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QUANTIFYING MONETARY PRODUCTION IN GRECO-ROMAN TIMES: A GENERAL FRAME

'Quantifying monetary production in Greco-Roman times: a general frame': to explain it in just a few words, this topic was and is still but less at present, a matter of debate among numismatists as well as a matter of hope for historians. Where are we some ten years after the numismatic debate which, in a way, culminated in a colloquium held in 1997 here in Rome. This colloquium was held on the other side of the hill, at the British School of Archaeology with, like us today, the efficient partnership of the *Istituto Italiano di Numismatica* ? [1]. Surely, the answer varies depending on the angle of view from which it is viewed.

1. *Historiographical perspectives*

I intend first to give a brief *status quaestionis* of the debate which divided those who claim that uncertainties are too large to give hope and those who maintain that, despite these uncertainties, calculations of coin quantities may be useful [2].

The debate (up to 1997). To quantify monetary issues struck through ancient history has long been a dream for historians and a frustration that numismatics have not been able to answer positively. To take measure of that frustration, it is enough to quote the delightfully perfidious comments of Arnold Hugh Martin Jones (1904-1970) in his paper entitled 'Numismatics and History' written in 1956 for the *Festschrift* of Harold Mattingly (1884-1964), the greatest scholar of his time con-

[1] The proceedings were published as a special dossier in the *Annali dell'Istituto Italiano di Numismatica*, 44, 1997.

[2] I tried to sum up (as fairly as I can) the debate in different places (with references to past literature): de Callataÿ 1997a, 2000, 52-59, 2005a, 549-58 and 2005b, 73-9.

cerning Roman coinages. Jones begins with the recognition that «*Numismatics is a science in its own rights*» [3]. He pursues with the statement that «*No more eminent example could be found of a scholar who had combined the roles of an historian and a numismatist than Harold Mattingly*» (Jones 1956, 13) before concluding with the catalogue of all what should be done in order to make a real profit of coins for the historians. In other words, Jones says: «Thank you Harold for all what you did, to have put an order in this uninviting numismatic evidence; now we, historians, may really begin the serious job». His conclusion deserves to be fully quoted: «*If numismatists wish to further assist historians, I would suggest that they pay less attention to the political interpretation of the coins. In this once neglected sphere a vast amount of valuable work has been done by numismatists in the last thirty years, but latterly the value of the numismatic evidence has tended to be overstrained, and its interpretation has become over-subtle. I would suggest that if they wish to move out of their own field, they could do immensely valuable work for the economic historian by giving him such information as I have suggested above – estimating the relative volume of issues and the life of the various coins …*» (Jones 1956, 32-33).

In the 1970's and the 1980's, this dream changed into hope with the implementation of statistical formulas (more than 15), some of these formulas were specifically designed for numismatic purposes. But statistics only provide tools and any estimation of the amount of struck coins relies on historical evidence. For the Greco-Roman world, the evidence is meager and it is submitted to interpretation. Our estimations will forever be affected by large uncertainties. The question which was hotly debated in the 1990's was about the meaningfulness of such extrapolations. Regarding the legitimate warnings of certain voices which drew up a catalogue of all the motives why the average productivity of the monetary dies must have been substantially different from one coinage to another, reality points to a more optimistic conclusion. Every time we are in position to check, results look consistent with a roughly similar average productivity (this is done essentially – but not only [see the survival rate] – by comparing the relative importance of a coinage through its number of dies and its role into the circulation through hoards) [4]. In the meantime, other progress was made in terms of our understanding, between the average productivity of gold and silver for example (with a lower productivity for gold).

There is a strong cultural aspect present in this debate. Most of us who have been trained as historians or philologists are not familiar with numbers. Mathematics as they are taught at school frame our minds to give the right number. There

[3] Jones 1956, 13.

[4] See recently Duncan-Jones 1999.

is little education for statistics or probabilities. Hence, many of us seem to be fearful of uncertainties as if what is not right is wrong, an out-of-purpose reaction. What we are looking for is not to give any right number (which is unreachable but not inexistent); it is to circumscribe the uncertainty to an acceptable level. That demands to fix limits beyond which hypotheses would appear as 'unlikely' or 'most unlikely' (which is less satisfying than 'excluded'). It is in this sense that I proposed to use the number of 20,000 coins per obverse die for silver coinages, with the idea that it may be multiplied or divided by two (10,000 to 40,000 coins) but most unlikely by three (6,666 to 60,000 coins) and, let say, quasi-excluded by four (5,000 to 80,000 coins), with only possible exceptions for samples of one or very few dies.

Could this range of uncertainty, multiplying or dividing the average estimate by two, be qualified as a large one? Certainly not to compare with many fields like astrophysics where scientists are used to thinking in terms of orders of magnitude of 10. Admittedly, this is wider than for a political poll made two weeks before the vote but this is what demographers routinely accept to face for their long term projections for example. In addition, this is similar to what experts of the IPCC (*Intergovernmental Panel on Climate Change*) are predicting in terms of global warming between the last two decades of the 20th century (1980-1999) and the last one of the 21st c. (2090-2099): an increasing of the temperature between 1.1 and 6.4 Celsius degrees [5]. We should not be afraid by an estimate which goes from 10,000 to 40,000 coins per obverse die. The real question is: is it helpful? Prior to beginning to deal with this, I would like to focus on recent developments which took place during the last decade (1998-2008).

