Anchoring: a historical perspective on frugal innovation

Versluys, M.J.; Sluiter, I.; Leliveld, A.; Bhaduri, S.; Knorringa, P.; Beers, C. van

2. Anchoring: a historical perspective on frugal innovation

Miguel John Versluys and Ineke Sluiter

2.1. INTRODUCTION: TOWARDS A DEEP HISTORY OF INNOVATION

In almost all of its definitions, applications and examples, the concept of frugal innovation tends to be related exclusively to capitalism and modernity (this *Handbook*, Chapter 1). There are some observations on its history, e.g. the fact that '[i]t is not a new phenomenon and many societies are practicing it through centuries' (Devi and Kumar, 2017: 66); or the statement that '[i]n the basic sense, frugal innovation has always occurred since the invention of Neanderthal hand tools from stones and bones to making do with what is on hand. Innovation in its most basic form is an old practice that has permeated our human make-up' (Bhatti, 2012: 5). Gupta (2016) has argued that many ancient cultures survived on frugal innovations. However, this historical perspective and its potential for the current debate on frugal innovation have not yet received the attention they deserve.

This chapter will therefore supplement the theoretical explorations and proper definition of frugal innovation in this first part of this *Handbook* by exploring its paradigmatic role in history. Our working definition of frugal innovation is that it is a form of *socially embedded action* (a practice), characterized by creative improvisation, that is inherently *inclusive*, in the geographic, cultural, social and economic sense of the word. We will therefore not pay attention to the somewhat more ideological aspects of frugal innovation, however laudable they may be. This omission concerns the focus that we see elsewhere on business models, empowering the poor in the Global South, promoting development, creating livelihoods and innovation strategies as defined in the introduction to this volume. A focus on inclusivity does retain the aspect of influence in multiple directions and global entanglement. Given the expertise of the authors, we will use 'Greco-Roman Antiquity' (known in the Western world as 'Classical Antiquity') as our case study. For the purpose of this chapter we define Greco-Roman Antiquity as encompassing the history of the Greek and Roman civilizations in their Mediterranean and Eurasian contexts in the period of roughly 500 BCE – 500 CE (see Naerebout and Singor, 2014). In this era, the ancient Mediterranean saw radical innovations and change and it is important to realize that quite a number of inventions from this period still define the Western world to this day, if rarely through an unbroken tradition or in the same form: from radical ideas such as democracy and monotheism, to materials such as concrete and glass, as well as the foundations of modern technology and philosophy (for general overviews of ancient innovations, see D'Angour, 2011, on the Greeks, and Flohr, 2016, for the Roman world).

Successful innovations always require (and have always required) a form of what we call *anchoring*; this can be illustrated with examples from Greco-Roman Antiquity. Inventions only become acceptable, understandable and desirable innovations when relevant social

groups can effectively integrate and accommodate them in their conceptual categories, values, beliefs and ambitions. This is the case when they can connect what is perceived as new to what they consider familiar, known or already accepted. When this is the case, new objects, ideas, practices or technologies become 'anchored'. For the purpose of this chapter, 'innovation' is understood as 'anchored invention', that is a new practice, object or technique that has become accepted and embedded. Anchoring can take place 'horizontally', through forms of analogical thinking between different (contemporary) domains, or 'vertically', when creative constructions of the past are used as an anchoring device (for these definitions and the following points, see Sluiter, 2017).

In order to better understand anchoring processes, it is important to realize five preliminary points. First, 'new' is not always really new; just as 'old' is not always old. What matters is whether certain social groups experience or construct a phenomenon as either familiar or new. Second, 'old' and 'new' are not neutral descriptors. They frequently are used as evaluative and appreciative terms, although their valuation is not stable, but may shift between different social groups and different contexts. For instance, the young may be more inclined than senior citizens to value the new positively, while in virtually all technology, what is old will be associated with the obsolete (i.e. will be negatively valued) rather than with the traditional, reliable or valuable, as it would be in some other societal domains. Third, the fact that innovation needs to be 'anchored' does not imply that anchoring will necessarily be an inhibiting factor for innovation. Effective anchoring can also support the pace of progress – we may compare the steady progression upwards of a mountaineer who anchors her or himself at every step but has every intention of reaching the top. Fourth, innovation does not equate moral progress, however well it is anchored. Dictators tend to be highly effective, but morally dubious promoters of 'anchoring' (Lamers and Reitz-Joosse, 2017). Finally, anchoring is a dynamic process. Anchors are constantly being construed and adapted, and help give shape to the tradition of a group. New phenomena initially in need of anchoring can at a later stage of their history be so familiar that they in turn can be used as anchors (see below on *skeuomorphism*). Multiple anchors can be used for the same phenomenon, and a single effective anchor can be used to make different new phenomena understandable.

Focusing on the concept of anchoring makes it possible to show that, in Greco-Roman Antiquity, innovation always was a form of socially embedded action or, in other words, a practice. This practice involves a variety of actors as well as heterogeneous forms of cultural knowledge and motivations. The actors are both human and non-human and although we will not deal with non-human agents in our analysis here, these are very important for understanding innovation as (skilled) practice (see Hodder, 2012, 2018). The interdependence of all such factors implies that innovation in Greco-Roman Antiquity had the potential of being inclusive in the sense that products, ideas, techniques and practices could be developed by and/or for social groups, and in geographical locations, that from a modern point of view would be outside the development mainstream. This notion of inclusivity should be clearly separated from the fact that Greco-Roman society was highly exclusionist at the same time: slaves and foreigners were, for instance, excluded from citizenship and the vote; women did take part in the polity, but in a particular way (Blok, 2017). However, these forms of political discrimination do not preclude participation in innovative practices. Moreover, many ancient innovations are based on borrowing ideas from outside one's own cultural domain or recombining older ideas rather than rudimentary invention, with processes of reverse diffusion, creative improvisation (which may be compared to jugaad) and bricolage being the norm. From this perspective virtually all

innovation in Classical Antiquity could perhaps be described as a form of frugal innovation. This is not to deny the relevance of concepts such as conspicuous consumption or the role of the elites, or even the state, particularly in the Roman empire, where the population was confronted with some negative results of innovations, e.g. pollution (see below). However, the claim holds true if one accepts inclusivity as the defining characteristic of frugal innovation.

