1. Durable economies: towards a new research programme

Harald Wieser, Florian Hofmann, Melanie Jaeger-Erben, and Max Marwede

> The 20th century has often been characterized by the emergence of a throwaway society. Paradoxically, it would be better described as a century of massive stockpiling. (Krausmann et al. 2017b: 1884)

1.1 Introduction

This book explores a new path to address a well-established problem: why do societies demand increasing volumes of natural resources? Today, the notion that the causes of rising demand for natural resources lie in patterns of *consumption and production* has become commonplace, even self-evident. In much the same way, claims that the solution to excessive levels of resource use is to be found in a shift to more *sustainable consumption and production* practices raise no further questions. If we take a step back to where this framing of resource use in terms of consumption and production comes from, we can see just how far the concept of consumption had to be stretched for such claims to make sense. For example, it has become entirely natural to associate activities as diverse as shopping for clothes, the public display of the latest gadgets, or watching television as acts of consumption. The same expansive understanding also underpins contemporary efforts to promote more sustainable forms of consumption, which are commonly associated with practices of repair, maintenance, or sharing, among many others. What is notable about any of these acts is that they leave the supposed objects of consumption fully intact or even transform them into something more valuable, which just goes to show what a long way the concept of consumption has shifted from its original meaning as a metaphor for eating and from its material sense of *destruction and using up* (Wilk 2004).

As the late David Graeber (2011) pointed out, it is indeed difficult to see, from a social and moral perspective, why it would be meaningful to consider social activities such as sharing an apartment or playing board games within the same analytical frame as driving to work or taking a hot shower. There are also obvious material differences between the latter activities, which use up energy and water, and the former, which do not destroy anything whatsoever. To be sure, as obvious as such differences may be, they do not necessarily translate into relevant analytical categories. For a long time now, environmental social scientists concerned with rising levels of resource use have been predominantly occupied with making the case for an agenda that moves beyond the traditional focus in research and policy on eco-efficiency in production (e.g. Cohen 2019; Lorek and Fuchs 2013; Princen 1999). The duality of consumption and production puts processes and dynamics of 'final consumption', at least on the surface, on a par with technological fixes in production, while also offering an opening into a policy discourse that has been dominated by economists (Murphy and Cohen 2001). Furthermore, amidst widespread beliefs that contemporary societies have transformed into 'throwaway societies', where the production of the new largely goes hand in hand with the generation of waste, whether an object is destroyed immediately, or later, is widely considered to be of secondary importance to the overall increase in resource throughput or 'levels of consumption'.

The analytical distinction between consumption and production may well have been necessary in establishing the study of how resources are used in the household sphere as an important field in its own right (Warde 2014). And perhaps the same holds true for putting at least some important matters beyond the narrow focus on production on the political agenda. However, as has become clear in the formulation of the United Nations' influential 'sustainable consumption and production' agenda, political recognition of consumption, alongside production, should not be mistaken with a serious tackling of the overall demand for resources. By and large, the targets and measures devised to implement the sustainable consumption and production agenda address established issues of technological improvements and consumer choice (Bengtsson et al. 2018; Gasper et al. 2019). However, more concerning, from our vantage point as researchers, is that the agenda has been built on highly questionable assumptions regarding the patterns and drivers of resource use.

Over the past two or three decades, the study of societies' relations to the material world has seen significant conceptual and methodological innovation. Never before has the scientific community had such a detailed

and comprehensive knowledge of society's 'metabolism': the compositions, volumes, and circulation of biophysical resources used to fulfil material needs (Krausmann et al. 2017a). Likewise, advancements in the theorisation of social change have increased recognition of the environmental significance of the infrastructures that support everyday lives and have laid the groundwork for new approaches to climate policy (Shove 2014; Welch and Southerton 2019). More generally, the 'material turn' has heightened interest in the material world across the (social) sciences; materials are no longer studied as mere carriers of social meaning but as essential building blocks of societies. Since then, the scientific community has seen the emergence of entirely new fields devoted to practices that have previously been largely overlooked, from repair and maintenance studies (Denis et al. 2016) to infrastructure studies (Edwards et al. 2009) and discard studies (Liboiron and Lepawsky 2022).