Recent developments (from 1998 to present). Generally speaking, it can be said that, contrary to the prevision formulated by Andrew Burnett in 1997 («*no doubt the debate will continue, but it does seem to have the potential to develop an independent literature of its own*») [6], what really happened was a *decrescendo*. Surely, the main protagonists, as Philip Grierson call them, Ted Buttrey [7] and I, both quickly lost any hope in order to convince one another [8]. In these circum-

[5] The number of species alive on earth is estimated between 5 and 30 millions, out of which c. 1.5 millions have been officially described (c. 10,000 new species are described every year).

[6] Burnett 1997, 1.

[7] The average die-output proposed in 1976 by T.V. Buttrey for the Crepusius *denarii* were built with no reference to textual evidence but reconstructing the number of working hours and days in a year (Buttrey 1976, 100-1).

[8] On the main protagonists, see Grierson 2001, 351: «*Thirty years of numismatics*. The only section in this that requires some comment is on pp. 58-60, dealing with estimates of mint output, for this subject is one that continues to preoccupy numismatists and on which their views remain deeply divided and on which, in the field of classical numismatics, the main protagonists are F. de Callataÿ and T.V. Buttrey».

Year	No Quantification	Quantification (in obverses dies)	Quantification (in coins)	
1998	2	2	4	
1999	8	3	2	
2000	3	3	1	
2001	5	1	2	
2002	1	6	2	
2003	2	3	1	
2004	3	2	5	
2005	2	2	2	
2006	1	5	2	
2007	2	3	3	
2008	2	-	2	
	31	30	26	
1999-2003	20	16	9	45
2004-2008	10	12	14	36
1998-2002	19	15	11	45
2003-2007	10	15	14	39

Table 1. - *The use of quantification in recent numismatic studies (1998-2008).*

stances, most numismatists refrained from jumping into what was denounced as an illusion [9]. As was pointed out by Richard Reece in 2003: «*The violent views expressed on estimations of the sizes of issues, a perfectly reasonable and proper thing to try to do, have unfortunately closed the subject down for the present. … The net result of all this is that the study of coins as struck is a very sadly underexploited resource*» [10]. This is, in turn, too pessimistic and looks possibly too influenced by the Anglo-Saxon numismatic world alone.

As a matter of fact, there is a growing use of die-output estimates. Looking at die-studies in ancient numismatics for the years 1998-2008, the numbers look significant. Table 1 gives a yearly summary of how many numismatic studies make no use of quantification at all further than the crude numbers given by the die-study (1st column) or are concerned to provide an idea of the size of the production. Among these last studies, there is a natural distinction between those which are dealing with obverse dies only (2nd column) and those which are not afraid to express results in number of coins (3rd column) [11].

There is a decreasing number of studies which pay no attention to quantification (twice less for the last *quinquennium*); but these still exist despite the fact that true die-studies were elaborated and that it wouldn't have cost great additional

[9] See, for example, Arnold-Biucchi 1999, 7-8: «Je m'abstiendrai de toute spéculation sur le nombre probable de monnaies frappées au total : la controverse sur la validité de certaines méthodes de statistique appliquées à la numismatique, loin de s'apaiser, sévit de plus en plus» or Papaefthymiou 2002, 214 : «Plusieurs propositions portant sur le nombre de pièces frappées par un coin de droit ont été formulées. Nous avons préféré ne pas nous hasarder à de tels calculs, …».

[10] Reece 2003, 141.

[11] The full references to that table are given in Annex 1.

labour to put numbers into perspective. On the other hand, a greater number of numismatic studies display some concern for quantification, either choosing to remain at the stage of numbers of dies or, more imprudently, playing with estimates expressed in numbers of coins. The general trend is going in the direction of the latter.

From a methodological point of view, few contributions appeared during the last decade. Richard Duncan-Jones made the hypothesis that dies may not have been cut when needed but instead at the start of every planned issue, with – as a consequence – very different productivities if the issue was prematurely canceled, but this hypothesis never gained much support even from himself [12]. Looking at the famous issue of Republican *denarii* in the name of Crepusius, the only one for which dies are numbered, Jörg Müller deals also with sets of dies. Two of them (Group 9 [Thyrsus] and 20 [Altar]) present suspicious gaps the author interprets as missing in our evidence not because these sub-issues were not struck but more likely because they disappeared at once, in a shipwreck for example [13].

For textual evidence, Patrick Marchetti proposed an improved reading of the only epigraphic evidence we possess, the *apousia* accounts of the Amphictionic League at Delphi. He reached the conclusion that we have to reduce the average estimates proposed by Philip Kinns [14]: the average productivity per obverse would have been close to 16,000 coins instead of 27,000 [15]. In her important die-study of Late Republican *aurei* in the name of both Caesar and Hirtius, Maria Cristina Molinari converts the 2,282 gold crowns weighing 20,414 pounds brought at the triumph of 46 BC into coins (see Appian, II, 102); making the debatable hypothesis that all the *aurei* of Caesar/Hirtius were struck with these crowns which were entirely melted down for that purpose, she pleads for a limited average productivity in the range of 6,000/7,000 coins per obverse die, which is in line with other evidence for gold coinages [16]. Since medieval textual evidence plays an important role in the debate, it is appropriate to evoke the synthetic article by Martin Allen entitled 'Medieval English Die Output' [17]. Considering the evidence gathered so far, he severely concludes: «*The figures might suggest that 'typical' average outputs of penny dies in this period were about 20,000-60,000 for obverse dies and 10,000-*

[12] Duncan-Jones 1999. For methodological criticisms, see Callataÿ 1997b, 71-72.

