargaining position they could exploit (cf. Rössner, 2012, pp. 574 f.), they would be willing to take them on much the same terms as pre-debasement money.

A related policy relied on the fact that most European polities (with the at least temporary exception of England) lacked clearly defined currency borders, which implied that many coins circulated outside their territory of origin. If a ruler copied a popular foreign coin, reducing its bullion content and changing the original design just enough to avoid exposing himself to the accusation of counterfeiting, he would have a good chance of finding consumers willing to accept it at its full face value. The most famous instance where such a measure was employed was the 'war of the gold "nobles"', that is, the imitation of English nobles by the Duke of Burgundy toward the end of the fourteenth century, which was designed to increase the inflow of gold into the Burgundian Netherlands (Munro, 1972, pp. 47 f.). However, similar policies were common in particular in parts of Europe such as the Holy Roman Empire, where a large number of currencies circulated side by side (Volckart, 2009, p. 105). If the ruler whose coins were threatened by underweight imitations reacted by debasing his own money, the result could be rounds of competitive debasements, '*guerres monétaires*', as Girard (Girard, 1940) called them, that in some cases could lead to extreme monetary instability.

Finally, some rulers were able to exploit their favourable geographical location. The archbishops of Cologne, Trier and Mainz and the Count-Palatine, for example, jointly

produced the so-called Rhinegulden, which became the most widespread commercial gold coin in the Holy Roman Empire and beyond. Obviously, the four rulers did not control any gold mines; and while Rhine wine was increasingly popular in the late Middle Ages, its export did not generate sufficient revenues to supply their mints with gold. However, the archbishops and the Count-Palatine did control much of the Rhine, which in the late Middle Ages developed into a transcontinental trade route of European importance (Chilosi and Volckart, 2011, p. 773). The customs posts that they maintained along the river demanded – occasionally by extortionate means – payments in gold, and this allowed supplying their mints with raw material and minting rhineguldens (Weisenstein, 1995, p. 171). Thus, if a ruler's territory straddled an important trade route and was costly to circumvent, he did not depend on a favourable balance of trade. Neither did he need to resort to manipulating exchange rates, debasing his coinage or imitating the products of foreign mints: Rather, he could exploit commerce to supply his mint, which would thus be in position that allowed it to produce a currency that was stable enough to become popular over a wide geographical area. Still, instances such as this were rare. Normally, the need to acquire the bullion necessary to keep up minting – and the stream of revenues derived from the mint – tended to water down the principles that Maximilian claimed to have learnt from his father's officials: Most medieval currencies were far less stable than the one he claimed to produce.

IV.

The previous section has shown that mint officials could enjoy different degrees of autonomy when it came to supplying the mint with bullion. In fact, how autonomous they were – that is, to what extent they were bound to follow directives of the political authority that officially enjoyed the right to issue a currency – differed in other fields, too. During the Middle Ages, rulers and governments experimented with a wide range of organisational options. One end of the spectrum was taken up by closely controlled officials who received fixed salaries. Semi-

independent entrepreneurs occupied an intermediate position: They might have to produce coins according to a prescribed standard and to pay a prescribed seignorage into the ruler's coffers but could in all other respects autonomously organise minting. The extreme end of the spectrum was taken up by entirely independent entrepreneurs who were free to determine monetary policies themselves. This implies that, on occasion, rulers were not even able to pursue their own policies in a core field of economic activity; it indicates that mint organisation was closely linked to issues of constitutional development and state formation.

One striking feature of the early Frankish coinage – the *trientes* or *tremisses* mentioned above – is that from about 570 the coins usually do not bear the name of the Merovingian kings ruling at the time they were minted. Rather, they are marked with the name of the mint and of the person who produced them, i.e. the moneyer. This does not only reflect the fact that the Merovingian kings never claimed a monopoly of minting; it was also a consequence of the breakdown of the state-run mints of late antiquity that ceased to be regularly supplied with bullion. In this situation, individuals – some of them wealthy and of relatively high standing – took over, producing coins as well as they could (Grierson and Blackburn, 1986, pp. 98-101). Many aspects of their currency are still poorly understood. Thus, the fact that moneyers marked their products with their names suggests some sort of accountability – but if they were accountable, then to whom? Hardly to the Merovingian kings, who do not even seem to have been willing or able to determine basic features of the Frankish currency such as the content of bullion of the *trientes* (Grierson and Blackburn, 1986, p. 109). Still, the seventh-century Frankish way of producing coins must have worked well enough to appear attractive to other rulers: seventh-century Anglo-Saxon England adopted the strongly moneyer-based organisation of mints (Naismith, 2011, p. 40).