Figure 1.1: Abandoned, forgotten or displaced durable objects, like this dismantled three-wheeler photographed on a Greek island, have become a common feature of landscapes.

Source: Harald Wieser.

Taking a critical distance from political discourse and paying close attention to matter – by counting material flows, following things, or examining how people go about their everyday lives – researchers 'on the ground' have generated a picture of contemporary resource use that differs profoundly from those conveyed by notions of 'consumerism', 'linear economy', or the 'throwaway society'. What their work collectively shows is that societies across the globe have grown increasingly dependent on the continuous input of resources to operate a growing stock of infrastructures, machineries, and other manufactured goods. They are societies where throwaway mentalities coexist with anxieties about throwing things away and where volumes of production far exceed volumes of waste. As far as the use of materials is concerned, the twentieth century was defined not so much by accelerating, destructive cycles of consumption and production as by a massive accumulation of things. In short, durables have taken centre stage.

These findings have profound implications for how we make sense of the historical growth in resource demand and, by extension, for devising effective strategies to reduce demand to environmentally sustainable levels. They suggest not only that investments in durables have accounted for a growing proportion of the resources extracted from Earth, but that durables have also come to mediate the biophysical transformation of the vast majority of consumables. The core claim of this book, then, is that durability lies at the heart of key dynamics of resource use and should be at the centre of research concerned with the development of alternatives to and causes of historical patterns. We are certainly not the first to point out the importance of attending to durables. There have been various attempts to revive the distinction between durables and consumables (or non-durables) (Dobeson and Kohl 2020; Haberl et al. 2017): ecological economists in particular have long been advocating for a distinction to be made between material 'flows' on the one hand and material 'stocks' on the other (Daly 1977; Georgescu-Roegen 1971). Following the idea that the central attribute of material stocks is their durability (Faber et al. 2005), this proposal to consider stocks can also be read as an invitation to attend to durables. However, few scholars have gone much beyond this distinction to inquire how durability is made and given value to. Also, the question of what makes durables distinct – and the consequences of this – has scarcely been addressed. But, above all, we feel that a focus on durability, which has social and technical as well as economic dimensions, and on the various agencies, institutions, and practices implicated in its qualification and valuation may provide a crucial link for

connecting material relations in everyday lives with the political economies of accumulation, distribution, and exploitation of natural resources.

This book thus explores an alternative approach to the issue of resource demand in advancing a novel concept of *durable economies*. As alluded to above, we understand them as processes that organise the qualification and valuation of durables – that is, all social and technical processes that define the ability of things to hold their shape and the value of these things (cf. Boltanski and Esquerre 2020; Çalışkan and Callon 2010). Practices of consumption, use, repair, design, production, gifting, saving, and hoarding are all important elements of many durable economies. In putting forward this new concept, our aim is decidedly not political. Durable economies are neither alternatives to normative concepts such as the circular economy, sharing economy, or foundational economy, nor do they correspond to a particular vision of what a durable economy should look like (cf. Phillips et al. 2013). Rather, we see durable economies as a vehicle for a research programme that explores economies, or elements of economies, of different times and spaces through a lens of durability. In relation to normative concepts such as the ones mentioned here, such a programme might, for example, adopt a comparative approach to critically examine how a circular or sharing economy seeks to exploit the economic value afforded by the durability of materials and artefacts. More generally, our hope is that this concept helps to reinvigorate scientific debate on the causes of rising demand for resources, while preparing fertile ground for the conception and development of more sustainable solutions.

This programme does not need to start from scratch but can build on a rich body of work that stretches across many scientific disciplines and fields of research. In many ways, such research has already proven the value of attending to durables as distinct entities for appreciating the patterns and causes of resource use, not least by generating far more convincing, alternative accounts of societies' historical and contemporary relations to the material world compared with those that continue to inform much of today's debates on 'sustainable consumption and production'. In proposing the concept of durable economies, this book seeks to give shape to this still highly fragmented research landscape around important issues such as repair and maintenance, discarding, product lifetimes, material accumulation, or reuse, many of which have given rise to their own research fields in recent years. In particular, there is still a major divide between situationist perspectives concerned with the social and technical aspects of durables on the one hand, and more structuralist

accounts that focus on economic processes of valorisation and devaluation of durables on the other.

