The Origin of Lydian and Greek Coinage: Cost and Quantity

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1.Introduction: Money, East and West

It certainly would not be justified to consider that money came into being with coined money, as if all the societies of the past that did not know coined money had no money at all. Under the form of one, or more often several specialized goods that performed the role of a privileged unit of account and/or that of store of value and medium of exchange, some form of currency has probably existed in all human societies.[1] In most of them however, the goods that performed these roles operated in a definitely limited context. They were goods of religious value obtained at the occasion of votive offerings, luxury goods that chieftains obtained from foreign trade, etc. In other words, in those societies money was not the equivalent of any possible commodity, simply because most of the products did not belong to the category of goods that could be obtained by some form of transaction, or because there existed a hierarchy of transaction networks. Thus, in the debate to determine whether or not money is a universal character of human societies, the answer must be yes, but with the strong caveat that 'money' does not play the same role in every society.

The Chinese tradition of money is a sufficient warning against the assumption that the Western path was the only one that was possible. In ancient China, copper or bronze coins, later also paper money were the main monetary instruments.[2] The jurist tradition considered that coinage was to have a fixed value corresponding to the intrinsic value of the metal. But the Confucian perspective considered that it had only a conventional value, whatever the actual weight of the coins. Although sometimes challenged by the variation of the value of metal, the Confucian attitude prevailed, thus giving to the Chinese money a strong fiduciary aspect. A striking characteristic of the ancient Chinese world is that precious metals, gold and silver, were not adopted as a monetary standard. Silver, but as a unit of account only, was adopted only under the Jin (1115-1234 CE) and Yuan (1260-1368 CE) dynasties, which were of foreign origin. Under the Qing or Manchu dynasty (1644-1911 CE), and under the

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[*] We would like to thank R. Saller for his help and advice in the preparation of this manuscript.
[1] For the material aspects, Haddon 1949.
[2] On these aspects, of course I write under the control of Chinese colleagues, who will be able to correct or supplement the views proposed here, which draw heavily on Thierry 2001, with previous bibliography.

influence of Western traders, silver circulated for taxes and for exchange between banks. But there was no single standard. Alloy could vary widely. The result was that transactions commonly needed weighing and verification of alloy. [on these questions, see the more recent works my W. Scheidel]

If the ancient Chinese tradition of money had from the start a tradition of fiduciary money, although in no way an exclusive one, the Western world (in this I rank both the societies of the Mediterranean world and those of the Middle East) followed a different path. In the states of the Fertile Crescent, from Mesopotamia to Egypt, later also in Greece, then in Rome, precious metals, first of all silver, tended to become the standard reference of value and to play the role of money. So it is basically the mercantile value of the metal that was the monetary reference. It is only comparatively in the more recent period, from the 17th and 18th century onwards, that the West has seriously begun to move towards a system of fiduciary money. The complete separation between gold and money for a great currency took place less than forty years ago, in 1971, when the American Federal Reserve abandoned the 'Gold exchange standard' monetary system and severed the link between the dollar and gold.

Yet, in this tradition of metal money, an innovation was introduced as early as around 600 BCE, or a little after that date: the minting of a precious metal coinage, an invention that was to be a lasting success in the Western world and far beyond. Did coinage represent something really new in comparison with weighed gold or silver? The question is still highly debated. But this will not be our main point here. Rather, we would like to concentrate on another issue. If in the Western tradition, the Greeks, or the Lydians and the Greeks, are famous for having been the first to strike precious metal, the precise reasons why this 'invention' took place –why in western Asia Minor? why around 600 BCE? what was the incentive to that innovation?– are still unclear. To quote a recent study, 'the enormous bibliography on the origins of coinage partly serves to highlight the continued absence of definitive answers to the fundamental questions of "who, what, when, why, where?".[3] One can but agree with this judgment. It is the object of the present paper to suggest a new solution to that old and vexing enigma.

2.Greece or the Orient?

If in the Western tradition the beginning of money is often equated with the Lydian-Greek coined money, it is because the coined money of precious metal 1) performed a role of

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[3] Thompson 2003, 67.

general equivalent for all the goods, 2) was in the same time a unit of account, a store of value and a medium of exchange, and 3) because, under the control of the state, it was the only commodity to which that role was acknowledged.