A large degree of organisational autonomy was not a feature of early medieval mints only. One aspect of the breakup of the Carolingian Empire was the spread of the right to issue

coins, which was acquired – or successfully claimed without the consent of a king or emperor – by a large number of secular and spiritual authorities. In order to ensure that their agents followed directives, many of these regional rulers entrusted their mints to servile members of their households, so-called *ministeriales*. However, as in other contexts – *ministeriales* were widely employed in all branches of administrations – lords tended to lose control of their agents (Bosl and Weis, 1976, pp. 76 f.). Where mints were concerned, this happened all the sooner because many were located in towns whose political clout grew in the high Middle Ages. With the rise of commerce, the economically independent inhabitants began to form communes which became increasingly interested in restricting the power of their lord (Ennen, 1972/87, pp. 122 ff.). This affected the mint officials' status: Their former servility lost all practical importance, though they continued to acknowledge a formal link with the towns' overlord. A twelfth-century poem reflected this: 'I am a moneyer, the mint here is my rightful fief' it has one such quasi-official claim, 'God knows I need to flatter no-one, being wealthiest in this town' (von der Hagen, 1850, p. 112).

Early on, rulers who had installed *ministeriales* to manage their mints lost their right to appoint the mint master, which was taken over by cooperatives formed by the persons involved in the work of the mint. These cooperatives, called 'serments' in France, 'ministeria' in Italy and 'Hausgenossenschaften' in Germany (Spufford, 1988, pp. 15 f.; Jesse, 1930, passim), became increasingly well-organised, admitting new members by co-optation only and gaining a large number of privileges. By the twelfth century, they exercised an almost unlimited jurisdiction in matters relating to coinage: counterfeiting, offences against regulations concerning the exchange of currencies etc. (Jesse, 1930, p. 60; Travaini, 1988, p. 45). In France and Italy their members continued to be directly involved in the process of minting. In Germany, they focused on the monopolies they enjoyed in the bullion trade and currency exchange. Monetary standards might still be determined by the lords of

the cities or increasingly by autonomous urban governments, but the corporations supplied the mints with raw material and financed the production of coins (Jesse, 1930, pp. 61 f.).

When the costs of minting grew – for example because mint-output had to be increased at short notice – the corporations occasionally turned out to be unable to raise the capital that was required to finance production. In such cases, rulers might re-assert their control, only to give it away by farming out their mint. This happened all over Europe and seems to have been increasingly common from the fourteenth century onward. Farms might last for varying numbers of years – from one in France to up to five or more in Germany and Italy – and both their degree of formalisation and the terms under which they operated differed hugely between localities (Spufford, 1988, p. 17; Travaini, 1988, pp. 49 f.). The underlying principle, however, was the same everywhere, with William Turnemire's contract with the English government from 1279 being a typical example. William pledged to 'cause money to be worked for the present in four places' i.e. at London, Canterbury, Bristol and York. 'And in each of the aforesaid three places, Canterbury, Bristol and York, he shall have under him a master to keep the said mint and its appurtenances; and he shall at his own expense bear the expenses and payments of his men in those places …. So that the said Master William shall bear all the charges and expenses in the said four places, and shall deliver the money to the king … ready in every respect at his own expense. And the king shall give him for every pound of sterlings seven pence' (Johnson, 1956, pp. 59 f.). The farm holder would thus be responsible for financing and organising every aspect of production; his profit would consist in a share in the regular seignorage.

William Turnemire was French, which was rather unusual, as Italian firms were particularly active in the management of mints. In Hungary, for example, entrepreneurs from Florence and Padua dominated mint farming in the fourteenth century, being also engaged in transferring Papal revenues and political subsidies to Rome (Stromer, 1973-75, pp. 87 f.). The

Frescobaldi firm, likewise from Florence, was running the mint of Merano for the Bishop of Trent and the count of Tyrol, the mint of London for the king of England and the mint of Castel Capuana for the king of Naples. Other Italians were active in Dublin, Toulouse, Lübeck and Wrocław/Breslau (Spufford, 1988, p. 17). In the 1430s, the Teutonic Order in Prussia negotiated with the Alberti of Florence – at that time one of the largest trading companies of Europe –, eventually deciding against this option, however (Volckart, 1996, p. 110).