2.2. AN OUTLINE OF THE ARGUMENT

We will first elaborate on innovation in Greco-Roman Antiquity in general terms and briefly look at how scholars have imagined (economic) innovation in the period (see Finley, 1965, with the critique by Greene, 2000, for brief overviews focused on technology and economy). There is an interesting and underexplored dialectic between, on the one hand, newly developing ideas about innovation and economic development at the end of the 19th century and the beginning of the 20th century, and, on the other hand, conceptions of Greco-Roman Antiquity from the same period. Most key players in the debate, such as Schumpeter, were educated in the Gymnasium and had a profound knowledge of Greco-Roman Antiquity, which often was their main historical point of reference (Baloglou, 2003). In this way, their view of innovation was coloured by (what they thought they knew of) Greco-Roman Antiquity while at the same time scholars of Greco-Roman Antiquity were influenced by the novel sociological understandings of their data and period (see Perlman, 1996). Although this will not be explored further here, this is another reason why a historical perspective on (frugal) innovation matters.

Subsequently we will explain the importance of the concept of anchoring for ancient innovation by looking at the process of skeuomorphism. We will then present two clusters of examples to illustrate our point more in depth. Our first example deals with ancient Greece and focuses on the domains of politics and culture. Our second example is taken from the Roman world and focuses on the domains of technology and culture. Since the latter is more in line with modern expectations about innovation, we will concentrate on the Roman example in order to show that the wider availability of non-local artefacts and technologies is frequently what drives innovation through processes of increasing connectivity and imperialism (top-down) and the appropriation thereof in the local context (bottom-up) by processes of co-creation. Let us remind you of our definition of frugality as explained above: many examples of innovation from Greco-Roman Antiquity are frugal in that the innovation can be shown to be an inclusive practice; they are not always frugal in the sense of "doing more with less for more" (Prabhu, 2017), especially not in the (late) Hellenistic and (early and middle) Roman periods (roughly 250 BCE – 250 CE), when through increasing connectivity the economy and many other developments were scaling up considerably. Be that as it may: for the interplay between the global (top-down) and the local (bottom-up) to be successful, anchoring processes are key.

We will reach several conclusions: first, as a process, frugal innovation is essentially about socially embedded action and therefore it should make the concept of anchoring part of its methodological and theoretical toolbox. Second, frugal innovation as mediated through all kinds of anchoring processes was an important mode of innovation in Greco-Roman Antiquity. In the technological domain, it may even have been the default. This result should be checked against the situation in other historical periods and cultures worldwide. However, whether or not this is a universal and global phenomenon in world history, the present 'turn to frugal' is better understood as a 'return to frugal'.

These conclusions lead to the following observation about the importance of the concept of 'anchoring' for understanding the status of 'frugal innovation'. In a way, the study of the deep history of innovation becomes, one might say, an anchoring device for the concept of frugal itself. We need to realize how culturally and historically situated the 'new' claims about frugal innovation are. In order to present frugal innovation as something new, it has to be off-set against 'what is not frugal'. The current focus on 'frugal' innovation as a socially embedded practice characterized by creative improvisation (see this *Handbook*) uses as its non-frugal foil the Schumpeterian and Research and Development (R&D) way of thinking about innovation characteristic of the 20th century. This paradigm sees innovation as an end in itself, a systematic practice, for which in principle unlimited resources can be used. Frugal innovation is negatively anchored ('we are NOT this' / 'this is NOT the right way forward') in that tradition.

However, our analysis suggests that our modern, R&D understanding of innovation is the historical anomaly, rather than frugality, which we now progressively rediscover. It can thus be anchored not only negatively, as off-set against the preceding tradition of the 20th century, but also positively (and 'horizontally') in the values of the 21st century, and historically ('vertically'), as a practice with far-reaching roots in the past. Be that as it may: both the concept of frugality and that of anchoring help to show how investigating social embeddedness is crucial to a proper understanding of what innovation really is and how it works (cf. De Massis et al., 2016, noting a research gap, in the Social Sciences, regarding the notions of tradition and embeddedness).

2.3. INNOVATION IN GRECO-ROMAN ANTIQUITY: GENERAL ASPECTS

Our modern interest in innovation has prompted historians to investigate the role of 'the new' in history, which has resulted, for instance, in important studies on 'the Greeks and the new' and 'the Medieval new' (D'Angour, 2011; Ingham, 2015). The study of innovation in fifth-century BCE Athens in particular forced scholars to reassess a newly apparent conceptual gap, a paradox even, between the actual and virtually omnipresent innovations (now newly in focus) and Athenian societal discourses about novelty, which seemed rather hostile. Athenians from the fifth century BCE set great store by their traditions, forefathers and ancestral customs and mythology. In many texts, innovation is referred to in disparaging ways. And yet the new was palpably there in their politics, their cultural institutions, their religion and their material culture. The concept of anchoring solves this conundrum in the study of the ancient world (Sluiter, 2017). The constant references to what was familiar or traditional in fact seem to have helped to accommodate the new.

