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Aspects of circular economy on an urban and inter-urban scale in the Roman age: towards a more holistic model

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Key words: *circular economy, Roman archaeology, Roman towns, Roman economy, Reuse, Recycling*

Parole chiave: *economia circolare, archeologia romana, città romana, economia romana, riuso, riciclo*

Abstract

During the last few years, interest in reuse practices in the Roman world has received increasing attention. On the other hand, the debate concerning the sustainability of contemporary economies has led to the refinement of theoretical tools such as that of circular economy. The paper examines, in the light of a circular economic framework, those aspects characterizing the Roman urban economy as circular. A series of activities and agents, sometimes leaving little archaeological footprint, reduced waste and optimized the use of fresh resources on a daily basis. These activities (maintenance, repair, secondary use, lateral cycling, recycling etc.) involved a wide range of materials and, far from occasional, they were well integrated into the so-called linear economic model (production, distribution, consumption, and discard). Although the available data are still fragmentary, this systematic review demonstrates that circular economy must be steadily included in the current narratives of Roman urban sites. Economic reasons seem to play a major role in moving the Roman urban circular mechanism; nonetheless, it also emerges a forma mentis *putting the object at centre, and not its economic, monetary value. Quantifying the overall impact of circular practices in the Roman urban economy still represents a major challenge, but the data so far collected point to a significant influence.*

Nel corso degli ultimi anni, l'interesse per le pratiche di riuso nel mondo romano è costantemente cresciuto. Contestualmente, il dibattito in corso sulla sostenibilità delle economie contemporanee ha prodotto il raffinamento di strumenti teorici come quello di economia circolare, applicabili con le dovute cautele anche al mondo antico. Alla luce della cornice teorica fornita proprio da quest'ultimo concetto, il contributo esamina in maniera organica tutti quegli aspetti che caratterizzavano l'economia urbana di una città romana in senso "circolare". Una serie di attori e di attività, dei quali spesso rimangono poche tracce archeologiche, contribuivano a ridurre la produzione di rifiuti e a ottimizzare l'uso delle risorse su base giornaliera. Queste attività (manutenzioni, riparazioni, uso secondario, lateral cycling, riciclo etc.) coinvolgevano un'ampia gamma di materiali e, lungi dall'essere occasionali, erano ben inserite nel cosiddetto sistema economico lineare (produzione, distribuzione, uso e scarto). Nonostante i dati disponibili siano ancora frammentari, questa rassegna mostra come nella percezione e nello studio dei centri urbani di età romana sia necessario integrare stabilmente anche le pratiche di economia circolare, per nulla secondarie. Motivazioni di tipo economico sembrano aver rappresentato il motore principale dell'economia circolare di età romana, ma dal panorama presentato emerge anche la presenza di una forma mentis *che poneva al centro dell'attenzione i manufatti in quanto tali, e non il loro valore economico monetario. Quantificare l'impatto specifico e cumulativo delle varie pratiche di economia circolare nell'economia urbana rappresenta ancora una grande sfida, ma tutti i dati in nostro possesso indicano che queste avessero un effetto di assoluto rilievo.*

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1. Introduction

It has been rightly advanced that "recycling economies, when efficient, are by their nature invisible in archaeological terms"[1]; indeed, the mechanisms, actors, and traces of Roman circular economy are still only partially visible. However, even though usually focused on specific classes of materials, interest in reuse practices in the Roman world has received increasing attention during the last decade, and an undisputable milestone in this sense is represented by the book edited in 2020 by C. Duckworth and A. Wilson[2].

At the same time, the ongoing debate concerning the sustainability of contemporary economies has led to the development and refinement of various theoretical tools and concepts, including that of circular economy.

These developments now allow for a global reevaluation of the Roman urban economic system: the evidence currently available, although inevitably not abundant, is far from negligible and when reviewed more holistically and combined with an adjusted model of circularity shows the existence of well-structured circular models on the urban scale.

The paper will show that circular economic practices, although often little tangible, must be acknowledged as routinary, more than exceptional, in the life of Roman towns. In addition, networks of circular practices emerge not only on an urban scale, but also on a regional and supra-regional scale, including the Mediterranean basin and continental Europe.

This review will allow then to move forward and ask for more questions, such as what the impact of circular practices on the urban economy was and who were the people behind these activities. Eventually, it will emerge a Roman attitude towards objects and resources that may have been less consumeristic than one might think.

The focus of this article will be primarily on small scale, regular activities, involving private individuals more than the local or central authorities. Those forms of circular economy involving building materials are, conversely, largely excluded from this analysis, as quite often they were top-driven and therefore require a different approach and much more space.

2. Combining new and old theoretical frames

Modern circular economy is intended as an economic system that is "restorative and regenerative by design and aims to keep products, components, and materials at their highest utility and value at all times"[3]; this means that "the value of products and materials is maintained as long as possible; waste and resource use are minimized, and resources are kept within the economy when a product has reached the end of its life, to be used again and again to create further value"[4].

The principles behind circular economy have alternatively been summarized as the 3 Rs (reduce, reuse, recycle) or even the 6 Rs (reuse, recycle, redesign, remanufacture, reduce, recover)[5].

It must be stressed that the idea of circularity, at first glance, may suggest that this form of economy is based only on reuse and recycling, but this is not the case: maintaining goods, making their systemic life as long as possible (through proper care and repair) is a crucial part of the circular economic model, as it aims to reduce waste and the use of fresh resources.

Besides an economic benefit, a positive environmental impact is often cited as one of the main traits of this form of economy. Another trait of contemporary circular economy theory is represented by the acknowledgement that understanding this process only in terms of efficient waste management and reuse (closed supply chains) is too limited: design and logistics are to be remodeled as well, for implementing an effective circular model.

These last aspects of circular economy can hardly be applied to the Roman world; the intention of approaching logistics and design in terms of sustainability would be arduous to demonstrate and there is also no sufficient evidence to evince an interest for environmental issues in modern terms. We will see that forms of circular economy seem to be driven principally by economic intent and by some cultural aspects; although there is some evidence supporting the elaboration of wider interests for the fate of our planet (see the discussion), it is likely that it was restricted to the field of literature. Nonetheless, obviously, this does not mean that forms of circularity in ancient economic systems did not exist, or that they had no social and even environmental impact.

[1] Needham *et alii* 1989.
[2] Duckworth, Wilson 2020.
[3] Ellen MacArthur Foundation 2016.
[4] European Commission 2015; see Geisendorf, Pietrulla 2018 and Kirkhherr, Reike, Hekkert 2017 for a wider discussion.
[5] See Winans *et alii* 2017 for further references.

Accounts of the economy of ancient urban centers rarely rely on the concept of circularity; whether the city is seen as a consumer entity, or as a redistributive/administrative one, the cardinal economic model assumed in historical and archaeological research is a linear one, based on the chain of production, distribution, use/consumption and finally discard of goods[6]. Some aspects of Roman consumption habits have also been labelled as consumeristic, therefore being on the opposite side of what could be considered a circular approach to economy[7].

A linear model already represents an oversimplification of the Roman economic system; the basic principle of saving resources, *per se*, is not alien to it and forms of joint production can be easily documented (e.g., animal husbandry, producing meat and leather/wool and, as a by-product, bone to be employed in workshops). However, the concept of circular economy can be usefully applied as it provides for a helpful theoretical umbrella to cover a series of restorative practices taking place also after consumption and discard. When applied to the study of ancient urban sites, the concept of circularity proves to be helpful because it embraces, in an economic perspective, a series of activities (usually tackled separately) making the local economic systems more feasible and effective, and it well describes the return of goods from what could be considered an archaeological context to the systemic context (or behavioral system).

If on the one hand circular economy in antiquity has never been tackled as a whole, on the other hand the single practices through which it is expressed have often been discussed in archaeology, both in theoretical and methodological terms, particularly in the context of Behavioral archaeology.

The definitions provided by M. B. Schiffer of reuse, recycling, lateral cycling, and curation are still of great use and are worth being briefly recalled, because they represent the theoretical backbone of archaeological thinking in terms of "object histories"[8] and because they conveniently fill the gap with the circular economy concept.

Reuse is defined as "a change in the user or use or form of an artifact"[9]. As a matter of fact, it includes most of the activities being part of circular economy, but it has no explicit economic connotation, which, conversely, is profitably provided using the circular economy concept. Reuse takes a variety of forms: lateral cycling, recycling, secondary use, and conservatory processes[10].

Lateral cycling involves only a change of user and to the extent that it leaves any traces in the archaeological record, these are very subtle. Recycling implies the loss of function and form of a given artifact, which becomes part of a new productive process (e.g., remelting of glass and metal objects). Secondary use happens when a given artifact is used for a different function, without requiring extensive change in its form: for instance, a Roman amphora initially employed for containing oil or wine, may turn out to be used as part of a drainage system.

Conservatory processes imply a change in an artifact's use intended to guarantee the artifact preservation through time, therefore lengthening its normal life; these processes usually imply a change of user, sometimes a change in function, and they are conventionally characterized as a cultural activity: heirlooms are a typical example of artifacts involved in conservatory processes with a clear social and cultural connotation.

Conservatory processes could also be labeled as curation[11]; in this paper both curation and conservative processes are intended very broadly, as processes prolonging the systemic primary use of an object (even if a change in function or meaning cannot be documented).

Overall, all these activities, minimizing the use of resources and the production of waste, shaped circular forms of economy in antiquity; they entailed precise agents, activities, goods, and networks, which can be investigated drawing from various, although scattered and fragmentary, sources, including archaeological data, literary sources, and epigraphic material.

3. Putting the pieces back together: forms of urban circular economy

Many of the activities involved in Roman circular economy have been already studied or at least mentioned. Nonetheless, they are usually presented separately, according to single practices or single classes of materials (e.g., glass recycling or pottery repair). Some of them have recently been put in a more comprehensive frame by Peña, J. T. 2020[12], but a more systematic collection, within the framework provided by the concept of circularity, for tackling the topic of the Roman urban economic organization, is still lacking.

[6] Scheidel *et alii* 2007.
[7] Greene 2008.
[8] E.g., Peña 2007; for the anthropological value of an approach to the history of objects, see Kopytoff 1986.
[9] Schiffer 1996, p. 28.
[10] Schiffer 1996, pp. 29-36.
[11] This term, used with some frequency since it was introduced by L. Binford, has not a straightforward meaning, and it has been used in the past to indicate a wide array of practices. For a complete discussion, see Shott 1996.
[12] Peña 2020.