[13] Müller 2006.

[14] Marchetti 1999, 109 (c. 10/15,000 coins per obverse die).

[15] On the numbers proposed by Marchetti, see de Callataÿ 2005b, 88, note 5 and de Callataÿ 2005a, 552.

[16] Molinari 2003, 202-4 (c. 6,675kg of gold divided by 8,01g [the average weight of an *aureus*] = c. 833,400 *aurei* divided by 124 original obverse dies [as estimated by the simplified formula of Carter] = c. 6,720 coins per obverse die).

[17] Allen 2004.

Number of obverses	Number of coins	Mint	Years
8,398	33,383	London & Canterbury	1281-1307
4,737	30,783	London & Canterbury	1307-1327
128	33,735	Kingston-upon-Hull	1300
93	35,040	Bristol	1300
79	12,000	London	1471-1482
68/69	90,000	York	1353-1355
54	23,444	York (royal)	1300
40	23,508	Exeter	1300
37	46,500	Shrewsbury	1249-1250
31	56,000	Bury St Edmunds	1280-1297
20	65,000	Bury St Edmunds	1280-1287
17	7,000 (or less)	London	1483
16	22,020	Chester	1300

Table 2. - *Medieval English die-output (Allen 2004, tables 4, 6 and 7 classified in a decreasing order of obverse dies).*

20,000 for reverse dies, but the extreme variations of the estimates in Table 7 and elsewhere in this article demonstrate the folly of any attempt to use a single arbitrary figure for average die-output to estimate the size of a coinage» (p. 49). Actually, his Tables 6 and 7 provide a nice case illustrating that the stability of the average increases with the size of the evidence. Here are the data classified in a decreasing order of the original die populations quoted in his Tables 6 and 7.

What we do observe is a quite stable average for large samples of about 100 dies and more, in the range of 30,000/35,000 coins per obverse die [18]. This is not as frightening as Martin Allen claims it to be. Furthermore, despite his warning about the «*folly of any attempt to use a single arbitrary figure for average die-output to estimate the size of a coinage*», Allen decided to be foolish himself since he found it appropriate to make use of such figures in his subsequent articles [19].

Medieval English pennies were very thin silver coins which were easy to strike in comparison to thicker Greco-Roman coinage. The average got for Medieval times (c. 30,000/35,000 coins per obverse die) should appear as an upper limit for ancient times. A lower limit is provided by a totally different approach: a comparison of survival rates through history [20]. This is an *ex absurdo* construction: it turns

[18] Annex II gives the die-output details for the large production of London and Canterbury between 1281 and 1327 (only issues with at least 400 obverses – see Allen 2004, Table 4, p. 45-6). Here, again, the spectrum of results is not very large (23,439-40,095 coins per obverse).

[19] M. Allen 2006, 260 («Documented outputs of English penny dies in the thirteenth and fourteenth centuries are generally between about 20,000 and 50,000 coins per obverse die and about 10,000-20,000 coins per reverse die, which might provide some indication of the possible outputs of the type 7 dies») and Allen 2007, 199 («The numbers of dies expected if the allocated outputs were actually produced, which have been estimated assuming an average output of about £100-£200 [24,000-48,000 coins] per obverse die»).

[20] de Callataÿ 2000b.

out that from the large evidence of the 609 die-studies for Greek coinages gathered in the two *Recueils quantitatifs* [21] that, as an average, every Greek obverse is now attested by 4.2 coins (92,550 coins/21,973 obverses). Moreover, many die-studies present a ratio 'number of coins/number of obverses' superior to 10 (92 out of 609 = 15.1%). The large *corpus* established by Margaret Thompson for the *Stephanephori* tetradrachms of Athens counts 473 obverse dies for 3,866 coins, a high *ratio* thus of c. 8.2 coins per die [22]. According to her postulation, a low average output of 6,000 means that the general survival rate is 1 coin out of 734. Such a result would be most astonishing since survival rates got for Middle Ages or even the 16th and 17th c. are in the range of 1 out of 5,000. This is unlikely. Despite uncertainties as always, we have no other choice than to consider that a die-output of 6,000 coins per obverse die for Greek coinages is seriously underestimated. I have to confess that I am a bit disappointed to have not seen any reference to this article so far, the one I would designate as the most important in my recent literature. My conclusion was: it would be imprudent – and a bit intellectually dishonest – to keep such a pessimistic vagueness alive and to pretend that no one could say if the average die-output was, all in all, closer than 5,000 specimens better than 60,000. Quite differently, it seems that the average die-output for Greco-Roman silver coinages could have been, more than ever, confidently placed in between 10,000 and 40,000 coins per obverse.