There are, of course, important differences between innovation in the Greco-Roman world and the period commonly referred to as modernity (cf. Schubert, 2017). Within the discipline of Classical (Greco-Roman) Studies, the exact nature of these differences has been the subject of intensive discussion in the debate on the ancient economy (see Morris, 1999; Morris et al., 2007; Manning, 2018, for sound interpretative overviews). In his Die Entstehung der Volkswirtschaft from 1893, Karl Bücher argued for the position that the household was the main unit of economic analysis for Greco-Roman Antiquity, with trade, industry and markets being marginal phenomena (Sommer, 2013: ch. 1). The notion of capital, he claimed, was not developed until the Middle Ages and onwards. For Eduard Meyer (1850–1930) and others,

on the contrary, the ancient economy was already distinctly modern in all its aspects. This debate continued over the 20th century: 'primitivists' such as Karl Polanyi (1886–1964) and the ancient historian Moses Finley (1912–1986), both working in the tradition of Max Weber (Finley, 1999, 1999; cf. Morris, 1999), emphasized the important differences between the ancient and modern economies. Others, such as Michael Rostovtzeff (1870–1952) in his *Social and Economic History of the Roman Empire* (1926), reconstructed for the Roman world what looks like a rather modern economy driven by innovation. The current *communis opinio* was inspired by the New Institutional Economics (NIE) as it developed from the 1970s and 1980s onwards (for NIE, see North, 2005): the economies of the Greco-Roman period and especially those of the Hellenistic (from 323 BCE) and Roman worlds with their interconnected markets, widespread money-lending, investment in farming, as well as trade and companies of government contractors (cf. Kay, 2014), were surprisingly advanced, yet distinctly pre-modern and firmly embedded in the institutions of their social contexts (for NIE within ancient history and archaeology as countering the 'primitivist' view, see Morris et al., 2007). The concept of innovation only plays a rather implicit role in this discussion (although see Wilson, 2002; Lo Cascio, 2006; and now Flohr, 2016), and would profit from a more profound debate. One crucially important element in such a debate should be the existence, role and impact of slavery, which has been proffered as the explanation for the absence of technological progress (Finley, 1965). This view was contested by Greene (2000), who demonstrates plenty of evidence for such progress and shows that slavery and innovation do not necessarily exclude each other. Therefore, while fully acknowledging the importance of recent debates on slavery (e.g. Webster, 2008), we will not discuss it further in this context.

One conclusion that is obvious even now is that investigating innovation in Greco-Roman Antiquity matters for two reasons in the context of this *Handbook*: it is a sound and useful historical comparison that might help us understand the specificity (or not) of the practice of frugality and it matters because this period was the historical benchmark for many of the main theorists of innovation in the Western world of the 19th and 20th centuries.

2.4. ANCHORING INNOVATION AND SKEUOMORPHISM IN GRECO-ROMAN ANTIQUITY

We define anchoring as the dynamic activity or process by which individuals or relevant social groups connect what they perceive as new to what they consider familiar (see Sluiter, 2017, and above).

The principle of skeuomorphism offers an apt illustration. In our own time, this is often taken to refer to the ways in which a digital interface imitates and evokes the design of a familiar object from the physical world. For instance, the icon used for WhatsApp on a smartphone is designed to represent an old-fashioned telephone receiver and a speech bubble. Similarly, streamed music albums are accessed by clicking on a musical note, a notation that is almost a millennium old, while your optically stabilized dual 12 megapixel camera is activated by clicking on an icon that shows an outdated photographic device from generations ago. There is a functional relationship between the depiction and what it evokes, and the action the user is supposed to take. On accessing the camera, one sees a button, which on being touched reveals that a picture was taken by the traditional sound of a mechanical shutter. All of this helps to 'anchor' the use of technological devices for the end user.

In archaeology, the term is mostly used to indicate objects produced in one material that are made to imitate or evoke the look of a different material. Tell-tale signs that one is dealing with skeuomorphism are features that seem to be retained as aesthetic decorations only. Greek ceramic pottery, for instance, was sometimes, in both shape, colour and decoration made to appear like the much more expensive tableware in silver and gold. Using a phrase strikingly similar to some descriptions of frugal innovation, Vickers (1998) called this 'the art of making much from little'. Such pottery skeuomorphs have been explained as the result of a 'trickle-down effect', making fashionable, but expensive consumer goods available to less wealthy customers by using readily available and relatively cheap materials. However, the opposite effect has also been demonstrated: in some cases, deluxe versions in crystal and gold were produced of what was originally an earthenware product (Calandra, 1998).

Interestingly, an important source of inspiration for new elite products was culture contact leading to cultural entanglement. In the aftermath of the so-called Persian Wars (a series of conflicts between the Greeks and the Achaemenid Empire that took place in the first half of the fifth century BCE; note that the designation 'Persian Wars' indicates a Greek perspective) a true Persomania or 'Perserie' emerged (Miller, 1997). This process has recently been interpreted as a form of cultural innovation called Persianism (Strootman and Versluys, 2017). The way in which Persian-looking objects underwent adaptations in form in order to be smoothly incorporated into Greek social practices is an apt illustration of both frugal innovation and anchoring. For instance, elite Persians used drinking horns, made of precious metal. The horns had a conic shape, with a narrow bottom and a wider top decorated with ram's horns. They were hand-held. The Greek version was made of clay, but the model was also tinkered with in significant other ways. For it to be of use in the Greek social practice of the symposium, it needed to be able to sit on a table; the pointed horn could not do this, hence the bottom of the Greek version was flattened. Moreover, more traditional, ceramic Greek drinking vessels afforded not only setting down, but also convenient picking up, passing along and holding: they always had handles, and this, too, was added to the Persian model. The earthenware version would not necessarily have been cheap: it would still have been the product of a skilled artisan, but it would be frugal in the sense that its material was more readily available as was the expertise necessary for making it. Furthermore, both the choice of material and the additions of handles and feet anchored the new product for its prospective users and made it functional for the social practice of the symposium. An understanding of the social and cultural embeddedness of the new objects enriches our grasp of this innovation (for this case see Miller, 1997).