Such a framework allows for an appreciation of how much circular practices were rooted, pervasive and ubiquitous in the urban economy, how they were linked with the so-called linear economy, which networks were involved and who may have played a relevant role behind the scenes.

As anticipated, these activities had the effect of reducing waste[13] and, conversely, optimizing the use of resources. The difference between them is often blurred, and, as it will be discussed below, they may have occurred at the same time or applied to the same object. Nonetheless, a minimal systematization seems to be necessary, for the sake of clarity, and for detecting all the different nuances characterizing the issue of circularity during the Roman age.

3.1 Conservative processes, maintenance, and repair

In his *Naturalis Historia*, Pliny the Elder suggests different methods for the proper preservation of copper and iron objects[14] ; although we cannot ascertain if and how these methods were ever applied on a large scale, the mention is interesting because it shows very clearly an attitude to extending as long as possible the systemic life of objects, particularly, but not exclusively, of those of some value. Indeed, this frame of mind was quite common at least before the second industrial revolution and it simply puts good care and effective maintenance at the center of everyday economy; it slowed down the linear chain leading from production to discard, producing a precise archaeological output, namely that of false residuals[15].

If conservative processes involve items with a special meaning for more than a generation (family memory and identity related to lateral cycling), then we are talking of heirlooms. This seems to be the case, for instance, of old Samian ware recovered in Late Roman graves, although simpler resale (lateral cycling, see below) has also been suggested as a possible explanation[16]. In general, whenever artifacts are noticeably older than others in the same funerary context, particular forms of curation and lateral cycling should be evaluated. Metal vessels were also frequently curated for long time, as it is demonstrated by the coexistence, in metal hoards, of items of different date[17].

More substantial, from the point of view of the archaeological outcome, is the issue of repair, the attempt to restore the previous form of a given object, usually for the same or for a similar purpose[18]. This practice, that represented an important block of circular economy, involved a variety of artifacts and included simple activities, which required almost no specialization, as well as more complex practices.

Although pottery was available in large quantities in the Roman world, it was also repaired, particularly if valuable (fine tableware) or if its substitution was a difficult matter (*dolia*). In the case of dolia, archaeological evidence and literary sources are relatively abundant[19] and indicate the same techniques employed for repairing smaller vessels: cracks were filled with pastes or lead and mended with metal staples fixed in holes drilled along the broken edges. These techniques draw on an ancient expertise, well documented in Greece[20] and going back to the Neolithic[21].

Archaeological evidence of repaired vessels, although often understudied[22], is widespread all-over Roman towns[23]; in Britain it is attested by the existence of workshops devoted particularly to repairing (and more extensively reworking - see *infra*) Samian ware vessels[24].

From a qualitative, economic point of view, it is important to point out a few traits of this phenomenon:

1. it did not involve precious, painted vessels, but valuable, although not precious items; in other terms, availability of items did not lead automatically to a consumeristic approach;
2. it required a certain degree of expertise and hardware, notably the ability and possibility of working with metals as well as with pottery;
3. from the few clues available, there seemed to be a real market for repaired ceramic vessels.

[13] Until the early 2000's the strategies of Roman waste management were rarely challenged. Since then, the literature on the topic has considerably developed and we now have a fairly good impression of the basic mechanisms and actors involved in urban rubbish disposal. Summing up these mechanisms, which basically brought rubbish out of the urban area, is not among the aims of this paper, but some major works are worth being cited, as they provide a fundamental part of the framework in which circular practices occurred: Raventós, Remolà 2000; Ballet, Cordier, Dieudonné-Glad 2003; Remolà Vallverdú, Acero Pérez 2011; Acero Pérez 2018. See also Furlan 2017 for a discussion on the impact of waste management on the urban archaeological record.

[14] Plin. Nat. Hist. 34. 21 and 34. 43.

[15] Artifacts whose systemic life was particularly long; Furlan 2019, p. 33.

[16] Wallace 2006.

[17] See Swift 2013, p. 94.

[18] Swift 2013, p. 95.

[19] Peña 2007, pp. 209-228; Cheung, Tibbott 2020; Cheung 2021.

[20] Dooijes, Nieuwenhuyse 2007; Nadalini 2007; Guldager Bilde, Handberg 2012.

[21] Nieuwenhuyse, Dooijes, 2009.

[22] Senior 1995, p. 95; Rotroff 2011, p. 118; Jervis, Kyle 2012.

[23] For the diffusion of this practice in a military settlement, see the recent Croom 2022.

[24] See Wild 2013 and Ward 1993, pp. 19-20, with further references.

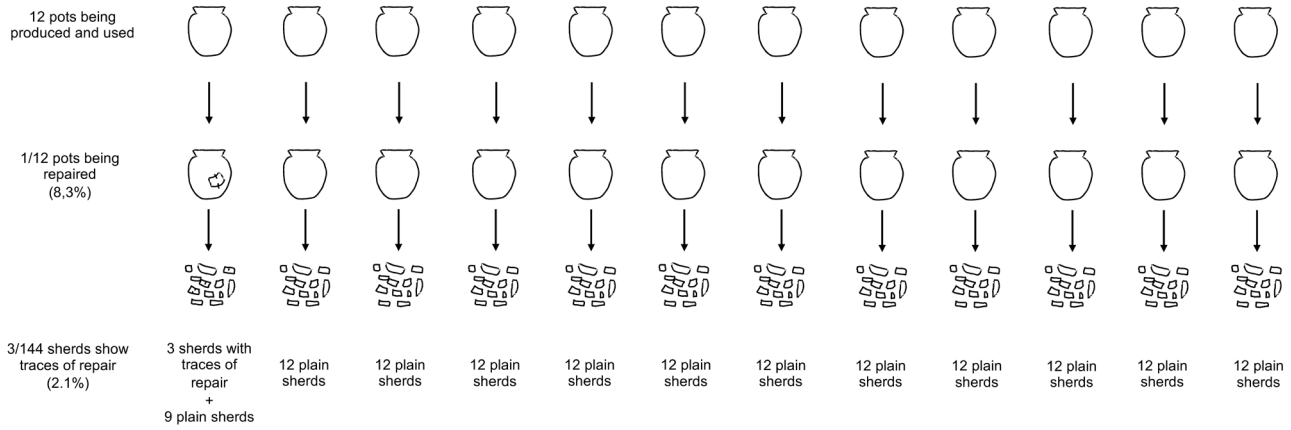

Fig. 1. The issue of fragmentation and repaired vessels. In this hypothetical scheme, 1/12 of vessels is repaired and each vessel breaks down into 12 pieces.

It is possible that these repairs were carried on in parallel with other "primary" activities, such as metalworking and ceramic production; nonetheless, we cannot exclude, particularly in larger urban environments (having a larger potential market), the existence of workshops specialized only in repairing and reworking ceramic vessels. In addition, based on modern analogy, the existence of itinerant craftsmen commissioned for repair has also been advanced[25].

From a quantitative point of view (although, as said, the available data is far from satisfying), the impact of repair on the whole population of ceramic vessels seems to have been limited: among the 35000 sherds inventoried during the Agora Excavation in Athens (from the Neolithic to the Turkish period), only about 0.5% displayed traces of repair. Similar figures (between 0.5 and 1%) emerge from other studies[26].

Nonetheless a quantification issue should also be considered; when one repaired vessel is discarded and breaks into fragments, only the mended sherds will show signs of repair. However, clearly, the whole vessel must be considered as repaired (fig. 1). This means that estimations based on sherds count should be seen as a minimum for the phenomenon. For having a more likely figure of the percentage of repaired vessels, the number of sherds showing traces of mending should be multiplied by the average number of fragments into which the studied vessels may have broken. An overall proportion of repaired vessels closer to about 5% seems to be, very tentatively, some more realistic.

Repairs made only with organic adhesives are even more rarely recognized and reported; nonetheless, when properly examined, this practice turned out to be numerically almost irrelevant. Out of 121000 sherds examined at the Romano-British site of Springhead, mostly dating to the 1st and 2nd c. CE, only 1 in every 2169 sherds displayed traces of glue[27].

Overall, a higher incidence is attested for classes such as Samian ware and *dolia*, whereas amphorae, available in large numbers and reusable in many ways, seems to have been little affected.

All the cited techniques of repair remained in use, in the very same form, in medieval Europe, being widespread down to very recent times[28], and therefore attesting a remarkable form of continuity through time.

Metalworks, which were more valuable than most ceramics, were also normally repaired. Again, Roman craftsmen could draw on long standing expertise: a 3rd c. BCE inscription from Delos informs us of the activities of the silver smith Aristarchus, who most probably took care of the offerings at the sanctuary; we know that he repaired three metal vessels (namely a crater, a cup and a cothon) and how much he was paid[29].

The same scenario emerges in Roman times: archaeological evidence from a sacred space in central Brescia points to the existence of a small workshop devoted to the constant repair of the metalworks thereby exposed. A simi-

[25] Cheung, Tibbott 2020, p. 184.

[26] For Athens and for further cases, see Rotroff 2011, pp. 118-119, with further references.

[27] Marter Brown, Seager Smith 2012.

[28] For 18th and 19th century America, see Beaudoin 2017. The Japanese art of *kintsugi*, still popular nowadays, is an "extreme", culturally driven form of repair.

[29] IG 11/2 161 A, 102-112. It has been proposed (Vickers, Gill 1996, pp. 56-57) that the cup was 'manufactured' by Aristarchos, therefore suggesting that he carried on a mixed activity (production and repair). Nonetheless, the verb ἐπισκευάξω, mentioned in the inscription, seems to refer more properly to repair. Moreover, the prices reported for the three items cited (two drachmas for a crater, one drachma and ½ obolos for a cup and 1 drachma for a cothon) are very similar, suggesting that similar operations were carried on (the manufacturing of a cup would have been much more expensive than the repair of the other two objects, as the cost of raw material should be considered).

Fig. 2. Detail of the fresco from the frieze of the *Praedia* of *Iulia Felix*, depicting the sale and, possibly, repair, of metal vessels (Olivito 2013, p. 53, fig. 33).

lar scheme has been observed in Luni, and this led M. Antico Gallina and G. Legrottaglie to interpret urban sanctuaries as crucial nodes in the network of curation, repair and, if necessary, recycling of metalworks[30].

