Mind the Gap! Roman Republican coin hoards from Italy and Iberia at the end of the second century BC

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1 Introduction

For many years I have been both collecting and analysing data on Roman Republican coin hoards.[1] The aim of these analyses has been to identify patterns of coinage found within these hoards, and to understand how these patterns came about. We can, for example, see how the coins in hoards that close immediately after the Battle of Thapsus in 46 BC reflect where Caesar's troops, and those of the *optimates*, went to after the battle.[2] During these analyses, I observed an unusual pattern in hoard closing dates for the period 118–97 BC.[3] From 118–113 BC the majority of hoards came from Italy or Sicily, after which there is a ten-year gap in the Italian sequence until about 104 BC. This gap is, in itself, highly unusual in a period of continuous coin manufacture. What makes this gap even more enigmatic is the fact that in the *same* period there is a peak in hoarding activity in the Iberian Peninsula. This peak in the hoards from Iberia exceeds all other periods during the Republic, even the Civil Wars. At the time my interpretations were tentative, as the analyses were based on Crawford's dating scheme[4] (see below). In 2007 I returned to this problem and analysed an expanded data set by individual issues.[5] This revealed that the pattern persisted strongly at the level of individual issues and that certain issues appeared to be key points in the sequence, especially, for example, RRC 286/1.[6]

This pattern, which for the sake of brevity I refer to as 'the gap', raises a number of questions. Is 'the gap' real, or is it a function of our dating schemes? If it does exist, can we identify which issues are involved? Why does this gap exist, and what might it tell us about the nature of coinage supply and use in the later Roman Republic?

The supply of Roman Republican coinage to the Iberian Peninsula was episodic, with the peak of coinage supply in the late second century noted above, and further peaks in the 70s BC and in the 40s BC during the first decade of the Civil wars (see Fig. 17).[7] Despite this episodic supply over the two centuries from the Second Punic War to the end of the Republic, Roman issues became the principal form of coinage in the Iberian Peninsula. Also, during these two centuries, many local coinages were struck on the Roman model, the so-called

1 Lockyear 2007, 2016.
2 Lockyear 2007, pp. 116–20.
3 Lockyear 1996b, sections 8.3.3–8.3.4.
4 Crawford 1974.
5 Lockyear 2007, pp. 77–9.
6 Abbrevations used in this paper: RRC = *Roman Republican Coinage* (Crawford 1974); RRCH = *Roman Republican Coin Hoards* (Crawford 1969c); IGCH = *An Inventory of Greek Coin Hoards* (Thompson *et al.* 1973).
7 Lockyear 2007.

‘Iberian *denarii*’, the date and function of which is still much debated.[8] Useful summaries of the monetary history of the area have been published by Ripollés.[9]

This paper has two aims. Firstly, it seeks to re-examine ‘the gap’ in depth and assess the strength and nature of the pattern, including which issues are associated with it. Secondly, it seeks to assess the impact on that pattern of the proposed re-dating of the issues from the end of the second century and the beginning of the first century BC by the late Harold Mattingly.[10] In working to achieve these two principal aims, the paper also demonstrates both the advantages and limitations of multivariate statistical analysis of coin hoard data. To conclude, some possible explanations for the pattern are discussed.

One may question why such an array of multivariate statistical techniques have been applied to this problem. Why not simply list the hoards and issues associated with ‘the gap’? Such a simplistic approach would be reliant on our available chronologies, be they Crawford’s, Mattingly’s or any other scheme. With such a subtle pattern, we need to apply techniques which are *independent* of those dating schemes. The difficulties are compounded by two other aspects of the data. Firstly, the issues vary greatly in size, some are very common, some are very rare. It is likely that part of the patterning we can observe in the data may be the result of simple random variation. We need methods which give us some indication of the confidence we can place on the results, not just in overall terms but also on each individual hoard and/or issue. Secondly, coins circulate. Just because an issue is released in place A, does not mean that in time it will not form part of the coinage pool in place B. For the current problem, issues released into the coinage pool in Italy will eventually arrive in Iberia and *vice versa*. This will inevitably cause some blurring of any initial pattern.

1.1 Dating schemes

The dating scheme presented in *Roman Republican Coinage* is not universally accepted, in part because of the tight date ranges offered that seem to many to be overly precise given the evidence available, and in part because new finds have forced a reassessment of some parts of the scheme. For the period under consideration here, the break in Crawford’s sequence between the issues of 100 BC and 92 BC is particularly controversial, especially as eight issues are squeezed into two years from 101–100 BC.

The most recent attempt to re-date these issues is that by Mattingly.[11] The new scheme is based on a combination of hoards and literary evidence and is presented in a series of three tables. Only the last of those tables, however, provides fixed dates for the issues. The remaining tables only provide a relative ordering, and so I have worked back through them assigning dates sequentially.[12] Many of the analyses below are independent of the dating schemes, but my imposition of dates on Mattingly’s tables should be kept in mind.[13] One of

8 Crawford 1985; DeRose Evans 2013; Knapp 1987.
9 Ripollés 2005, 2012.
10 Mattingly 2004, chapter 13.
11 *Ibid.*
12 RRC 324 occurs twice in Table 2 on p. 206. The first occurrence is incorrect and should be RRC 321 which is re-dated to 100 BC. RRC 211–13, 272 and 339 were omitted from Mattingly’s scheme as they consist only of bronzes.
13 In the *Coin Hoards of the Roman Republic* database (CHRR; Lockyear 2007, chapter 2) I adopted a crude but effective method of implementing these alternate dating schemes by simply duplicating the COINTYPE table and editing the affected issues. This enabled comparative data sets for analysis to be created with ease. One impact of simply assigning dates back sequentially through Mattingly’s tables is that the earliest issues

Mattingly's aims was to assign issues to the period 99–93 BC, left almost devoid of *denarius* issues by Crawford.

The impact of Mattingly's changes can be assessed by looking at the impact of the change in the dates. Of the 144 issues affected, only ten issues have a date change of five or more years and 77 issues change by two or less years. Looking at the closing dates[14] of the 71 hoards used in this paper,[15] the biggest change is seven years, which affects only three hoards, whereas 49 hoards have a change of less than four years. In terms of broad-brush dating of the issues it would seem that the new scheme has a relatively minor impact.

1.2 The data

Since the publication of *Patterns and Process*[16] efforts have been made to improve the coverage in the CHRR database for material relating to this period. In particular, listings for the hoards used by Mattingly were sought out and entered. The data are not, however, without problems. For example, the Terranova de Sicilia and Manfria hoards (TDS & MNF) are argued by Crawford to be two lots of a single hoard[17], whereas the La Oliva hoard (RRCH 197) is thought to be two hoards by Chaves Tristán.[18] One must also remember that not all the hoards have the best data quality. For example, the La Oliva hoard (OL2) has only 45 coins recorded from an estimated 600–700. The São João dos Caldeireiros hoard (SJ1) is a particularly complex hoard. This hoard — also known as the Mértola hoard — is unpublished, although it has been examined by both Michael Crawford and Terrence Volk.[19] My listing is derived from Crawford's lists now housed in the British Museum.[20] Mattingly's list, created from a combination of Volk's and Crawford's, varies from the data used here, however. For example, Mattingly has 15 examples of 286/1, M. SERGI. SILVS Q., whereas Crawford lists 26 examples.

Rather than weed the data set of all potentially problematic data — which would almost certainly leave us with no data at all — I prefer to work through the analyses and omit any problematic assemblages as they arise, noting, of course, which these were and why. Appendix A contains details of all the hoards used, whilst Table 1 provides a summary.

[insert Table 1 near here]

Included in the analysis in 2007 were hoards closing between 118 and 97 BC. However, use of Mattingly's dates changes the hoard selection slightly, for example the Patrica and La Loba hoards (PTA & LOB) date to 119 BC using Crawford's dates and 118 BC using Mattingly's. Using a date bracket of 119–97 BC (RRC dates)[21] gives us 71 hoards which contain at least one *denarius* (Table 1, and Appendix A). Of those hoards, 18 have less than

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considered by Mattingly (his Table 4, RRC 197 onwards) are dated from 153 BC to 133 BC. This creates an artificial gap between the issues prior to RRC 197 which Crawford dated to 169–158 BC and RRC 197. For our purposes here, however, this problem is irrelevant.

