'LIGHT ON MANY JOURNEYS': A CRISIS IN CHARLES II'S SCOTTISH SILVER COINAGE LEADING TO THE CLOSURE OF THE MINT

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Introduction

In the second half of the seventeenth century, and following the Restoration in 1660, Scotland still possessed its own coinage, issuing both silver and copper coins.[1] The silver coins issued by Charles II, consisted of four, two, one, and half merk pieces struck from 1664 until 1675 and dollar, half, quarter, eighth and sixteenth dollar pieces produced from 1675 to 1682. In 1682 King Charles II ordered the closure of the Mint in Edinburgh while its chief officials were investigated for corruption. The Mint reopened in 1687. The events leading to the closure of the Mint are closely associated with two individuals, the Master of the Mint, Sir John Falconer, and the General of the Mint, Charles Maitland, Lord Halton, later 3rd Earl of Lauderdale (1620–91), the brother of the Duke of Lauderdale. Also implicated as joint General was the eldest son of Charles, Richard, Lord Maitland, who subsequently became Richard, 4th earl of Lauderdale.[2]

In roughly the two decades preceding the closure of the Mint, there appears to have been a long list of grievances against Lord Halton and his brother, the Duke of Lauderdale. The latter was a very influential figure and a member of the 'Cabal', an acronym for the names of the five ministers ruling Britain between 1668 and 1674. In the *Account of Scotland's Grievances by reason of the Duke of Lauderdale's ministries* in the *State Tracts* privately printed in the reign of Charles II and published in 1692, there is the following passage:

> the fourth grievance is, the 'corruption of our Mint and coinage', whereof my Lord Hatton, the Duke of Lauderdale's brother is general; this complaint was grounded in the universal clamour of the people; who hath found for several years, that the intrinsic value of our silver coin is sensibly diminished, both in its weight and fineness, to the nation's great dammage and dishonour; besides it doth add to the resentment, that the same Lord Hatton having some years ago filled the country with a light copper coin, without observing either the quantity or the weight and value prescribed, was nevertheless by my lord Lauderdale's means secured and indemnified; it is also remembered, that the better to enable him to this depravation of our silver coin, the Dutch dollars, called the Leggdollars, usually imported by our merchants, and current amongst us at 58d, per piece, were cryed down by the Duke of Lauderdale's procurement to 56d, for no better reason known, than that they might be brought in for bullion to the Mint-house for his brother's benefit: but though, that all demanded in Parliament about this matter was, that there might be an examination of the coin appointed, and an account given of the bullion which hath been long neglected; yet the memorial given in for that effect was not regarded: it is true my Lord Lauderdale after the December adjournment of the parliament, did move his Majesty to write a letter, and thereupon bring the business to a trial before the council; but in a manner so partial, that I profess it is my admiration how any man should have a confidence strong enough for such practices.[3]

The Duke of Lauderdale died in 1682 without issue, his dukedom became extinct and so Charles became the 3rd Earl Lauderdale. The above passage helps to set the scene leading up to the events of November 1681.

In November 1681 'a commission came down from his majesty to examine the accompts of the treasury, how the king's public money hath been spent, and employed these several years bygone'. The commission consisted primarily of enemies of Lord Halton and in May

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1 Bateson 1997, 143–9.
2 Cochran-Patrick 1876, I, cxci; II, 186–97; Murray 1969, 117–18.
3 Howell 1816, 170.

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1682 'they (the commission) proceeded, while Halton was yet in London, to take cognition by the declarations upon oath of all the members and officers in the Mint; and it is said Sir John Falconer in hopes to liberate himself, at least on promises that it should extenuate his own guilt, did do great lengths to load Halton with misdemeanours and malversations, by inverting the king's part of the emoluments of the Scots Mint to his own private gain'.[4] Another claim by Falconer against Halton was for 'making the fineness below the standard',[5] and a third accusation was 'in coining 17,000 stones of copper money, beyond the quantity contained in his majesty's two warrants for the copper journeys: all which struck as much, if not more, against himself as master, than against Halton; yet he presumed his openeness and ingenuity would procure him favour'.[6]

At the trial in the Court of Session the two were found guilty and were ordered to pay a very large sum (£72,000 sterling). This sum was actually never paid in full, and Lord Halton, although at the time of the investigation stripped of his offices, was able to regain his post as a member of the Privy Council in 1686. The same outcome was not reserved for the Master of the Mint who on the news of the verdict on 6 November 1682 'died suddenly of *creve-coeur* [broken heart]'.[7] On 24 November he was declared *felo de se* (felon to himself), an archaic legal term implying that he had committed suicide. On this account his 'movable escheat' passed onto Hugh Wallace on behalf of the Crown.

What was the evidence presented in the Court of Session? 'The lords found a grain above and below the standard weight, and two grains above and below eleven penny fine, as the standard of the intrinsic value and finess, were allowed only as a latitude to work on, where casually they fell above or under, because it would be insuperable labour to be precise; but found them culpable, the king's advocate proving they wrought on the remedies beneath standard, *as a constant advantage* [our italics], so that when they came to trone, or weigh a merk piece, if they found it exact weight, they would pare, raze or scrape a grain off, till it came to be remead; which fraudulent practice being known, the lords found them liable for restitution of these grains; and finding the article of John Falconer's bond to Alexander Maitland, was maid up of thir remeads, they resolved to confiscate the said sum to the king.'[8]

'Malversation' refers to all punishable acts committed while in the exercise of a public office, while 'journey' referred to each time a year the Mint was active. 'Heavy on this journey' was a term used to mean that the weight of metal coined yielded fewer coins than the number expected because each coin was above the standard weight. Hence there was a loss to the Mint, but, conversely, when coins were 'light on this journey' this meant that more coins were minted but at lesser weight, then the Mint gained.[9] Examination of the Mint registers for the years 1664–73 showed that 'from 1667 onwards, the term 'light on this journey' occurs with much greater frequency than its converse'.[10] Furthermore, one of the Lauderdale manuscripts contains a statement showing that between April 1674 and November 1676 the coins minted were light by nearly 10/12 stone, giving a gain to the Mint of £8,168 11*s*. Scots.[11] But did that gain go to the King's purse or to that of Lord Halton? It seems that the Commission thought the latter. However, regarding the practice *per se*, namely 'being light on any particular journey', this seems to have been an 'accepted' route.

Demonstrating 'malversations' associated with the production of coinage based on non-destructive pXRF (portable X-ray Fluorescence) analysis of numismatic evidence is a complex issue.[12] This is because analytical methods (destructive or non-destructive) which can determine chemical compositions cannot, on their own, corroborate or refute wrong-doing, the details and ramifications thereof being often quite complex. The fact that contemporary

4 Howell 1816, 157–8.
5 Howell 1816, 160.
6 Howell 1816, 160–1.
7 Howell 1816, 172.
8 Howell 1816, 178.
9 Murray 1969, 119.
10 Murray 1969, 119.
11 Murray 1969, 120.
12 Photos-Jones 2011.

accounts show that 'for the year 1677 every one of the twenty four journeys was "light"'[13] suggests that the system was deliberately and repeatedly manipulated. Presumably it would have been up to the officials of the Mint to make sure that 'the profit' was returned to the Crown. In any case, given the close scrutiny to which the Mint could have been subjected to at any time by the Government, it is unlikely that its officials would have been blatant and obvious in their malversations unless the Master of the mint *and* the General felt 'confident' of their position. For anyone with a lesser degree of confidence any wrong-doing would have required considerable subtlety.

The question addressed here is whether either the fineness and/or the weight of the Charles II silver coinage was affected, an act which would have complied with the commission's findings that the two parties were found guilty. It is clear that the personalities of the three men, their connections and standing within the Edinburgh political scene of the late 1600s had a major role to play. This had particular reference to Lord Halton and his son since, of the two parties concerned, Falconer seemed to have been the 'weaker link'. Whether the latter took his life through an act of conscience or was forced to do so, it is not possible to tell.