So far, no-one has systematically examined under which conditions rulers and urban governments farmed out their mints. Lack of capital was one obvious factor, but an analysis of a related phenomenon, i.e. tax farming, suggests that other issues may have played a role. According to Edgar Kiser (Kiser, 1994, p. 290), pre-modern rulers used their own administrative apparatus when they were able to adequately monitor and sanction the behaviour of their tax collecting officials. When direct control was impossible or too costly, they resorted to farming because this provided them with a reliable income and gave their agents a strong incentive to collect taxes. In other words, market relations – farms – prevailed when high monitoring costs made hierarchies inefficient. Often, the situation in minting was similar. In particular in late medieval Western and Southern Europe, some mints had a huge output: Already in the 1220s, the Canterbury mint produced well over 3 million pennies per year, which amounts to about 11,000 per day or more than 1,000 per hour, if we assume a working year of about 275 days and a working day of 10 hours (Spufford, 1988, p. 20; cf. Penn and Dyer, 1990, p. 366; Clark, 2005, p. 1308). The Flemish mint output about a hundred years later was even larger (Blockmans and Blockmans, 1979, p. 83). Under such conditions, monitoring production was a major task. As we will see below, producing coins was a complicated process that offered numerous opportunities for fraud and embezzlement. A ruler might employ a technical official – an assayer – to check the correct weight and

fineness of the coins. In addition, he might try to increase transparency for example by inviting representatives of urban elites to witness the assaying process – an option chosen for example by the grandmaster of the Teutonic Order in 1380 (Volckart, 1996, pp. 49 f., 396). However, making sure mint officials did not defraud him by manipulating the costs of raw materials and wages or by underreporting the quantity of money they produced with the aim of paying less than the agreed seignorage was a different matter. Farming out the mint reduced such difficulties. If a ruler could make potential farmers bid against each other, he could even auction off the farm for a lump sum which he would receive in addition to the seignorage. This probably accounts for the popularity of mint farming in the late Middle Ages.

However, there were parts of Europe were small mints proliferated. In the Holy Roman Empire of the fifteenth century, for example, even important estates such as Saxony or Brandenburg preferred maintaining several relatively small 'workshop mints', not least because sending money over large distances was dangerous in times when the enforcement of public peace left much to be desired (Ilisch, 1988, p. 159). Moreover, most mints belonging to smaller estates such as counts, barons, abbeys or towns operated only intermittently. Farming out such mints was impractical: It would have been unattractive for the potential farmer and unnecessary for the minting authority that, , was still capable of monitoring the mint personnel's performance given the small scale of production. Hence, most mint masters worked under conditions that began resembling those of modern public officials. They received a fixed and contractually determined salary, part of which was normally intended to cover the wages of their staff, too (Ilisch, 1988, pp. 163 f.). They also were regularly sworn in to their office. The oath the mint master of the town of Braunschweig took in about 1400 was typical: He promised 'for the present year to faithfully preside over the mint, to the good and

the benefit of the council and the whole town, and not to seek my own advantage above the salary that the council grants me' (Bode, 1847, p. 187).

V.

Coin production itself required not only organisational skills but also expertise in metallurgy. Determining the amount of pure gold or silver in an alloy was one of the most important tasks. The simplest way of doing this made use of a pair of instruments that allowed checking the fineness of precious metals: touchneedles and a touchstone. The touchstone was a dark, smooth stone like basalt; the edge of the coin that was to be tested was scraped over it, leaving a coloured streak. This colour was then compared to that of the streaks left by the touchneedles made of gold and silver of varying and known degrees of fineness. The method allowed the fine silver or fine gold content of coins to be determined with an accuracy of about 2 to 3 per cent (Redish, 2000, p. 22). Anything more precise required melting the coins with lead which would amalgamate with the base metals they contained and which would also be absorbed by the porous earthenware of the crucible. The pure gold or silver remained at the bottom of the pot, with the metal's high surface tension forming it into small beads that were weighed and set compared to the original weight of the alloy (Emmerig, 2006, p. 8).