A Greek literary source informs us that when a metal vessel was to be repaired, it could have been sent to the foundry, showing that the same workshops producing metalware also provided restoration[31]. The same organization is attested also in the Roman age, as strongly suggested, for instance, by the archaeological evidence produced by some late republican workshops in Tona, Catalonia, where materials to be employed for production, repair and recycling coexisted; among them, metal scrap to be recycled was most probably acquired from itinerant merchants[32].

The issue of itinerancy emerges also if we examine aspects of the network of repair occurring on an urban and inter-urban scale. Besides the most complicated processing (welding and remelting), most repairs were performed with rivets and a thin sheet of metal; this implies that a whole *officina* was not necessary and craftsmen skilled in repairing metal vessel[33] may have been itinerant, offering their services in local markets. The idea of the existence of itinerant craftsmen is not new; we have seen that it has been advanced also for the repair of dolia and it may well be applied to the repair of metalwork in the Roman world.

A scene depicted on a frieze from the *Praedia* of *Iulia Felix*, in Pompeii, may give some support to this idea[34]. The fresco shows different scenes taking place in an open area in front of a portico, most probably to be recognized as the forum. One segment (fig. 2) clearly portrays the selling of metal vessels (the types of vessels depicted can by compared very precisely to specimens recovered during the excavations of the site); two customers, one accompanied by a child, and the seller can be easily recognized. On the background, a fifth character is sitting, hammering another metal vessel leaning on a truncated-pyramidal object to be interpreted as an anvil. This craftsman is conventionally interpreted as a metalworker, but his activity is not specified. Nonetheless, the absence of any heat source (whose presence, in the middle of a forum, would be problematic) may point to the fact that the vessel was not being produced and that a heat source was unnecessary. Even the raising technique (forming a metal vessel through cold working, starting with a metal disc) requires annealing between each round of hammering, and this can be achieved more easily in a properly equipped atelier. Although other viable options may be suggested (the realization of personalized cold-working decorations?), the repair of existing metalware, through riveting or other cold working, is a plausible alternative.

[30] Antico Gallina, Legrottaglie 2012, pp. 137-138.
[31] Lysias apud Athenaeum 5.209, cited in Vickers, Gill 1996, p. 99.
[32] Balboa *et alii* 2013, p. 319. See also Duran *et alii* 2017.
[33] The existence of κασσιτεράτες (tinsmiths) is attested by papyrus BGU 4 1087 (Egypt, end of the 3rd c. AD). Cfr Leroy Wallace 1938, p. 206.
[34] See the fundamental Olivito 2013, pp. 48-56, with further references.

The fact that the scene is represented in the open, in the context of what looks like a temporary market, point to the fact that the craftsman and the seller, possibly working in tandem, were itinerant. Indeed, itinerancy has already been suggested for other figures and activities shown in the same frieze, such as the selling of textiles.

Repair of metal vessels by itinerant craftsmen was quite common in medieval Europe. The comparative case of Roma blacksmiths and tinsmiths is illuminating: their activity goes back as far as the mid 9th c. CE. By the 14th c. CE, their presence is well documented in the Byzantine Empire and later they are attested all around Europe, well into the 20th century[35]. Their activity document the existence of an inter-urban network made of people living on the repair of damaged metal items, providing a service for the urban communities, and actively participating in optimizing the existing resources.

Putting all these pieces together, a similar panorama of itinerant tinsmiths seems to be very plausible also for the Roman world. Repair on single artifacts could be very extensive and somehow border with substantial reworking: this is the case, for instance, of a cauldron recovered in a domestic context, again in Tona, which appeared to be made of two halves belonging to two different vessels, then riveted together. With the same technique, the object had also been repaired multiple times[36].

Simple repairs could also be a domestic business. Repairing agricultural tools was common in rural contexts[37], but evidence of small domestic repairs is documented also in cities such as Milan[38]. This indicates that basic skills in metalworking were more widespread and rooted among the urban population than has generally been assumed.

One question arising is, again, how common repairing metal vessels was. S. Mustață, studying the Roman vessels from Dacia Porolissensis, observed that kitchenware displayed more repairs than tableware, concluding that intensive usage played a role greater than the length of the use-life of a given object; she also observed that out of 33 cauldrons from the 3rd c. CE Neupotz hoard, only less than a half were not repaired, and most of the repaired vessels displayed more repairs[39].

A similar trend has been observed in a series of late-antique/early medieval hoards recovered in northern Italy, near Mantova. The hoards included several Roman and Late Roman vessels, the great majority of them bearing signs of repair[40]. A late Roman hoard from London - Drapers' Gardens displays a lower percentage of repaired items (3 out of 23, with an iron tripod and a spare handle among the last), but still with a percentage of 13%[41].

These contexts provide a vivid idea of how much the repair of metalware was widespread. They also point to a key social aspect of the issue of minimizing waste: this was not an issue only for the lower strata of Roman society; limiting waste was practiced also by the elites (those who could afford precious metalware in relevant numbers, such as in the case of the cited hoards[42]), meaning in turn that this was not only a mere necessity, but also a cultural driven process. In other terms, waste and squandering were avoided also among those who could afford it; economical motivations were not alone in shaping the Roman behavior towards the use-life of objects.

The repair of textiles was also widespread, although, clearly, archaeological data are scant. The recent synthesis published by J. P. Wild[43] offers an exhaustive view on the phenomenon: patches and the repairing of edges are well documented and involve different fabrics in the most different contexts, ranging from Northern Britain to Egypt. We are dealing with a very simple activity, which could be carried on domestically; this had the output of lengthening the use of clothes and reducing the need for newly manufactured products. It has been claimed that in Pompeii *fullonicae* also dealt with used clothes to be recovered[44].

Again, this phenomenon was not restricted to low/mid-quality products; for instance, there is evidence that expensive wool tunics, worn after long use, were repaired in Egypt[45], whereas other textile remains attest that Chinese silk clothes were repaired in Palmyra[46].

Wooden objects, ranging from pieces of furniture to buckets, were also commonly repaired[47], although the scarcity of wooden finds preserved in the record prevents us from a solid quantitative appreciation. Repair of wooden barrels is particularly interesting[48], as it is part of the large economic network of Roman wine and beer supply.

[35] See de Vaux de Foletier 1970.
[36] Balboa *et alii* 2013, pp. 319-320.
[37] See Quercia 2011, pp. 207-208.
[38] Grassi 2011, p. 17.
[39] Mustață 2017, p. 83, with further references.
[40] Gelichi 2009, p. 37.
[41] Gerrard 2009.
[42] This of course doesn't mean that people with a humbler background did not regularly use metalware. This is clearly demonstrated, for instance, by the distribution of finds in the whole insula of the Menander in Pompeii, investigated by P. M. Allison (https://leicester.figshare.com/articles/dataset/Insula_of_the_Menander_at_Pompeii/14494557).
[43] Wild 2020.
[44] Flohr 2013, p. 69.
[45] Wild 1994.
[46] Schmidt, Colinet 2000, pp. 37-38, with further reference to the catalogue and plates.
[47] See Sands 2021, for a recent overview, also including medieval and iron age case studies.
[48] Sands, Marlière 2020.

This activity had to be performed by skilled coopers and it is attested in Roman Britain, one of the last rings in the chain of distribution of wine in the Empire. The existence of coopers repairing barrels is attested in London and at the fort of Vindolanda, but it was likely to occur in many other sites as well. From an economic perspective, this phenomenon shows the integration of repair activities in a main, "linear" economic chain.

After the brief overview proposed, three main points arise:

1. the integration of curation and repair practices in more complex economic and social networks, including mass production and long distance trade;

2. the existence, besides indubitable economic reasons, of a cultural milieu taking in consideration the value of things and their care, as suggested by the evidence of extensive repair of objects belonging to the elite, who could have easily replaced them[49]. In our case, objects do not seem to be perceived only as replaceable economic goods, or consumables; conversely, the way in which they were curated and regarded reveals a deeper and palimpsestic concept of value, with an economic component, well visible when particular items were indeed hardly replaceable, but also with a sociological, ideological and even aesthetic one;

3. the variety of actors, places and forms of activity involved, often in relation to different levels of expertise. Repair was practiced by different agents according to different levels of competence required: the user himself (basic repair), itinerant craftsmen (potentially a wide range of repairs, hypothetically with a preference for cold-working techniques), more or less sophisticated workshops (necessary for tricky welds or for restoring artworks).

3.2 Extensive reworking

Between repair and proper recycling stands the substantial reworking of artifacts. An object goes back to the manufacturing process as raw material and a new artifact is produced, often with a different function, but the original form and function are still recognizable.

A clear example is provided by the extensive reworking of amphoras documented at the site of Mons Claudianus, in the eastern desert of Egypt; these vessels were used as "parent material" for manufacturing a peculiar range of beakers and bowls. The amphora spike was removed, and the resulting part was sized and shaped until it took the form of a new vessel. Eventually, the new bowls and beakers were often decorated with incisions and excisions and occasionally blackened and/or lightened[50].

Other items, such as incense burners, were produced in a similar way. At the extreme point of this range, we have labels, ostraca, game pieces, and stoppers[51]. Made of amphora sherds, stoppers were particularly popular in the Roman world. In Julio-Claudian contexts from the city of Padova, they derived from body sherds amounted to 84 % of the 114 stoppers examined[52], but these finds are very common also in several mid and late Roman contexts all over the Empire.

The process of extensively reworking a vessel did not require the set of skills of a professional potter and necessitated almost no infrastructure: it has been proposed that at the site of Mons Claudianus beakers and bowls were produced by the workers employed in the nearby quarries, familiar with the use of chisels[53].

Mons Claudianus cannot be considered a proper urban site and a lack of supply of fresh vessels may well represent the reason for this peculiar production; yet the case cannot be considered completely isolated. On the other side of the Empire, the above cited Romano-British workshops involved in Samian ware repair also produced new vessels out of old ones, sizing down, cutting, and polishing used ceramics[54]. In sites such as Piercebridge, spindle whorls made from Samian ware were not uncommon[55].