In light of this historical framework and our reading of the events, this article presents a programme of analysis of a series of Charles II silver coins, of various denominations, housed at the Hunterian Museum, University of Glasgow. The coins varied in date from 1664 to 1682, to cover the period referred to in the documents, and they included one of Charles I as well as some struck subsequent to the Mint's re-opening in 1687 (under James VII and II).

Table 1 gives the weight of various Charles II merk standard denominations[14] and includes a conversion table for the weights used at the Scottish Mint.[15] The Scottish Mint Troy ounce weights differed from the English. Cochran-Patrick gives the relationship between the two mints: 480 grains and 576 grains to the Troy ounce used in the English and Scottish Mints respectively.[16] Since 1 Troy ounce = 31.1 grams, it follows there were 15.43 and 18.52 grains to the gram, or 0.065 and 0.054 grams/grain for the English and the Scottish Mints respectively.

TABLE 1. Weight of Charles II coins, in grains and deniers (after Murray 1969, 120), in English Troy grains after Stewart 1967 and in Scottish Troy grains after Burns 1887

Coin	*Deniers*	*Grains*	*Primes*	*Seconds*	*Wt. (Scottish gr.)*	*Wt (English gr.)*	*Wt (g) assuming English. equivalent of 480 gr. per Troy oz*	*Wt (g) assuming Scottish equivalent of 576 gr. per Troy oz.*
4 merks	21	3	14	-	508	415.18	26.91	27.43
2 merks	10	13	19	-	253.79	207.59	13.68	13.71
Merk	5	6	21	12	126.92	103.79	6.73	6.85
Half merk / eighth dollar	2	15	10	18	63.46	51.89	3.36	3.4
sixteenth dollar					31.73	25.8		1.73

Note: Weights used at the Scottish Mint are quoted by Murray 1969, 116, n.1: 24 seconds =1 prime; 24 prime = 1 grain; 24 grains = 1 denier; 24 denier = 1 ounce.

Throughout the seventeenth century Scottish silver coins were struck at 11 deniers.[17] This implies that 11/12ths consisted of silver and the remainder of copper. Therefore 'eleven penny fine' implied a composition of 91.6 per cent silver. Allowances were made, as is clear from the statement of the Lords: 'two grains above and below eleven penny fine, as the standard of the intrinsic value'. From Murray's conversions in Table 1, 11 deniers equal 264 grains; it follows that 11.1 denier (equivalent to 266 grains) would give a composition of 92.5 per cent silver,

[13] Murray 1969.
[14] Murray 1969, 120.
[15] Murray 1969, 116.
[16] Cochran-Patrick 1876, I, lxxxiii, Table J.
[17] Murray 1969; Stewart 1967, 157.

while 10.9 denier (equivalent to 262 grains) would give a composition of 91 per cent silver. Given the foregoing we suggest that a range between 90 and 93 per cent silver would have been deemed acceptable.

Regarding weight, again allowances were made, as is again clear from the statement of the Lords: 'a grain above and below the standard weight'. A grain in weight corresponds to a range between 0.054 (Scottish)/0.065 (English) grams above and below the required weight Howell notes that they (at the Scottish Mint) would 'pare, raze or scrape a grain off'.[18] This implies that they were in a position to control weight to that level, although with what accuracy it is difficult to ascertain.

Method of analysis

Analyses were carried out in the Hunterian Coin Room using a Niton XL3t 900 SHE GOLDD Alloy Analyser, with a 50kV Ag X-ray tube, 80MHz real time digital signal processing and two processors for computation and data storage respectively; analyses were undertaken in the 'precious metals' mode with resolution of *c.*165 eV at 35 KeV. The coins, which appeared to be in good condition, were not cleaned in any way before analysis. Each coin was placed on the sample holder at a fixed distance from the X-ray source. The X-ray beam covered an area of 0.8 cm diameter. Each side of the coin was analysed twice for 60 seconds. Following analysis, the data was transferred via the Niton Data Transfer software to an Excel file and the spectra and the quantitative element determinations were scrutinised. The compositions were normalised to 100 per cent. The assayed Brett standards provided to us, courtesy of Niton UK, included NKPU5, NKPU6, NKPU7, NKPU8 (see Appendix 1 for accuracy and precision determinations). Weights were recorded to two decimal places (Table 3, p. 170).

Surface enrichment in silver is a common issue associated with silver alloys, in coinage or other artifacts. In the past, silver enrichment represented less of a problem since it was permissible to rub off some of the surface of the coin prior to analysis. This was the case with two studies on Scottish coinage: one, by Metcalf who used the XRF Isoprobe instrument to examine the quality of Scottish sterling silver dating from 1136 to 1280,[19] and the other by McKerrell and Stevenson who analysed some of the National Museum of Scotland's collection of Anglo-Saxon coins.[20] Both studies focused on abraded and polished coins respectively. In an attempt to establish instrument compatibility with existing data sets, we have compared Metcalf's XRF Isoprobe analyses of Scottish and English silver pennies in the Ashmolean and British Museum Collections[21] with ours (pXRF) of similar examples from the Hunterian's collection. Metcalf's study was based on cleaned and abraded coins; ours was on the existing surface. In our analyses, presented in Appendix II, the majority of coins fall in the range of 93−96 per cent silver with only four of our coins falling above the upper range. Metcalf's results, based on a much larger data set, showed the same trend towards a high silver content (93−95% Ag). It can be safely argued that both sets of analyses, one on surface (ours) and the other on abraded/'core' (Metcalf's), point to similar 'elevated' silver contents in the English and Scottish silver pennies, at least with respect to sterling (92.5% Ag) or 11 denier equivalent (91.6% Ag).

Surface enrichment of silver in silver-copper alloys has been extensively reviewed by Beck *et al.*, who applied a number of techniques including XRF, SEM-EDAX and PIXE for analysis and metallography for microstructure to silver-copper standards (80/20 to 30/70%) and some Roman silver coins.[22] They concluded that silver enrichment of coins arises mainly from the blank fabrication, at which stage there is segregation of the silver-rich phase to the surface; there may also be the later effects of corrosion and leaching which can add to the overall silver

[18] Howell 1816, 178.
[19] Metcalf 1977.
[20] McKerrell and Stevenson 1972.
[21] Metcalf 1977, 81−4.
[22] Beck *et al.* 2004.

enrichment. In their study of Viking age silver ingots by XRF, Kruse and Tate noted that surface enrichment could be significant.[23]

We undertook to address further the issue of comparative analysis between surface and core, with the pXRF. Two silver coins outwith the Hunterian's collection − a 1669 merk and a 1675 eighth dollar − were made available for sectioning.[24] A sliver was cut out of each coin, mounted on metallographic resin and ground and polished. Both the polished section as well as the unpolished surface of the same sample were analysed with pXRF. The results in Table 2 indicate that the merk has a slightly higher silver content on its surface than in section, suggesting there might have been some surface enrichment. On the other hand, the eighth dollar points to the opposite that is, slightly higher silver in the core. The number of analyses on the sections was restricted by the size of the slivers since the X-ray beam diameter was greater than the width of the sample.