The Roman world shows similar examples. During the first centuries CE in the city of Tongeren (present-day Belgium) pottery was produced from local clays (for this case study see Geerts et al., 2016; Geerts, 2020). These clays would turn red or grey when fired. Up north, still in the Roman province of Germania Inferior, where production had started earlier and was much more advanced, pottery made from white-firing clays was popular. To get on the bandwagon and profit from the existence of this more developed repertoire in other parts of Germania Inferior and its prestige, potters in Tongeren now started to put white slip on their (red- or grey-firing) pots to increase appeal to local consumers. This slip was a kaolinitic clay. The practice has puzzled archaeologists for a long time: why would you cover your red- or grey-firing clays with a layer of white slip when there is no practical reason to do so? However, the relationship with the prestigious product seems to solve the puzzle. The slip-covered pots even seem to have developed into a (local) tradition of the area around Tongeren. It also resulted in further-reaching new practices there, as potters started to experiment with slip in

ways not previously attempted. This process could well be understood as a successful frugal innovation: there was no white-firing clay available near Tongeren and importing the clay (or the pots) would have been more expensive and time-consuming than adding the layer of white slip. Using locally available means, the fashionable new product was now made available in an inclusive way and became the springboard for further tinkering and innovation.

2.5. PROCESSES OF INNOVATION IN ANCIENT GREECE: POLITICS AND CULTURE

Innovation affects all domains of life, even though the 21st century tends to focus on the domains of technology, the hard sciences and medical science as its source. Given that modern interest, we have devoted more attention to the intersection of technology and culture in the previous sections and will do so again in our Roman examples. However, by way of brief illustration, we will here illustrate the principle of anchoring innovation in politics and the cultural domain for ancient Greece.

The 'invention of democracy' is traditionally assigned a precise date and place: the year is 508/7 BCE, and the place Athens. In that year, right after the expulsion and murder of the last monarchical 'tyrants', the politician Cleisthenes restructured the city-state into three geographical areas: city, coast and interior. Small and traditional local communities, called 'demes', were grouped into 30 so-called 'trittyes': ten for the city, ten for the coast and ten for the interior. Larger units (tribes or phylai) were then formed out of three 'trittyes' each, one from each area. Thus, the city-state came to consist of ten tribes, which were about equal in number of citizens. Each of the types of unit had a political role, and all male citizens had equal rights. The result was a grassroots democracy, in which citizens took part in self-government on every level, from their local demes to the council of the people in which policies for the whole city-state were decided. In the demes, they would self-govern with their direct neighbours, but for the tribes to function effectively the members needed a sense of shared purpose and belonging, as well as sensitivity to different needs in different parts of the city-state, since all tribes would have members from city, coast and interior, whose interest did not necessarily align.

This form of government was radically new, and to be successful it thus had to be effectively anchored on many levels. For this chapter, one example must suffice: how were the tribe members given a sense of belonging to those larger units? How would they have a sense of common ground with demes-men from very different areas that belonged to the same tribe? On a very basic level, this was achieved by giving each tribe a name derived from mythical figures from Athens' heroic past, a feat ascribed to reformer Cleisthenes himself. One tribe would be called 'Erechtheus', for instance, and another 'Aegeus'. The original bearers of these names were henceforth known as the 'eponymous heroes', the mythical figures for whom the tribes were named. The names were forms of vertical anchoring (see above), i.e. anchoring using the familiarity of a shared past: the tribes had taken over the responsibilities of these famous 'good kings', responsible for all of Athens. The coherence of the whole group of ten tribes and ten heroes was reinforced by the establishment, in the fourth century BCE, of a 'monument to the eponymous heroes' in the civic centre of the city, the agora. In this highly visible place, on a marble podium, ten statues were erected, one for each hero. Collectively, they marked the central 'information point' of the city, where decisions were posted and other

forms of information published. The use of familiar symbols from the past to anchor the new constitution (by giving symbolic names to the tribes) had now become a recognizable anchor for other political functions ('information centre').

The first half of the fifth century BCE not only saw major innovations in politics, but also in other domains. An important cultural development was the introduction of drama: tragedies and comedies. These were new literary forms, meant for performance in a civic and religious context in dramatic competitions. All citizens would watch these plays together during a festival for the god Dionysus – there is no way to separate the political from the religious or the cultural domains here. Again, one could point at many forms of anchoring, many ways in which the new would strike the audience as simultaneously familiar. A particularly noticeable characteristic of Greek tragedy is its unique integration (or possibly cultural appropriation) of all the different authoritative cultural formats available in Greek poetry at this point. These different poetic forms had originated in different parts of Greece and were traditionally marked linguistically by the use of different dialects and also by different metres and rhythms. The new genre of Athenian tragedy used all of them. The epic world of Homer was an important source of inspiration for the themes of the plays. Epic forms of narrative, including characteristic features of (Homeric/Ionic) dialect, vocabulary and sometimes metre, were present in the messenger speeches that formed part of each play. The impressive older tradition of choral lyric, its language marked by the Doric dialect, was used in tragedy in the choral songs with its lyrical metrical structure, and in general in the role of the tragic chorus for the voice of the community. In the dialogical parts of tragedy, the iambic metre was used, which was also well-known in yet a different part of pre-existing Greek literature. In short, tragic drama could easily be perceived as something distinctly novel, but also as the cosmopolitan and panhellenic poetry befitting the new position and imperialistic power of Athens. This is particularly important if one realizes that many allies would be visiting Athens during some of the major festivals. Everyone could recognize parts of their own cultural traditions in these new, typically Athenian, dramas, which the complete citizen body could appreciate. This is anchored innovation in the cultural domain. Interestingly, in this process there is Athenian agency but no recognizable intentionality. The new form emerges in the same period as Athens' flourishing. The plays were privately funded, although the funding counts as a type of indirect taxation. Many playwrights contributed to the development of the genre. Professional actors worked with citizen choruses, stage hands, technicians, musicians, designers, etc. We see the end product and assess its effects, perhaps rather than its intentions, in the context of Athenian political developments. This is socially embedded action, and it is also anchored and inclusive innovation.