14 Where the latest coin in a hoard is assigned a date range, the earliest date is used.

15 Previous analyses have included the hoard from Borgonuovo (BRG) due to an error in the database.

16 Lockyear 2007.

17 Crawford 1974, note to table XI, page 67.

18 Chaves Tristán 1996, Nos. 24 & 32, here hoards OLI & OL2.

19 Mattingly 2004, notes 3 and 7, pp. 200–1.

20 I am extremely grateful to Michael Crawford for helping me with these. They are less clear than usual due to the extreme haste with which the list was created.

21 The four hoards with a closing date of 97 BC derive that date from *quinarii*.

30 well identified *denarii*[22]— the minimum hoard size used previously — leaving us with 53 hoards compared to the 41 hoards used in *Patterns and Process*. Some of the very small hoards clearly have an unreliable closing date. This is nicely illustrated by the mixed denomination Panicale hoard (PAN) which closes in 89 BC with two *quinarii* of RRC 343, but the latest *denarius* dates to 115 BC. Similarly, the Bugiuleşti hoard (BUG), that has only two coins and closes in 112 BC, cannot have been deposited much before the massive export of *denarii* to Dacia in *c.*75 BC.[23]

All the hoards bar two come from Italy/Sicily or Iberia, the exceptions being the Bugiuleşti and Lauterach (LAU) hoards which come from Romania and Austria.

2 The analyses

In the following section, I have divided the analyses up into a series of questions and answers. As much as possible I have tried to describe the methods and the results in plain English. Technical details have been relegated to Appendix B, and detailed comments on the data or the techniques have been relegated to footnotes. I have not included any formal mathematical justification for the methods used as they are all standard techniques widely discussed in the statistical literature.

Multivariate statistical techniques can be seen as simultaneously simple and complex.[24] They are complex in the sense that the underlying mathematics is non-trivial. They are simple, however, in that with modern software, undertaking the analyses is relatively straightforward. Provided the analyst understands the aim of the technique, how to interpret the results, and its limitations, it is possible to apply these methods without a detailed understanding of the underlying mathematics.

2.1 How has the new data, and Mattingly's dating scheme, affected 'the gap'?

Figure 1 shows the closing date of the 61 hoards in the data set that have over ten coins, using Crawford's dates. 'The gap' can be clearly seen: only one Italian hoard closes between 115–105 BC. Comparing this graph to one calculated using Mattingly's scheme (Fig. 2) shows a few differences. For example, the peak at the end is more spread out, reflecting Mattingly's attempt to assign issues to 99–93 BC. There is, however, still only one Italian hoard closing in 'the gap', which has the same duration but with slightly different beginning and end dates.

Figure 1: Closing date of hoards using the dating scheme from *RRC*. The 'gap' lies between the dashed lines.

Figure 2: Closing date of hoards using the dating scheme from Mattingly 2004. The 'gap' lies between the dashed lines.

22 A "well identified" *denarius* is one which can be given a reference down to a single RRC issue if not to an exact type. For example, a coin which can be said to be RRC 299, but not specified if it is 299/1a or /1b is considered "well identified" and is given the appropriate accuracy code in the database (see Lockyear 2007, pp. 17–19). In Table 1, the total number of well identified coins is given in the column "good total".
23 Lockyear 1995, 1996a, 2008.
24 Baxter 2003, pp. 16–18.

2.2 Can 'the gap' in the closing dates of hoards be seen in the overall structure of the hoards?

Just looking at closing dates does not, obviously, take into account the hoard *structure*, *i.e.*, the quantities of coins of different dates within each hoard. This can be very informative. For example, Republican hoards from Dacia have been shown to have a very similar structure, whatever their closing date.[25] That structure closely resembles Italian hoards of the mid 70s BC, indicating that large numbers of *denarii* entered Dacia at about that date, after which the supply was much lower and somewhat erratic. One way to examine hoard structure is to use a technique called Hierarchical Cluster Analysis. This technique aims to divide the assemblages, whatever they are, into groups or 'clusters' on the basis of some form of measurement, in this case the numbers of coins by year of striking.[26] The analyst may be looking for 'real' groups in the data, or may be seeking to simply subdivide (or 'dissect') a continuum of variation in a repeatable fashion. In the case of coin assemblages, we are unlikely to have firm groups and are normally dissecting a continuum.

There are many varieties of Hierarchical Cluster Analysis and the one chosen for the current analysis — Dmax-based cluster analysis — has proved successful in the analysis of coin data previously and has been explained in detail elsewhere.[27] It has been used successfully in the analysis of both hoards[28] and site finds.[29] The technique has two stages:

Figure 3: Calculating the Kolmogorov-Smirnov distance, Dmax, for three hoards closing in 100 BC.

1. Firstly, a measure of how similar (or dissimilar) the hoards are to each other has to be calculated. Many such measures are available but here we will use the Kolmogorov-Smirnov distance, Dmax, as a measure of dissimilarity. This is most easily explained via a graph (see Fig. 3). Each hoard is converted into a cumulative proportion curve, *i.e.*, the number of coins for each year expressed as a proportion, is added to the sum of all the previous years to create a curve that goes up from zero to one. Each curve is then compared to every other curve and the maximum absolute difference is our measure of dissimilarity. In Fig. 3 the curves for Paterno (PAT) and Bevagna (BVG) show that the two hoards are very similar to each other. Consequently, the value of Dmax is small: 0.08. Conversely, hoards Olival da Soalheira (OSO) and Paterno (PAT) are very different and thus Dmax is large, 0.52.
2. Secondly, the hoards are now iteratively joined into groups called clusters. Firstly, the two most similar hoards, *i.e.*, the pair with the smallest value of Dmax, are joined into a cluster and the average dissimilarity between that cluster and the rest of the hoards is calculated. Having done that, the next smallest value for Dmax is found, the hoards joined into a cluster, and the Dmax values recalculated. The process continues until all the hoards form one large cluster. This technique, known as average linkage, is

25 Lockyear 1995, 1996a, 2008.
26 See, for example, Baxter 1994, chapter 7.
27 *e.g.*, Lockyear 2000.
28 Lockyear 1995, 1996a.
29 *e.g.*, Walton 2012.

only one of a number of methods for creating clusters.[30] It was chosen because it was successful in the previous analyses. The results can be presented as a tree-like graph called a dendrogram. The lines in the dendrogram show at which level of dissimilarity each hoard is joined to a group. The dendrogram can be 'cut' to create the desired number of clusters and shows which hoards are in each one.

The analysis was run twice: once using Crawford's dates and once using Mattingly's. As the technique uses cumulative proportion curves, very small hoards are likely to be a problem. In the past I have used a minimum hoard size of 30 *denarii*.[31] Running the cluster analysis using the 53 hoards of this size suggested five groups in the data: two 'singletons' (*i.e.*, clusters with only a single member, in this case hoards CO1 and PZ1) and three larger clusters corresponding to an early, middle and late group (see Figs. 4– 5).

Figure 4: Dendrogram from cluster analysis, RRC dates. Iberian Peninsula hoards in italics.

Figure 5: Dendrogram from cluster analysis, Mattingly's dates. Iberian Peninsula hoards in italics.

The early cluster contains 15 hoards with a median closing date of 114 BC (RRC) or 111 BC (Mattingly). Eight of the hoards come from Italy and seven from Iberia. It represents, therefore, early hoards (or hoards with an 'archaic' structure) and is evenly split between the two regions.

The middle cluster from both analyses contains 23 hoards in common. Two hoards, Almadenejos and Idanha-a-Velha (ALM & IAV), occur in the middle group using Crawford's chronology and the late group if using Mattingly's. The middle group has a median closing date of 103 BC (RRC) or 101 BC (Mattingly). Of the 23 hoards in common, five come from Italy and eighteen come from Iberia. Both the two extra hoards in this group when using Crawford's chronology also come from Iberia. This cluster shows a clear bias to Iberia and mainly includes hoards from 'the gap.'

The late cluster contains 11 hoards in common, with the addition of the two hoards mentioned above when using Mattingly's chronology. The cluster has a median closing date of 100 BC (RRC) or 95 BC (Mattingly). In this case nine of the hoards come from Italy and only two or four from Iberia, depending on the dating scheme used.

Of the two singletons, Pozoblanco (PZ1) is unusual in having a large percentage of coins of issues RRC 281 and 282,[32] the latter being the issue struck in Narbo in 118 BC. The other singleton, Villanueva de Córdoba (CO1), is unusual in that 40% of that hoard consists of issues from RRC 274–281, giving it a very modern profile.[33]

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30 Shennan 1997, pp. 239–40.
31 Lockyear 2007, p. 183.
32 38%, Lockyear 2007, p. 72
33 See Lockyear 2007, Fig. 5.20, p. 70.