As for the western tradition, a strong debate has developed in the more recent years on the originality, or not, of the Lydo-Greek coinage as compared to the development that took place in the Orient.[4] This debate has been stimulated both by the reassessment of textual sources and by a series of new hoard discoveries. They contained in various proportions silver ingots, 'Hacksilber'(lumps of silver) and small silver jewels. Such hoards have been found all over the region from Iran to Mesopotamia and Syria. These characteristics can be observed in the hoards of Zincirli (Cilicia, 8th century), Ashur (Northern Mesopotamia, before 614 BCE, date of the destruction of Ashur), Nippur (Southern Mesopotamia, 7th century), Qala'at al-Bahrain (ancient Dilmun, Persian Gulf, 650-550 BCE) and Nush-i Jan (near Hamadan, ancient Ecbatana, probably late 7th century).[5] As for the amount of hoards, the most striking evidence comes from the southern Syrian area, where for the period of the Iron Age (11-10th century to the 7th century BCE), 25 hoards have been discovered.[6] These hoards correspond mainly to excavations conducted in Israel or the territories under the control of the Palestinian Authority. Thus there is little doubt that more systematic excavations in other areas would lead to a multiplication of finds. The southern Syrian hoards present the pattern of silver objects mentioned above, with in addition some gold for two of them. Ten of these hoards were made of one or several bundles or linen bags of metal pieces. In some cases, these bags or bundles were more or less of the same weight. The weight of the hoards ranges from 26 kg for the Eshtemoa hoard to 19 g for the Tel Miqne-Ekron F hoard.

The textual evidence (the Bible or the Mesopotamian archive texts) proves the usage of small sealed bags, the seals attesting both the purity and the amount of precious metal involved. But there is even more: in Assyria and in Egypt, the textual evidence tends to prove the existence of ingots of precious metal, bearing a seal of guarantee of the authority. If such is the case, what does remain of the alleged 'invention' of coinage by the Lydians and the Greeks? They would have only systematized solutions that had been known for centuries, or millenniums, in the Orient.

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[4] The high scientific level of the publications, the contents of which can only be briefly summarized here, as well as the rigor and fair play of the subsequent debate are worth underlining.

[5] Survey in Gitin & Golani 2001, 38-39. On the Nush-i Jan hoard, see below in more detail.

[6] Balmuth 2001; Thompson 2003; Kletter 2003, with Kletter 2004. Thompson and Kletter present the same evidence, but in a different way, Tompson's accounting separately hoards from the same finds (hence her figure of 34 hoards as compared to Kletter's 23). We follow Kletter 2003 in the accounting of the hoards, including his Tawilan and Desert Cave hoards, and add the still unpublished Akko and Ashkelon hoards from Thompson's presentation.

The argumentation requires a careful attention. Although the main thesis of continuity can hardly be accepted, it provides an important insight on the way the phenomenon of coined precious metal must be understood. Usage of metal along this pattern was not new in the 7th century. But intensification there certainly was and with Gitin and Seymour it is correct to assume the existence of a Phoenician and Assyrian connection. In the late Iron Age, the intensification in transactions of weighed silver, even if it was under forms that had long been known, leaves no doubt. Silver metal had not become the unique unit of account and payment, as other commodities like barley, wool, wine, sheep were still in use in parallel for the same purpose. Nevertheless, states, temples or individuals had ever more recourse to it in a money usage. No one would now revive for such accumulations the old theory of the 'silversmith's hoards' the way it was still done not so long time ago.

Others however point to the fragmented and discontinued evidence from the Orient, which sharply contrasts with the consistent development of the phenomenon of coinage in the Greek world. The kings of Persia, but also the independent pharaohs of Egypt in the 4th century BCE did strike their own coinage. But the many different societies under the control of the Great King as well as the Egyptian society seem to have been strangely reluctant to adopt the Greek system of coinage when it came to be known to them. Thus, it seems clear that indeed there was something specific in the development of the Greek system of coinage.

Some consider that in fact it did not matter at all whether silver was coined or not, as it was the metal that made the money, not the seal it bore.[7] Indeed, it is absolutely right that in Greece like in the Orient the base of money was the metal, not the seal. From that viewpoint it is the continuity, not the opposition, between Greece and the Orient that should be stressed. That coinage made no difference is another story (see below). But the lesson to be drawn is nevertheless that from Syria to Mesopotamia and Iran silver could be used for payments of all kind in the 7th and 6th century and was not only a unit of account.