2.6. PROCESSES OF INNOVATION IN ANCIENT ROME: TECHNOLOGY AND CULTURE

"In many places, and in many ways, the Roman world looked like no world had done before; and to a considerable extent, this was due to innovation", Miko Flohr (2016: 1) states in his review article on innovation and society in the Roman world. Technological innovation indeed mattered greatly to the Romans and would determine the outlook of their world. Repertoires of material culture proliferated (such as the emergence of glass blowing on a quasi-industrial scale; the upscaling of metal working; and the industrialization and innovation in pottery

production), and (building) techniques greatly advanced. As a result, the repertoire expanded and simultaneously the techniques became both more specialized and standardized than ever before (Greene, 2000; Wilson, 2002). As we have explained above, all this innovation was certainly not always frugal in the sense of "doing more with less for more" (Prabhu, 2017). Hong et al. (1994) have even argued that Roman lead and silver mining and smelting activities were the first to pollute the (northern) hemisphere to such a degree that this Roman ecological footprint can still be traced in the Greenland Ice (for these data see Büntgen et al., 2011, and cf. Manning, 2013, and now the detailed evidence presented by McConnell et al., 2018; their wind model explains that the pollution must have come from Europe rather than China). A comparable impact of Roman industrialization on the landscape is visible to this day in the Roman gold mines in Spain or Roman quarries in the Egyptian eastern desert: already the Romans (and Greeks) had their environmental problems (Hughes, 2014). People living in the Roman period were aware of the impact their innovations had on the environment: the study of this awareness within literary works (a very important source for the history of mentalities in Greco-Roman Antiquity) is called 'ecocriticism' (Garrard, 2014). In historical studies, there is now an important place for environmental history, studying not only the human effects on the environment, but also the reverse: the influence of environmental factors on human history (McNeill, 2010) – we could include innovation here.

These innovations and their upscaling have often been associated with central (imperial) power and the urban centres of the Roman Empire. These were certainly important, for instance for the Roman grain trade with its Empire-wide circulation of grain and the massive, novel and innovative storage facilities at Rome's ports of Ostia and Portus (cf. Erdkamp, 2005). We use the word upscaling on purpose here as this concept also plays an important role in the discussion about (the frugality of) innovation in the modern world (cf. Bocken et al., 2016). The growth and stability of the Roman Empire led to intensification and innovation in almost all domains of society. This process was fuelled by the presence of huge cosmopolitan centres, cosmopoleis, such as Rome, Antioch and Alexandria, which probably had close to one million inhabitants, and the intense relations obtaining between them. Connectivity on a Mediterranean as well as a Eurasian scale had become so intense in the Roman period that scholars now frequently use the concept of globalization to try to properly understand it (cf. Pitts and Versluys, 2015). The second century CE shows a true economic boom, and many now understand the Roman economy in (relatively) modern terms, as we have discussed above. For that matter, Roman science, too, has much more in common with the modern sciences than we tend to think (as convincingly argued by Lehoux, 2012) – but we will not draw that debate into our argument here.

If we compare this bird's eye view of innovation and technology in ancient Rome (see Greene, 2000; Wilson, 2002; and Flohr, 2016, for more depth, examples and bibliography) with the example of frugal innovation through skeuomorphism in Tongeren discussed earlier in this paper, it becomes clear that the period saw both: real frugality and the modern-type innovation with entrepreneurs and the imperial administration both functioning as corporations in a way and able to scale things up (for the quantification of the Roman economy and its innovation see Bowman and Wilson, 2009; for scale in the Roman world, see Duncan-Jones, 1990). Both types of innovation, however, were largely inclusive practices in which processes of anchoring played a key role. Before illustrating this by the example of *opus caementicium* (concrete), we would like to underline that responsibility for what we recognize as modern-type innovation cannot be assigned to the entrepreneurs and the imperial administration alone. Recent research

shows that the free rural poor also had a lot of innovative potential, and that they profited from the increase in volume and possibilities in their own way. Marzuolo (located in ancient Etruria, Italy), for instance, has been reconstructed as a planned site of an innovative, multi-craft community actively experimenting with the production of mass consumer goods such as ceramics, metal and glass (Vennarucci et al., 2018).

The remainder of this section will be devoted to a brief discussion of *opus caementicium* (concrete) as an example of a spectacular (inclusive) innovation from the Roman world. Our modern word cement is etymologically related to the Latin *caementicium* and this building material still characterizes Western society to this day. It is interesting to note that the Roman novelty that is *caementicium* is even now being explored for its potential for frugal innovation: Roman cement (in fact, mortar) has the physical characteristic that it gets stronger when exposed to sea water. This stands in sharp contrast to our modern concrete made of Portland cement, which is not supposed to change; if it does, this counts as damage. Because of this quality of Roman concrete, it has recently been proposed to use it to build the seawall for the Swansea lagoon.[1]

Opus caementicium was a novel material made of diverse components and in use in the city of Rome by the second century BCE, although the exact date of origin remains debated (cf. Mogetta, 2015). It was made of lime mixed with volcanic ash (called pozzolana) to form a mortar into which pieces of stone or other building materials (called *caementa*) were laid. This ground-breaking innovation, responsible for a building boom in Latium in the late-republican period and for the imperial-period Pantheon in Rome, still the oldest concrete building in the world, was the result of a very long development characterized by trial and error. The practice of optimizing structural performance took a lot of time and (contextual) experience, for instance with regard to optimal curing. Not without reason, a text dating to 105 BCE (called the *Lex Puteolana*) mentions 1 November as really the final day in the year for building in concrete. Astrid Van Oyen (2017) has very thoroughly analysed the innovation of Roman concrete as an inclusive practice, something she describes as the organic 'growth' of *opus caementicium*. Context dependence defined even the actual building process itself as "[c]aementa were sorted both in relation to one another (within the layers) and in relation to the structure and its loadbearing requirements" (Van Oyen, 2017: 142). Building in concrete was thus very much a contextual practice and therefore different concretes developed along different pathways; an observation that is in line with the "developmental approach" to innovation of Knappett and Van der Leeuw (2014). Moreover, Van Oyen's analysis shows how concrete as a building material developed along a trajectory of continuous redefinition, categorization and differentiation. One example of this is the (continuous) experimentation with different kinds of volcanic ashes. Another example, as already mentioned above, is the discovery that the structural stability of *opus caementicium* is enhanced by exposure to seawater. We have only recently learned that this is due to the dissolving of the volcanic ash component over time, which creates room for crystals to grow, something that much enhances the durability of the concrete in the long run (Jackson et al., 2017). The Romans did not know about this process, and did not 'invent' their mortar with this goal, but found out these effects over time, through practice.