This analysis has clearly shown that the pattern previously noted goes deeper than just the closing date of the hoards, but is also a reflection of the overall coin hoard structure. Figure 6 shows the average cumulative percentage curve from each cluster. The early cluster contains both hoards with early closing dates, but also hoards with a later closing date but an archaic structure such as Cogollos de Guadix, Puebla de los Infantes and Cástulo (COG, PUE & CSL). Similarly, the middle cluster also contains some late closing hoards such as Olmeneta, Olival da Soalheira and São João dos Caldeireiros (OLM, OSO & SJ1). The late cluster consists almost exclusively of hoards closing in 100 BC (RRC dates) or 100–94 BC (Mattingly dates).

Figure 6: The average profile of hoards from the three main clusters. Solid lines: RRC dates; dashed lines: Mattingly's dates.

2.3 Can we see 'the gap' if we analyse the hoards independently of the rival dating schemes?

The analyses performed so far are reliant on the dating schemes given by RRC or Mattingly. We can, however, analyse the hoards at the level of individual issues using Correspondence Analysis.[34] This method seeks to identify the underlying trends in the data and to represent those patterns in a series of graphs, which are accompanied by some diagnostic statistics. It is, essentially, looking for the pattern whilst trying to ignore the noise. The technique is used widely in the social sciences[35] and has been successfully used in archaeology.[36] Formal discussions of the technique for archaeologists are available,[37] and I have provided a detailed explanation along with worked examples specifically for numismatists,[38] as well as discussions of the technique in relation to the analysis of site find assemblages and hoards.[39] In numismatics, the technique has been both criticised and promoted in the same review.[40]

Readers wishing the more technical details are referred to the citations in the notes. For our purposes here we simply need to note the following.

1. The aim of this technique is to enable a complex data set to be plotted as a series of simple two-dimensional graphs. To do this, the technique calculates a series of new synthetic axes where axis 1 represents the main underlying pattern in the data, axis 2 presents the next most important source of variation, and so on. In coinage studies, the first axis often represents date (*e.g.*, early to late hoards).
2. The results of the technique are plotted on one or more scattergrams, technically called maps as both the *x* and *y* axes should be at the same scale. Usually two maps are produced, both showing axes 1 *v*. 2 but one representing the 'objects' (in our case hoards) and one representing the variables (in our case RRC issues). More subtle patterns can be observed by examining axes 3 and beyond although in hoard studies

34 Greenacre 2007; Lockyear 2007.
35 *e.g.*, Greenacre & Blasius 1994.
36 *e.g.*, Cool & Baxter 1995, 1999, 2002; Pitts & Perring 2006.
37 Baxter 1994, 2003; Baxter & Cool 2010; Shennan 1997.
38 Lockyear, forthcoming. A draft is available on Academia.edu.
39 Lockyear 2000, 2007.
40 Esty 2003, p. 924, *cf.* p. 925–6.

these can quickly start representing the variation in only a very small number of issues.

3. Two points on a map plotted close together are likely to be similar in some way, and two points plotted at a distance are likely to be dissimilar. In our case here, two hoards plotted close together are likely to contain a similar range and proportion of coinage issues. Similarly, two issues plotted close together are likely to have a similar distribution across the hoards.
4. As the process of calculating the axes and plotting the scores is an attempt to simplify a complex data set, some items will not fit that simplified pattern well. Consultation of the accompanying diagnostic statistics (more properly known as decompositions of inertia) enables one to identify which items (hoards and/or issues) fit the pattern, and which should be ignored.[41] One of the most useful of the diagnostic statistics is 'quality' which scores out of 1,000 how well a point 'fits' the map. A simple analogy may help to explain this. Imagine we have a map of Midtown Manhattan on to which we plot the location of every person at midday on one specific day. We will, obviously, have lots of points along the sidewalks, and in rows along the roads. We will also have a huge mass of points at 350 5th Avenue. This mass of points represents the large number of people in the Empire State Building. For the people on the sidewalk, the point on the map is a good representation of their location, and in CA terms would have a high 'quality'. For the people on the 86th floor observation deck of the Empire State Building, their coordinates may be accurate in terms of eastings and northings, but fails to show their height above street level, and would, therefore, have a low 'quality'. As a result, the position of items with a very low quality should not be given any great meaning when interpreting a map from CA. The diagnostic statistics for the analysis shown here are given in Tables 3 and 4 in Appendix B.
5. By comparing the maps and consulting the diagnostic statistics, an interpretation for each axis can be given.

Although the strength of CA is its ability to examine large numbers of hoards and issues simultaneously and represent them in a small number of graphs, its main weakness is that the results can be negatively affected by very unusual assemblages.[42] The normal procedure is to note the unusual assemblages and re-run the analysis omitting them.

In my previous analyses the minimum hoard size has been set at 30 *denarii*. In this analysis, however, we are only interested in the pattern of the latest issues and so all those prior to RRC 260 were removed from the analysis, *i.e.*, those issues struck before 128 BC (RRC). As a result eleven of the hoards fell below 30 coin limit[43], but these were retained for the initial run of the analysis. A further complication arises when one considers Mattingly's arrangement. Issues RRC 261–7 included in this data set are placed by Mattingly earlier than RRC 260. Unfortunately, there is no simple break in the sequence which would result in identical data sets whichever arrangement was followed, and so I stuck to using the same issues as we have used so far.

41 I have provided a fuller discussion of the decomposition of inertia elsewhere (Lockyear 2007, 57–9).
42 For example, the coin assemblage from the excavations of Fishbourne Roman Palace had a huge negative impact on the results of the CA of site find data from Britain (Lockyear 2000).
43 In addition, RRC 309 was removed as there was only a single example in the data set from the Sierra Morena (El Centenillo) hoard (CEN).

An initial analysis showed that, as previously,[44] the Idanha-a-Velha hoard (IAV) has a strong influence on the results because it has 145 examples of RRC 319, some 70% of the coins of that type in the data set.[45] It was decided to omit that hoard from the rest of the analyses.

Figure 7: CA map of the coin issues, first (*x*) and second (*y*) axes of inertia. Symbols represent date brackets according to *RRC*, numbers are *RRC* issues.

Figure 8: CA map of the coin issues, first (*x*) and second (*y*) axes of inertia. Symbols represent date brackets according to Mattingly, numbers are *RRC* issues.

Figure 9: CA map of the hoards, first (*x*) and second (*y*) axes of inertia. Symbols represent country of origin. The three letter hoard identifiers are given in Table 1.

Figure 10: CA map of the hoards, first (*x*) and second (*y*) axes of inertia. Symbols represent clusters from the previous analysis. The three letter hoard identifiers are given in Table 1.

Figures 7–10 show the results from the CA of the final data set. Figure 7 shows the map of the issues. The first axis has early issues plotted to the left and later issues plotted to the right, *i.e.*, the classic time gradient seen in many CAs. The second axis has middle period issues plotted at the bottom, and the later issues plotted at the top. As a result, the issues lie in a classic 'horseshoe curve' on the map, a very common result in data sets with a strong underlying gradient such as time, space, or even social status. The symbols in Figure 7 represent periods of time according to the RRC scheme which can be compared to Figure 8 where the same results are presented using Mattingly's dating scheme. Although varying in detail, the two schemes are remarkably in agreement in their broad brush strokes. RRC issues 280–286, dating to 120–116 BC, are the least coherent group in Fig. 7 although RRC 283 and 284 both have a low quality on this map and their position should be taken with caution (see Table 3). On the evidence of the maps, at least, Crawford's grouping of the issues from 105–100 BC seems more in keeping with the hoard evidence than Mattingly's, although as we shall see, translating the CA maps into precise chronological sequences is not without difficulties. Apart from issues RRC 271 and 286, there is also a noticeable gap between the batch of early issues in the upper left quadrant and the batch of issues in the lower right. RRC 271 is quite a rare issue with only 20 coins in the data set, and a low quality of 22; its precise position, therefore, is not meaningful. RRC 286, however, is a common issue with 234 coins in the data set and a quality of 316, and therefore its position between the two batches of issues is meaningful.