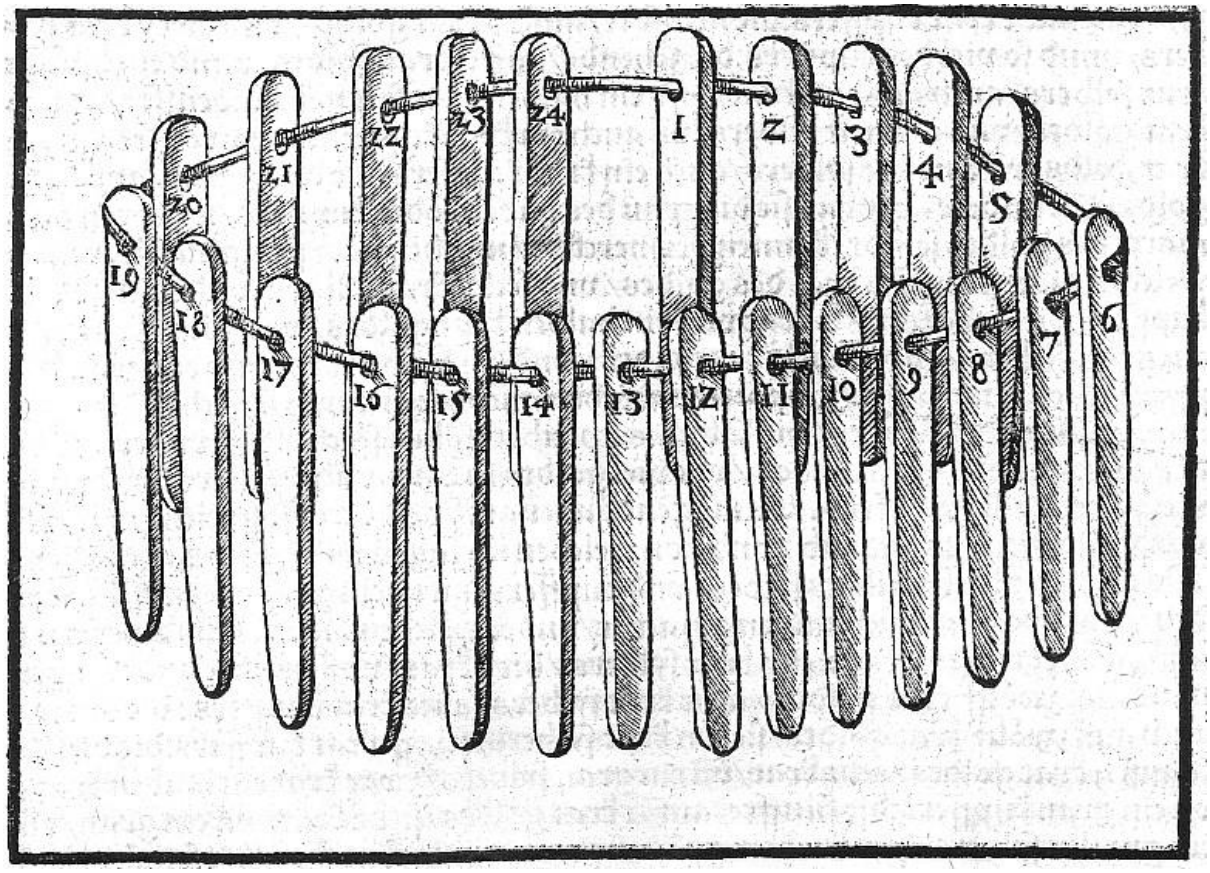

Fig. 4. A set of touchneedles. From Georgius Agricola's 'De re metallica libri XII*' (1556).*

Professional money changers, merchants and on occasion even peasants paid careful attention to the fine silver or gold content of the coins they were handling: Touchstones and touchneedles were widely known. Consumers sometimes tried to exploit minute differences between individual specimens of the same type of coins by culling, melting and selling those whose bullion content was highest. This could end in speculative crazes which could ruin whole currencies. Hermen Bote, a late fifteenth-century chronicler from Braunschweig, described such an episode: According to him, merchants were the first who 'traded and bought money for money or goods that were bullion and silver, and in this way became exceedingly rich, until at last the common burghers learned this trade too: Whoever had a good silver penny or a gulden of full weight solely looked to his advantage, until finally the peasants, too, learned this, so that no good penny, *groschen* or gulden would stay in circulation: whenever one appeared it was withdrawn' (Bote, 1880, p. 410).

To prevent such developments, it was essential that coins were produced as uniformly as possible, with deviations from the legally defined bullion content being kept to a technically unavoidable minimum. This, in turn, required precisely mixing the alloy of which the coins were minted – a complicated task that was not made simpler by the use of widely diverging regional metrological systems none of which was based on decimal relations between their respective different units. Thus, the most common unit of weight used to measure precious metals was the mark (locally different, anywhere between 190 and 250 metric grams) that was divided into 24 carats when measuring gold, and into 8 ounces, 12 deniers or 16 lots when measuring silver. Smaller units were e.g. the quentin ($^1/_{64}$ of a mark), the engels ($^1/_{160}$ mark), the grain ($^1/_{288}$ mark) etc. These units did not only denote weights, but also percentages: Thus, the carat was one twenty-fourth or 4.2 per cent, the quentin one sixty-fourth or 1.55 per cent and so on.