Overall, as opposed to the manufacturing of stoppers and tokens and to common repair, extensive reworking for producing new vessels or spindle whorls seems to be less widespread and a simple lack of supply of fresh items seems to be the main reason for it.

The issue of extensively reworked glass, although attested[56], seems to be quantitatively less significant, as glass could be easily and very effectively recycled (see below).

[49] L. M. Senior (Senior 1995) has already discussed the concept of value with relation to the mending of pottery; drawing from previous scholarship (Allen 1987; Binford 1962; Schiffer, Skibo 1987) the author proposed a partition of values into four categories, namely technomic, socio-technic, ideo-technic and aestetho-technic, also acknowledging that they can occur at the same time.

[50] Tomber 2006a, pp. 181-193; Tomber 2011.

[51] Tomber 2006b, pp. 289-300.

[52] Cipriano, Mazzocchin 2012-2013, p. 97.

[53] Tomber 2006a, p. 182.

[54] Wild 2013.

[55] Ward 1993, pp. 20-21. See also Swift 2013.

[56] Swift 2013, p. 103; Price, Cottam 1998, p. 9; Kehrberg 1992.

The extensive reworking of artefacts, as a whole, probably did not have a decisive impact on the optimization of resources in the Roman economy; however, it clearly demonstrates the existence of an attitude, when necessary, to make good use of every available resource, transforming rubbish (or potential rubbish) into something different and useful.

3.3 Secondary use

The reuse of objects with a different, new function, without or at most with minor modifications, was a widespread practice in the Roman world.

The secondary use of pottery, particularly amphorae, has been largely discussed in literature, and it is not worth being discussed in detail; it was a very common activity and amphorae were so abundant and versatile that the forms of their secondary use were the most varied (pipes, architectural elements, containers for different uses, components of hydrogeological features, coffins for infant burials etc.[57]). In Rome, some of the amphorae imported in the city were already emptied at the river-port, and then promptly redistributed for secondary use and/or lateral cycling[58].

Again, it is hard to quantify the economic impact of secondary use. A substantial percentage of secondary use goes easily undetected, precisely because between primary use and final discard there is no substantial modification of the object (e.g., a cooking pot reused as a chamber pot and then crushed and discarded). Surely it was a widespread practice, that slowed down the passage to final discard, therefore actively contributing to a more sustainable economic system.

Fortunately, the specific reuse of amphorae as packaging containers for different goods has been recently thoroughly examined and some quantitative appreciation of the impact of this practice has been proposed: using computational simulative modelling, a test on Africana 1 amphorae, although to be considered as a proof-of-concept, substantially confirmed previous estimations made by J. T. Peña[59], showing that an incidence of reuse roughly between 20 and 40 per cent is very likely. Interestingly, the study also stressed the important, direct role directly played by port sites in this network[60].

Except for funerary contexts, the secondary use of glass and metal has attracted the attention of scholarship much less than recycling, although it must be stressed that secondary use is, again, often difficult to ascertain, particularly without the help of chemical analyses. Nonetheless, this clearly does not mean that glass and metal vessels were not used for purposes different from the initial ones. On which scale this happened, given the available data, it is extremely difficult to say.

A general lack of conservation, as usual, drastically hampers our ability to detect the secondary use of wood. In this case, nonetheless, a few examples testify how long, and complex, the passage between primary use and firewood could be. A flourishing market for the secondary use of ship timbers seems to have existed in coastal settlements: complete hulls or single parts could be directly reused as harbor facilities, according (again!) to a practice attested until recent times[61]. In Berenike, Red Sea, the reuse of naval timbers in Late Roman buildings is attested[62], whereas in Cervia, on the Adriatic coast of Italy, boat timbers were used for the construction of bulkheads in the local saltworks[63].

Besides ports, the secondary use of timber is attested, also by literary sources, in several Roman cities[64], and it must be assumed that it was a fairly common practice; we know little of Roman furniture in these terms, but it seems reasonable to expect similar patterns, before the final use as firewood or simple abandonment and decay.

Finally, the secondary use of textiles is attested, particularly in funerary context; the reuse of fringed cloaks and bedspreads as shrouds clearly attests this practice[65].

In general, the issue of secondary use in the Roman world has still unevenly come to light, with some aspects, particularly concerning pottery, better known than others. Moreover, some of the above cited activities (see timber) lay between proper secondary use, recycling, and extensive reworking. Despite the possible exception of amphorae, we have also seen that it is difficult to weight the quantitative impact of secondary use on the global urban economy. In this case, we can truly say that this aspect of circularity is almost invisible in archaeological terms.

Despite these limitations, a couple of interesting points emerge from a qualitative point of view.

Concerning the reuse of timber and the reuse of amphorae as architectural and hydrogeological features, what is interesting from an economic point of view is the probable mixture of public and private agents and interests: public

[57] The literature on the topic is enormous. Refer to Peña 2007, pp. 119-192 for an overview with further references.
[58] Rodríguez Almeida 2000, p. 125.
[59] Peña 2007, pp. 335-337.
[60] Brughmans, Pecci 2020.
[61] Ford 2013.
[62] See Sidebotham, Zych 2012, with further references to previous works.
[63] Beltrame 2019.
[64] Including Rome itself; see Furlan 2019, pp. 56 and 75, for some examples and for the implications for radiocarbon dating.
[65] Wild, Wild 2014, p. 95, with further references.

and private works could easily drain reusable woodworking and amphorae from public contractors as well as from private ones.

A geographical pattern, to be confirmed by large scale analyses, can also be suggested for the same two categories of items: hydrogeological features, often employing hundreds or thousands of reused amphorae, were clearly more widespread in lower plain environments, therefore implying the existence of a bigger market for these materials in those towns there located.

Instead, the market of the secondary use of timber must have been particularly developed in port cities, where a certain amount of material was constantly provided by decommissioned ships.

3.4 The forms of lateral cycling

Lateral cycling simply indicates a change of owner; by itself, the activity does not imply a lengthening of the common use life of a given artifact. In practice, nonetheless, it takes the shape of the sale of second-hand materials, therefore actively contributing to the forms of circular economy in Roman towns.

In this case, *stricto sensu* archaeological evidence cannot be very helpful, unless the commercialization of second-hand materials was associated with repair. Fortunately, other sources help filling the gap.

The existence of local markets for second-hand materials is indicated by literary sources; Petronius, describing the activity of one of these markets, suggests that the origin of some objects, namely clothes, was at the very least doubtful[66]. This information attests the existence of a black market, where stolen items were resold in manners which can be considered fairly common still today.

Of course, also a regular market existed for second-hand materials. It is likely that used fabrics were sold, together with new garments, in dedicated *basilicae* and fora[67], although there are no certainties about this. In any event, written documents clearly indicate the existence of a proper market for second-hand clothing[68], with different prices according to different gradations of wear. We have a mention, curiously, also for second-hand looms[69].

It is difficult recognizing with some certainty the mention of second-hand materials in the Diocletian's Edict on Maximum Prices; the explicit reference to new silk garments, nonetheless, clearly indicate the existence of a market for the non-new ones, therefore allowing to include even precious silk clothing among the second-hand textiles available[70]. It would be interesting to ascertain if this practice led to the distribution of precious textile also among less wealthy groups, being used clothes, presumably, much more affordable than new garments.

In the Edict, some materials are indicated as "second quality" and their price is lower than "first quality" items. Only in a few instances, "second quality" can be intended as "second-hand": this interpretation so far has been explicitly suggested for papyri[71] and for some marbles[72]; for both materials it seemed to exist a certain market, but there is still debate on how it was organized.

At the very least drawing from more ancient Greek evidence[73], it seems reasonable to assume the commercialization of second-hand metalware also in the Roman period, although it is difficult dealing with a process almost invisible in archaeological terms.

The use of building materials was often regulated by local and even imperial authorities, and overall responded to different mechanisms; therefore, it has been excluded from the present discussion. Moreover, in many cases, more than lateral cycling, secondary use and recycling clearly came into play. Nonetheless, a little digression highlights an interesting phenomenon, that is the existence of a market for second-hand tiles, which likely involved private dealers on a small urban scale. This is documented by a painted sign preserved in Pompeii[74], indicating the selling of tiles removed from older buildings (fig. 3). The inscription itself and its location *intra moenia* suggest that this activity took place in the urban context. Sadly, we do not know if this sale happened continuously or occasionally or if other materials were sold together with tiles. Tiles could be easily removed and replaced, an activity which could have happened on a regular basis, or in accordance with specific refurbishment activities. Tiles could be re-employed as they were, to cover another roof or just to replace single broken tiles, something which could have occurred with a certain continuity; alternatively, they could be reused for other purposes, typically as building material in walls, drains or in any lined structure. The sale of second-hand tiles may have directly involved single privates, or it may have entailed the existence of middlemen.

[66] Petr, *Sat*, XII.
[67] Respectively CIL VIII.20156 and AE 1909.4. See Corbier 2005, p. 422. As anticipated, part of the above-mentioned fresco from the *Praedia* of *Iulia Felix* also shows itinerant sellers of textiles.
[68] Wild 2020, pp. 64-66.
[69] Carroll 1985, pp. 171-173.
[70] Muthesius 1995, p. 303.
[71] Caroli 2016.
[72] Corcoran, DeLaine 1994.
[73] Vickers, Gill 1996, p. 99.
[74] CIL IV 7124 = ILLRP 1121; Della Corte 1936, p. 333; Frank 1938.

Proper auctioneers should also be included among the agents involved in the market for second-hand materials[75]. This category was made of public heralds or criers and private auctioneers; accordingly, their economic and social status, as well as their impact on urban economy, may have varied a lot. Their activity embraced booty sales, the disposal of any kind of properties confiscated by the state and even the periodic distribution of wares and foodstuff in the city. However, they also played the role of middlemen for anyone who wanted to make some money getting rid of used items, and they sold the former properties of debtors; these activities, in particular, clearly put these figures among the agents of lateral cycling.

Overall, it is striking how much the whole set of activities labelled as lateral cycling share with modern practices[76], thus suggesting forms of continuity, possibly lasting for centuries, which surely deserve further investigations.