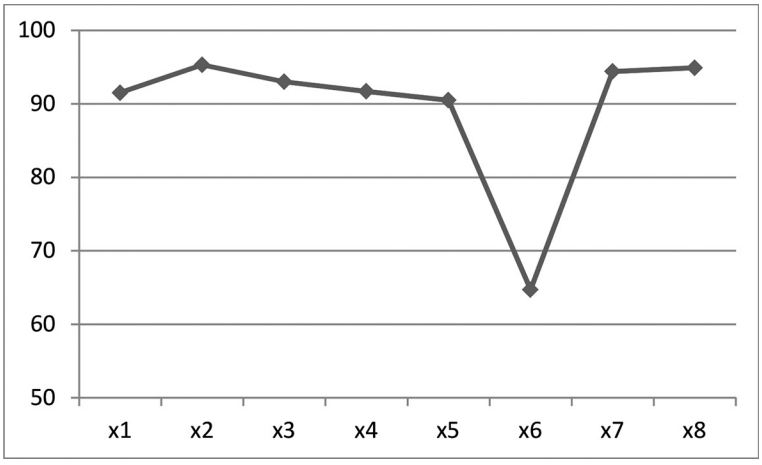
TABLE 2. Compositions of the section and surface of coins determined by pXRF analysis and normalized to 100 per cent

Coin	*Ag*	*Cu*	*Au*	*Pb*	*Zn*	*Sn*
1669 merk surface (6)	95.9	3.8	0.08	0.04	0.03	<LoD
1669 merk section (2)	94.0	5.7	0.08	0.06	0.04	<LoD
1675 eighth dollar surface (4)	90.0	8.1	0.08	0.10	0.06	0.33
1675 eighth dollar section (2)	90.6	9.1	0.08	0.11	0.05	<LoD

Note: The element contents are expressed as wt. percentages. Number of analyses is given in brackets. Ratio of %Ag section/%Ag surface for 1669 merk = 0.98; for 1675 eighth dollar = 1.01. LoD Limit of detection.

Given the analysis above, an additional set of analyses was undertaken to ascertain variation in Ag composition from surface to core by scanning electron microscopy with energy-dispersive X-ray analysis (SEM-EDAX). The small segments of the two coins were carbon coated prior to examination with a Philips ESEM XL30 with Oxford Instruments Energy-dispersive X-ray (EDX) microanalysis in Chemistry at Glasgow University.

Spot analyses were carried out at regular intervals along a single scan across the section of each coin. The values of normalised weight percentage of silver at each spot are given in Fig. 1; the variations in silver content along the line of measurements are small, and there appears to be no systematic upward gradient of silver concentration from core to surface indicating surface enrichment in the Charles II silver coins. However, these results are indicative rather than conclusive as the issue of surface oxidation, in the form of a sulphide layer, needs to be

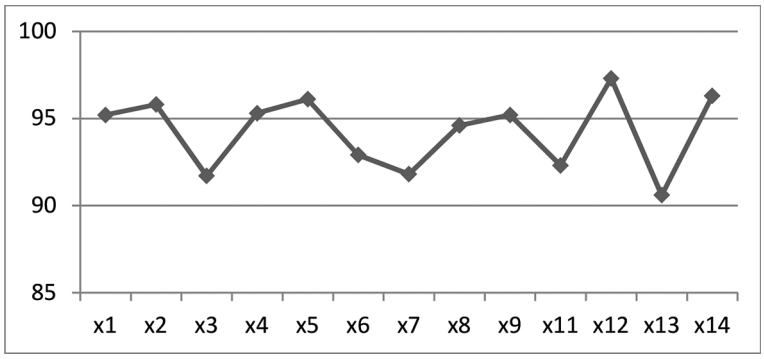


Position of spot analysis	*Percentage Ag*
x1	91.5
x2	95.3
x3	93.0
x4	91.7
x5	90.5
x6	64.7
x7	94.4
x8	94.9

Fig. 1a. Variation of percentage silver content across the section of a 1669 merk on a spot by spot basis from one external surface (position 1) through the core (positions 2−7) to the other external surface (position 8). Composition table (right).

[23] Kruse and Tate 1992.

[24] These were kindly presented by Peter Mitchell for this specific purpose.



Position of spot analysis	*Percentage Ag*
x1	95.2
x2	95.8
x3	91.7
x4	95.3
x5	96.1
x6	92.9
x7	91.8
x8	94.6
x9	95.2
x11	92.3
x12	97.3
x13	90.6
x14	96.3

Fig. 1b Variation of percentage silver content across the section of a 1675 eighth dollar on a spot by spot basis from one external surface (positions 1, 2, 12–14) through the core (positions 3–7) to the other external surface (positions 8–11). Composition table (right).

accounted for. Indeed in the case of the eighth merk spot analysis at places revealed up to 2.5 per cent S. Sulphur was not present in the core. The line scans in Fig. 1 show normalized data to 100 per cent and have only taken into account Ag and Cu.

Results: Fineness

Table 3 presents the results of the analyses and weights of the Charles II coinage. The silver contents are quoted in two forms: (a) as determined from the Niton software and (b) following correction by a factor calculated from the regression line arising from calibration with standards (see Appendix 1; calibration factor is 0.996). Figs 2a and 2b show silver content ranges

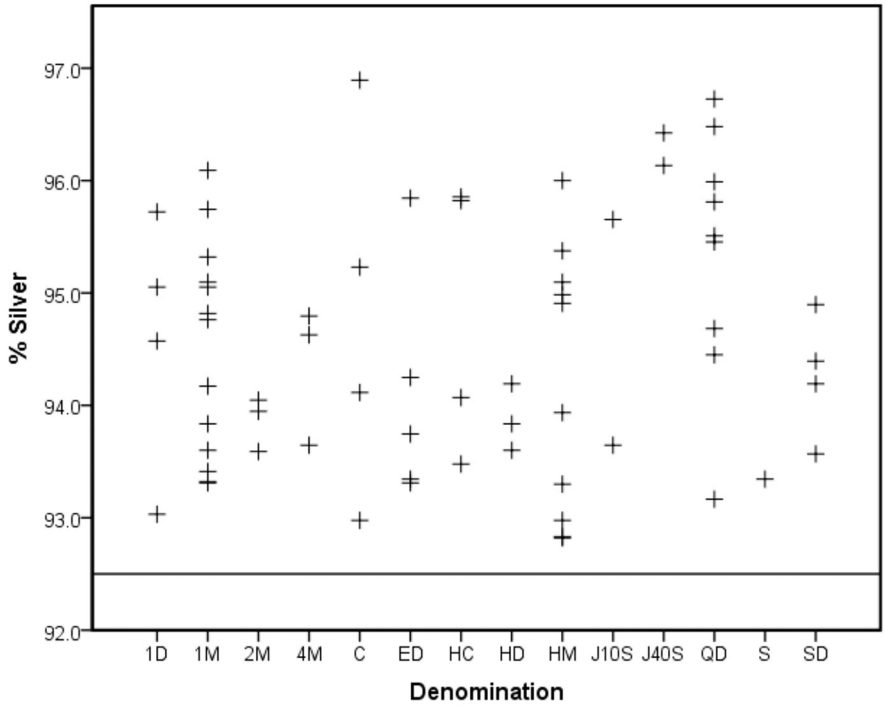


Fig. 2a. Silver content according to denomination: **1D** 1 dollar; **1M** 1 merk; **2M** 2 merk; **4M** 4 merks; **C** (English) crown, **ED** eighth dollar; **HC** (English) halfcrown; **HD** half dollar; **HM** half merk; **J10S (**James VII) ten shillings; **J40S** (James VII) forty shillings; **QD** quarter dollar; **S** (James VII) shilling; **SD** sixteenth dollar. The 92.5% Ag level is marked.

by denomination (Fig. 2a) and by year (Fig. 2b). The mean and standard deviation of each denomination are also given. All measurements are above the 92.5% Ag line, the majority ranging between 93.5% and 95.5% Ag with a mean of 94.6% Ag. This alloy resembles more Britannia silver at 958 fineness rather than sterling silver at 925 or indeed the 916 equivalent to 11 deniers. There is little variation in alloy composition after the reopening of the Mint. Displaying the ratio of Cu/Ag plotted against Ag content (both in percentages). When examining the Cu/Ag ratio in (%) it is clear from Fig. 2c that this ratio remained constant (3−6%) and consistently below the theoretical value (Cu/Ag = 9.2%) for a period of well over twenty-five years.