Thus what made the difference between coined and weighed precious metal? As compared to weighed metal, there was clearly an advantage in the fact that coined money was weighed once and for all. The seal of the state authority (if admittedly it was a state authority) thus guaranteed the weight of the round of metal, as well as it bore testimony of the alloy of its metal. But if the advantage of coined metal thus seems clear, and if the Oriental societies were technically in the capacity of producing coins, why was it that the Lydians and Greeks made the break through, and not the oriental societies?

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[7] Kim 2001; Kroll 2001b.

3.The explanations that have been proposed

Until the 1950s, the explanation proposed by Aristotle (or what was understood from Aristotle's explanation) was the one that was universally favored: the first coinage had been introduced for the necessities of international trade. According to the historian Herodotus, who without any doubt was right on the issue, the first coinage was minted in Asia Minor, exactly by the Lydian kingdom. In fact, the metal used for this first coinage was electrum, an alloy of gold and silver. It is now fairly certain that coinage was introduced around 600 BCE. The coins discovered in the excavation of the great temple of Artemis of Ephesos, the Artemision, bear testimony of this first phase. They are conventionally alluded to as the 'Artemision hoard', although in fact they do not constitute a hoard stricto sensu (or only a minor part of them). These first electrum coins were struck on the same standard by the Lydian kings, but certainly also by a series of Greek cities of the coast, among them Miletus and Teos, and also by Phokaia, but on a different, local standard.

On the base of this material, two main arguments have been raised against Aristotle's commercial explanation. In a challenging article, R.M. Cook noticed that the first electrum coins of Asia Minor were comparatively of high value, and thus inappropriate for a daily use on the agora. Cook refered to Plutarch's *Life of Solon*, quoting Demetrios of Phalerum himself saying he quoted the axones of Solon on the Athenian agora. Thus by the time of Solon (594 BCE) the price of a sheep would have been of one silver *drachma* (*ca*. 4.33 g). Assuming that the relation between silver to electrum was the same as that of the classical period (1:10), and as the smallest coins of the Artemision are 1/96th (0,15 g) of a stater of 14.3 g, this would mean that the smallest electrum coins would have had the value of one-third of a sheep: this obviously excludes sales on the agora, the daily market, when prices were comparatively extremely small. The 'one-third of sheep' has become a *locus classicus* that can now be found in every article or reference handbook and is never any more re-discussed.[8] Actually, this does not contradict Aristotle, who said that the usage of money derived from foreign trade, thus involving large payments. But drawing parallels with 18th century Britain, where according to him large payments were made with ingots, not with guineas, Cook also excluded that electrum coins might have been used for that purpose, unless they had been previously weighed, like bullion was. Again, the argument has had a

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[8] Nicolet-Pierre 2001, 255; de Callataÿ, 2001; Le Rider, 2001, 69. We fully rediscuss the issue elsewhere and show that this estimation is likely to be overvalued. Besides, the smallest electrum coin that has been found is now a 1/192 of stater, a coin weighing actually only 0.08 g,of a diameter of 2.5 mm, but bearing both an obverse and a reverse type (Konuk 2003, n° 20, p. 33 and 175).

wide success. Besides, C.M. Kraay added that even later Greek silver coins, with the exception of Athens and the region of Thrace-Macedon, did not export their coinage at a long distance and thus that coins had no practical use for foreign trade.[9] This explanation is still often considered as on the whole fully valid.[10]

It is beyond doubt that these theories have played a critical role in challenging old orthodoxies. Yet, the detail of Cook's and Kray's arguments is in itself not beyond doubt. One argument will be sufficient here to challenge these views. The very idea of Cook that no important payment was ever made in terms of coins, but only under the form of weighed bullion is an assumption that directly contradicts the evidence (to say the least). We have so many documents that testify to the contrary –for Greek Antiquity from the Classical and Hellenistic period– that it is clear that this argument can hardly be valid. Among a thousand other testimonies, a few of them are worth quoting here. It is in coined money that all public or private contracts were stipulated, that all public or private loans were made, or that payments had to be made on the agora, as is shown by the famous Athenian law of 375/4 or by the law of Gortyn on the usage of silver money. It is in coins of good silver money of international standards that the prices of important commercial transactions were stipulated and that those transactions were realized. All the more, a basic fact is that in the Greek world, coins were not weighed, but counted.