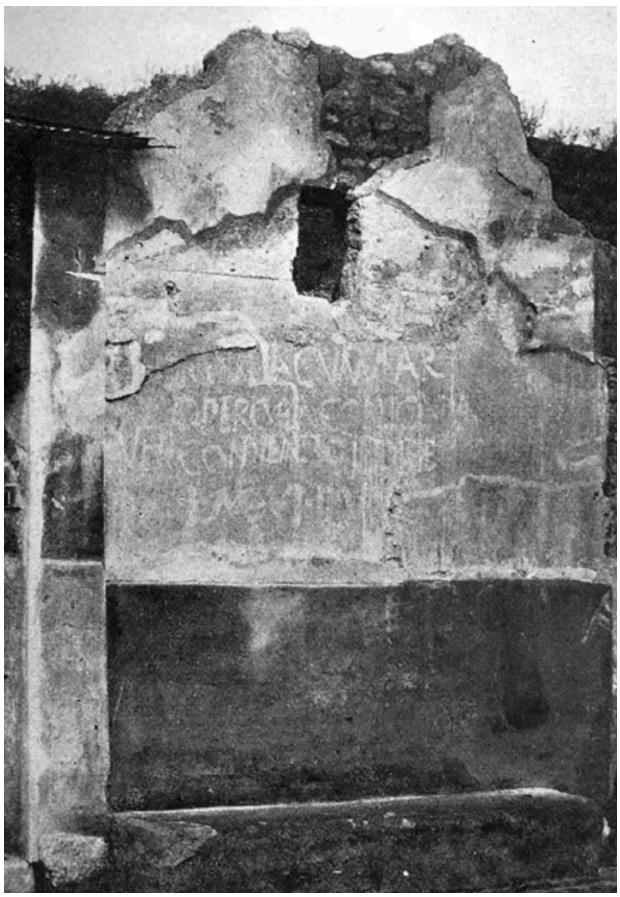

Fig. 3. Pompeii: sign advertising the sale of second-hand tiles (Della Corte 1936, p. 332).

3.5 Recycling

Recycling is by far the better investigated circular economy practice, although even in this case the panorama is uneven, being the recycling of some materials (glass and metal) better known than others (pottery). It is not possible to recall here every aspect of this vast topic; I will focus only on a few aspects, which are particularly relevant in terms of economic networks, agents involved, and quantification of the phenomenon.

1. A first point concerns the global arrangement of the market for the materials to be recycled. In the case of glass and metal, it assumes a complex, layered shape.

The existence of an interregional market for cullet is strongly suggested by the recovery of cargo shipwrecks transporting materials undoubtedly intended to be recycled. This is the case of the well-known *Iulia Felix*[77], a transport ship sunk in the north Adriatic Sea. The hold of the ship contained a wooden barrel filled with 140 kilograms of cullet, certainly intended to be recycled. Moreover, a conspicuous part of the fragments produced evidence of previous recycling. It has been suggested that long distance commerce of cullet was occasional[78] and certainly, among the commodities transported on any cargo ship, cullet was not supposed to be the main good to be traded. Filling spaces, otherwise empty, for an extra profit seems a reasonable option[79]. There are no other wrecks such as the *Iulia Felix* and data from port sites are difficult to interpret. Nonetheless, the phenomenon may have been more than occasional in some regions. A peripheric province like Britain, for instance, seems to have received very little raw glass[80]. The exclusive import of finished objects is an option, but the size of the *officinae* detected in London (the main reception site), together with the fact that broken glass uses much less volume than new vessels, may indicate the import of cullet from the nearby regions. Similar flows could be argued for the land routes connecting London with minor sites in the region, where the blowing of recycled glass is clearly attested.

Interestingly, the same picture emerges as we look at metal scrap. A shipwreck recovered off the coast of Brindisi, likely coming from Greece, produced an assemblage made of large chunks of bronze statues. The statues, most probably originally belonging to a public place, were cut along the joints, and there are no doubts about the fact that they were intended to be recycled[81]. The recent, extraordinary discovery of a shipwreck from Caesarea, loaded with parts of bronze statues and other metalware[82], crucially confirms the existence of some sort of Mediterranean network for the trade of metal scrap.

[75] See Rauh 1989.
[76] Several instances are reported in Strasser 1999.
[77] Silvestri 2008; Silvestri *et alii* 2008; Tortorici 1994.
[78] Keller 2005.
[79] Therefore, playing the role of "parasite goods"; Mannoni, Giannichedda 1996, p. 226.
[80] Jackson, Paynter 2021.
[81] Antico Gallina, Legrottaglie 2012, p. 138, with further references. See also Gianfrotta, Pomey 1981, pp. 183-185.
[82] See Sharvit, Buxton 2022 for a preliminary report.

After all, long-distance trade of metal waste is attested at least from the 6th c. BCE[83], and there seems to be no doubt that it was also part of the Roman economy.

2. A second level of distribution for glass and metal scrap to be recycled is represented by regional and sub-regional networks, where itinerant traders may have played, again, an important role. It has already been anticipated that in Tona, Catalonia, the production and repair of metal objects coexisted with recycling fueled by scrap, probably acquired from itinerant merchants (see above). Possibly excluding the most precious metals (gold and silver), the activity of itinerant junk dealers may have played an important role for providing recyclable materials in smaller centers, where the level of consume and discard supplying "fresh scrap" was quantitatively lower; in other terms, connecting small and bigger sites helped reaching a sustainability threshold for the single workshops, making available the necessary quantity of recyclable metal. Certainly, scrap was collected on a sub-regional basis, as indirectly demonstrated by several craftsmen hoards, containing the most various objects, in the most various conditions and often with different chronologies[84].

A similar framework may be suspected in the case of glass, and it has been already glimpsed concerning Britain; the certain existence of a smaller urban market (see below) and, to some extent, of long-range trade, makes likely the presence also of a mid-range economic structure. Although on a very different basis, a provincial network of glass recycling is attested in Byzantine Jordan no later than the 9th c. CE[85].

As anticipated, a local, urban market also existed. For glass, this is very vividly attested by literary sources, reporting the existence of hawkers roaming around and giving sulphur sticks in exchange for cullet, therefore performing a door-to-door collection[86]. At one point, cullet was also likely sorted, at least according to color: I. C. Freestone[87] highlighted that mixing occurred, but also that patterning was detectable, with some typologies of glass conserved more carefully than others.

An aspect which is underemphasized in current research is the fact that what was occurring was a form of barter, apparently living alongside the urban monetary economy. This adds a further level of complexity to the market(s) of reuse, pointing not only to the integration of linear and circular forms of economy, but also to the combination of the monetary system with non-monetarized forms of exchange.

Similar patterns, not necessarily involving barter, should have existed also for metal scrap[88]; Gellio (referring to Lucian) in his *Noctes Atticae* mentions a junk dealer (*scrutarius*) selling, together with half a shoe, half of a strigil[89], most likely to be recycled.

Concluding, the market of recycling of glass and metal cannot be considered monolithically nor simplistically: it was geographically layered, it included stationary as well as itinerant activities, it connected big and smaller centers, it included monetarized and non-monetarized forms of exchange, and, finally, it involved a variety of actors, including proper traders, junk dealers, door to door collectors and skilled craftsmen.

1. The economic impact of the recycling of pottery, bricks, and tiles, as temper in new terracotta or as aggregate in mortars, has received by far insufficient attention. Yet, the phenomenon certainly existed. The occurrence of extensive and organized recycling of pottery (not secondary use!) has already been suggested[90], particularly regarding the production of mortar[91]. J. T. Peña pointed out that vessels (*testae tunsae*[92]) could be preferable than bricks, as thinner and easier to crush and grind, therefore providing the ideal aggregate for mortars[93]; pozzolanic properties also added a technical advantage over other inert aggregates. The dimension of the issue becomes clearer considering that for each part of lime an average of 2-3 parts of aggregate was needed.

Considering the presence of ceramic temper (or grog, or *chamotte*; fig. 4) in many Roman bricks, a similar picture emerges: although with varying proportions, starting with the late Republican period in Rome bricks are characterized by an impasto systematically (and not occasionally) containing *chamotte*[94].

Overall, there is no evidence suggesting that the "industry" of recycling ceramic materials was secondary; the large abundance of reusable material, and the continuous demand for mortar and bricks in almost any building activity point to the existence of a recycling system far from occasional. Ceramic vessels were so common that a structured

[83] Antico Gallina, Legrottaglie 2012, p. 138, footnote 123.
[84] For the collection of scrap in post Roman Britain, also with several references for the previous situation, see Fleming 2012. See also the older Manning 1972.
[85] Keller 2005, pp. 69-72.
[86] See the fundamental Leon 1941. Relevant passages, therein reported, are in Martial, Statius, and Juvenal.
[87] Freestone 2015, p. 33.
[88] Rodríguez Almeida 2000, p. 124; Antico Gallina, Legrottaglie 2012, p. 136.
[89] Gell. 3, 14, 10.
[90] Slane 2011, p. 106.
[91] Siddall 2011.
[92] Vitr. 2. 5. 1.
[93] Peña 2007, p. 263.
[94] Ferrandes, Oriolo 2019.

Fig. 4. Aquileia, area of the Roman theatre: groundwater emphasizes the presence of abundant *chamotte* (reddish inclusions) in the bricks of a major drain, 1st c. BC-1st c. AD (photo by the author).

system of collection may have been unnecessary; more or less regular collection (see below the topic of provisional discard) and dump mining (see below), with a minimum of selection, may have been sufficient for guaranteeing the necessary amounts of sherds to be recycled.

2. Glass and metals were likely to undergo multiple recycling processes throughout their systemic life; this is not only logical, but it has also been clearly demonstrated archaeometrically[95]. In turn, of course, this ascertainment indicates the systematicity and the extent of the practice of recycling. However, it also pinpoints the fact that a quantitative appreciation of the phenomenon, in absolute terms, is extremely difficult. Assemblage comparisons and archaeometrical analyses are likely to indicate a minimum threshold, more than an actual figure of the impact of recycling in the economy of glass and metals. The same can be said about the use of literary sources: the mention in Pliny that, for casting statues and tablets, about one third of the alloy should derive from recycled copper[96], gives us a *terminus minimum* of the impact of recycling, not yet its actual computation (clearly, the third part of recycled copper, may in turn have been recycled, entirely or partially, more than once).

A further element of complexity is provided by geographical variability: those regions closer to the production area of raw glass, namely the eastern Mediterranean, seem to display a lower dependency on cullet, whereas the impact of recycling increases gradually moving westwards and northwards[97].