The use of *opus caementicium* can be understood as an inclusive practice, also in the geographical and cultural sense of the word. This is illustrated by the earliest known example of large-scale underwater Roman concrete technology, which is to be found at the site of Caesarea Maritima, on the Levantine coast. Around 20 BCE, King Herod the Great built the

largest artificial harbour in open sea that the world had seen so far, encompassing about 100,000 m^2. Large amounts of pozzolana were brought from Italy to build the breakwaters but the technology was also further developed through local, Hellenistic building techniques and experiences (see Brysbaert, 2007, for what is called Cross Craft Interaction in Antiquity). It is the Caesarea experiment that enabled the further development of Roman maritime concrete in the imperial period. This would result, more than a century later under the emperor Trajan (who ruled from 98–117 CE), in the building of Portus, Rome's large new harbour consisting of a hexagonal basin roughly 350 metres wide. This port, lined with warehouses that would play an important role in the second-century CE economic boom described above, could accommodate more than 100 ships. Portus, often described as the pinnacle of Roman engineering innovation, was in fact the result of a process of co-creation, that is to say many small steps were taken over a longer period of time by many different actors in many different locations before coalescing into this innovative result (cf. Ziman, 2000).

2.7. CONCLUSION: THE THEFT OF INNOVATION HISTORY?

In this paper we have investigated frugal innovation as essentially a form of socially embedded action. Given the importance of the role of relevant social groups in the acceptance and diffusion of innovation, the concept of 'anchoring' forms an important addition to the conceptual toolbox for thinking about (frugal) innovation, since anchoring is the activity or process through which what is perceived as new can be connected to what is considered familiar. We have shown that frugal innovation in the sense of inclusive innovation, in the geographical, cultural, social and economic sense as defined above and mediated through all kinds of anchoring processes, was an important mode of innovation in Greco-Roman Antiquity; it may even have been the default. If we take a historical perspective on what innovation entails or can be, it becomes clear that 'good-enough' solutions that get the job done (Radjou et al., 2012: 109) and the redesign of technologies and products in order to arrive at applicable solutions (this *Handbook*, Chapter 1) are what probably drives innovation and its diffusion (Latour, 1986; Rogers, 2003) throughout history. In fact, therefore, it is not 'frugal' that is the alternative perspective that needs explanation, but the (ahistorical and typically Western) idea that innovation is about linear economic growth enabled by unlimited resources. Jack Goody (2006) would see this as an example of 'the theft of history': the claim by the Western world to have invented, for its own exclusive benefit, all the major institutions that make modernity possible, thus constructing a 'great wall' dividing not only the West from the rest but also Modern from Ancient. Whether or not frugal innovation is indeed a universal and global phenomenon in world history, the current turn to frugal is better understood as a *return* to frugal.

In this chapter we have therefore made an important distinction between our detection of frugal processes in history and the development and use of the *concept* of frugal innovation as a mode of thinking. The latter, i.e. exploring the concept of frugality, is an attempt at pushing back against the R&D way of thinking about innovation characteristic of the 20th century and that in turn means that 'frugal innovation' is negatively anchored in its direct conceptual precursor, from which it wishes to distinguish itself. Frugality is thus regarded as an opposite and alternative: something is frugal only in comparison to what is not frugal. However, our historical comparison suggests that the modern, R&D understanding of innovation is the

historical anomaly in need of an explanation, whereas frugality may rather have been the historical norm.

The concept of anchoring, therefore, does double duty in this chapter as it comments on frugality *as a process of innovation in history* and *as a concept about innovation in history*. It intertwines with frugality in providing tools for thinking about social embeddedness and its crucial role for understanding what innovation as 'accepted novelty' really is and how that process works. But the concept of 'anchoring' also helps in understanding how the idea of frugality – presented as a new phenomenon although many historical examples exist – could win its place in conceptualizing innovation. 'Frugal innovation' can lay claim to novelty as a conceptual tool, but this should not be confused with claiming novelty for the practice of frugal innovation as a process of inclusive innovation in history.

From our historical perspective it is odd that frugal innovation is considered to be so disruptive by some authors (see this *Handbook*). This may have to do, we conclude, with the fact that frugal innovation brings the inclusive and hence polycentric nature of innovations into sharp focus, thus undermining the (as we have seen rather ahistorical and typically Western) idea that innovation is a rational and predictable achievement leading to economic growth. The diffusion of the new and its progressive anchoring often extends creative agency to a variety of users or social groups. These are the agents furthering the spread of a specific novel artefact, practice, idea or technology by adapting it to their local needs (Latour, 1986). Innovation is thus always 'in the making' as an emergent entanglement of a large variety of participants. Research on frugal innovation has the potential to bring innovation as (inclusive) appropriation into sharp focus because it shifts the burden of explanation away from technology and design success alone to include the human factor and application contexts. That is not only important to better understand the history of innovation but also to manage its future (Appadurai, 2013).

ACKNOWLEDGEMENTS

This study was supported by the Dutch Ministry of Education, Culture and Science (OCW) through the Dutch Research Council (NWO), as part of the Anchoring Innovation Gravitation Grant research agenda of OIKOS, the National Research School in Classical Studies, the Netherlands (project number 024.003.012). For more information, see www .anchoringinnovation.nl. Both authors are PIs within that project. We would like to thank the coordinators of LDE Centre for Frugal Innovation in Africa for involving us in their work as well as for their feedback on a first draft of this chapter. We have greatly profited from our participation in the NIAS Lorentz workshop *Capturing Frugal Innovation* (February 2019) and would like to thank in particular José Guimón, Elsie Onsongo and Jaideep Prabhu for their feedback on our work in progress. We thank André Lardinois for the example of the eponymous heroes and Mark Locicero for his information on the environmental problems of the Greeks and Romans. Miko Flohr, André Lardinois, Eric Moormann and the anonymous reviewer for the *Handbook* made a number of useful suggestions, for which we are grateful. Any remaining errors are obviously our own.