A problem set by a mid-fifteenth-century mathematical textbook shows how complicated manufacturing an alloy was using such units of measurement: ‘Item, a mint master plans to alloy 36 marks of silver whose fineness is 8½ lots with 53 marks 9 lots whose fineness is 8½ lots and 68 marks 12 lots with a fineness of 9¾ lots in such a way that the resulting bullion is 6¼ lots fine. He has old coins whose fineness is 3½ lots and which he wants to add to the alloy. The question is: How much of this aforementioned coined silver does he need to use in order to produce silver that is 6¼ lots fine?’ (Vogel, 1954, p. 118). Solving equations such as this (using Roman numerals and at best with the help of an abacus) was part and parcel of every mint master’s work.

Fig. 5. Using Hindu-Arabic numerals became common only at the end of the Middle Ages; before then, people used calculating boards with counters or, at best, an abacus (from Gregor Reisch's 'Margarita Philosophica' (Freiburg, 1503), fol. 79 verso).

Once mixed, the alloy was cast into ingots that were hammered until they reached the thickness required for the future coins. These so-called flans were produced by workmen such as the one shown on sitting and hammering a sheet of metal in the middle of the

woodcut illustration to Maximilian I's autobiography (fig. 1). The next step was cutting coin-sized pieces of metal (blanks) from the flan; the woodcut shows that this was done with shears, one of whose arms was fixed to a base such as a workbench (on the left of Fig. 1). The weight of the blanks of gold and large silver coins was individually checked and adjusted (*al pezzo*, to use the technical term), again using shears to cut off superfluous metal (underweight pieces went back into the crucible). The blanks of small coins were tested *al marco*, that is, the moneyer checked whether a prescribed number of them had a prescribed total weight, ignoring variations among the individual pieces (Emmerig, 2006, p. 13). If the alloy contained a high proportion of base metal, the blanks might be left for some time in a vat with wine scale acid. This would dissolve the base metal at their surface, leaving a thin coating of pure gold or silver. Finally, the blank was placed between two steel dies each of which was engraved with a negative of one side of the design of the coin. The lower die was fixed to a wooden block; the upper was placed by the moneyer on top of the blank and hit with a hammer – a process that transferred the dies' design onto the coin (this is what the workman on the right shown in Fig. 1 is doing, cf. Emmerig, 2006, pp. 16 f.). In the course of the production process, the metal was regularly re-heated to keep it from splitting. Like treating the blanks in acid, this caused a loss of weight which by the late Middle Ages was carefully recorded at each stage (as shown in the background of Fig. 1). Even in small mints, the whole process was characterised by a highly developed division of labour that despite the absence of mechanisation allowed a fairly large output.

VI.

Fig. 1 shows the young White King visiting such a small workshop-like mint. However, through his marriage to the daughter of the last autonomous duke of Burgundy in 1477 Maximilian became ruler of the Netherlands, the most developed part of Europe outside Italy. Flanders, Holland and Brabant had an advanced minting culture: In the late 1470s, the

quantity of money their mints issued equalled on average more than nine tons of fine silver per year; ten years later it was still almost seven tons per year (Munro, 2009, p. 78). We are therefore probably right to regard the woodcut from Maximilian's autobiography at least in part as an artistic simplification: Even before he became ruler of Burgundy, the Habsburgs controlled the rich silver mines of the Tyrol whose output they turned into coins (Moeser and Dworschak, 1936), and this must have happened in mints that had more staff than the few persons shown in Fig. 1. Once lord of the Netherlands, Maximilian became familiar with 'factory mints' (Spufford, 1988, pp. 19 f.) operating on a vastly larger scale. Still, the general economic, political and administrative principles that he had learned as a young man in his father's mint remained the same, and the woodcut that illustrated his autobiography shows an important part of them.

Illustrations

Fig. 1. http://digi.ub.uni-heidelberg.de/diglit/jbksak1888/0115 (creative commons-license CC-BY-SA 3.0 DE).

Fig. 2. https://archive.org/details/manueldenumismat02blanuoft (not in copyright).

Fig. 3. https://archive.org/details/dancabre00holb (Copyright either not claimed or not renewed; item is in the public domain).

Fig. 4. http://www.deutschefotothek.de/documents/obj/88960409/df_tg_0000409 (Gemeinfrei).

Fig. 5. https://archive.org/stream/gri_c00033125008256329#page/n161/mode/2up (not in copyright).

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