3. As anticipated, there is evidence that urban sanctuaries, at least to some extent, played a role in the economy of repair and recycling of metals. The above discussed evidence from Brescia and Luni (as well as the existence of Greek precursors) suggests that workshops within sanctuaries were devoted not only to the constant maintenance and repair of the metalworks therein present, but also to recycling; renovations, episodes of *damnatio memoriae*, or simply the expertise gained through time by these workshops, combined with external demand, triggered the recycling of metal scrap. That sanctuaries in antiquity represented crucial economic points, at least in terms of redistribution patterns, is a well-known fact. As keepers of substantial collections of various artifacts, they also seem to have played an important role as centers of curation and recycling. This is an aspect which deserves deeper and systematic future investigations.

4. Glass, metals, and pottery were not the only materials to be recycled in Roman towns. A variety of other recycled materials played a fundamental role in productive processes. The recycling of urine[98] was well organized in the urban

[95] For glass, see, by way of example, the above cited case of the *Iulia Felix* and Jackson and Paynter 2021. For metals, see Ponting 2002, p. 559, with further references.

[96] Plin. *Nat. Hist.* 34. 20.

[97] Freestone 2015, p. 33-34.

[98] Panciera 2000, p. 101, footnote 41; Peña 2007, pp. 200-202; Cordier 2003, p. 55. See also Brissaud 2003. Ancient sources include Mart. 6, 93 and Macrob., Sat. 3, 16, 15. M. Flohr and A. Wilson (Flohr, Wilson 2011) argue that the importance of urine in *fullonicae* has been overestimated and they dismiss most of the evidence related to the use of vessels as urinals in the streets (although they do not provide for an alternative explanation). However, the two authors acknowledge: "The fact that farmers, shepherds and craftsmen used aged human and animal urine on a systematic basis meant that there must have been institutionalized systems of urine collection" (Flohr, Wilson 2011, p. 151).

network, as evidenced by the presence of containers (reused amphorae) in the street corners of Pompeii; in fact, urine played a fundamental role in the various processes (including dyeing and cleaning) taking place in *fullonicae*, as well as for softening leather. The recycling of urine may have been organized in even more sophisticated ways, as indicated by a lead pipe connecting a public urinal in Ostia with two nearby, underground *fullonicae*[99]. The famous "urine tax" imposed by Vespasian[100] indicates not just the intervention of the public authorities in this market, but also its importance and profitability[101].

Textiles could also go through a process which could be labelled between secondary use and recycling; *centonarii* seems to have performed, on a wider scale, the otherwise domestic task of patchworking older, worn garments into something new. The debate on the role of *collegia centonaria* has been active for decades. One hypothesis viewed *centonarii* as firefighters. Although this possibility is still admitted, particularly for a late age, there seems to be now consensus on the fact that at least part of the *collegia* grouped textiles dealers of some sort[102]. This is supported by the retrieval, in Aquileia, of an epigraph mentioning a *vestiarius centonarius* and the authenticity of the discovery has been convincingly demonstrated by A. Buonopane[103]. *Centones* (rags) were likely the raw material for the clothing of the paupers, who could not afford brand new garments. They were also used for manufacturing cheap curtains, blankets, and coverings for military hardware[104].

Given the distribution of wealth in the Roman society, characterized by the presence of a large urban *plebs* with little spending power, the market for clothes made of recycled textiles should not be considered secondary.

As observed above, a precise quantification of the impact of recycling is still extremely difficult; concerning glass and metals, multiple recycling adds further complexity to the issue. However, comparing well sealed primary deposits and urban dumping sites, it has been recently possible to demonstrate that the vast majority of the metals and glass items discarded, in a time frame included between the half of the 1st c. CE and the 4th c. CE, was systematically recycled, with only a negligible part being eventually thrown away in urban dumps[105].

It is clear that the reuse of materials as elements of new productive chains was a widespread activity, including an articulated array of practices, peoples, networks (on different scales) and materials; far from occasional, recycling can be considered an important part of the Roman urban economy, closely associated (and sometimes necessary) to several productive activities conventionally considered as part of the so-called linear economic system. This is clear from a technical point of view (see the case of urine), but also in a purely economic perspective: E. M. Stern, examining the prices of raw glass and finished glass objects in the Diocletian's Edict, concluded that a glassblower's activity could barely survive, without limiting waste and relying on recycling[106]. In other terms, a circular economic approach was necessary for the very survival of glassblowing activity.

3.6 Scavenging and dump mining

It has been discussed how organized forms of collection and distribution, on local, regional, and even interregional scale, were an integral part of reuse practices, particularly recycling. Together with these structured activities, other less organized practices may have occurred with some continuity; these practices can be labelled as scavenging or as dump mining, and they are still part of the modern world[107].

Scavenging and the people who were involved in it often left little footprint both in the written sources and in the archaeological record. Indeed, besides analogy with following periods, their presence can usually be perceived only faintly through some proxy indicators.

Post depositional digging and mixing in dumps can leave very little stratigraphic evidence, and indeed it is seldom reported. If visible, small cuts recorded in dump stratifications may be related to these activities.

[99] Bradley 2002. Although the interpretation is questioned (Flohr, Wilson 2011, p. 152), an association between public urinals and *fullonicae* has also been highlighted, for example, in Rome (Coletti 2015) and in Florence (Scampoli 2010, pp. 25-34).

[100] Suet. *Vesp*. 23.3.

[101] Labelling of use of urine in *fullonicae* as "recycling" may be questioned, as urine had no actual primary use. In any case, we are dealing with the use of waste material for a productive activity playing a vital role in the sustainability of a whole industry. Similarly, organic waste, was largely used for manuring, being therefore an important element in agriculture and horticulture. Conversely, it is more difficult to be label the use of animal horn and bone for crafting activities, by itself, as recycling, as they were considered full-fledged resources from the start (together with animal flesh), and certainly not waste (joint production). Finished bone or horn objects were, instead, properly reused in many ways.

[102] See Liu 2009.

[103] Buonopane 2003.

[104] Wild 2020, pp. 79-80.

[105] Furlan, Andreatta forthcoming. Dumping sites contain, on average, only 3,5% of small fragments of glass and 2,5% small metal items, without even taking into account building materials and organic matter.

[106] Stern 1999, pp. 463-464.

[107] For an historical overview, see Downs, Medina 2000.

Given the "upstream" existence of organized forms of collection, even the typical low amount of easily recyclable materials in Roman urban dumps[108] cannot be automatically attributed to dump mining; small heaps of homogeneous artifacts, if not traceable to a single dumping episode, could indicate the sorting of material directly in the dumping site.

Overall, it must be acknowledged that secure evidence for ancient scavenging and dump mining is extremely scarce. They have been tentatively called into question in the case of Mons Claudianus, as a mean for recovering those vessels to be extensively reworked[109], and as a factor shaping the overall assemblage composition, in the case of some byzantine refuse mounds investigated in Gortyn, Crete[110]. This lack of data makes the evaluation of the impact of dump miners on circular economy difficult and the sorting of reusable rubbish directly in dumps, perhaps, should not be overemphasized[111].

Still, this absence of evidence does not fully demonstrate the evidence of absence: the analogy with later periods suggests that dump mining was a practice likely to occur, representing the very last step allowing for the recovery of single, reusable artifacts, although, probably, with a limited impact.

Eventually, the occasional scavenging of older funerary contexts seems to be a very peculiar practice, deserving a different approach and an examination on its own[112].

3.7 Bulk reclamation

Once deposited, wasted materials, together with the sediments accumulated through time, could be reused *en masse* for the construction of floor make ups, embankments, land reclamations and other features involving the redeposition of volumes of unsorted material[113]. In other terms, the bulk reclamation of materials implied the re-entry, within the urban boundaries, of what had been already deposited outside the city walls.

This practice, which was quite common, is attested by the redeposited materials themselves, but it can be perceived also in dumps; large quarry pits have been recorded for instance in Merida[114], and it is likely that other substantial negative features detected in *extra moenia* landfills lead back to the same activity.

Clearly this practice was not continuous but occurred when private or public urban building programs involved the substantial reshaping of spaces and architectures; the more the building activities were intense, the more the bulk reclamation of materials was likely to occur.

It must be stressed that the redeposition of volumes of materials did not necessarily involve dumping areas; the request for sediments with precise technical features (e.g., compressive strength, drainage capacity) imposed the search for corresponding specific mining basins, where the occurrence of previously deposited artifacts was occasional and rare. If no specific technical requests had to be satisfied, or in case sediments rich in artifacts were exactly what was needed, then the use of materials located near the city centers, exactly where municipal dumps were accumulated, represented the ideal option.

3.8 Provisional discard/storage/ hoarding

To be effective, most reuse practices, particularly recycling, must rely on a proper management of waste, as trash itself is a primary source. This means that, in antiquity as well as today, in a circular system rubbish cannot be simply thrown away without any form of sorting and differentiation. This can occur at different stages of the "waste stream"[115] and, clearly, sorting can be very effective as well as little effective, also according to different classes of materials.

Organized forms of collection or less structured activities of scavenging contributed to the formation of selected assemblages of homogenous materials, which were separately stored before reuse. As anticipated, the accumulation of cullet or metal scrap in precise containers or dedicated spaces, often part of those very workshops then reusing those materials, was a common practice. In the same way, used amphorae could be stored for a while, waiting for some form of reuse.

This set of practices represents just an intermediate passage between collection and proper reuse, and it does not have, by itself, an economic impact. Nonetheless, the evidence of temporarily stored waste often represents the only archaeological proxy for arguing the existence of a productive activity making use of reusable material.

[108] Reported, e.g., in *extra moenia* dumps from Pompeii (Emmerson 2020, p. 118), Merida (Acero Pérez 2018, p. 343), Jerusalem (Bar Oz *et alii* 2007), and Mons Claudianus (Maxfield 2001, p. 399). For the organization of the collection of rubbish in Roman towns, see footnote 13.

[109] See above; Tomber 2011, p. 112.

[110] Zanini 2009, pp. 85-86.

[111] See Emmerson 2020, pp. 93-94.

[112] Brent 2020.

[113] For the appreciation of this phenomenon in Pompeii, see Emmerson 2020, pp. 118-119, and Dicus 2014. See also Bonetto, Furlan, Ghiotto 2017.