In the present time, three main explanations are proposed to justify the shift to coinage and especially its beginnings under the form of electrum strikes in Asia Minor: a social explanation (the will to guarantee to everyone the payment of his due), an equalitarian medium of payment for the state, or a source of direct profit for the sate. But each of these explanations has its flow. For instance, J.H. Kroll has made the good argument that if making a profit had been the main aim of striking the first electrum series, it would be puzzling that ca. 550 BCE Croesus would have abandoned that policy for issuing the gold and silver 'croeseids', with almost no profit at all. On the whole, every single explanation proposed could also apply to the Orient. *Per se*, there seems to have been no technical obstacle to the development of coinage in the Orient. Thus the 'Lydian invention' of Herodotus seems even more puzzling.

4. Cost: Weighing and striking

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[9] Kraay 1964.
[10] Nicolet-Pierre 2002, 255; Thompson 2003, 94.

Our starting point is the state of Western Asia Minor around 600 BCE and in the first half of the 6th century. Succeeding in the role formerly taken by the Euboeans and then the Cretans or other central Greece states like Corinth, the Greek cities of Western Asia Minor had in every field taken the lead of Greek expansion. A market system was now taking shape in Greece. It sharply contrasted the situation of the Orient, where rations or payments in kind from the State (as distinct from the society) or from the temples heavily competed with payments in weighed silver.

Before coming to the cost of weighing, it will be necessary to start from the issues raised by the minting of the coins themselves. The fabrication of a coin, technically known as brassage, involved several operations: preparation of the metal, casting into a mould, verification of the weight of individual blanks, preparation of one or two dies (if both the obverse and reverse were to bear a type), and striking operation itself. For the first electrum coin, it has been also suggested that no mould was used.[11] The instrument that was used to draw the molten metal would have had a predetermined volume. Then the drop of metal would have been put on a striated surface. The craftsman should have had a special skill. Whatever the right solution and notwithstanding the skill of the worker, which indeed was required, it would have been impossible to reach a reasonable precision in the weights of the coins if in the final phase of the process these weights had not been rigorously verified on the scales. This must have been a painstaking job, all the more if indeed no system of molding or casting was used and if the blanks were prepared one by one.[12] But precisely, the first electrum coins testify of an astonishing precision of the weights. A closer look to what can be considered some of the first issues of electrum coinage (although of course it cannot be proved that this was the first coinage - but this would not change the argument) provides a starting point to the reasoning.

Designation	*Denomination*	Weight	'Artemision hoard'	*Total / den.*
Stater	1	14.30	—	0
Hemistater	1/2	7.15	7.16; 7.15; 7.08	3
Trite	1/3	4.75	4.8; 4.73 (2); 4.71; 4.70 (2); 4.7 (8)	14
Hekte	1/6	2.40	2.38; 2.37; 2.36; 2.33	4
Hemihekton	1/12	1.20	1.30; 1.20; 1.19 (4); 1.18; 1.17(2); 1.1	10
1/24	1/24	0.60	0.64; 0.60 (2); 0.6; 0.58 (3); 0.57; 0.55; 0.53	10
1/48	1/48	0.30	0.30; 0.3; 0.29 (3); 0.27	6
1/96	1/96	0.15	0.16; 0.14 (2); 0.13	4
1/192	1/192	0.075	—	

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[11] Nicolet-Pierre 2002, 26.

[12] On the fabrication of blanks and the casting technique, Nicolet-Pierre 2002, 26-28.