In this light, I appreciate as eminently reasonable, the conclusion expressed by Maurice Sartre: "*Statistical methods applied since some years, even if you disagree about the number of coins struck with one die (20,000, 30,000 or 40,000, a difference from simple to double thus !), allow quantitative assessments of first value for historians dealing with economics and exchanges*" (my translation) [23].

2. *Academic perspectives*

The academic context to apply such numismatic quantifications is not favourable. I am going to comment about three categories of academics: numismatists, historians and economists.

Numismatists. On a very general level, young students are less attracted by the classical world and the number of trained numismatists who are in position to do research has not improved during recent years. The late Carmen Alfaro and Andrew

[21] de Callataÿ 1997c and 2003.

[22] Thompson 1961, 709-10.

[23] Sartre 2002, 188 («*Les méthodes statistiques mises au point depuis quelques années, même si vous n'êtes pas d'accord sur le nombre de pièces frappées avec un coin (20 000, 30 000 ou 40 000, soit une différence du simple au double !), permettent des appréciations quantitatives de première importance pour l'historien de l'économie et des échanges*»).

Burnett rightly pointed out the fact that: «*There are today fewer numismatists, and collectors, than there was a generation ago, and in some countries there has been a change of emphasis from detailed studies of particular periods towards more broad-ranging approaches to the processes and broad trends of many subjects, for example archaeology. This has tended to lead some research away from numismatics into more general studies, though it is also leading, in some fields like early Greece, towards a much more integrated and stimulating treatment of coinage in its social and cultural context*» [24]. They interestingly pursued: «*our impression is that* (scientific studies) *are fewer in number than before, partly because of expense, but also because the results they provide, though extremely important, have not been seen to revolutionize the subject, as was previously hoped. Much the same could be said of statistics; again they play an important role, but there has been a retreat from the optimism of previous years about the potential, for example, of using coins to make quantitative studies of past economies*» (p. XII). It is a disenchanted voice we are hearing here.

In 1997, I had fun calculating that, by maintaining the pace of publications, we would have a die-study for all Greek coinages before the end of the 21st c. (in 2093 to be precise) [25]. Such a prediction is likely to be inaccurate. The Summer Seminar of the American Numismatic Society – long a major provider for die-studies – does not escape the general trend: here too, the number of topics including a die-study has severely dropped in recent years. As a matter of fact, university professors who are encouraging numismatic die-studies are not numerous around the world. To quote some names, Michel Amandry in France, Maria Caltabiano in Italy or Katerini Liampi in Greece, appear as exceptions to the rule.

To perform a die-study is a complicated and long task which requires patience and skill and may easily appear as not rewarding enough, especially since it needs to pass through an ocean of sale's catalogues [26]. In addition, for young students eager or anxious to make their way in academia, die-studies present another disadvantage by nature: they necessarily attach their authors to limited topics. The ratio between transpiration and inspiration may look unattractive for those who want to demonstrate how smart they are [27].

[24] Alfaro Asins & Burnett 2003, XI.

[25] de Callataÿ 1997c, 325.

[26] In the same time, die-studies have recently been implemented to new numismatic spheres. See for example Esty & Spencer Smith 2001.

[27] The recent European academic reform very much favours the Anglo-Saxon way (Oxford-Cambridge) to produce a PhD (to show how smart you are in less than 300 pages) to compare with, let's say, the German tradition (to prove how you know the rules and are a hard-worker in no less than 600 pages). We may argue that this looks as a short-term strategy for the simple reason than the fate of smart ideas is to be superseded by smarter ones. Instead, everyone who makes a die-study is producing a new piece of evidence.

Historians. Generally speaking, it is a long time now that economists, should they be Marxists or not, no longer give the key tone to historians as they did in the 1970's. Cultural anthropologists, building far more on models rather than on numbers, have replaced them. For ancient Greek numismatics, we may refer to the work of Leslie Kurke, whose innovative approach was rewarded by a MacArthur Award, or to Sitta von Reden as true examples of applied cultural anthropology. This came along with a revival of interest for iconography and religion, themes which – after a nearly uninterrupted preponderancy since the start of numismatic studies in the 16th c. – fell in disgrace some 30 years ago. Even worse: within the large realm of economics, macro-economics, the ultimate goal of these quantifications, is no more triumphant. It is all too obvious that there is less attention now than in the recent past for quantified ancient economy.

Moreover, among historians of economy, the old (secular) debate between 'Modernists' or 'Formalists' (to whom most numismatists are suspected to belong) and 'Primitivists' or 'Substantivists' left exhausted opponents, trying each whatever their side to supersede the debate. I am even convinced that Alain Bresson has recently done it for ancient Greek economy [28]. Numismatists come late for historians: their numbers would have been more happily welcomed two decades ago. We are thus left with the strange taste of a long quarrel about ancient economy without seriously taking into account numismatic evidence (almost completely ignored by Primitivists).

Above all, to estimate the amount of coins struck by ancient civic and state powers does not give the amount of coinage actually put into circulation and, in addition, says nothing about credit. In other words, we are far from being able to say how monetized ancient economies were (and we should welcome with great suspicion every claim of such kind).