NOTE

1. https://www.theguardian.com/science/2017/jul/04/why-roman-concrete-still-stands-strong-while-modern-version-decays; cf. Brandon et al. (2014), and especially Jackson et al. (2017).

REFERENCES

Appadurai, A. (2013), *The Future as Cultural Fact. Essays on the Global Condition*. London & New York: Verso.

Baloglou, C.P. (2003), 'Schumpeter's gap and the economic thought in Hellenistic times.' In: J. Backhaus (ed.), *Joseph Alois Schumpeter. Entrepreneurship, Style and Vision*. Dordrecht: Kluwer, pp. 327–335.

Bhatti, Y. (2012), '*What is Frugal, What is Innovation? Towards a Theory of Frugal Innovation'*. Working Paper at http://dx.doi.org/10.2139/ssrn.2005910

Blok, J. (2017), *Citizenship in Classical Athens*. Cambridge: Cambridge University Press.

Bocken, N.M.P., A. Fil, and J. Prabhu (2016), 'Scaling up social businesses in developing markets'. *Journal of Cleaner Production*, **139**, 295–308.

Bowman, A.K. and A. Wilson (eds) (2009), *Quantifying the Roman Economy: Methods and Problems*. Oxford: Oxford University Press.

Brandon, C.J., M.D. Jackson, J.P. Oleson, et al. (2014), *Building for eternity. The history and technology of Roman concrete engineering in the sea*. Oxford: Oxbow Books.

Brysbaert, A. (2007), 'Cross-craft and cross-cultural interactions during the Aegean and Eastern Mediterranean Late Bronze Age'. In S. Antoniadou and A. Pace (eds), *Mediterranean Crossroads*. Athens: Pierides Foundation, pp. 325–359.

Büntgen, U., W. Tegel, K. Nicolussi, M. McCormick, D. Frank, V. Trouet, et al. (2011), '2500 Years of European Climate Variability and Human Susceptibility'. *Science*, **331**, 578–582.

Calandra, E. (1998), 'Stesse forme, materie diverse: spunti di discussione per l'età ellenistica e romana'. In: *Il vetro dall'antichità all'età contemporanea: aspetti tecnologici, funzionali e commerciali. Giornate Nazionali di Studio.* Milano: Il Comune di Milano, Settore Cultura e Musei, Civiche Raccolte Archeologiche a Cernusco sul Naviglio, pp. 87–92.

D'Angour, A. (2011), *The Greeks and the New. Novelty in Ancient Greek Imagination and Experience*. Cambridge: Cambridge University Press.

De Massis, A., F. Frattini, J. Kotlar, A. Messeni Petruzelli, and M. Wright (2016), 'Innovation through tradition: lessons from innovative family businesses and directions for future research'. *Academy of Management Perspectives*, **30**, 93–116.

Devi, W.P., and H. Kumar (2017), 'Frugal innovations and Actor-Network Theory'. *The European Journal of Development Research*, **30**(1), 66–83.

Duncan-Jones, R. (1990), *Structure and Scale in the Roman World*. Cambridge: Cambridge University Press.

Erdkamp, P. (2005), *The Grain Market in the Roman Empire. A Social, Political and Economic Study*. Cambridge: Cambridge University Press.

Finley, M.I. (1965), 'Technical innovation and economic progress in the ancient world'. *The Economic History Review*, **18**(1), 29–45.

Finley, M.I. (1999), *The Ancient Economy*, 2nd edn, originally published in 1973. Berkeley, Los Angeles: University of California Press.

Flohr, M. (2016), 'Innovation and society in the Roman world'. *Oxford Handbooks Online*.

Garrard, G. (ed.) (2014), *The Oxford Handbook of Ecocriticism*. Oxford: Oxford University Press.

Geerts, R.C.A. (2020), Colour-coded for your convenience. Skeumorphism in Roman pottery production in Germania Inferior. In C. Viegas (ed.), *Rei Cretariæ Romanæ Fautorum Acta* 46. *Congressus Tricesimus Primus Rei Cretariæ Romanæ Fautorum. Napocæ Habitus. MMXVIII*. Oxford, 475–480.

Geerts, R.C.A., E. Hartoch, S. Rekk, F. Vilvorder, and J. Yans (2016), 'From clay to container. Roman pottery production at the Beukenbergweg, Tongeren (Belgium)', *RCRF Acta***, 44**, 341–349.

Goody, J. (2006), *The Theft of History*. Cambridge: Cambridge University Press.