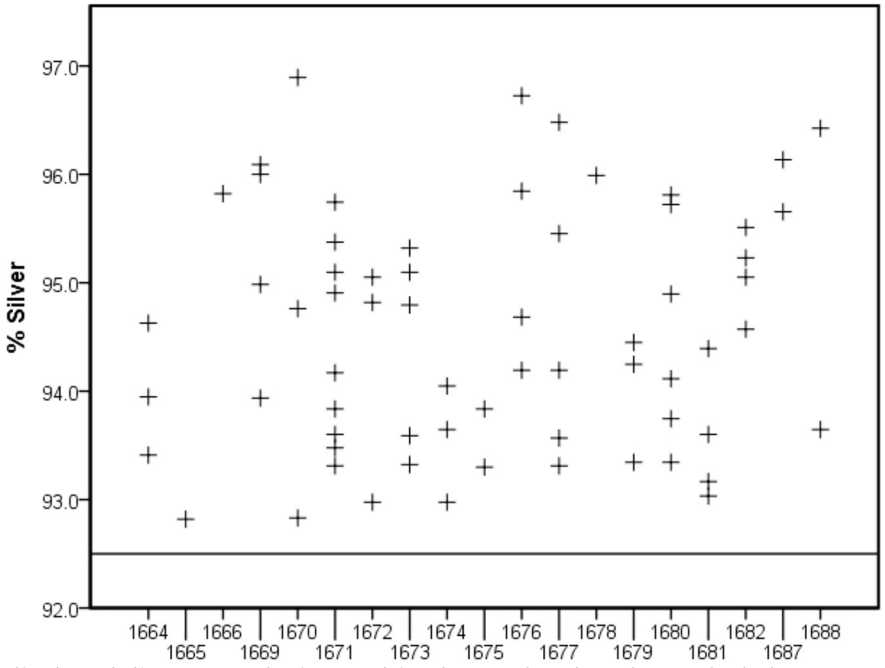


Fig. 2b. Distribution of silver content in the Scottish coins as a function of year of minting

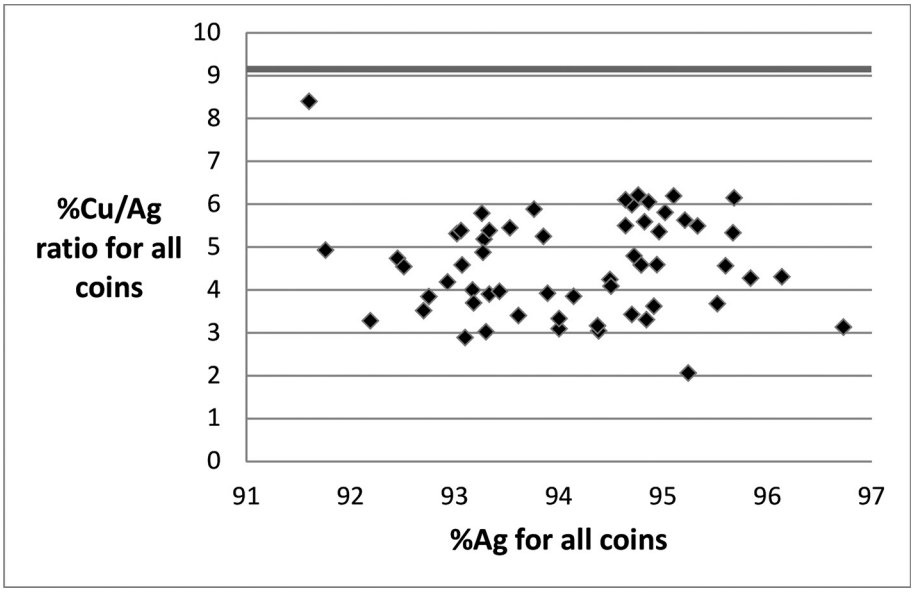


Fig. 2c. Plot of Cu/Ag ratio (in %) vs Ag content (in %)
Note: The ratio is between 3 and 6 per cent. Red line corresponds to the ratio (Cu/Ag = 9.2%) for the standard 11 denier coin.

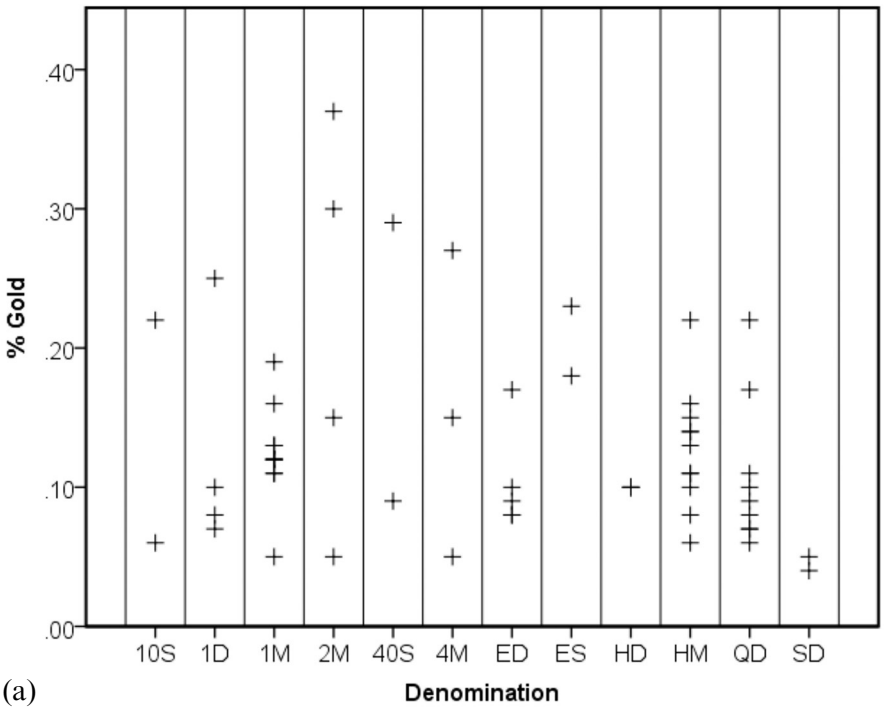
TABLE 3. The composition (weight percentage element) and (presently measured) weights (in grams) of Charles II coins