The amount of coinage in circulation depends of several factors: 1) the amount of struck coins released by the mints of course but also the length of circulation which implies knowledge on when issues were pull out of the circulation by official decree or when they disappeared by natural wastage. We know very little about these two factors and this is not the place to enter into detail, but I would attract your attention on wastage which may have varied largely and had heavy consequences on the amount of coins in circulation. Richard Duncan-Jones estimated a yearly wastage of more than 4% for some late Republican *denarii*, a tremendous *ratio* to compare with the one of 1% or 1.5% we are more ready to accept looking at hoards in general[29]. If real, this ratio severely affects the idea we may have of a

[28] Bresson 2007.
[29] Duncan-Jones 1999.

plentiful circulation in the 70's and 60's BC due to the numerous issues struck for the Civil War.

Credit is another major issue, and also a very hot one since the publication of a recent article of William Harris: '*A Revisionist View of Roman Money*' [30]. In contrast to the classical (and Finleyan) view which maintains that credit was limited in Greco-Roman times and was mainly restricted to consumption credit, many recent studies have pointed out a far more extended use of credit. Relying on written evidence, and to begin with the correspondence of Cicero in specific, Harris pushed the case further than ever. If he is right, it would mean that «*Roman monetary system was far indeed from relying entirely on coinage*» or, in other words, «*that credit-money added very significantly to the Roman's Empire money supply*» (p. 24). No doubt, this 'revisionist view' will be commented on, being endorsed or criticized. Elio Lo Cascio will focus on this specific point. My own suspicion is that the pendulum has possibly swung too far in the opposite direction now, but the *onus* of proof doesn't anymore belong to those only who defend the vision of an enlarged credit in Greco-Roman times.

Economists. After the numismatists and the historians, the economists: how do they consume the knowledge we are dealing with? Everyone should read the strong statement made by Marcello de Cecco in his conclusions of the colloquium *Mercati permanenti* organized by Elio Lo Cascio in 1997: «*unfortunately all this talk about gold and silver is a very poor production – I can assure you – of what we can do, and frankly, we don't need it, because you will never have the quantitative evidence, you will never produce anything which is definitive, you can only have qualitative stuff and that is what we need, because now our discipline, as economists, is intent, in itself, denying this predominance of macroeconomics, and going back to the analysis of microphenomena…*» [31]. In line with him, we may certainly agree on two points. First when he wrote: «*You (ancient historians) may realize that we (modern economists) are going towards you rather the other way round*» (de Cecco 2000, 272).

Far from trying to reach a unified model with an enthroned economy dictating its laws, economists are struggling with an embedded economy (just like ourselves) with a major interest for institutions. Secondly, when addressing the ancient historians, he concluded: «*You don't have to think: 'If I don't put on distinctive modern clothes, nobody will read me'. Nobody will read you anyway. So, only interested people will read you, and interested people want to know the unadulterated truth, and they want to know it with your own instruments, the ones that were given to you*

[30] Harris 2006.
[31] de Cecco 2000, 269.

in two thousand years, not the ones you learned from a few outmodel economists» (de Cecco 2000, 273) [32].

3. *Historical perspectives*

The third and last part of this paper intends to address the real concern: why is it important to quantify ancient coinages? How and to whom is it helpful? Many warnings have been expressed and modesty surely is commanded. But there is no reason to give up or to demoralize in front of – I ironically resume – numismatists who say «You cannot do it!» and historians who say «It does not help us!».

Economists. To start with economists (modern economists), there is nothing to really catch their attention in these calculations, except the spectacle of historians studying coins and money as an embedded phenomenon, in which institutions certainly play a role but possibly not as much as for the actual economy with all its regulator agents (as constantly illustrated during these last weeks by the Fed for example). Coins were struck to face state expenditures and the agenda for these expenditures was heavily dictated by military purposes. When dealing with long term views, historians are more ready to integrate wars, which involve risk and chaos, as fundamental factors for economic change.

Numismatists. At the lower level, the benefit to quantify monetary productions goes to numismatists. It helps to define the purpose of specific coinages. As odd as it may appear to historians, many numismatic die-studies fail to address the question of why? Why this coinage was produced? Quantification forces us to explicitly assume our choices: was it for trade (as it was the most common implicit assumption in the past)? Was it for state expenditures, mainly military (as we are more and more tempted to consider)? Or was it only to express some pride, for motives of propaganda? It seems crucial for numismatists to themselves formulate the most likely explanation of why coinages were struck. Quantification very much encourages us to face these questions, even when results are inconclusive.

But sometimes, results are conclusive. Two kinds of favourable cases may emerge: either because there is not enough, or because there is too much, whatever the accepted average die-output may be (10,000 or 40,000).

Not enough. There are more occurrences for the 'not enough' case, as illustrated by most Roman Provincial coinages. Michel Amandry, Bernard Rémy and their students have produced an impressive set of die-studies for Roman Pontus and Pa-

[32] With a hard attack against the use of quantity theory of money: «*the quantity theory of money: you cannot prove it, it's useless for us, what can we make of it, or with it? it's past, it's finito, it's no more. Maybe the Bundesbank believe in it, but not all of them*» (de Cecco 2000, 271).

phlagonia. (see the contribution of Amandry in the volume). They convert the original number of obverse dies first into coins (with an average of 20,000 coins per obverse) then into annual pay for Roman soldiers. Results tend to be impressively limited: two centuries of issues are not enough, in the best case scenarios, to pay more than 1,000 soldiers for one year in fresh coins (Amasia), many times less in other cases. However, the original number of obverses can be estimated around 28 for Sebastopolis and 35 for Comana, the smallest mints under review [33]. These numbers are not particularly small in terms of dies but nevertheless could not afford to pay more than c. 200 soldiers during one year, which means – considering that these coinages were struck from Tiberius to Septimus Severus – no more than 2 salaries every year, an unlikely result for the trade hypothesis.