Table 1 : The 'Artemision hoard' coins (simplified data from Nicolet-Pierre 2002, 115)

On a total of 51 coins, the four larger denominations (from stater to *hekte*) are in a number of 21 or ca. 41%, the smaller denominations (from *hemihekton* to 1/96) are in a number of 30 or ca. 59%: a large majority of coins thus consisted of very small fractions. Yet, the extreme precision of the weights of the smaller fractions of *electrum* has been stressed by M.J. Price and can be testified from table 2. From the previous table, it can be observed that deviations from the standard are usually very small, usually of a few hundredths of grams: such a precision must have been extremely difficult to reach in the conditions of the time. Obviously, this precision reflects a deliberate choice made by the issuing authorities, with a special attention for the smaller denominations. Deviations from the standard were more damageable to the users of small coinage (this is an issue of relative error). But this was especially true as the metal was electrum, if indeed we should admit that its value was tenfold that of silver, as in the later Classical period.[13] All the more, as considered the high value of electrum, the absolute error could mean a rather important loss for the user even for small units. The monetary authorities who struck the first coinage were clearly aware of the problem and faced it by an exceptional precision in the weights of the smaller denominations.

But the operation of striking coins had a financial cost. If we (provisionally) admit that the cost of preparing a blank and striking was the same for a large or for a small denomination, it is easy to understand that the cost of striking 14.30 g in 1/96 of electrum was 96 times superior to the cost of striking one stater of full weight (or 192 times for 1/192 coins). The consequence is that relative cost of striking can be defined by an equation of the form $y=n/x$, where n is the value of brassage (in weight of metal), x the weight of the coin, and y is the percentage of brassage to coin weight. In other words, this cost is in an inverse proportion to the weight of metal. This rule is of critical importance for the issuing of small fractions, especially if like in the case of the electrum fractions we have extremely low weights.

But what was the value of n in Antiquity and especially in the first phase of coinage? Or in other words what was the marginal cost of striking one coin? The model proposed here would have remained purely theoretical had not data from late medieval Europe fortunately provided illuminating information on production costs (see table 2). But these data also show irrefutably that the model of rising relative costs for smaller denominations was a critical issue. In fact, the relative cost of brassage increased dramatically with the smaller fractions

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[13] See already above on the uncertainty on the actual figures.

change. For instance for the florentine *picciolo* of 0.052 g, the percentage of production cost to actual value of the coin soared to 15.65 percent: for 6.4 coins produced, one paid the production cost. This was an even more serious issue for the *double mite* of the Low Countries, where the production cost was over one-third of the value of the coin, and even almost 50% in Flanders for the same denomination. For heavier denominations, and of course especially for gold coins, this proportion fell to low or negligible figures. An interesting characteristic is also that the cost is not constant, but varies from one series to the other. This can be explained by many factors: variation of the amounts of production for single denominations, or care given to the production of the coin itself. It can be observed that the cost per unit is systematically lower for smaller denominations, and this can be linked to a deliberate will to lower the cost per unit. Indeed, although this cost per unit (see right column in table 2 below) is in all nine examples lower for smaller denominations, yet the actual proportion of the cost to the value of the coin remained very high: in absence of reduction of such a production cost, the relative cost would have almost risen to the value of the coin, thus making the production financially unbearable. Thus, it was a temptation for the mint, unless there were precise specifications in the contract with the state, to produce above all larger denominations.[14]

State	Name of coin	Legal value	x Silver/gold content (mg)	y Brassage (%)	n Thoretical brassage in weight of metal (mg)	Brassage as a proportion to 1,000 mg
1	2	3	4	5	6	7
Florence 1347	Picciolo	1d	52	15.65	8	1/123
	Quattrino	4d	217	6.22	13	1/74
	Grosso	32d	1960	1.20	23	1/42.5
	Fiorino	744d	3537	0.14	5	1/202
England 1349	Farthing	1/4d	283	3.64	10	1/97
	Half-penny	1/2d	570	2.96	17	1/59
	Penny	1d	1178	1.94	23	1/43.5
	Noble	80d	8188	0.42	34	1/29
Flanders	Double mite	1/12d	53	43.71	23	1/43
	Gros	1d	1018	9.73	99	1/10
	Noble	72d	7649	1.58	120	1/8
France 1402	Denier	1d	145	10.67	15	1/64

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[14] From one state to the other, the system of production was not the same. In Florence prevailed a system of specific seignoriage rate for each denomination (the seignoriage was the mint equivalent of each denomination): 0,6%for the *fiorino*, 4,6% for the *grosso*, 6,6% for the *quattrino* and 17.8% for the *picciolo* (the profit of the state, defined by the difference with the brassage, was thus quite limited for the small denominations, a little more important for the larger denominations, especially the *grosso*). In France and the Netherlands, 'the mint price was the same regardless of denomination, but the mintmaster was permitted to deduct different production costs from gross seignoriage', which was a way to subsidize the production of the smaller coins by that of the larger ones (on these aspects, see in detail Sargent & Velde 2002, 52-3).