Hunterian Museum collection	*Coin*	*Ag corr.*	*Ag*	*Cu*	*Au*	*Pb*	*Zn*	*Fe*	*Sn*	*Hg*	*Wt.*	*Percentage difference from theoretical wt.*
18631	4 merk 1664	94.6	95.0	4.6	0.07	0.19	0.02	0.09*	<0.3		26.6	3.0
18632	4 merk 1673	94.8	95.1	4.3	0.12	0.15	0.05	0.11*	<0.3		26.17	4.6
21009	4 merk 1674	93.6	94.1	4.9	0.27	0.39	0.09	0.12	0.99		25.13	8.4
18633	2 merk 1664	93.9	94.4	5.1	0.03	0.19	0.05	0.23	<0.3		13.38	0.8
18634	2 merk 1673	93.6	94.1	4.9	0.37	0.17	0.13	0.2	<0.3		12.86	4.4
18635	2 merk 1674	94.0	94.5	5.1	0.15	0.08	<LoD	0.14	<0.3		13	3.4
18636	merk 1664	93.4	93.9	5.6	0.13	0.2	0.04	0.15	<0.3		6.55	4.4
18637	merk 1669	96.1	96.3	3.3	0.14	0.07	0.03	0.1	<0.3		6.17	9.9
18638	merk 1670	94.8	95.1	3.3	0.3	1.04	0.06	<LoD	1.01		6.03	12.0
18639	merk 1671	93.6	94.1	5.4	0.13	0.26	0.05	<LoD	<LoD		5.65	17.5
18640	merk 1671	93.3	93.8	5.5	0.16	0.28	0.06	0.3*	<0.3		5.91	13.7
18641	merk 1671	94.2	94.6	4.8	0.05	0.1	<LoD	0.42	<LoD		5.89	14.0
21010	merk 1671	95.7	96.0	3.4	0.11	0.2	0.05	0.22	0.4		5.93	13.4
21005	merk 1671	95.1	95.4	4.0	0.12	0.29	0.02	0.17*	1.07		6.2	9.5
21006	merk 1671	93.8	94.3	5.1	0.12	0.15	0.04	0.17	0.47		6.13	10.5
18642	merk 1672	95.1	95.4	3.7	0.17	0.34	0.06	0.37	<0.3		6.35	7.3
18643	merk 1672	94.8	95.2	4.1	0.11	0.25	0.08	0.18	0.36		5.7	16.8
18644	merk 1673	93.3	93.8	5.5	0.16	0.28	0.07	0.12	<LoD	*c*.1.0% obv., 0.4% rev.	6.13	10.5
21007	merk 1673	95.3	95.6	3.8	0.19	0.2	0.02	0.14	0.8		5.86	14.4
21004	half merk 1665	92.8	93.4	6.1	0.15	0.2	0.04	0.09	0.33		3.16	7.1
18645	half merk 1669	93.9	94.4	4.9	0.1	0.27	0.05	0.3	<LOD		3.09	9.1
18646	half merk 1669	96.0	96.2	3.5	0.06	0.06	<LOD	0.06	0.5		2.96	12.9
21011	half merk 1669	95.0	95.3	4.1	0.13	0.37	0.02	<LoD	0.46		2.82	17.1
23284	half merk 1672	93.0	93.5	5.4	0.22	0.27	0.09	0.39	1.41		3.17	6.8
23286	half merk 1675	93.3	93.8	5.8	0.15	0.06	<LoD	0.06	1.11		3.13	7.9
23287	dollar 1680	95.7	96.0	4.2	0.03	0.04	0.04	0.02*	1.1		26.44	3.6
23288	dollar 1681	93.0	93.6	6.0	0.07	0.12	<LoD	0.08*	1.1		26.2	4.5
23289	dollar 1682	95.1	95.4	4.4	0.08	0.03	<LoD	0.06*	0.89		26.5	3.4
21012	dollar 1682	94.6	94.9	4.7	0.1	0.16	0.04	<LoD	<LoD		26.48	3.5
23290	half dollar 1675	93.8	94.3	5.3	0.1	0.07	0.02	0.07*	1.08		12.9	4.2
23291	half dollar 1676	94.2	94.6	5.1	0.1	0.07	<LoD	0.06*	<LoD		13.06	3.0
23292	half dollar 1681	93.6	94.1	5.5	0.2	0.09	<LoD	<LoD	<LoD		12.89	4.2
23293	quarter dollar 1676	94.7	95.0	4.2	0.22	0.24	0.03	0.13	0.44		6.61	3.5
21013	quarter dollar 1676	96.7	96.9	2.7	0.08	<LoD	0.03	0.25	<LoD		6.46	5.7
23294	quarter dollar 1677	96.5	96.7	3.1	0.09	0.02	0.02	<LoD	<LoD		6.6	3.6
23295	quarter dollar 1677	95.5	95.7	4.1	0.08	0.05	<LoD	<LoD	0.47		6.53	4.7
18291	quarter dollar 1678	96.0	96.2	3.4	0.17	0.05	<LoD	0.14*	1	0.04	6.09	11,.1
23296	quarter dollar 1679	94.4	94.8	4.8	0.12	0.05	0.02	0.15	<LoD	0.13	6.48	5.4
23297	quarter dollar 1680	95.8	96.1	3.4	0.06	0.18	<LoD	<LoD	0.5	0.04	6.62	3.4
23298	quarter dollar 1681	93.2	93.7	5.9	0.07	0.12	<LoD	0.16	<LoD		6.57	4.1
21020	quarter dollar 1682	95.5	95.8	3.8	0.1	0.12	0.02	0.13	0.9		5.56	18.8
23299	eighth dollar 1676	95.8	96.1	3.5	0.09	0.08	<LoD	0.1	0.97		3.26	4.1
18292	eighth dollar 1677	93.3	93.8	5.4	0.17	0.09	<LoD	0.4*	1.1		3.11	8.5
21021	eighth dollar 1679	94.2	94.7	5.1	0.08	0.09	<LoD	0.15	1.4		3.18	6.5
21014	eighth dollar 1680	93.3	93.8	5.7	0.1	0.16	0.04	<LoD	<LoD		3.19	6.2
21001	eighth dollar 1680	93.7	94.2	5.4	0.08	0.12	<LoD	<LoD	0.58		3.24	4.7
21015	sixteenth dollar 1677	94.2	94.6	5.2	0.04	0.06	<LoD	<LoD	<LoD		1.63	5.8
21002	sixteenth dollar 1677	93.6	94.0	5.0	0.27	0.33	0.06	0.12	0.56		1.56	9.8
35399	sixteenth dollar 1680	94.9	95.2	4.3	0.05	0.18	<LoD	0.11*	1		1.51	12.7
21003	sixteenth dollar 1681	94.4	94.8	4.2	0.18	0.34	0.03	0.28	0.93		1.73	0
18290	half merk 1670	92.8	93.4	6.0	0.11	0.28	<LoD	0.09*	1.1		2.76	
18455	half merk 1671	95.4	95.7	3.8	0.11	0.27	<LoD	<LoD	0.8		3.25	
18284	half merk 1671	94.9	95.2	4.3	0.08	0.24	<LoD	0.11*	0.8		3.01	
23285	half merk 1673	95.1	95.4	3.8	0.16	0.33	0.07	0.14	<LoD		2.99	
21008	half merk 167-	95.2	95.5	3.7	0.14	0.24	0.11	0.3	0.9		3.3	

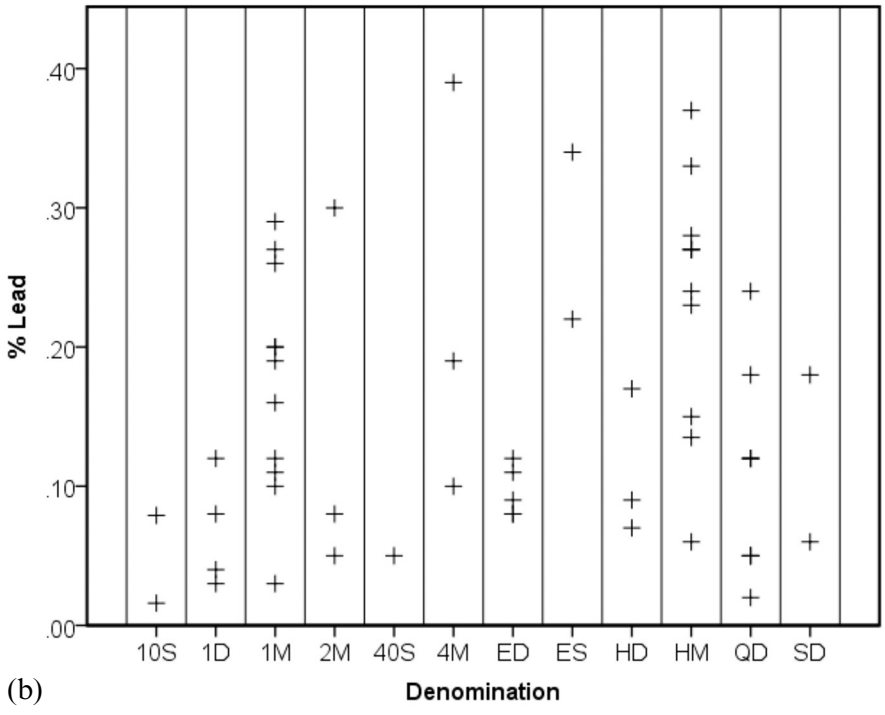
35460	crown 1670	96.9	97.0	2.6	0.03	<LoD	0.14	0.029	0.26		30.4
35461	crown 1674	93.0	93.5	4.4	0.23	0.056	0.74	0.844	0.24		29.88
35462	crown 1680	94.1	94.5	4.7	0.06	0.076	0.11	0.34	0.24		29.76
35463	crown 1682	95.2	95.5	3.9	0.04	0.044	0.11	0.135	0.21		30.02
18901	halfcrown 1641–3 rev.	95.9	96.09	2.12	0.18	0.18	1.18	0.11	<LoD	0.15	14.19
18901	halfcrown 1641–3 obv.	94.1	94.49	2.34	1.52	1.59	0.45	0.13	1.2	*c.* 6% obv.	14.19
35464	halfcrown 1666	95.8	96.1	3.1	0.09	0.077	0.05	0.325	0.22		14.19
35465	halfcrown 1671	93.5	94.0	5.5	0.06	0.159	0.03	0.118	0.18		14.66
35466	shilling 1677		93.8	5.4	0.1	0.215	0.11	0.17	0.18		5.89
35467	shilling 1679	93.3	95.1	4.2	0.05	0.05	0.1	0.261	0.19		6.05
21016	40 shillings 1687	96.1	96.3	3.5	0.09	<LoD	<LoD	<LoD	0.97		18.27
21017	10 shillings 1687	95.7	95.9	3.7	0.06	0.16	<LoD	<LoD	<LoD		4.6
21018	40 shillings 1688	96.4	96.6	2.9	0.06	0.22	0.07	0.079	<LoD	<0.5	18.34
21018	10 shillings 1688	93.6	94.1	5.4	0.04	0.29	0.04	<LoD	<LoD		4.55