Figures 9–10 are maps of the hoards themselves, the former with symbols representing where they were found and the latter the clusters according to the analysis conducted above (section 2.2). Unsurprisingly, the clusters do indeed arrange themselves quite nicely along the first axis with a little mixing at either extreme. The Manfria hoard (MNF) is somewhat oddly placed lying with the early hoards despite a closing date of 103 BC. It has a lowish quality on this map of 124 (Table 4). This small hoard of 33 coins 'out of about 100'[46] has a large gap between RRC 295/1 and its last coin, RRC 320/1. Crawford[47] believes that this

44 Lockyear 2007, p. 77.
45 *cf.* Volk 1994, pp. 47–8, 51.
46 Crawford 1969c, No. 198.
47 Crawford 1974, note to Table XI, p. 67.

hoard is part of the Terranova di Sicilia hoard (TDS) and states that the published list is incorrect and the hoard actually ends with the issue of M. Aurelius Scaurus, RRC 282/1.[48] As can be seen, in terms of its overall profile it does indeed look like an early hoard as its position on the map lies close to the other early hoards. This illustrates how robust the technique can be even when there are a few potential errors in the data.

In terms of geographical origin, Figure 9 shows the hoards in the upper left quadrant are mainly Italian, those in the bottom left are mainly Iberian, and those to the right are mainly Italian once more. The pattern seen in the basic closing dates of the hoards (Figs. 1–2) persists through into this analysis by individual issues. Any suspicion, therefore, that the pattern is merely an artefact of the dating schemes used, can be dispelled. Some of the hoards, especially those lying near the origin of the graph, have a very low quality. Often these are very small hoards, *e.g.*, Aznalcóllar (AZN) has a quality of 14 and only 20 coins, and Olival da Soalheira (OSO) has a quality of 18 although it is slightly larger with 45 coins. The position of these hoards on this map cannot be given any weight. Conversely, many hoards have a high quality, *e.g.*, Imola (IMO, 798), Maddaloni (MAD, 700) and La Oliva (OLI, 581) and their positions can be treated with confidence.

Comparing Figures 7 and 9 we can see that there is group of Iberian hoards, mainly belonging to the middle cluster, plotted in the bottom left quadrant, in precisely the area where there is a gap in the sequence of issues. We have to interpret this in terms of the axes. The first axis contrasts early issues (approximately RRC 260–283) with late issues (approximately RRC 311–329). The second axis picks out the middle issues (approximately RRC 285–306). The Iberian hoards in the lower left quadrant, therefore, have a mix of early and middle period coin issues, the hoards in the upper left quadrant mainly early coins, and those in the upper right quadrant mainly later coins. We can illustrate this by using proportional circles to represent the abundance of each coin type within a hoard. Fig 11 shows a selection of issues as proportional circles plotted on the CA map.

Figure 11: The abundance of four RRC issues in hoards plotted on the CA map. Small open circles are hoards that have no coins of that issue, hoards plotted in light gray have a low quality (< 100). The area of the filled circles is proportional to the percentage that issue forms within a hoard. For hoard names, *cf.* Fig. 9.

There is a great deal more which could be obtained from a detailed examination of the results of this analysis, but for our purposes we have achieved our objective of showing that ‘the gap’ can be seen in the hoard data at the level of the individual issues.

2.4 How sure can we be of the position of the hoards and issues in the CA? Can we use them to suggest a new ordering of issues?

The hoards we are using are, we assume, random selections of *denarii* in circulation. Obviously, the distribution of coin types in a small hoard is going to be a less reliable guide to the coinage pool than the distribution within a moderate sized hoard. Likewise, rare issues will occur almost randomly in hoards and are therefore less easy to date. As numismatists, we are instinctively aware that this is the case.

48 Unfortunately, I have been unable to locate Crawford’s revised listing of the Manfria hoard in his archive and so, for purposes of illustration, have used the published list here.

CA, however, is a purely geometrical technique. It takes the data, in this case coins and hoards, and produces information about the underlying pattern. Can we investigate how 'real' the pattern is, and how much the results might vary simply by chance? Bootstrapping is a statistical technique which allows the analyst to examine such problems. In bootstrapped CA the data is resampled to produce, essentially, a simulated set of hoards on which CA is performed. By resampling and reanalysing the data repeatedly, usually around 10,000 times, we can visually assess how much an individual hoard or issue would vary simply due to chance variation.[49]

The results of a bootstrapped CA are presented in Figs. 12–13 where each ellipse contains *c.* 95% of all the points from the 10,000 replications, whilst the point represents the actual coin issue or hoard.[50] A small ellipse indicates a point, either a hoard or an issue, where its position did not vary much between analyses and one in which we can be confident of the position of that point. A large ellipse indicates a point where there are large differences between the analyses and where we should be cautious about placing too much weight on its position when interpreting the results. In Fig. 12 I have highlighted the ellipses for the twenty 'best' hoards, *i.e.*, those with the smallest ellipses and which, therefore, did not vary much when resampled. Many of these are the larger hoards, such as the São João dos Caldeireiros hoard (SJ1) which has 464 coins in the analysis, although some are smaller, *e.g.*, the Maddaloni hoard (MAD) which has 117 coins in the analysis. We can also see the hoards which are more problematic. In Fig. 12 I have highlighted the Manfria hoard, discussed above, and the large size of the ellipse clearly shows that this small hoard with only 17 coins in the analysis is unreliable.[51] This is reflected in the quality for these hoards mentioned above: 124 for Manfria, 798 for Imola and 700 for Maddaloni.

Figure 12: Bootstrapped CA map of the hoards, first and second axes of inertia. The twenty smallest ellipses have been plotted in black. Manfria's ellipse is indicated by the broken line, see text for details.

Figure 13: Bootstrapped CA map of the issues, first and second axes of inertia. The twenty-three smallest ellipses have been plotted in black. The ellipse for RRC 271 is indicated by the broken line, see text for details.

Of perhaps more interest is the map for the issues (Fig. 13). Again, I have highlighted the smaller ellipses. The mass of overlapping ellipses for the earlier issues in the top-left quadrant is unsurprising. This mass of points represents early issues, all struck before the closing date of the earliest hoard. These issues have had time to circulate, and their distribution across hoards is largely random variation. Once we move beyond that initial mass, we see RRC 286/1 once again lying in 'the gap'. Contrast this with RRC 271 where the centre of the ellipse is in 'the gap', but the size of the ellipse clearly shows how unreliable its position is, largely because there are only 20 coins in the analysis. Once we move beyond those issues, however, we can start seeing a sequence in the highlighted issues. For example, RRC 308 appears to be later in the sequence than RRC 316 or 317, but RRC 318 could either

49 Lockyear 2013; Ringrose 2012.
50 The previously published analysis of this data using bootstrapping (Lockyear 2013, pp. 4747–8) only contained the 38 hoards used in the earlier analyses (Lockyear 2007, pp. 77–9).
51 I have examined the relationship between sample size and the size of the ellipses elsewhere (Lockyear 2013, pp. 4751–2) and shown that this varies from data set to data set.

be earlier or the same date. Other rare, unreliable issues with large ellipses include RRC 324 with only nine coins in the data set or RRC 269 with only 17 coins.

For our purposes here, we can be confident in the existence of 'the gap', and we can start to see which hoards are likely to be reliably associated with it, such as Santa Elena, La Oliva or Sierra Morena (hoards SEL, OLI & CEN). We can also pick out some of the issues that clearly seem to be associated with 'the gap' such as RRC 285, 289, 291 and 296. The results suggest some adjustments are needed to the relative sequence of issues suggested by Crawford and Mattingly, but further work would be needed to develop a chronological ordering of all the issues.

Can we divide the issues into groups associated with before, during and after 'the gap'?

It would be helpful to know which issues are associated with 'the gap' and to see how they are represented in the hoards, much as we divided the hoards into early, middle and later period hoards as a result of the Cluster Analysis. Doing this in a repeatable, objective manner without using the rival dating schemes is problematic. One final technique would allow us to do this at the level of issues: *Hierarchical Clustering of Principal Components*, or HCPC.[52] We have already seen how Cluster Analysis creates groups, and how Correspondence Analysis identifies the main patterns while discarding the 'noise'. HCPC combines these two techniques by performing a Cluster Analysis not on the original data, but on the scores derived from the CA. It does this because the CA has discarded the 'noise'. The results can be directly plotted on a CA map.

Applying the technique to our data suggests three groups in the hoards, and three groups in the issues. Examining the grouping of the hoards (Fig 14), it is very similar to that we obtained using Dmax-based clustering earlier. Excluding the two singletons from that analysis, eight hoards are grouped differently in this analysis.[53] Some of those hoards are quite small, *e.g.*, the Mértola hoard (MER) has only 21 coins in this analysis, or the Manfria hoard (MNF) discussed above. Remembering that we are *dissecting a continuum* and not looking for clearly defined groups, this is a very good result. I shall refer to these hoards as being from the early, middle and late clusters. It should be remembered that this is not the same as having an early, middle or late closing date as this is based on the *overall* pattern in the hoards, not the specifics of the closing date.