My entire PhD about coinages struck during Mithridatic wars was built around the 'not-enough' argument [34]. The idea was to maximize the following three forms of data needed to convert dies into pay, using 1)the highest extrapolated original number of dies, 2)the high average of 40,000 coins for the output of every obverse and 3)the high estimate of a yearly pay of 320 Attic drachms. Proceeding in such a manner, we may be confident that proposed numbered results will exceed the real ones. Nonetheless, for Mithridates Eupator himself, king of Pontus, as for Tigranes, king of Armenia, there is a large gap between the numismatic evidence and their military expenses. We may partly reduce the gap, arguing that numbers for the armies in our written sources are grossly exaggerated, but we cannot fill it. That leads to a non-symmetrical consequence: indeed, most coins (if not all) were produced to match military expenses but these military expenses were not mainly paid by coins. Quantification forces us to more precisely define for what purpose coins were struck and used. This particular case strongly suggests a link with mercenaries, a qualitative result thus, that would have been impossible to reach through the simple comparison of numbers of dies.

Philology may also be affected by quantification and the 'not enough' reasoning. There are two words in ancient Greek which mean "silver": *arguron* and *argurion* (with a *iota*). The common assumption is that *arguron* (without the *iota*) refers to uncoined silver while *argurion* (with the *iota*) designates silver coins. I formally challenge this view [35]. Along with textual evidence, quantification proofs to be decisive in order to modify the meaning of *argurion*, which does not neces-

[33] See also *e.g.* Komnick 2003 (with 18 obverses engraved at a single moment; see my review in *RBN*, 150, 2004, 247-249) or Draganov 2007 (with the high number of 181 obverses for a value which does not allow to pay more than 1,000 soldiers during one year; see my review to appear in *RBN*, 154, 2008).

[34] de Callataÿ 1997d.

[35] de Callataÿ 2008.

sarily refer to "silver coins" but only to silver money, to silver considered as a means of exchange. Indeed, large amounts of *arguriou* are quoted in several contexts for which, even with the best accommodations we can offer, there is no possibility to connect enough coins. The consequences of such a semantic deconstruction are not negligible. It turns out, for example, that large penalties paid to Rome by Hellenistic defeated monarchies were not paid in coins, as believed up to now, at least, not mainly. This clearly affects general ideas we may have about the availability of coined metals at that time.

Too much. Sometimes, there is 'too much' as illustrated by the late *Lysimachi* tetradrachms struck in Byzantium. With more than 200 obverses dies engraved in 15 years (Groups 3 and 4 of my study: c. 90-76 BC) [36], this reaches far beyond the needs of any city, Athens included [37]. A yearly average of 14 obverse dies for tetradrachms was not even reached by the most powerful Hellenistic kings, with the only exception of Alexander the Great. There is definitely too much for Byzantium [38]. This, at least, is a result we may get through comparison between numbers of dies.

But there are cases for which quantification by coins prove to be helpful to qualify abundance or paucity. During the years 69 to 73 AD, an army of c. 50,000 soldiers (five legions and the auxiliaries) was engaged in the Judean wars for a total cost estimated at c. 39 millions *denarii* [39]. These are impressive numbers indeed. But the numismatic evidence is even greater since it seems that we may connect monetary issues for an approximate total of c. 45 millions *denarii* to these events [40]. As such, this context seems to provide a rare example of a large army durably paid for only with fresh coins.

Quite differently, in certain cases, particularly when one deals with small but re-

[36] See de Callataÿ 2007, 129-130 and 136. Precise numbers are 210 obverses for 15 years (c. 90-76 BC), with a yearly average of 14 obverses for tetradrachms.

[37] See de Callataÿ 2005b, 83.

[38] 14 x 20,000 tetradrachms = 280,000 tetradrachms = 1,120,000 drachms = 4.7 tons of coined silver (for a tetradrachm of 16.8g) = 186.7 talents of Attic silver = enough to fully pay in fresh coins at least 3.500 soldiers (at the high salary of 320 drachms a year).

[39] Amandry 2002, 141-143. At the annual cost of 1,134,000 *denarii* per legion to which one will add 2,805,000 *denarii* for the auxiliaries.

[40] I would be tempted to propose the following estimates: c. 26,000,000 *denarii* for tetradrachms (320 obverses x 20,000 x 4), c. 19,000,000 *denarii* for *aurei* (95 obverses x 10,000 x 20) and 580,000 *denarii* (29 obverses x 20,000) = c. 45,5 millions *denarii*. Calculations made by M. Amandry are problematic in a few instances (95,5 x 20,000 = 1,910,000 [not 1,970,000]; 1,970,000 x 20 = 39,400,000 [not 47,512,000]). His calculation for gold looks overestimated since he is using a multiplying factor of 20,000 coins per obverse (instead of a lower value of 10,000 as I think more realistic); the original number of obverses for Group 1 is very fragile (15 coins for 13 obverses, hence an original number of 73.6 dies as calculated by the simplified method of G. C. Carter).