Note: The last column gives the percentage difference between the actual weight and the (higher) theoretical value. Limit of detection (LoD) Pb <0.03%, Zn <0.01%, Fe <0.02% and Sn <0.15%. See text for * in some Fe determinations. Theoretical weights are given as follows: 4 merks = dollar = 27.37 g ; 2 merks = half dollar = 13.68 g; merk = quarter dollar = 6.87 g; half merk = eighth dollar = 3.48 g ; sixteenth 1/16 dollar = 1.74 g.

Turning to the impurities, gold, lead and zinc are present at less than 0.5 per cent (Figs 3a–c). There is no correlation between gold content and date of issue. Among the denominations, gold is most variable in the 2 merk followed by the 4 merk coins. Iron was often detected on one side of the coin but not the other (as indicated by those entries in Table 3 with *) suggesting its presence was associated not as impurity in the silver but as surface contamination. Mercury was present in low concentration in a few coins – 18291, 18644, 23296 and 23297 – and at a significant concentration in 18901.



(a)



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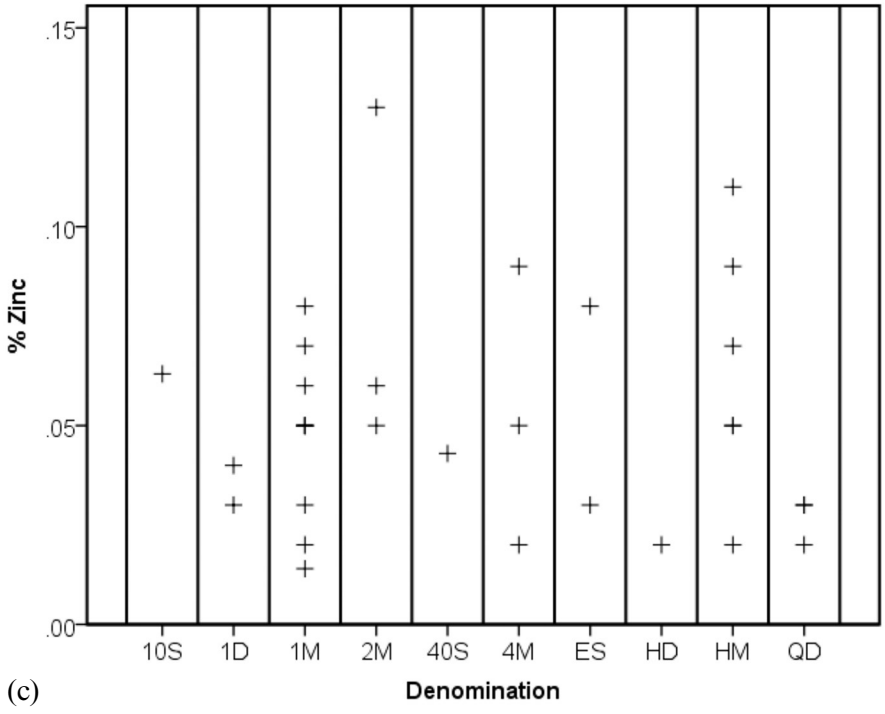

(c)

Figs. 3a–c Distribution of content of (a) gold, (b) lead and (c) zinc in all Scottish coins except GLAHM 18644 and 18901, according to denomination

Results: Weight measurements

Turning now to the issue of the coins' weights (see Table 3), all of the coins are lighter than their theoretical weights with variations up to 20 per cent for some of the lower denominations, such as the merks. We have no theoretical values for the 40 shilling and the 10 shilling coins. We regard wear and tear as being minimal on account of the coins' good condition, and so that leaves deliberate tampering of the coins. Figs 4a (merks) and 4b (dollars) show the weights in reference to their standard values, all below their theoretical values. Therefore, on the issue of weight, we are in agreement with the king's advocate that 'they wrought on the remedies beneath standard, as a constant advantage'.

When examining the weights of precious metal coins there is an additional factor which needs to be considered, namely culling.[25] Once a new issue has been put into circulation there is a natural tendency for the public to remove the higher weight coins for hoarding or melting down. This practice has been recorded in the thirteenth century in association with the Venice Mint.[26] Stahl notes that in medieval Europe, given that the public could retrieve any precious metal from the coinage through refining by any goldsmith or silversmith, it was customary for people engaged in commercial transactions to 'pay attention to the weight of individual pieces (rather than counting the individual coins) and follow a policy of spending the lighter ones and saving the heavier ones'.[27] Culling is somewhat fortuitous and incomplete, with the result that a small number of coins close to or slightly above the standard weight usually remain.[28] However, this does not appear to be the case with the Hunterian coins analysed here, where not one of the weights recorded in Table 3 is above the standard. The same trend is to be found with the coins of these issues in the Ashmolean Museum, Oxford.[29] The large group of 203 silver coins of this period at the National Museum of Scotland (Table 4) displays a similar pattern.[30]

Thus, with the exception of the smallest value, the sixteenth dollar, of which four of the eight specimens are over standard by less than one grain, none of the other weights is above. There is an odd consistency here, suggesting the coins of these issues were culled by the Mint authorities prior to their being put into circulation. Howell's account that they (the Mint) 'pared and razed off' grains suggest that there may have been a persistent practice for a combined clipping and culling, not on the part of the public but the Mint itself, at least for that twenty-year period.

TABLE 4. Weights of silver coins in the National Museum of Scotland collection

Denomination	*Coins*	*Mean wt (gr.)*	*Standard wt (gr.)*	*Percentage of standard*	*Range*
4 merk	12	403.9	415.2	97.3	397.2–408.6
2 merk	21	197.6	207.6	95.2	182.2–204.4
Merk	70	95.1	103.8	91.6	85.3–100.6
Half merk	39	48	51.9	92.5	42.4–50.8
Dollar	9	407.7	415.2	98.2	401.3–411.2
Half dollar	4	202.3	207.6	97.4	201.4–204.1
Quarter dollar	25	99.7	103.8	96.1	96.1–102.8
Eighth dollar	15	49	51.9	94.4	44.7–50.8
Sixteenth dollar	8	25.9	25.8	100.4	24.7–26.7

[25] We are grateful to Edward Besly for suggesting that this aspect be included to cover a larger corpus.
[26] Stahl 2000, 76.
[27] Stahl 2000, 227.
[28] Besly and Cowell 1991, 66–7, Table 3 and 69, Fig. 1.
[29] Ashmolean and Hunterian, *SCBI* 35, Pl. 96–103 *passim.*
[30] We are grateful to Nicholas Holmes, National Museum of Scotland, for supplying weights from the forthcoming NMS *SCBI* volume covering seventeenth-century Scottish coins.