Figure 14: HCPC clusters plotted on the CA map of the hoards, first and second axes of inertia.

Examining the issues (Fig. 15), we can see that the three groups divide nicely on the map. RRC 286/1 is placed in the early cluster which, remembering Fig. 11, makes sense. We now have a way of looking at the issues in three groups which we can interpret as roughly correlating to early, middle and late issues. As with the hoards I will refer to these as early, middle and late clusters. The hoards and issues which make-up these clusters is given in Table 5.

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52 Alberti 2013, pp. 40–2, 47–50.
53 Almadenejos (ALM), Córdoba (CO2), Cástulo (CSL), Mértola (MER), Manfria (MNF), Penhagarcía (PNH), Ricina (RCN), Taranto (TR1).

Figure 15: HCPC clusters plotted on the CA map of the issues, first and second axes of inertia.

Tables 2a and 2c show the number of coins from each issue in hoards of each cluster, *i.e.*, coin types in the early cluster in hoards of the early cluster, and so on. The percentages in Tables 2b and 2d are calculated from all the coins in hoards of that cluster. From these tables we can see that early coins in early hoards are evenly spread between Italy and Iberia, middle coins in middle hoards are, however, dominated by Iberia (25.3% compared to 5.3%) whereas the latest coins are again associated with Italy. Even in terms of just raw numbers, Iberia dominates the middle period hoards with 2,778 coins compared to only 761 from Italy.[54]

We can check the influence of the hoards which do not fit the map of the first two axes from CA by excluding all hoards and issues with a low quality. In Tables 2c and 2d I have excluded any issue or hoard which has a quality of less than 150 on the CA map of the first two axes. We can see that the pattern is clearer with 23.9% middle cluster coins coming from middle cluster Iberian hoards but 32.1% of late cluster coins coming from late cluster Italian hoards.

We have now successfully defined which issues are associated with which part of our hoard pattern, and these are listed in Table 5.

54 Remember these are well-identified *denarii* from issue 260/1 onwards.

3 Discussion

To summarise the results so far:

1. The bar charts show that the previously identified pattern in closing dates can be seen whichever dating scheme is chosen.
2. The cluster analyses show that this pattern persists through the date structure of the hoards, again no matter which scheme is chosen.
3. The CA and bootstrapped CA shows that the pattern can also be identified at the level of individual issues. The pattern can be seen to be 'real' although the association of some issues or hoards needs to be treated with care, mainly in the case of small hoards or small issues.
4. The HCPC allows us to group the issues into those mainly associated with the early period (RRC 260–284, 286, 289), the middle period (RRC 285, 287, 290–298, 300–307, 311–314) and late period (RRC 299, 308, 316–330). Only a small number of issues appear out of sequence compared to RRC, *e.g.*, 299.

There are two levels of interpretation needed to explain the observed pattern. The first level is to explain the mechanical processes by which the pattern was created. The second level is to explain why those mechanical processes occurred.

Possibilities for the first level are:

1. Variation in the pattern of coin production.
2. Variation in the pattern of coin supply.
3. Variation in the numbers of hoards buried.
4. Variation in the numbers of hoards recovered in Antiquity.
5. Variation in the numbers of hoards recovered/published in modern times.

These possibilities are not necessarily exclusive. To deal with option 5 first, I cannot see how selective recovery and reporting could have created the observed pattern. In fact, it is because of the efforts of Crawford as well as Italian and Spanish scholars that we have enough data to undertake an analysis like this.[55]

Option 1 can be examined by looking at the relative size of the issues (Fig. 16).[56] Although the pattern does vary from year to year, there are no obvious breaks in production. All the issues in this period are thought to have been struck in Rome with the one exception of RRC 282 which was struck at Narbo. I am unaware of anyone who has argued that any of these issues were struck in Spain.

Figure 16: Size of issues defined by RISC values for the period 118–100 BC (RRC chronology).

As regards option 2, clearly the pattern of supply is a factor here. For a short period of time, probably about 10 years, the Roman state appears to have been preferentially sending

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55 A comparison could be drawn with hoard pattern between Romania and Bulgaria which is an artefact of differential reporting (Lockyear 2007, pp. 167–8). Thanks to the efforts of Evgeni Paunov, this situation is improving.

56 I coined the term 'relative issue size coefficient' as an alternative to treating Crawford's die estimates as actual counts (Lockyear 1999, p. 226).

new coin to Iberia rather than spending it within the Italian peninsula. Keeping in mind that hoards cannot be dated to periods where no coins were supplied, some of our 'early' Italian hoards may have been deposited in 'the gap' but contain no coins of that period. Similarly, some of the Iberian hoards which close in 'the gap' were probably deposited after it. As shown in the cluster analysis, the Olival da Soalheira and São João dos Caldeireiros hoards (OSO & SJ1) have a late closing date, but an overall structure similar to hoards from 'the gap', which supports this idea. It also seems likely that there was an increase in hoarding activity and non-recovery within Iberia (options 3–4) at this time.

How might we interpret this pattern of supply and hoarding? Crawford[57] showed that the numbers of hoards recovered reflected periods of violence but Kent[58] demonstrated that the *location* of those hoards did not reflect the location of that violence. Duyrat[59] compared the distribution of hoards in Hellenistic Syria between the 4th and 1st centuries BC with periods on known warfare, and found that increases in hoarding were associated with some events but not others. In a recent paper, Guest[60] has reviewed the history of linking hoards to military activity or periods of unrest, and also discussed the problems with using this explanation universally. For example, the mass of radiate hoards found in Britain in the second half of the 3rd century AD cannot be easily explained in this way.[61]

Examining the broader pattern of hoarding (Fig. 17), we can see that there are very few gaps in the sequence in Italy except at those times when very few coins were struck, *e.g.*, the gap in the 60s BC. The peaks in Italy in the 80s, 70s and 40s are connected to the Social and Civil Wars and Spartacus' revolt. They do not just reflect increased hoarding activity, however, but are also a reflection of the pattern of coinage production.[62] The peak of hoards in the 70s, for example, is partly the result of the small size of coin issues in the 60s BC.

Figure 17: Numbers of hoards with over 20 well identified coins in the CHRR database from the late Republic classified according to date of latest coin following RRC. (Data as of July 2015.)

The pattern of hoarding in Iberia, however, is very erratic when compared to Italy. There is a large peak in the period we are examining, but the numbers of hoards from Iberia is never greater than Italy at other dates. Most curiously, there are no peaks in hoards in the 130s BC and the 80s BC when we know there was military activity in Iberia.

Although I agree with Guest that the universal application of the unrest/military model for the explanation of hoarding activity is flawed, in this case we are not only dealing with an increase in hoarding, but the deliberate supply of coins to Iberia by the Roman state and not to Italy. This pattern of *supply* over a relatively short period of ten years makes it unlikely that longer term processes such as ritual activity are the cause. This pattern of supply may be linked to issues of taxation, for example, but the simplest explanation is that the Roman State was having to pay for something, possibly the military. Conversely, we have no historical references to military activity in Iberia in this period apart from the incursion of the Cimbri

57 Crawford 1969a.
58 Kent 1988.
59 Duyrat 2011. I would like to thank David Biedermann for bringing my attention to this paper and Frédérique Duyrat for supplying me with a copy.
60 Guest 2015.
61 Bland 2018.
62 Lockyear 2012, pp. 203–7.

and Teutones into northern Spain in 103 BC from whence they were pushed back into Gaul by the Celtiberians before their eventual defeat by Marius in 102 and 101 BC. Erdkamp[63] has demonstrated how difficult it is to supply an army *on campaign* in Iberia. Maintaining a military presence when not on campaign must have required a steady supply of cash.[64] This could be the explanation for the supply of coinage, but what about the increase in hoards? Villaronga attributes part of the pattern to the incursion of the Cimbri and Teutones,[65] but many of our hoards are a long way to the south. Remembering the famous incident recorded by Pepys in his diary, mere *rumour* could be sufficient to cause hoards to be buried at some distance from the location of the troubles.[66]

This purely military explanation for the pattern is at odds, however, with the distribution of hoards compared to recorded military events elsewhere. We know that Rome was at war with Jugurtha in North Africa from 112–106 BC, and that successive armies were stationed in southern Gaul to fight the Cimbri and Teutones including that defeated at the Battle of Arausio (modern Orange) in 105 BC and the eventual victories at Aquae Sextiae (Aix-en-Provence) in 102 BC and Vercelli in 101 BC. We have, however, not one hoard of Republican *denarii* from North Africa or southern Gaul at this date. Perhaps this is a reflection of the wider adoption of the *denarius* in Iberia compared to those regions.