Mints	Annual output
Silver in the name of Alexander the Great (c. 332-c. 290)	c. 350.0
Ptolemy II Philadelphus (285-246 BC)	c. 132.0
Ptolemy I Sôter (c. 295-285 BC)	c. 100.0
Late Ptolemaic kings (c. 164/3-c. 91/90 BC)	c. 100.0
Cistophoric coinages (c. 175-c. 130 BC)[1]	c. 49.3
Demetrius Poliorcetes (c. 306-c. 287 BC)	c. 48.2
Antiochus III (223-187)	c. 44.0
Athens (c. 185-c. 45 BC)	c. 39.5
Seleucus IV (187-175 BC)	c. 32.0
Bithynian kings (128/7-74/3 BC)[2]	c. 31.7
Tetradrachms of the Seleucid kings (c. 300-c. 235 BC)	c. 24.0
Mithridates Eupator (c. 97-64 BC)	c. 23.3
Mausollus (c. 377/6-c. 353/2 BC)	c. 18.8
Idrieus (c. 351/0-344/3 BC)	c. 17.1
Attalid tetradrachms (263-190 BC)	c. 11.3
Rhodes (c. 408-c. 190 BC)	c. 9.5
Cappadocian kings (c. 130-78/7 BC)[3]	c. 7.4
Tarent (c. 510-c. 281 BC)	c. 3.4
Maroneia (c. 510-c. 60 BC)	c. 2.6
Miletus (c. 294-c. 86/5 BC)[4]	c. 2.2
Phaselis (c. 525-c. 130 BC)	c. 1.2
Chalcis (c. 338-c. 87)[5]	c. 1.1

Table 3. - *Some Hellenistic annual outputs for silver coinages(in equivalent of obverses for Attic drachms)*.

markable issues by their size (*e.g.* Greek decadrachms) or their iconography [41], one may be tempted to consider them as medals better than as coins, a clearly dangerous assumption. Quantification is there to remind that we are dealing with mass-produced items.

The so-called 'Porus' coinage struck during Alexander the Great campaigns are certainly rare but six known obverses and 17 reverses (for 24 coins) make it hard to sustain the recent claim that these coins were actually medallions [42]. It is likely that more than 100,000 of them were struck for a value of about 125 silver Attic talents, a huge amount indeed. Taking into account this criterion of evaluation, most Greek coinages would be medals.

Historians. Beyond numismatic monographs dealing each with one specific coinage, quantification is above all helpful in order to put things in perspective at a higher level with no reason for historians to ignore such results. A first but very

[41] Elkins 2006, 219 (with 5 obverses and 7 reverses, this issue probably represents a distribution of one coin to any spectator for no more than a couple [2 or 3?] of audiences in the Colosseum).

[42] Holt 2003, 139-140 (and *passim*).

Mints	Attic drachms	Talents	Tons of silver
Silver in the name of Alexander the Great (c. 332-c. 290)	c. 364.3	c. 1,214	c. 31.4
Ptolemy II Philadelphus (285-246 BC)	c. 132.0	c. 440	c. 11.4
Ptolemy I Sôter (c. 295-285 BC)	c. 100.0	c. 333	c. 8.6
Athens (c. 185-c. 45 BC)	c. 39.5	c. 132	c. 3.4
Tetradrachms of the Seleucid kings (c. 300-c. 235 BC)	c. 24.0	c. 80	c. 2.1
Rhodes (c. 408-c. 190 BC)	c. 9.5	c. 32	c. 0.8
Miletus (c. 294-c. 86/5 BC)[1]	c. 2.2	c. 7	c. 0.2

Table 4. - *Annual outputs for Some Hellenistic silver coinages (in Attic talents and tons of silver [with a die output average of 20,000 coins]).*

helpful step is to assemble data coming from hundreds of die-studies (more than 700 now for the Greek world). At this stage, we do not need to quantify in terms of coins. We may stay at the 'die's level', with a systematic use of a common unit. The equivalent of an obverse die for silver Attic drachm is the natural choice for Hellenistic coinages. It indeed helps to realize that, in the long-run (*i. e.* more than a century) the annual average output for civic mints is less than the equivalent of 10 obverses for Attic silver drachms (Rhodes: c. 9.5; Tarent: c. 3.4; Miletus: c. 2.2) with the unique exception of Athens (39.5), while, for Hellenistic kings, the average is superior to ten and in the range of 20-50 for major kings such as the Seleucids or Mithridates Eupator. Beyond that point, we are left with the huge Ptolemaic coinage (c. 100.0, which means c. 25 obverses for tetradrachms every year) and, as an ultimate mark to be sure, tetradrachms and drachms struck in the name of Alexander the Great during four decades (c. 332-c. 290 BC) with a yearly output of c. 350.

The landscape provided by these estimates (which all derive from extrapolated original numbers of obverses) looks coherent in terms of relative sizes, denying again the statements made on the impossibility to compare different coinages. Clearly, die-output averages did not differ very much, otherwise we wouldn't be able to explain the general coherency of these numbers.