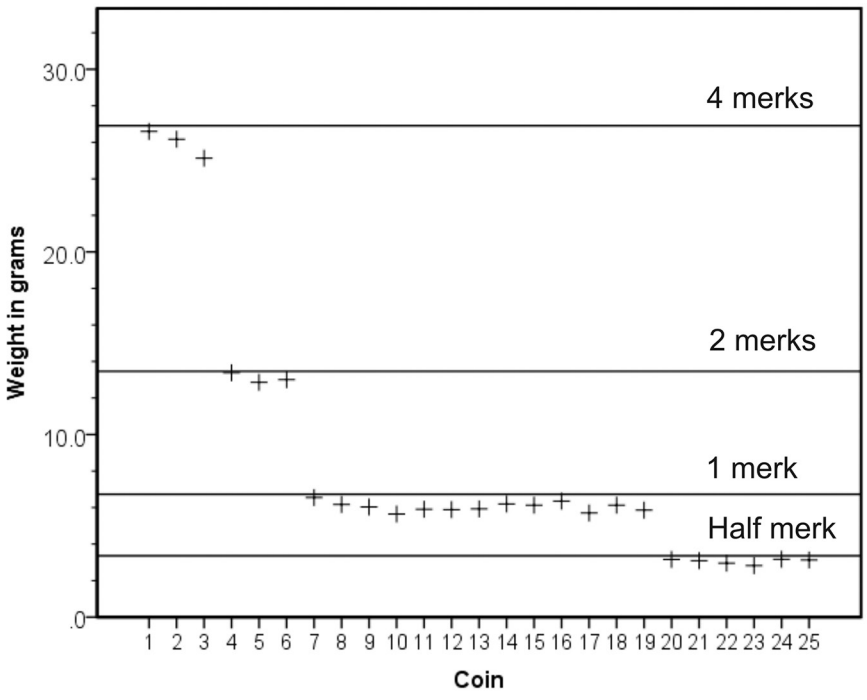

Fig. 4a. Actual measured weights (g) of individual Charles II 4 merks, 2 merks, merk and half merks
Note: Theoretical weights are shown as horizontal lines, except for the sixteenth dollar.

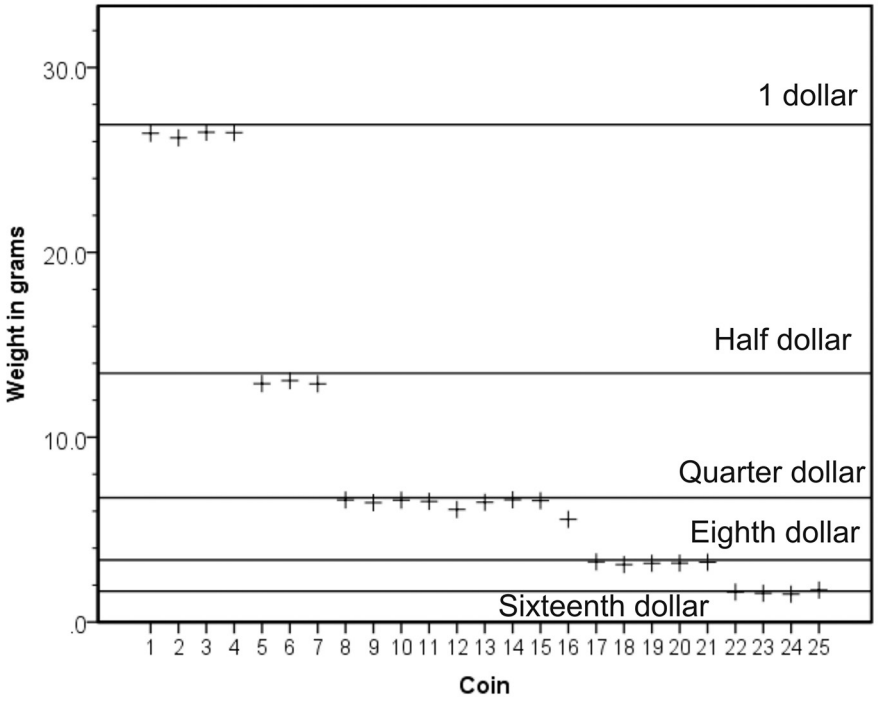

Fig. 4b. Actual measured weights (g) of Charles II dollar, half, quarter, eighth and sixteenth dollar
Note: Theoretical weights are shown as horizontal lines, except for the sixteenth dollar.

Discussion

This article has set out to determine the fineness and measure the weight of a number of Charles II coins of various dates from 1660 to the closure of the Mint in 1682. It has also examined the evidence 'against' the Generals (Lord Halton and his son) and the Master (Sir John Falconer) of Charles II's Edinburgh Mint. The results suggest the following: first, the fineness of the coins is above that of 11 denier (916), and second, the weights of the coins lie below the theoretical values for merks and dollars.

Regarding the fineness, considerable effort has gone into ascertaining that the 'higher than expected' silver values do not arise either from surface enrichment or from instrument calibration issues. Accuracy and precision (Appendix 1) were measured, and both were found to be very good for silver, less so for copper. Data comparisons with similar data sets (silver English and Scottish coins previously analysed also with XRF, Appendix 2) were carried out. In order to assess the possibility of silver enrichment on the surface the Charles II silver coins, it was possible to section two coins, a 1669 merk and a 1675 eighth dollar, and analyse by pXRF both the section and the surface of the cut slivers. It was established that for the merk there was essentially no difference in silver content between section and surface (Ag ratio between core and surface = 1.01) and for the eighth dollar the ratio was similar (ratio = 0.98).

To corroborate the existence of these very small differences between section and surface, the two slivers were also analysed with SEM-EDAX, which allows point by point analysis as opposed to area analysis provided by pXRF. The SEM-EDAX data confirmed the absence of silver enrichment trends between surface and core. The excellent agreement between pXRF and SEM-EDAX analyses lead us to confirm that, if variations due to surface enrichment exist, they are small and on occasion even negligible. Since silver enrichment is related to the way the blank is produced, rather than its silver content, and, although we cannot confidently extrapolate on the basis of these two coins to the entirety of the collection, we suggest that the practice was consistent enough throughout the period to produce coins with no significant surface silver enrichment.

Having addressed the issue of surface enrichment, we believe there is good reason to accept the results at face value, namely that the fineness was consistently high and indeed above that documented in the numismatic literature as standard. We cannot provide a definitive reason as to why this was the case. In examining the four coins minted *after* the reopening of the Mint (Table 3, p. XXX) (1687 40 shilling (96.1% Ag); 1688 40 shilling (96.4% Ag); 1687 10 shilling (95.7% Ag); 1688 10 shilling (93.6% Ag)) it is clear that there is no substantial 'fall' in the silver content; it remains above 11 denier. In their XRF analysis of English Civil War coinage of Charles I, and having abraded the surface sufficiently to acquire a clean edge, Besly and Cowell pointed out that 'coins produced to a silver standard of 925 may give results in the range 91–94% silver. Those lying outside these limits are therefore significantly different from the standard, while those giving results below 90% or above 95% may be regarded as certainly "out of remedy"'.[31] As mentioned earlier, for the Scottish Mint, the accepted range was 90–93% Ag.

What about the malversations? There have been accusations that Lord Halton was responsible (it could not have been just himself, without Falconer's assistance) for the fineness of the silver coins being below standard; however, this is not corroborated by the chemical analysis since the amount of silver in each coin routinely exceeds 11 deniers. Regarding the weights, as we have argued above, who exactly benefitted from the Mint being 'light on many journeys' is not clear, but given the accusations levelled against Halton by the commission, it seems it must have been Lord Halton. One passage in the documents may be worth investigating further. This is Lord Halton's association with the mis-management of copper stock at the Mint. Falconer in his statement against Halton declared that he (Halton) was responsible for 'coining 17,000 stones of copper money, beyond the quantity contained in his majesty's two warrants for the copper journeys'. It may be useful to examine the quality of the Charles II

[31] Besly and Cowell 1991, 59.

copper coinage over the same period at the Edinburgh Mint, and with regards to its possible silver content. An evaluation of the composition, with pXRF, of the source material, namely, the silver bullion (Dutch Leggdollars or other) may illuminate further the reason for the elevated, with respect to standard, silver content. There is, in our view, considerable further work to be carried out in the future by combining the documentary numismatic record with non-destructive pXRF, with potentially very interesting results.