Rather than the pattern representing an increased level of military activity — not necessarily actual campaigning — at the end of the 2nd century BC in Iberia, perhaps it is a result of a need for the Roman state to both obtain fresh manpower? The defeat at Arausio is claimed to have resulted in 80,000 casualties. Or maybe simply to avoid having to open a third front at this period? Whatever the correct explanation, this could provide a context for the pattern of coin finds in Italy at this period discussed by Stannard[67] which appears to show strong links between Baetica and Italy at the end of the second century.

In this paper I have conclusively demonstrated that 'the gap' exists, and is also reflected in the pattern of supply of coinage. Although the *precise* dating of 'the gap' remains uncertain, it is not a product of the dating schemes used. The interpretation of the pattern, however, remains much more speculative and open to other possible explanations. In achieving these results, I have also demonstrated the strength and applicability of multivariate statistical analysis to coin data. Undertaking these analyses is relatively straightforward using the freely available R statistical system.[68] More time-consuming is the collection of the data. For the Roman Republic, however, this is now freely available via the CHRR*Online* database.[69]

Appendix A: Hoard details

The format of the catalogue is as follows: the name of the hoard (as in CHRR) is followed by the date it was found, if known, and then the hoard's identifier is given in SMALL CAPITALS. The country where the hoard was found is followed by the closing date using the *RRC* chronology. After the RRCH number (if listed), the numbers of coins in the hoard is then

63 Erdkamp 2010.
64 Chaves Tristán 2014.
65 Villaronga 1993.
66 Wheatley 1895, vol. 6, p. 379, vol. 7, pp. 143f.
67 Stannard 2005.
68 R Development Core Team 2012.
69 `http://numismatics.org/chrr/;` Lockyear 2016.

given, followed by the number of well-identified *denarii* used in the analysis in [ ]. The source of the data is then given: MHCPR for Michael Crawford's personal records held in the British Museum and PUB for a published source. If there are any comments about the find, these are then given followed by the references. An * indicates the source of the data in the CHRR database.

La Loba (LOB)
Spain, 119 BC
13 *denarii* [13]
PUB
Found in the wall of a house during the excavation of the mine ‘La Loba’.
No associated artefacts.
*Chaves Tristán (1996), pp. 51–54

Patrica 1935 (PTA)
Italy, 119 BC
100 *denarii* [100]
PUB
Found during agricultural work in a ceramic vessel and was divided amongst the finders. Only part of the hoard was recovered.
*Backendorf (1998), pp. 99, 392–3; Petrillo (1990).

Gerenzago 1909 (GER)
Italy, 118 BC
RRCH 167
60 *denarii,* 6 *victoriati,* 2 *quinarii,* 54 copies of *drachmae* of Massalia [49]
MHCPR
Found in a ceramic vessel.
Backendorf (1998), pp. 72, 333; Ricci (1909); Patroni (1909).

Jesi (JES)
Italy, 118 BC.
67 *denarii* of an unknown total [67]
PUB
Backendorf (1998), pp. 77–8, 341–2; *Sorda (1973).

Naples (NAP)
Italy, 118 BC.
8 *denarii* [8]
MHCPR

Terranova di Sicilia (TDS)
Sicily, 118 BC
RRCH 168
78 *denarii* [71]
MHCPR

Bevagna 1929 (BEV)
Italy, 117 BC
RRCH 171
784 *denarii,* 5 *sestertii,* 104 *victoriati* [721]
MHCPR
Found in a ceramic vessel during work on a sports field.
Backendorf (1998), p. 42; Catalli (1991, p. 336).

Lauterach 1880 (LAU)
Austria, 117 BC
RRCH 170
23 *denarii,* 1 plated hybrid, 3 Celtic silver coins [22]
MHCPR
With silver and bronze ornaments.
Lockyear (2007), p. 249.

Laives Reif 1985 (LVS)
Italy, 116 BC
22 *denarii* [22]
PUB
Complete. Found during the stripping of a site before excavation with a bulldozer.
*Backendorf (1998), pp. 78, 342; Vittorio (1990).

Maddaloni 1913 (MAD)
Italy, 116 BC
RRCH 172
310 *denarii* (+25 extraneous examples), 26 *victorati,* (+1 extraneous misc. bronze) [283]
Found during the construction of a pipeline in a coarse pottery jar.
MHCPR
Maiuri (1914); Backendorf (1998), pp. 80–1, 346–8.

Naples, National Museum (MNP)
Italy, 116 BC
35 *denarii* [35]
PUB
Found in museum collection, unsure origin and unsure it is a hoard but looks like it from the composition.
*Giove (2002).

Chiclana de Segura 1972 (CHL)
Spain, 115 BC
22 *denarii* [20]
PUB
Found with 38 pieces of jewellery.
*Chaves Tristán (1996), pp. 58–60.

Carissa 1920 (CRS)
Spain, 115 BC
4 *denarii*, 73 Iberian *denarii* [4]
PUB
*Chaves Tristán (1996), pp. 61–5.

Pozoblanco, before 1870 (PZ1)
Spain 115 BC
RRCH 174
84 *denarii* out of 1000 [79]
MHCPR
Chaves Tristán (1996), pp. 55–7; Villaronga (1993), no. 83.

Taranto 1897 (TR1)
Italy, 114 BC
RRCH 176
102 *denarii* [96]
MHCPR
Backendorf (1998), pp. 123, 450; Gabrici (1898); Mattingly (2004), hoard Ta.

Villanueva de Córdoba 1958 (CO1)
Spain, 113 BC
130 *denarii* (although 1 is missing) [127]
MHCPR
Found with two bracelets and a bronze situla.
Chaves Tristán (1996), pp. 66–79; Mattingly (2004), hoard C2; Villaronga (1993), no. 89.

Herdade da Mìlia (HDM)
Portugal, 113 BC
492 *denarii* (+16 extraneous *denarii*) [473]
PUB
Found in a ditch in an amphora.
Chaves Tristán 1999, pp. 166–8; *Marques de Faria 1991–2 pp. 80–3.

Alcalá del Río 1979 (ADR)
Spain, 112 BC
163 denarii [158]
PUB
Blázquez (1987–8), no. 27; *Chaves Tristán (1996), pp. 79–92; Villaronga (1993), no. 70.

Bugiuleşti 1963 (BUG)
Romania, 112 BC
RRCH 177
2 *denarii* [2]
PUB
Listed by Chiţescu as isolated finds.
*Chiţescu (1981), pp. 335–6.

La Barroca 1953 (LAB)
Spain, 112 BC
RRCH 178
74 *denarii*, 2 Iberian *denarii*, 42 *drachmae* of Emporiae [69]
MHCPR
Blázquez (1987–8), No. 25.

Mértola (MER)
Portugal, 112 BC
53 *denarii* [53]
PUB
Chaves Tristán 1999, pp. 167–8; *Marques de Faria 1991–2 pp. 84–6.

Segaró 1881 (SEG)
Spain, 112 BC
RRCH 180
47 *denarii*, 2 Iberian *denarii*, 963 *drachmae* of Emporiae (+3 extraneous bronze coins) [43]
MHCPR
IGCH 2342 lists this hoard as S. Agarro, Mommsen (1881, p. 809) lists it as Segaró, Villaronga (1993), No. 47 as Segueró.

El Centenillo 1911 (EL1)
Spain, 110 BC
RRCH 181
72 *denarii* (+1 extraneous *denarius* of 318/1b), 2 *victoriati* [71]
PUB
"The coins and other objects, which came to light on digging the foundation for a hut, were scattered in the soil, and if they had originally been gathered altogether in a receptacle all traces of it had disappeared… The hoard consisted of… the armlet and the fragments of a torc…, of fragments of silver ear-rings and of other ornaments" (Hill and Sanders 1912, p. 65).
Hill and Sanders (1912), *Chaves Tristán (1996), pp. 194–7, Marcos Alonso (2009).

Córdoba 1916 [?1915] (CO2)
Spain, 109 BC
RRCH 184
224 *denarii*, 1 *victoriatus*, 80 Iberian *denarii*, 1 *drachm* of Suguntum [214]
PUB

Found during the digging of a hole for a large oil-vessel. No surviving container but burial site is within a Roman cemetery either side of the Roman road to Cástulo (Hildburgh 1922, pp. 161–2). "The present find included, in addition to the bowl, the coins, and the rough lumps above mentioned, a fragment of a second vessel and a number of interesting personal ornaments of several kinds, some bent out of shape, some with small parts missing." (Hildburgh 1922, p. 163).
Chaves Tristán (1996), pp. 93–104; *Crawford (1969b), pp. 85–93; Hildburgh (1922); Mattingly (1925), pp. 395–6; Mattingly (2004), hoard C1.