[114] Acero Pérez 2018, p. 345.

[115] See, again, footnote 13.

Examples of hoards of metal scrap intended to be recycled are numerous; among others[116], the case of Tona has already been cited and some more examples from Pompeii are listed further below (aspects of integration). Glass fragments assemblages, several from Britain, are also well attested[117]; the barrel filled with cullet recovered in the hold of the *Iulia Felix*, from a certain point of view, can be interpreted as an extreme case of these deposits. Documented cases of heaps of potsherd specifically stored for being recycled are comparatively rarer; a few examples from Pompeii, collected by J. T. Peña[118], give at least an approximate idea of the phenomenon.

4. Aspects of integration

The existence of a multicraft or cross-craft organization of productive activities in Roman towns has already been discussed in the framework of the so-called linear model[119].
Although up to this point the different activities participating in urban circular economy (with building activity largely excluded) have been discussed separately, it has already emerged how they could be integrated both among each other and with the "linear" productive, distributive, and consumptive chain.

The integration of production, repair, and recycling within metal workshops has emerged clearly and it is indicated by further case studies. In Pompeii, alongside very specialized ateliers, other workshops provided at the same time for the production, repair, and retail of metalware[120]. In Lattes (Gaul) some *officinae* seem to have been involved in both repair and recycling activities[121].

Although located in a rural context, a craft facility investigated at Spolverino (Tuscany) demonstrates that linear economy and recycling could coexist in the same site, also involving the exploitation of different materials; here the same complex hosted a range of activities, including the recycling of metals and glass. Moreover, the single workrooms shared common facilities (such as a kitchen) and the access to a regional market, facilitated by the proximity to a river route[122].

The above-mentioned case of urban sanctuaries, embodying workshops performing various functions, also represents a relevant example of an integrated system.

Although yet to be fully studied, a case study from the city of Aquileia seems to suggest even further forms of integration[123]. During a period ranging approximately between the 4th and the 5th c. CE, the local theatre, which was not used for performances anymore, hosted a series of workshops in the external *fornices*, alongside a dumping area in the old *orchestra*. The production and recycling of iron and bronze is well attested, and some evidence of the processing of lead also emerged. The evidence for repair, although scant, is yet to be fully assessed, whereas some indicators point to the possibility that some workrooms hosted the production of gold and glass objects.

If preliminary observation were confirmed by further extensive studies, a single, large, still (most probably) public building hosted an array of well-integrated activities, functioning as a remarkable urban hub combining the so-called linear economy and circular practices.

Aspects of integration emerge non only looking at workshops or groups of workshops; it has been observed that if we look at the reuse of amphorae a crucial node was represented by ports; it follows that they were at the same time distributive hubs according to a linear economic model and also to a circular one. Moreover, it has been observed that port sites were clearly favorite centers for the reuse of naval timber.

Integration emerges also at the micro-level, looking at single artifacts. R. Sands and E. Marlière explored, exploiting the model of object's biographies, the systemic life of the Roman wooden barrels reaching the northern frontier of the Empire[124]. The repair of these barrels has already been discussed above, but the archaeological evidence collected also unveiled a more complex panorama: the same object could go through several changes of hands (multiple lateral cycling), being then extensively reworked and reused with completely different functions. The case of casks with multiple property markings, then cut and reused as tubs, is just one among the many options attested.

In the same way, metal vessels curated, repeatedly repaired, and then hoarded as raw materials for being recycled are far from uncommon (see above) and represent the tangible evidence of various circular practices.

[116] See footnote 84.
[117] Some examples in Paynter, Jackson 2016, p. 34.
[118] Peña 2007, pp. 251-252.
[119] E.g., Murphy 2021; see also the Late Antique case of Sagalassos presented in Murphy, Poblome 2021.
[120] Quercia 2011, p. 210.
[121] Quercia 2011, p. 211.
[122] Sebastiani, Derrick 2020.
[123] Relevant preliminary observations are published in Ghiotto, Fioratto, Furlan 2021; Ghiotto *et alii* 2018; Borsato nd.
[124] Sands, Marlière 2020.

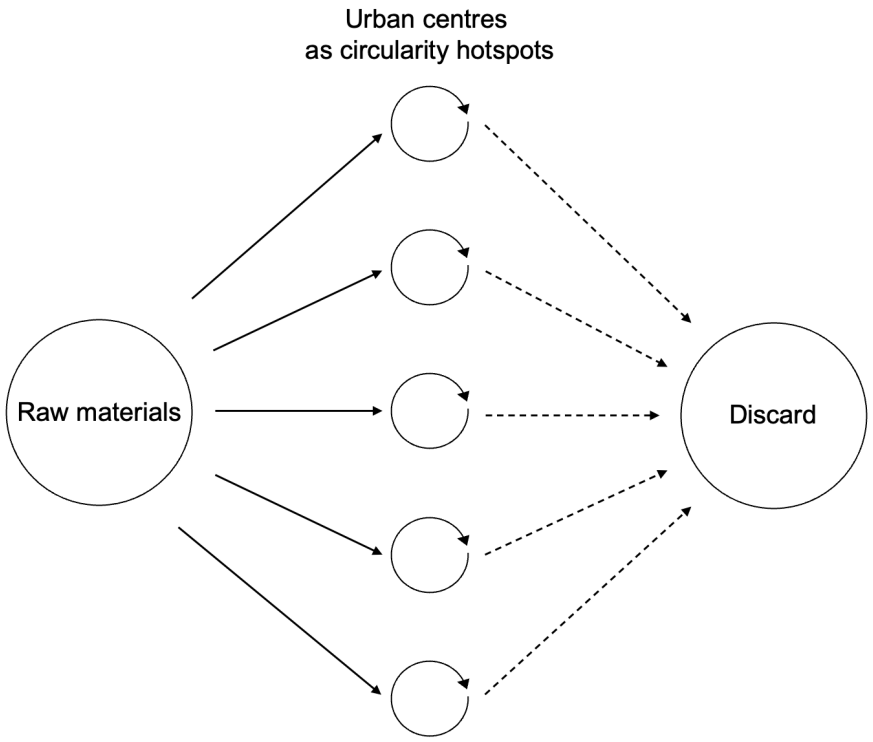

Fig. 5. Roman urban centers can be represented as hotspots for the development of circular economic practices: the use of raw materials is optimized through proper stewardship and continuous reuse. Only what is no longer conveniently reintroduced into the system is eventually discarded.

Finally, an extreme case is represented by the recycling of Roman materials in manufacturing processes beyond the limits of the Roman world: recent archaeometric analyses demonstrated that the glaze applied on Parthian pottery was obtained from recycled Roman glass[125]. Although, at present, this seems to represent an isolated case, it must be considered particularly important, as it shows that materials to be recycled had no political and cultural borders, and that they could also be reemployed in manufacturing processes differing from the primary one, at least to some extent.

5. Discussion

What emerges from the proposed review may look somehow anecdotal and far from being systematic. This is certainly due to the very fragmentary nature of the available evidence and this, in turn, is only partially produced by the state of the art of archaeological and historical enquiry. As anticipated, a major role is played by the very nature of the processes investigated, which, by themselves, tend to hide or completely cancel their traces, producing an absence of evidence which should not be misinterpreted as evidence of absence.

However, although the framework emerging has still to be considered as a heuristic representation, it displays considerable consistency, both internal (different sources of evidence are extremely coherent and so is the whole set of practices highlighted) and external (what emerged for the Roman world is in line with what can be ascertained for other historical periods).

Rather, the scattered nature of the evidence does not allow to appreciate yet a diachronic development of the phenomenon of circularity in Roman towns, simply because the number of available data, in different time frames, is still insufficient.

Having said this and settling for roughly handling the Roman imperial period as a whole, what comes to light is a well rooted and articulated set of activities, all coherently pointing at making the Roman urban economy more sustainable and therefore reducing the input of fresh resources and the output of discard (fig. 5). In other terms, urban centers did not only represent consumer poles, but also a set of interconnected filters, slowing down the discard of what was produced and consumed.

In addition, other relevant, specific points of various nature emerged: some of them can be briefly summed up as follows, and each of them would deserve further investigations in the future:

1. A quantification issue affecting our perception of ceramic repair, which may have been slightly more significant than assumed before.

[125] Wood 2022, pp. 3-7.

2. The possibility that itinerant tinners provided for repair, together with single households and more structured ateliers.
3. The practice of extensive reworking, which was likely pushed by shortage in the supplying chain.
4. The role of port centers in the secondary use of amphorae and naval timber.
5. The existence of a market for second-hand materials of any sort.
6. The layered structure of the market of recycling of glass and metals (local, regional, and supra-regional).
7. The understudied recycling of ceramics.
8. The role of sanctuaries as hubs.
9. The possible role of dump miners.
10. The impact of bulk reclamation, transforming rubbish into building material.
11. The integration of different forms of reuse.

Other aspects, however, promptly deserve some more clarifications and discussion, and they allow to push forward further considerations.

A first point concerns the mental attitude emerging behind the practices described. The economic reasons behind the adoption of a circular approach in antiquity are self-evident; the reduction of waste and the optimization of the available resources produced an economic benefit, to the point of being unavoidable for the sustainability, at least in certain areas, of activities such as glassblowing. The use of second-hand materials by the lowest classes of the Roman society also has its roots in economic necessity.

Nonetheless, particularly when examining the case of curation and repair, some cultural aspects also emerge. There seems to be an attitude towards proper care and curation which puts the object at the center, and not its economic value; in other terms, we may say that objects had a value *per se*, not only as carriers of an economic, countable equivalent. This frame of mind clearly comes to the surface when considering not so much the more obvious cases of curation, when the cultural reasons for preserving an object cross the border with issues of memory, status, and identity (yet existing and fundamental), but when considering the more subtle curation (by both rich or less rich individuals) of objects which cannot be considered as cheap throwaways, but which are, after all, easily replaceable items. The repair of undecorated sigillata, as well as the continuous patching of metal vessels with no particular aesthetic characteristics, with very humble and utilitarian functions and which could have been replaced fairly easily (at the very least by owners who may have belonged to the mid-high society), testify for this *forma mentis*. The explicit interest that existed in Roman times for the preservation and maintenance of buildings, well evincible by Latin juridical sources[126], represents a good analogue of this mindset; furthermore, as anticipated at the beginning, this way of thinking was not uncommon until very recent times[127].