	Blanc	10d	1448	6.46	93	1/10
	Écu	270d	3948	0.72	28	1/35
Low Countries 1433	Double mite	1/12d	45	36.34	16	1/61
	Gros	1d	814	4.51	36	1/27
	Philippus	48d	3598	0.94	33	1/29.5
Milan 1447	Denaro	1d	37	20.5	7	1/132
	Sesino	6d	272	8.56	23	1/43
	Grosso	24d	1175	2.25	26	1/38
France 1460	Denier	1d	109	12.5	13	1/73
	Blanc	10d	1086	4.94	53	1/18.5
	Gros	30d	3258	2.32	75	1/13
	Écu	300d	3321	0.56	18	1/54
England 1467	Penny	1d	707	3.11	21	1/45
	Groat	4d	2828	3.11	87	1/11
	Ryal	120d	7643	0.55	42	1/23
Castile 1471	Blanca	1/2mr	39	24.39	9	1/105
	Real	31mr	3195	1.49	47	1/21
	Enrique	420mr	4553	0.50	22	1/44

Table 2: Production cost (brassage) in late medieval Europe

(from Sargent and Velde 2002, 51, supplemented by columns 6 and 7.

Gold coins in italics, legal values in local pence=d, in maravedis in Castile=mr)[15]

—Column 6 [(= col. 4 x col. 5 / 100)] gives the theoretical marginal price of one coin for the denomination.

— Column 7 [1/(1,000/col. 6)] gives the theoretical relative cost of production of a 1,000 mg coin if the cost was the same as that of the production of the denomination.

Thus columns 6 and 7 present the same value under two different forms. They allow a direct comparison between the costs of production. In column 7, the proportion (for instance first row, 1/123) means that if the price of the production of one hypothetical 1,000 mg coin had been the same as that of the *picciolo*, the cost would have been 1/123 of the weight of the coin. It is that figure that can be used to make comparisons and to estimate what would be the relative cost of coins of various denominations if the cost of production was the same for all the denominations. Thus, if the relative cost of production of the *picciolo* had been the same as that of the *grosso*, viz. with $y = n/x$ where $n = 1/42.5$ (or 0,023 g, see column 6) and $x = 0.052$ g (weight of the *picciolo*, column 4), the percentage to the weight of the coin would have been 45%, when it was actually only 15.65%.

Is it legitimate to use these data for Antiquity? The answer must unmistakably be yes. The technology of minting had not changed between Antiquity and the late medieval period. An illustration of 1516 shows the emperor Maximilian observing the various operations involved in a mint.[16] They would not have been performed differently in Antiquity. It is even fascinating that a recently published red-figure vase painting shows a worker striking the blanks exactly in the same position (with anvil between his open legs) as its early Renaissance

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[15] All figures in col. 6 and 7 are rounded.
[16] Leonard Beck, from Burgkmair, *der WeißKunig*, reprint Vienna 1775, reproduced in Sargent & Velde fig. 4.2, p. 49.

successor.[17] They do not involve any kind of machine: thus the productivity of Antiquity can hardly have been higher, and production costs lower. In fact, in the first phase of experimentation, they must inevitably have been high. This is the key to the understanding of the beginning of coinage. Furthermore, once again, the extreme precision of the weights of the smaller denominations –admittedly not the quality and cost of their dies– can hardly have produced a more important lowering of the production cost per unit than that we observe for the medieval period. All in all, any figure can only be a guess. But the medieval data provide not only a *caveat* against the temptation to consider that production costs as a whole were negligible: they help us to evaluate what these costs could be in Antiquity.