Baix Llobregat (LLO)
Spain, 109 BC
117 *denarii* [112]
PUB
Blázquez (1987–8), no. 28; *Villaronga (1977); Villaronga (1993), no. 49.

Montoro 1936 (MON)
Spain, 109 BC
RRCH 182
20 *denarii* [15]
MHCPR
Blázquez (1987–8), no. 29; Chaves Tristán (1996), pp. 378–9; Villaronga (1993), no. 79.

Strongoli 1931 (STR)
Italy, 109 BC
RRCH 183
4 *denarii*, 3 *asses*, 1 *quadrans* [4]
MHCPR
Backendorf (1998), pp. 118–9.

Sarrià 1870 (SAR)
Spain, 108 BC
50 *denarii* [48]
PUB
Error in publication/CHRR corrected 16/07/2015.
Probably out of 400 *denarii.* The hoard was found during works and divided between the finder's eight children. This appears to be one lot of the eight.
Blázquez (1987–8), no. 32; *Villaronga (1982); Villaronga (1993), no. 50.

Albánchez de Úbeda 1979 (ADU)
Spain, 106 BC
16 *denarii* [15]
PUB
Blázquez (1987–8), no. 33; Chaves Tristán (1996), pp. 127–37; *de Paula Perez Sindreu (1984).

Sierra Morena (El Centenillo) 1920 (CEN)
Spain, 106 BC
RRCH 186
617 denarii [592]
PUB
Blázquez (1987–8), no. 34; *Chaves Tristán (1996), pp. 120–6;
Mattingly (2004), hoard SM;
Sandars (1921); Villaronga (1993), no. 87.

Pozoblanco 1980s (PZ3)
Spain, 106 BC
74 *denarii* [74]
PUB
*Chaves Tristán (1999), pp. 144–50.

Castillo de las Guardas 1856 (CLG)
Spain, 105 BC
113 *denarii* [113]
PUB
Found with other silver objects.
Blázquez (1987–8), no. 35; *Chaves Tristán (1996), pp. 178–88.

Jaén (JA2)
Spain, 105 BC
128 *denarii* [128]
PUB
*Chaves Tristán (1999), pp. 151–61.

Torre de Juan Abad 1934 (JUA)
Spain, 105 BC
RRCH 189
476 denarii (+2 extraneous *denarii*) [476]
PUB
In a silver bowl with silver ornaments.
*Vidal Bardán (1982); Blázquez (1987–8), no. 37; Chaves Tristán (1996), pp. 138–76; Mattingly (2004), hoard TJ; Villaronga (1993), no. 88.

Avvocata (AVV)
Italy, 104 BC

RRCH 190
25 *denarii* [21]
MHCPR
Backendorf (1998), p. 40.

Aznalcóllar 1908–1919? (AZN)
Spain, 104 BC
35 *denarii* [35]
PUB
Blázquez (1987–8), no. 39; Chaves Tristán (1996), pp. 189–93; *Crawford (1984), Villaronga (1993), no. 71.

Cogollos de Guadix 1958 (COG)
Spain, 104 BC
83 denarii [83]
PUB
Blázquez (1987–8), no. 40; Chaves Tristán (1996), pp. 198–206; *Mendoza Eguaras (1978); Villaronga (1993), no. 75.

Penhagarcía, about 1920 (PNH)
Portugal, 104 BC
RRCH 191
110 denarii [103]
MHCPR
Out of a larger hoard, with gold and silver ornaments.
Blázquez (1987–8), no. 38; Villaronga (1993), no. 82.

Manfria, before 1955 (MNF)
Sicily, 103 BC
RRCH 198
33 *denarii* [32]
PUB
Crawford (1974, p. 67, note to table XI) states that this hoard is part of the Terranova de Sicilia hoard (TDS) but I have been unable to locate the revised listing.
*Griffo (1958)

La Oliva 1848 (OL2)
Spain, 103 BC
45 *denarii* [45]
PUB
Chaves Tristán (1996), p. 366 argues that this hoard is *not* part of OLI (RRCH 197) as believed by Crawford. Mattingly (2004) combines the two hoards following Crawford. Hoard was originally 600–700 coins.
*Chaves Tristán (1996), pp. 366–8; Mattingly (2004), hoard Oli.

Puebla de los Infantes, around 1985 (PUE)
Spain, 103 BC
145 denarii, 2 quinarii, 2 victoriati, 1 *quadrigatus* [131]
PUB
Villaronga (1993, pp. 45–6) argues that the poor condition of the coins indicates that they are the unsaleable parts of a number of different hoards.
Blázquez (1987–8), no. 54; *Chaves Tristán (1988); Chaves Tristán (1996), pp. 214–29, Villaronga (1993), no. 84.

Santa Elena 1936 (ELN)
Spain, 102 BC
21 *denarii* [21]
PUB
Blázquez (1987–8), no. 53; *Chaves Tristán (1996), pp. 235–7; Mattingly (2004), hoard SE; Villaronga (1993), no. 86.

San Lorenzo del Vallo 1950 (LOR)
Italy, 102 BC
RRCH 195
310 *denarii*, 1 copy of a *denarius* [299]
MHCPR
Found during agricultural work.
Backendorf (1998), p. 112; Generoso (1990); Mattingly (2004), hoard SL; Procopio (1952).

Largo di Torre Argentina, Rome (LTA)
Italy, 102 BC
16 *denarii*, 3 *quinarii* [15]
MHCPR
Found during excavations of the temples.

Pagliuzza 1989–1991 (PAG)
Sicily, 102 BC
390 *denarii* [390]
PUB
Out of 541 *denarii*. First lot of 403 coins found during agricultural works, second lot of 138 found during excavations of the rural site in the following years. The 390 coins displayed at the exhibition in 1991 are listed and include examples of all issues. The remaining 151 examples were being cleaned

and were to be published by R. Macaluso. Found with sherds of a ceramic vessel.
Mattingly (2004), hoard Pa; Mantegna Pancucci *et al.* (1991).

Rio Tinto, between 1903 and 1910 (RIO)
Spain, 102 BC
RRCH 194
44 *denarii* [44]
MHCPR
Carson (1952); Chaves Tristán (1996), pp. 230–33; Villaronga (1993), no. 85.

Sierra Morena 1929 (SMR)
Spain, 102 BC
RRCH 196
3 *denarii*, 9 Iberian *denarii* [3]
MHCPR
Blázquez (1987–8), no. 43; Chaves Tristán (1996), pp. 234, Villaronga (1993), no. 65.
Since this study was completed the paper by Marcos Alonso (2009) has come to my attention which lists 12 *denarii* from this hoard and changes the closing date to 109–108 BC.

Cachapets (CAC)
Spain, 101 BC
266 *denarii*, 2 *victoriati* [262]
PUB
*González Prats and Abascal Palazón (1989); Villaronga (1993), no. 72.

Chão de Lamas (CDL)
Portugal, 101 BC
6 *denarii*, 1 Iberian *denarius* [5]
PUB
*Alfaro Asins (1989).

Cástulo 1978 (CSL)
Spain, 101 BC
47 *denarii* [47]
PUB
Probably complete, no surviving container.
Blázquez (1987–8), no. 46; Chaves Tristán (1996), pp. 238–43; *Collantes Pérez-Ardá (1978); Villaronga (1993), no. 74.

Elena (ELE)
Italy, 101 BC
RRCH 199
62 denarii [59]
MHCPR
Out of an unknown larger number. Part of the hoard was stolen.
Backendorf (1998), p. 65; Pozzi (1960–61), p. 153.

La Oliva 1861 (OLI)
Spain, 101 BC
RRCH 197
1269 *denarii*, 1 Iberian denarius [1247]
PUB
Chaves Tristán (1996), p. 244 argues that this hoard is not the same as OL2 *contra* RRCH 197. Mattingly (2004) follows RRCH and combines the two hoards.
Blázquez (1987–8), no. 44; *Chaves Tristán (1996), pp. 244–340; Mattingly (2004), hoard Oli; Mommsen (1863), pp. 15–64; Villaronga (1993), no. 80.