As discussed at the beginning of the paper, there is little evidence in the Classical Antiquity supporting the idea of a widespread concern for the effects of the overexploitation of resources on the environment. However, a passage from Pliny the Elder may represent, to some extent, a distinguished exception. When discussing of metals in his Natural History, the author stated:

illa nos peremunt, illa nos ad inferos agunt, quae occultavit atque demersit, illa, quae non nascuntur repente, ut mens ad inane evolans reputet, quae deinde futura sit finis omnibus saeculis exhauriendi eam, quo usque penetratura avaritia[128].

"The things that she has concealed and hidden underground, those that do not quickly come to birth, are the things that destroy us and drive us to the depths below; so that suddenly the mind soars aloft into the void and ponders what finally will be the end of draining her dry in all the ages, what will be the point to which avarice will penetrate" (translation H. Rackham, LCL 394).

The philosophic and moralistic intent of the author is evident, and the attitude emerging can be considered as a literary *topos*; and yet the text reflects a wide (and very modern) perspective, although probably limited to a very small group of people, going even beyond a different perception of objects and materials, and linking the exploitation of resources and the fate of our planet.

The integration of the so-called linear economy with the circular economy is another aspect powerfully emerging from the proposed review, at least as much as the integration of different circular activities. In the Roman world circularity did not exist on its own; it was both rooted in and entangled with the whole economic system. The economy of glass is a clear example of this: recycling needed the production of fresh products and their discard, but it also effectively contributed to supply the distribution and consumption chain.

With the circular and linear economies integrated, larger towns, hosting a wider and more diversified market, may have been prominent sites for the development of circular processes. Producing more waste, major centers could

[126] Marano 2012.
[127] See Strasser 1999.
[128] Plin. *Nat. Hist.* 33. 1.

also have played a pivotal role in the distribution, mostly on local or regional scale, of discarded materials to be employed as raw material also in minor settlements.

In synthesis, the dependence on the economic system as a whole means that the circular economy could reach, in absolute terms, higher peaks in larger towns.

Another interesting characteristic of the Roman circular economy, practiced by and also supplying a non-elite community, is that it seems to be non-monetarized in many regards. The evidence concerning the collection of cullet through barter is clear, but it is reasonable to suspect that other passages in circular economic activities were non-monetarized: besides those activities which could have been carried out domestically, the collection of ceramic sherds to be recycled, the bulk reclamation of materials, and the secondary use of amphorae may well figure among them. On the other side, we may presume that the practices of repair, long distance trade of recyclable materials, and part of the second-hand market (lateral cycling) were based on the use of coins. The Diocletian's Edict indicates that part of this market was monetarized.

Monetarization tends to go hand in hand with different levels of organization. On the one side we have well-structured activities, such as that of *centonarii*, organized in *collegia* somehow resembling the medieval guilds of *rigattieri*[129], where the integration within the framework of the monetarized systems is unquestionable. On the opposite side we have the activity of single collectors, which, in the case of broken glass, was certainly based on barter (cullet for Sulphur sticks). Although scarcity of coins may be called into question in this regard, it must be observed that the use of coinage was simply not necessary.

In synthesis, if on the one side the Roman linear economy seems to be, at least for a long time, well monetarized, on the other side the Roman circular economy appears to lay in a grey zone, between a monetarized market and a set of activities based on barter and even on simple collection[130].

The modern concept of "informal economy" well describes the grey zone where circular economic practices take place: the concept has different shades and definitions but in general it indicates a part of the economy, typically urban, characterized by marginal, small activities, with no clear legal regulation, involving particularly personal, informal working and exchanges based on reciprocity[131]. In the modern world, this concept is usually employed to describe sectors of the so-called emerging economies, but interestingly, it has also been adopted to describe some traits of the medieval urban economy[132]. From the evidence discussed so far, it seems also applicable to the Roman economy.

In this grey zone, forms of circularity were always present. However, the review showed that quantifying the overall and individual impact of circular practices on the Roman economy still represents a major challenge. Reliable quantification is made extremely difficult also by the complex nature of the urban archaeological record, which provides most of the available data.

According to the current state of the art, we must settle for an impressionistic view and for relative figures more than for absolute ones. It does not seem that the overall impact of circular economies was negligible; the estimations provided for the recycling of glass and metal, for the secondary use of amphorae, for the incidence of repaired metalware, and for the diffusion of stoppers made from amphora sherds point to a substantial, well perceivable effect; other activities certainly seem to have had, quantitatively, a minor economic role. But if one questions whether circular practices made a difference in Roman economy, the answer is certainly yes.

This consideration overturns the well rooted association of circular economy and decline. This is still widespread in scholarship and the common approach to the practices of reuse in the early medieval period is a clear example in this sense. And yet it has been demonstrated how circularity and reuse are an organic part of the Roman economic system, in periods of expansion or not. In fact, the integration of the circular and 'linear' economies suggests that periods of expansion of the last should correspond to periods of expansion of the first. The reuse of amphorae as packaging containers seems to well explain this point: a higher productive output, say, of wine, implies more amphora reuse for sustaining the correspondent distribution. Similarly, an effective redistribution of scrap metal as raw material for new products assumes the existence of a market large enough to provide continuous waste.

This is a very important point, but this overturning of the traditional view should not surprise too much: a positive correlation between economic growth (note that economic growth does not imply the even and equal distribution of its output) and the diffusion of circular practices has already been stressed for the contemporary era[133] and for the Roman period itself[134].

[129] Meneghin 2015; 2016; 2020.

[130] For the coexistence of barter and monetarized exchange in 19th century United States recycling economy, also in relation with the hierarchical organization of labour, see Strasser 1999, particularly pp. 76, 81.

[131] Bellanca 2008.

[132] Meneghin 2015.

[133] Downs, Medina 2000, p. 34; Strasser 1999, p. 100.

[134] Holleran 2012, p. 220.

Circular economies, which always existed, may become more visible in periods of crisis because the whole economy tends to contract. Certainly, if economic crises imply the difficult supply of certain goods, circular practices may turn out to be implemented, making up for the lack. Nonetheless, generalized crises imply a general reduction not just in supply, but also in demand, therefore involving circular practices as well as the linear economy.

Assuming widespread reuse as a baseline, it would then be possible to investigate the reasons of its fluctuations in time on a sounder basis, overcoming the traditional dichotomy economic expansion/crisis, and investigating, instead, more concrete and specific issues, such as the variations in the availability of resources, transportation costs and prices fluctuations, and the increase or decrease of inequalities.

Finally, one of the most evanescent aspects of the Roman circular economy is represented by its actors. Most of the practices of circular economy in Roman towns are known only in general terms and they have also been largely understudied by scholarship. The people beyond these practices are even less known, to the point of going unnoticed.

Some of the social groups involved are a little better perceivable: skilled glassblowers and metalworkers have left bigger footprint and have been the subject of dedicated studies. Some evidence is also known of proper traders such as *centonarii*. They represent, clearly, those of higher status involved into the circular market.

Nonetheless, a salient feature of circular economy is the participation of groups of urban unskilled or low-skilled laborers. Of these people, sadly, we know almost nothing. Sorting, collecting, transporting, redistributing; these are the main, ubiquitous activities in which they were likely involved, with the labels of peddlers, hawkers or ragpickers (*ambulatores, institores, scrutarii, stercorarii*). The *scrutarius* cited above, selling metal and leather junk, seems no different from modern rag and bone men (*chiffonniers, straccivendoli*), figures still popular in many European countries until the 80's of the 20th century, and whose presence can be traced back at least to early medieval period[135]. The possible role played by slaves in the economy of reuse represents a completely unexplored field.

The co-existence, with different specific functions, of groups with markedly different status, suggests some form of hierarchical organization; this, again, is not unknown in later periods[136].

Another important actor is represented, of course, by the users: what is typical of circular systems is that users are not intended just as consumers (someone wearing second-hand clothes or employing a repaired vessel), but also as producers. A glassblower, in a circular system, is both the producer of new objects and the purchaser/consumer of trashed glass. For the huckster collecting cullet, the glassblower, through intermediaries or not, is primarily a client, but he is also the one foraging the market with items then trashed.

This intersection of interests, activities and actors is based on the mobility of objects: circularity made objects cross social borders, and therefore they connected social groups that, otherwise, would have been even more separated.

6. Conclusions

As anticipated, "recycling economies, when efficient, are by their nature invisible in archaeological terms"[137]; this surely means that the data available to tackle the topic may never be satisfying, being them, conversely, characterized by fragmentation, incompleteness, and uncertainty. Paradoxically, these are indicators of an efficient system, and presently what can be offered should be considered as a preliminary, heuristic model of this system, more than an end point.

However, this survey of the current state of the art has already revealed an articulated network of practices, which pushed forward some considerations on the nature, organization, and significance of circular economic activities in Roman towns. Although there is still a long way to go, circular economy must be included and considered in the current narratives of Roman urban sites.

In the future, a more organic and detailed view and a proper quantitative appreciation of the phenomenon likely represent the main issues to be tackled. Yet, to further engage with this topic, archaeological agendas should shift their objectives and consistently and robustly target those contexts providing the best data[138]; urban dumps, productive sites, and temporary disposal facilities should be challenged by field research projects much more. Similarly, a better awareness of the registration of traces of repair, reworking or reuse would be more than welcome in the field of finds studies. The study of artifacts still favors a very sectorial approach, according to different classes of materials, whereas it has been demonstrated that a more holistic perspective would be more productive and better suited to address issues such as the integration of different forms of economy.

[135] See the list of jobs published in Shatzmiller 1994.
[136] See footnotes 128 and 129.
[137] Needham *et alii* 1989.
[138] Bavuso *et alii* forthcoming.

Finally, a diachronic approach would provide for new elements to consider circularity in perspective, on the long durée. Looking at the array of practices described, one can recognize activities and agents which continued to be popular through the ages, until our times (see for instance the above-mentioned junk dealers, the issue of itinerant tinners, or the very current rediscovery of sustainable clothing and reusable containers). This simple consideration suggests that comparative studies to the evolution of the practices of circular economy may represent a prolific field to be investigated in the next future. Eventually, Roman circular economy may well turn out to be not a considerable exception, but, much more likely, part of a shared trend.

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