One issue has however been left aside so far: that of metal. The value of electrum is admittedly superior to that of silver. But for gold in the late medieval period, *n* is frequently around 1/25. If this had been the case also for electrum at the beginning of coinage, and if *n* had been admittedly lower for fractions, but with a rate not lower than 1/50, the relative cost of a 1/96 of 0,15 g would have been 13%:
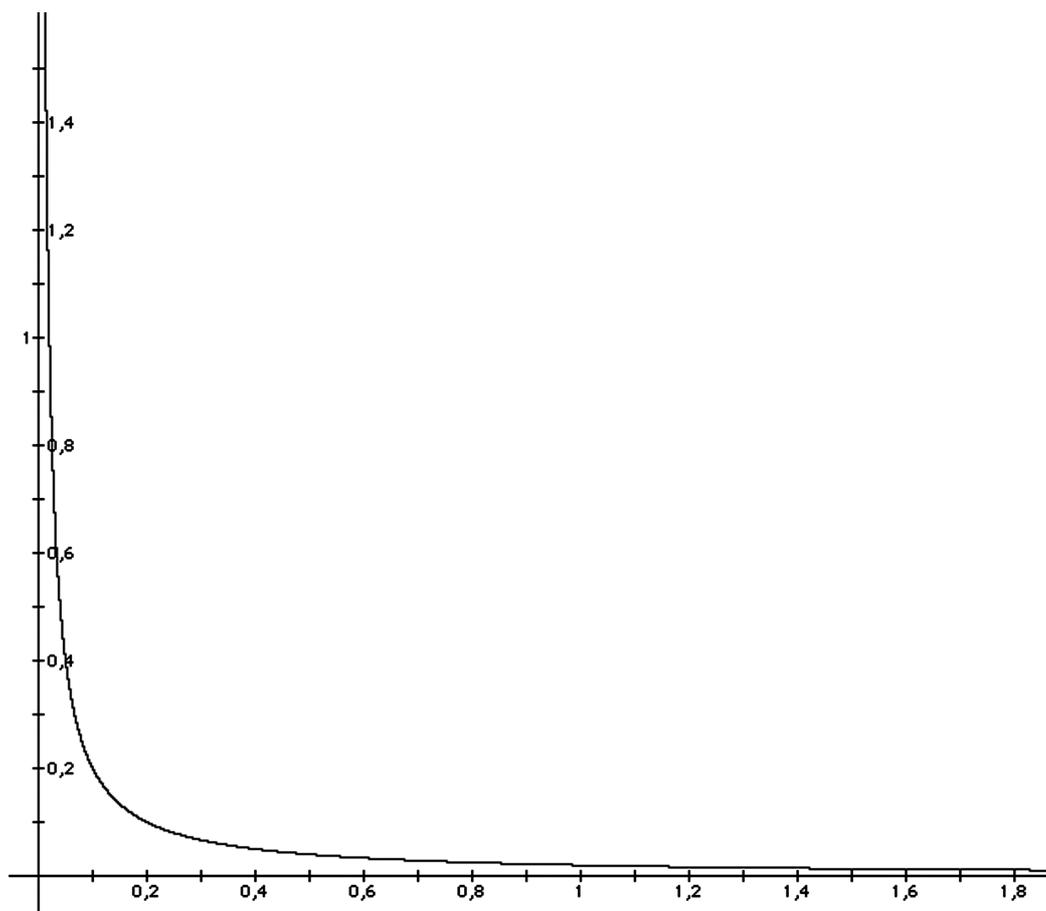

Chart 1: Relative cost of minting one coin with n = *1/50*

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[17] Konuk 2003.

These costs of production would still be better than those of Flanders and the Low Countries in the late medieval period.

A possible objection against the cost production theory might be that we have no proof that ancient minting authorities were conscious of the issue of increasing cost for the fractions. It would be easy to overrule it by saying that the constraint existed necessarily, even if the monetary authorities had not been fully conscious of the issue. But there is even a proof that indeed they had a full knowledge of the small change issue: in the Hellenistic period fractions had generally a mean weight lower than the official standard: this was obviously a way to compensate their superior production cost.[18] Indeed, it would be unsafe to attach too much importance to precise figures, as for Antiquity data fail completely. Unless some new inscription or papyrus suddenly provides more information on the subject, the exact figures (that inevitably must have varied in the course of time and in the various regions, just like in late medieval Europe) will remain unknown. But, in a similar technical environment, the medieval data provide enough parallels that suggest that the relative production costs of the smaller electrum fractions must inevitably has been high.