Ricina, before 1882 (RCN)
Italy, 101 BC
RRCH 201
299 *denarii* [271]
PUB
Backendorf (1998, p. 129) lists the hoard under Villa Potenza. Hoard contained 300 coins.
Backendorf (1998), p. 129, 461–3; Mattingly (2004), hoard Ri; *Tambroni Armaroli (1882–4).

Santa Elena 1903 (SEL)
Spain, 101 BC
RRCH 193
568 *denarii*, 6 Iberian *denarii* [537]
PUB
Found in two lead purses, with a silver bar.
Blázquez (1987–8), no. 41; Chaves Tristán (1996), pp. 207–13; *Sandars (1905); Villaronga (1993), no. 86.

Almadenejos 1976 (ALM)
Spain, 100 BC
100 *denarii*, 1 *victoriatus*, 2 Iberian *denarii* [95]
PUB
Out of 200 or 300 coins in total. Found with a torque, a bracelet and a vessel, all in silver. The latter was destroyed.
*Chaves Tristán (1996), pp. 344–54, 610.

Azuara 1890 (AZR)
Spain, 100 BC
RRCH 204
1 *denarius*, 409 Iberian *denarii* [1]
PUB
Blázquez (1987–8), no. 47, *RRCH; Villaronga (1993), no. 93.

Bologna 1886 (BLG)
Italy, 100 BC
92 *denarii* [92]
PUB
Out of about 122 coins. Found during building work.
*Backendorf (1998), 44, 258–9.

Bevagna 1980 (BVG)
Italy, 100 BC
232 *denarii*, 1 *victoriatus*, 1 *quinarius* [227]
PUB
Complete. Found during archaeological excavation, in a ceramic vessel, which may have been placed in a wooden box.
*Backendorf (1998), 42–3, 256–8, Catalli (1991); Mattingly (2004), hoard Be.

Cerignola (CG2)
Italy, 100 BC
97 *denarii*, 1 *victoriatus* [96]
MHCPR

Crevillente, before 1949 (CRE)
Spain, 100 BC
RRCH 206
4 *denarii*, 1 Iberian *denarius* [4]
MHCPR
Out of 22 coins. Found in a quarry six meters below the ground surface.
Blázquez (1987–8), no. 49. Mateu y Llopis (1951), p. 227; Villaronga (1993), no. 57.

Crognaleto 1900 (CRG)
Italy, 100 BC
RRCH 212
149 *denarii*, 14 quinarii, 4 *victoriati* [137]
MHCPR
Found by a farmer along the river Vomano.
Backendorf (1998), pp. 64, 315–7; Mattingly (2004), hoard Cr.

Carovigno 1882 (CVG)
Italy, 100 BC
RRCH 208
478 *denarii* [459]
PUB
Found during roadworks outside the town in a ceramic vessel. Out of about 3,000 coins.
*Backendorf (1998), pp. 52, 284–6; Mattingly (2004), hoard Ca; Nervegna (1882–4).

Gioia dei Marsi 1899 (GDM)
Italy, 100 BC
RRCH 213
222 *denarii*, 37 *quinarii* [220]
MHCPR
Found in a bronze vessel. Backendorf (1998, n. 133), following Fabricotti (1990), believes that RRCH is in error, and that this hoard dates much later, to 42 BC, and was found in Avezzano in 1915. For this article, I have kept to the listing in Crawford's personal records which is based on his inspection of the coins in the Museo Archeologico di Chieti.
Ambrosoli (1899); Backendorf (1998), pp. 40, 252–3; Fabricotti (1990); Mattingly (2004), hoard Gi.

Idanha-a-Velha (IAV)
Portugal, 100 BC
1350 *denarii* (including 4 copies), 12 Iberian *denarii*, 5 drachmae of Arse [1340]
PUB
Blázquez (1987–8), no. 52; Mattingly (2004), hoard Id; *Villaronga (1980); Villaronga (1993), no. 60.

Imola 1913 (IMO)
Italy, 100 BC
RRCH 210
532 *denarii*, 12 *victoriati* [500]
MHCPR
Found during the construction of a waterworks, in a ceramic vessel. Perhaps sixty coins went missing.
Backendorf (1998), pp. 74–5, 335–8; Mattingly (2004), hoard Im; Negrioli (1916).

Olmeneta 1879 (OLM)
Italy, 100 BC
RRCH 203
405 *denarii* (+ 3 extraneous *denarii*) [397]

PUB
Found in a ceramic vessel during agricultural pipe-laying. Backendorf (1998, p. 92) disagrees with Crawford's exclusion of 3 *denarii* and dates this hoard to 85 BC.
Backendorf (1998), pp. 91–2, 372–4; *Fiorelli (1879); Mattingly (2004), hoard Olm.

Orce 1940 (ORC)
Spain, 100 BC
RRCH 211
73 *denarii* [72]
MHCPR
Blázquez (1987–8), no. 51; Chaves Tristán (1996), pp. 355–61, Villaronga (1993), no. 81.

Olival da Soalheira 1896 (OSO)
Portugal, 100 BC
112 *denarii* [112]
PUB
Found in a grove, the nearest named place is Monforte da Beira. Found with two gold and four silver necklaces.
Chaves Tristán (1999), pp. 166–7; *Marques de Faria (1991–1992), pp. 87–92.

Paterno 1914 (PAT)
Sicily, 100 BC
RRCH 207
150 *denarii* [149]
May be from a larger hoard.
MHCPR

Salvacañete *c*.1930 (SAL)
Spain, 100 BC
RRCH 205
12 *denarii*, 62 Iberian *denarii* [9]
MHCPR
Found with silver ornaments.
Blázquez (1987–8), no. 48; Villaronga (1993), no. 63.

São João dos Caldeireiros 1941 (SJ1)
Portugal, 100 BC
658 *denarii* (+4 extraneous *denarii*), 1 *quinarius* [657]
MHCPR
Also known as Mértola. As far as I am aware, this hoard remains unpublished and thus a definitive listing is not available.
de Castro Hipólito (1960–1961), p. 89, no. 130; Mattingly (2004), hoard Me.

Appendix B: Technical details of statistical techniques used

The majority of the statistical analyses undertaken in this paper used the R statistical system which is freely available from the internet.[70]

Cluster Analysis

The calculation of the Kolmorogov-Smirnov distance was undertaken using a custom script available from the author. The clustering was undertaken using the `agnes` command from the `cluster` package, version 1.15.2[71] using the option for average linkage.

Correspondence Analysis

The CA was undertaken using two packages: `Canoco`, a standalone MS-DOS package[72] and the R package `FactoMineR`.[73] The former was used as the companion program, `Canodraw`, creates basic PostScript files which can be manually edited to provide high-

70 R Development Core Team 2012.
71 Maechler *et al.* 2015.
72 I am grateful to the University of Southampton for allowing me access to their copy of this package.
73 Husson *et al.* 2015.

quality maps. The latter, via the author's `simSimCA3D`, provides the decompositions of inertia using the format preferred by Greenacre[74] which are provided in Tables 3–4.

The final data set (*i.e.*, all hoards over 30 *denarii* omitting all issues prior to RRC 260 and RRC 309, as well as Idanha-a-Velha) had a total inertia of 1.119 with the first four axes having eigenvalues of 0.265, 0.105, 0.074, and 0.059 accounting for 23.7%, 9.4%, 6.5% and 5.3% of the variation in the data set respectively.

The calculation of the scores on the axes by the various CA packages varies slightly and although the relative positions remain identical the absolute values may vary. Maps 7–10 were created using the results from Canoco. Similarly, the algorithms used may results in an axis being reversed. This was the case between Canoco and the other packages for the first axis and so the scores used in the subsequent maps have been reversed to facilitate comparison.

Bootstrapped CA

Bootstrapped CA is available through Ringrose's R package `cabootcrs`.[75] Ringrose kindly sent me his code when the package was under development which I have continued to use as I am able to manually edit the maps to produce the figures used here. The analysis was run using 10,000 replicates and Poisson resampling.

HCPC

HCPC is a routine available in the `FactoMineR` package cited above. The technique first requires the analysis of the data set using `FactoMineR`'s CA choosing how many dimensions should be calculated and thus used in the clustering routine. This was run using 10 dimensions. The clustering is then run on the results of the CA twice, once for the rows and once for the columns. The dissimilarity measure was Euclidean distance and the clustering performed using Ward's method (`ward.D`). The number of clusters created was decided by the routine (`nb.clust=-1`).

The clusters are given in Table 5. The maps were created by editing the earlier maps from CANODRAW to reflect the cluster memberships.

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74 Greenacre 2007.
75 Ringrose 2012.

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