APPENDIX 1: ACCURACY AND PRECISION DETERMINATIONS

Percentage accuracy was determined from the measured value divided by the certified value × 100, using the instrument's 'precious metals' mode. Accuracy for Ag was 99%, but 91% for Cu (Table 5a). Precision was calculated from replicate analyses each of the obverse and reverse of a £1 sterling coin of 2012 and expressed as %coefficient of variation ((standard deviation/mean) × 100) (Table 5b). For silver, precision and accuracy are reassuringly good, while the accuracy for copper determination is relatively poor.

TABLE 5a. Accuracy determinations with respect to precious metal standards from four replicate analyses

NKPU Standard	*Certified %Ag*	*Mean %Ag*	*Certified %Cu*	*Mean %Cu*
NKPU5	92.8	93.1	7.2	6.8
NKPU6	99.99	99.91		
NKPU7	92.72	93.16	6.57	6.08
NKPU8	88.51	89.78	10.16	8.6
Overall accuracy for Ag: 99%				
Overall accuracy for Cu: 91%				

TABLE 5b. Precision of Ag and Cu determinations in £1 sterling silver coin of 2012

	Mean of six analyses	*S.D.*	*Precision*
Cu	7.21	0.029	0.405
Ag	92.73	0.028	0.03

APPENDIX 2: SCOTTISH AND ENGLISH PENNIES

Table 6 gives the composition of twelve Scottish and English pennies in the Hunterian's collection. In comparing the two data sets for Scottish and English pennies, obtained with pXRF (ours) and XRF (Metcalf 1977), it is clear that the majority of coins analysed fall in the range of 90–95% silver with only four of our coins falling above the upper range. Au, Pb, Zn and Fe appear as impurities with possible presence of Bi detected in some.

TABLE 6. Composition (weight % element) and weight of Scottish and English pennies

Coin	*Description*	*Ag*	*Cu*	*Au*	*Pb*	*Zn*	*Fe*	*Bi*	*Wt (g)*
GLAHM35468	England: Stephen type 1 Carlisle	94.30	4.10		0.25	0.04	0.335	present	1.35
GLAHM35469	Scotland: David I phase d Roxburgh	90.85	7.83	0.43	0.69	0.048			1.03
GLAHM35470	England: Henry II Tealby A1 London	93.69	4.26	0.33	0.75	0.051	0.75		1.42
GLAHM35471	Scotland: William I Crescent and Pellet II Edinburgh	93.6	4.895	0.28	1.04	0.037			1.44
GLAHM35472	England: Short Cross class 1 London	95.17	3.46	0.32	0.66	0.033	0.26		1.21
GLAHM35473	England: Short Cross class 7 London	96.15	2.55	0.36	0.80	0.024			1.37
GLAHM35474	Scotland: William I Short Cross A Edinburgh	96.05	2.77	0.19	0.70	0.035	0.06		1.45
GLAHM35475	Scotland: William I Short Cross B Hue Walter	96.57	2.42	0.20	0.60	0.026			1.38
GLAHM35476	England: Long Cross class 2 London	91.53	4.47	0.26	0.81	0.036	2.57		1.50
GLAHM35477	England: Long Cross class 5g London	89.95	5.96	0.20	0.81	0.050	1.87	present	1.49

GLAHM35478	Scotland: Alexander III Long Cross III Berwick	95.9	2.74	0.32	0.79	0.024	0.13	1.25
GLAHM35479	Scotland: Alexander III Long Cross VII Glasgow	92.50	6.54	0.24	0.41	0.046	0.11	1.41

A comparison of the two data sets, Metcalf's (with XRF) and ours (with pXRF), is shown in Fig. 5. Metcalf's data set ranges between 90 and 95% Ag, the majority between 93 and 95% Ag. Our data set is substantial smaller but still shows the majority containing between 93 and 96% Ag. Only two samples contain *c*.90% Ag.

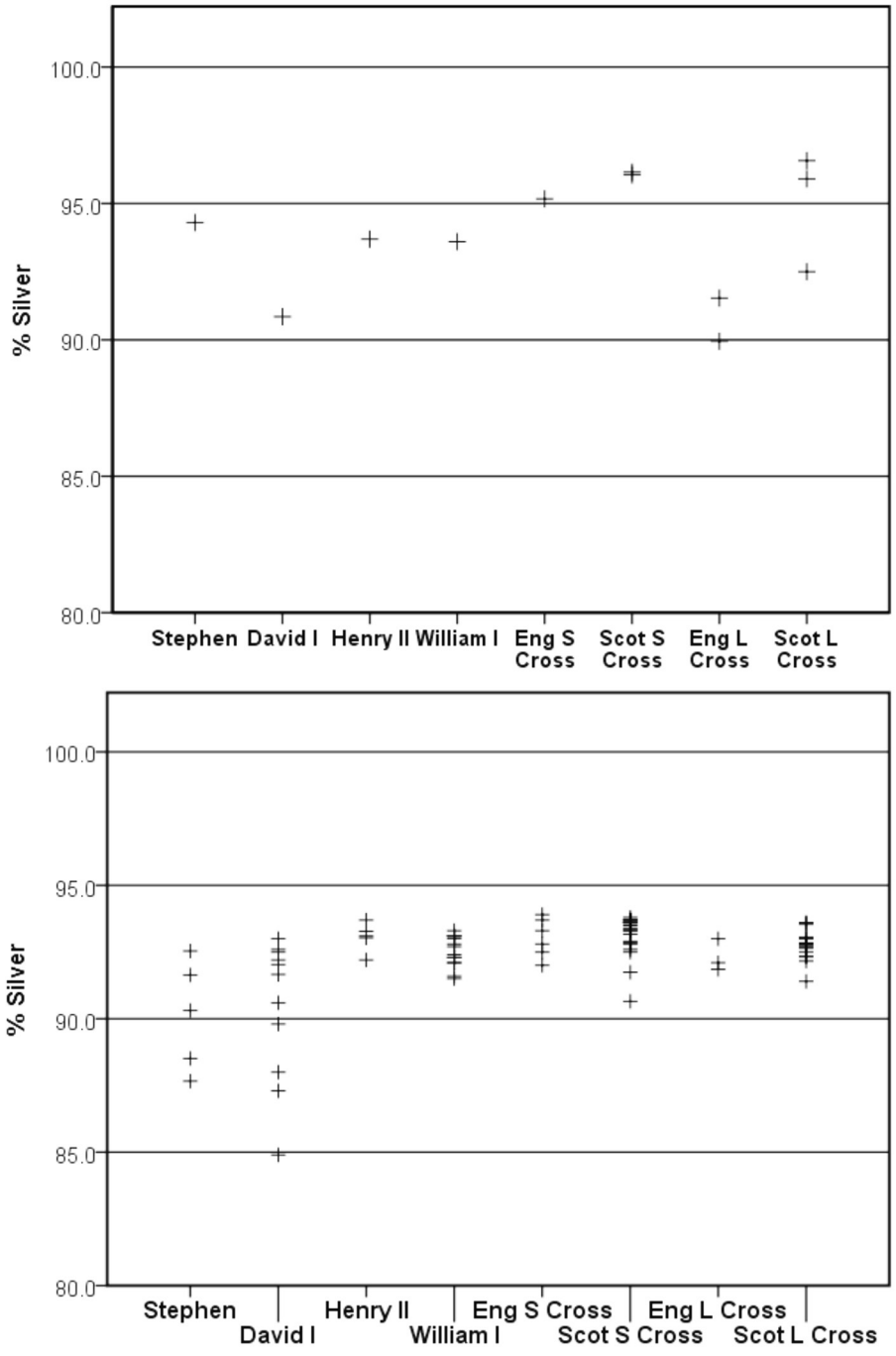

Fig. 5. Silver content in Scottish and English pennies analysed by us (top) and by Metcalf (1977) (bottom)
Note: L and S Cross refer to Long and Short Cross respectively.

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