Coming back to that issue of weighing itself (that is 'before' coinage), it is now clear that weighing very small quantities of metal implied a precision that 'amateurs' could absolutely not reach. If electrum was to be used in a monetary usage, and indeed no argument can overturn that view (see also in detail below), then the precision needed implied a highly skilled job, which could only be performed by a specialist. The inevitable centralization of the process is the first prerequisite that lead to the weighing of blanks of the same weight. It is quite possible, although admittedly not fully proven, that the small electrum beads bearing no other mark or symbol found in the 'Artemision hoard' or other contexts reflect that first phase. But beyond the necessary technical precision implied by the usage of electrum, there was also another issue: that of the cost of weighing, and especially of weighing a small quantity of metal. We can now see that the relative cost of a single operation of weighing, in order to provide the high precision that was required by electrum, inevitably followed a pattern similar to that of the strike itself: that of a dramatic increase for lower values. One could consider that the cost of weighing only would have been much lower than that of striking a coin. But this is far from certain: striking a coinage was part of a standardized, uniform process, which inevitably lowered the costs. Adjusting minute lumps of electrum in the scales to reach the desired weight must have had a real cost. At least, we know that in the

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[18] See Ashton 2001 for the smaller units of the mint of Rhodes.

Hellenistic period, a uniform rate of 5% was exacted to exchange coins from one standard into another. Yet this implied no other operation than counting the coins and taking in charge the risk of the exchange operation itself. Weighing by a specialist must also have had a relatively significant cost. If for a given quantity of metal the operation was performed once a year, this was not really too serious a loss. But if the operations were more frequent, the social cost of weighing and re-weighing inevitably soared: if the cost was only 10% of the value of a small scrap of metal, after ten cycles the users lost an amount equivalent to the value of the weight unit. This must have soon become unbearable. The only solution was to weigh the metal unit once and for all and to strike a coin: thus the transaction costs linked to the usage of money plummeted radically. This in turn immensely accelerated the speed of circulation and the movement of transactions. The utility of the operation of minting was thus maximized, which lowered the relative cost of minting. It came a time when the advantage of the coinage system became clear to all. The advantage of coinage was thus not, or not only, a matter of 'convenience', as is often stated a bit hastily. It was fundamentally a matter of cost, while the guarantee of the alloy made the transaction secure, thus limiting the incertitude in the transaction. 'Convenience', which cannot be denied, is thus only the socio-psychological side of the issue.

5.Conclusion:

The switch to coinage was made possible by general conditions prevailing in western Asia Minor at the turn of the 7th and 6th centuries. The contrast with the Orient is clear. There, private initiative existed but the prevailing economic forms were the state and palace economies. Payments in rations as well as in kind were predominant and while payments in terms of weighed metal actually existed, silver was often used only as a unit of account while actual payment took the form of wool, barley or sheep. Around 600 BCE, the Greeks were in a phase of transition towards a market economy. The Greeks of western Asia Minor, who developed a mixed culture with the Lydians, were the most advanced of them all. In the Greek world, the state was no different of the community of citizens. It was thus directly interested in the regulation of transactions between its members, for this was the very base of its existence: hence a series of regulations on the market, but especially the controls of weights and measures. However, this is not sufficient to explain the creation of coinage.

The key to this innovation is to be searched in the issue of cost of weighing of small quantities of precious metal. The precision required implied a specialization of the task and a cost that soon proved unbearable for small weights. Minting a coinage brought the adequate

answer, as the operation of weighing and guaranteeing was made once and for all. The switch to coinage represented an important improvement in the lowering of transactions, thus in turn producing a huge acceleration in the movement of transactions themselves. This provided the best conditions for a lowering of the absolute and relative production costs of coins: the first success of coinage in itself made the operation of minting an ever more profitable operation, by a lowering of its social cost. This made possible the second phase, silver coinage, and later the third phase, the introduction in parallel of bronze coinage.

Quoting C. Cippolla, to whose memory they dedicate it, R. Sargent and F. Velde entitled their challenging book on medieval and modern coinage *The big problem of small change*. One can be in full agreement with that formulation. As has been demonstrated here, the issue of small change is also the key to the understanding of the question of the beginning of coinage, *viz.* also that of the existence of coinage *tout court*.

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