Greene, K. (2000), 'Technological innovation and economic progress in the ancient world: M.I. Finley reconsidered'. *The Economic History Review*, **53**(1), 29–59.
Gupta, A.K. (2016), '*Grassroots Innovation. Minds on the Margin are not Marginal Minds'*. India: Penguin Random House.
Hodder, I. (2012), *Entangled. An Archaeology of the Relationship between Humans and Things*. Oxford: Oxford University Press.
Hodder, I. (2018), *Where are We Heading? The Evolution of Humans and Things*. New Haven & London: Yale University Press.
Hong, S., J.P. Candelone, C.C. Patterson, and C.F. Boutron (1994), 'Greenland ice evidence of hemispheric lead pollution two millennia ago by Greek and Roman civilizations'. *Science*, **265**(5180), 1841–1843.
Hughes, J.D. (2014), *Environmental Problems of the Greeks and Romans*, 2nd edn. Baltimore: Johns Hopkins University Press.
Ingham, P.C. (2015), *The Medieval New. Ambivalence in an Age of Innovation*. Philadelphia: University of Pennsylvania Press.
Jackson, M.D., S.R. Mulcahy, H. Chen, Y. Li, Q. Li, P. Cappelletti, and H.-R. Wenk (2017), 'Phillipsite and Al-tobermorite mineral cements produced through low-temperature water-rock reactions in Roman marine concrete'. *American Mineralogist*, **102**(7), 1435–1450.
Kay, P. (2014), *Rome's Economic Revolution*. Cambridge: Cambridge University Press.
Knappett, C. and S. van der Leeuw (2014), 'A developmental approach to ancient innovation: The potter's wheel in the Bronze Age east Mediterranean'. *Pragmatics & Cognition*, **22**(1), 64–92.
Lamers, H. and B.L. Reitz-Joosse (2017), *The Codex Fori Mussolini. A Latin text of Italian fascism*. London: Bloomsbury Academic.
Latour, B. (1986), 'The powers of association'. In J. Law (ed.), *Power, Action and Belief: A New Sociology of Knowledge*? London: Routledge and Kegan Paul, pp. 264–280.
Lehoux, D. (2012), *What Did the Romans Know? An Inquiry into Science and Worldmaking*. Chicago: University of Chicago Press.
Lo Cascio, E. (ed.) (2006), *Innovazione technica e progresso economico nel mondo romano*. Bari: Edipuglia.
McConnell, J.R., A.I. Wilson, A. Stohl, M.M. Arienzo, N.J. Chellman, S. Eckhardt, E.M. Thompson, A.M. Pollard, and J.P. Steffensen (2018), 'Lead pollution recorded in Greenland ice indicates European emissions tracked plagues, wars, and imperial expansion during antiquity'. *Proceedings of the National Academy of Sciences*, May 2018, **115**(22), 5726–5731 (https://www.pnas.org/content/115/22/5726, last accessed 21 September 2019).
McNeill, J.R. (2010), *Mosquito Empires: Ecology and Warfare in the Greater Caribbean, 1620-1914*. Cambridge: Cambridge University Press.
Manning, S. (2013), 'The Roman world and climate: Context, relevance of climate change, and some issues'. In W.V. Harris et al. (eds), *The Ancient Mediterranean Environment Between Science and History*. Leiden: Brill, pp. 103–170.
Manning, J.G. (2018), *The Open Sea. The Economic Life of the Ancient Mediterranean World from the Iron Age to the Rise of Rome.* Princeton: Princeton University Press.
Miller, M.C. (1997), *Athens and Persia in the Fifth Century. A Study in Cultural Receptivity*. Cambridge: Cambridge University Press, reprinted 2004.
Mogetta, M. (2015), 'A new date for concrete in Rome'. *Journal of Roman Studies*, **105**, 1–40.
Morris, I., R.P. Saller, and W. Scheidel (2007), 'Introduction'. In W. Scheidel, I. Morris, and R.P. Saller (eds), *The Cambridge Economic History of the Greco-Roman World*. Cambridge: Cambridge University Press, pp. 1–12.
Morris, I. (1999), 'Foreword' (to the updated edition). In: M.I. Finley (ed.) *The Ancient Economy*. Berkeley, Los Angeles: University of California Press, pp. ix–xxxvi, 2nd edition.
Naerebout, F.G., and H. Singor (2014), *Antiquity. Greeks and Romans in Context*, Malden & Oxford: Wiley Blackwell.
North, D.C. (2005), *Understanding the Process of Economic Change*. Princeton: Princeton University Press.
Perlman, M. (1996), 'Introduction'. In J.A. Schumpeter, *History of Economic Analysis*. With a New Introduction by Mark Perlman. Oxford & New York: Oxford University Press.

Pitts, M., and M.J. Versluys (eds) (2015), *Globalisation and the Roman World. World History, Connectivity and Material Culture*. Cambridge: Cambridge University Press.
Prabhu, J. (2017), 'Frugal innovation: doing more with less for more'. *Philosophical Transactions of the Royal Society A*, **375**, 20160372, pp. 1–22.
Radjou, N., J. Prabhu, and S. Ahuja (2012), *Jugaad Innovation: Think Frugal, be Flexible, Generate Breakthrough Growth*. John Wiley & Sons.
Rogers, E.M. (2003), *Diffusion of Innovations*, New York: Free Press.
Rostovtzeff, M. (1926), *The Social and Economic History of the Roman Empire*. Oxford: Clarendon Press.
Schubert, C. (2017), 'Innovation minus modernity? Revisiting some relations of technical and social change'. In P.W. Stockhammer and J. Maran (eds), *Appropriating Innovations. Entangled Knowledge in Eurasia, 5000 – 1500 BC*. Oxford & Philadelphia: Oxbow, Chapter 2.
Sluiter, I. (2017), 'Anchoring Innovation. A classical research agenda'. *European Review*, **25**, 20–38.
Sommer, M. (2013), *Wirtschaftsgeschichte der Antike*. München: beck.
Strootman, R., and M.J. Versluys (eds) (2017), *Persianism in Antiquity*. Stuttgart: Franz Steiner.
Van Oyen, A. (2017), 'Finding the material in 'material culture'. Form and matter in Roman concrete'. In A. Van Oyen and M. Pitts (eds), *Materialising Roman Histories*. Oxford*:* Oxbow, pp. 133–152.
Vennarucci, R.G., A. Van Oyen, and G. Tol (2018), 'Una comunità artigianale nella Toscana rurale: il sito di Marzuolo'. In V. Nizzo and A. Pizzo (eds), *Antico e non antico. Scritti multidisciplinari offerti a Giuseppe Pucci*. Milano: Mimesis.
Vickers, M. (1998), *Skeuomorphismus oder die Kunst, aus wenig viel zu Machen*. Mainz: Philipp von Zabern.
Webster, J. (2008), 'Less beloved. Roman archaeology, slavery, and the failure to compare'. *Archaeological Dialogues*, **15**(2), 103–123.
Wilson, A. (2002), 'Machines, power and the ancient economy'. *Journal of Roman Studies*, **92**, 1–32.
Ziman, J. (ed.) (2000), *Technological Innovation as an Evolutionary Process*. Cambridge: Cambridge University Press.