To take it one step further, let's apply a die-output average of 20,000 coins to see what it gives expressed in talents and tons of silver. Here, we are dealing with large samples of hundreds or thousands of dies, with a reduced risk of abnormality (the larger the sample, the lower the risk). These numbers are indeed uncertain but by no means are they illusions. They give us far better than an order of magnitude.

The main benefit to express results in tons of silver is to afford comparisons with other data, either within or outside the period. These annual silver monetary outputs may be compared with other estimates as revenues for major Hellenistic monarchies [43], the total amount of coined silver for the Hellenistic world or even

[43] On these revenues, see Le Rider & de Callataÿ 2006, 170-174.

Silver
1 obverse die for tetradrachms (20,000 x 17.2g) = 0.34 tons of silver
Annual monetary silver production for the Ptolemies (25/40 obverses) = 8.5/10.9 tons of silver
Annual revenues of the Ptolemies (10,000/15,000 talents) = the equivalent of c. 259/389 tons of silver
Annual monetary production to compare with revenues for the Ptolemies = c. 1/22th-c. 1/34th
Total amount of silver coins = c. 2,000 tons
Total amount of available silver = c. 20,000 tons
Gold
1 obverse die for staters (10,000 x 8.6g) = c. 0.09 tons of gold (c. 0.86 tons of silver for a ratio 10:1)
Total amount of gold coins = c. 200 tons (c. 2,000 tons of silver for a ratio 10:1)
Total amount of available gold = c. 2,000 tons (c. 20,000 tons of silver for a ratio 10:1)

Table. 5. - *Some silver and gold estimates for the Hellenistic world.*

the total amount of available silver, coined or uncoined. As it has been argued elsewhere, the assumption is that Hellenistic precious metals, for the main part, were not converted into coins. It is unlikely that gold coins represented more than 1/10th of the available gold at that time [44]. Table 5 gives the main important estimates which we may reconstruct for gold and silver within the Hellenistic world.

Beyond a doubt, it seems to me that they give at least orders of magnitude. The total amount of silver coins, for example, here estimated at c. 2,000 tons, may be divided or multiplied by two (I would be surprised if possible by three) but certainly it has to be estimated in thousands of tons, not in hundreds, and not in tens of thousands. This frame is bound by external evidence among which numbers for later periods, beginning with the Roman Empire, and the gold/silver ratio play a major role.

There is a lot of exciting work to do with these quantifications, either at the lower level of die-studies, or on higher levels including the inscribing of the Greco-Roman monetary world on a long-run perspective. Moreover, numbers give different feelings depending on the level you are. We may be first impressed, at the first level, by the huge amount of coins struck in Greco-Roman times, billions litteraly for the Greek world and tens of billions for the Roman Empire [45], often prompting the conclusion that it was a lot. But, put into perspective, what we know about the yearly rate of monetary production or the volume of coins put into circulation often does not look impressive when compared with the possibilities offered and the needs required by the political units under review, sustaining the idea that monetization was actually limited. However, if going still further, we venture into diachronic comparisons up to the 17th c. AD, there is no doubt that monetary

[44] de Callataÿ 2006.

[45] The total amount of obverse dies engraved for the Greek world is in the range of 200,000 (c. 25,000 dies for the 609 die-studies gathered in *RQEMH* and *RQEMAC* which seem to cover c. 12.5% of all the Greek issues). That makes c. 4 billions of coins (with an average output of 20,000 coins per die).

quantifications nurture the idea that the Hellenistic and the Roman worlds were more monetized, as far as coins are concerned.

I would not conclude without offering a final warning insisting on the spectrum of uncertainties we have to accept. Some twenty years ago now, I estimated the entire coinage struck in the name of Alexander the Great in between c. 332 and c. 290 BC to be some 200,000 talents [46]. This number was found attractive since it is very close to the c. 180,000 talents taken by Alexander as booty in the Persian treasuries. I used then the high estimate of 30,000 coins as the average die-output whatever being the metal. It actually seems more accurate to multiply the original number of obverses by 20,000 for silver and by 10,000 for gold [47]. As a consequence, instead of 200,000 talents, the coinages in the name of Alexander are now reduced to c. 90,000 talents[48] and the general equivalence with the Persian booties is gone. So Marcello de Cecco is correct: we will never have the quantitative evidence; we will never produce anything which is definitive (but who does?), we can only have qualitative stuff (this is to be appreciated) and, he adds, that is what we need. And that is what we can offer.

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[46] de Callataÿ 1989, 272.

[47] But, as exemplified for Roman *aurei*, dies for gold may have lasted longer than for silver under regular process (which indeed makes sense since gold is softer than silver: see de Callataÿ 1997b, 67-70).

[48] c. 1,200 obverse dies for staters (x 20 x 10,000 = c. 240 millions drachms), c. 3,000 for tetradrachms (x 4 x 20,000 = c. 240 millions drachms) and c. 3,300 for drachms (x 20,000 = c. 66 millions drachms) = c. 546 millions drachms = 91,000 talents = c. 2,350 tons of coined silver.

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Annex 1
References to Table 1

I have tried to take into account every relevant study published from 1998 onwards. However, it is likely that, despite my efforts, several studies are missing in this annex. I apologize in advance for these shortages which, hopefully, will not affect the general trend of the calculations.

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