In this introductory chapter, we seek to show that, although different research communities inspired by the 'material turn' have approached durables from different perspectives and with different methods, they have arrived at largely complementary insights concerning the drivers of resource demand. In presenting and discussing some of the core insights, we consider research rooted in the study of material flows at the aggregate level, situated material cultures, and political economies (cf. Trentmann 2017), although our coverage of the literature is by no means exhaustive. Durability has also been subject to significant debates in fields such as micro-economics (Waldman 2003), design studies (Fletcher 2012), and marketing (Kostecki 1998), while many of the more recent debates fall within the domains of product lifetimes (see Rivera and Lallmahomed 2016) and the circular economy (see Rabiu and Jaeger-Erben 2022). While most of these strands in the literature are mainly concerned with sustainable futures and have produced important insights that will be taken up in the remaining chapters of this book, our focus here is on the past and present of resource use. Specifically, we consider three lines of inquiry. The first views material histories through the lens of recent advancements in material flow accounting. This allows us to get a clearer picture of the roles of durables in global patterns of resource use. The second relates to situationist accounts that we broadly associate with studies of material cultures (cf. Vannini 2009). This line of inquiry provides a sense of the significance of durables in everyday lives and of how people think about and engage with durables. The third considers durables from a political economy perspective to better grasp the roles of durables in the accumulation of capital. While our treatment of the respective debates is necessarily crude, it should be sufficient to support our claim that a focus on durability allows researchers to generate vital insights into the drivers of resource demand and that there is great value in these dispersed research communities entering into conversation.

Before we move on to engage with the literature and outline what we see as the contours of a research programme on *durable economies*, we need to make two final points. The first is a brief note on the notion of durables. We deliberately speak of durables rather than 'durable goods' because durable things can be 'bads' as much as they can be 'goods' (see also Lepawsky, this volume). A neutral framing represents an important step towards a balanced and critical engagement with durable economies. The second point concerns our proposal for a new research programme and its relation to the dominant framing

of issues relating to resource use in terms of '(sustainable) consumption and production'. This framing has long gained a life of its own way beyond scientific debates, and it is not our intention to formulate an alternative political paradigm. For the foreseeable future, researchers – for better or worse – will need to continue to define their own strategies for coping with this framing, whether they ignore it entirely, publish in sustainable consumption and production journals, or find productive ways to translate their research findings into the language provided by the framing. We do, however, contend that the framing is ill-suited for getting to grips with the many fundamental patterns of resource use in contemporary societies and that alternative analytical frameworks are needed for this. To be clear, we are certainly not advocating the abandonment of the concepts of consumption and production, although we concur with recent critiques of an overly expansive interpretation of the former (Evans 2020). The framing goes beyond matters of definition. The dualistic opposition of consumption and production is integral to various debates, narratives, and diagnoses, from the 'consumer society' to the 'throwaway society', which are mostly perspectives in which durables and associated practices of repair, maintenance, or reuse are said to disappear. It is this framing of 'consumption and production', with its assumptions about the dynamics and causes of resource use, and its analytical value, that we seek to challenge. In the following section, we provide a brief synthesis of how the growing demand for resources has been made sense of within this framing, with particular attention to durables. We then go on to show how those assumptions contrast with the research findings of studies that focused on durables.

1.2 The end of durables?

The main accounts of increasing resource demand that grew to prominence several decades ago, from the rise of the 'consumer society' to the more environmentalist 'throwaway society' thesis and the notion of a 'linear' or 'take–make–dispose economy', are still prevalent and, at least in their fundamentals, they are widely considered valid to this day (see, for example, Crocker 2018; Hellmann and Luedicke 2018). Even though such terms have different connotations, they are all linked to the same assumption regarding the most dominant pattern of resource use: that material objects have become more short-lived, with the result that durables have increasingly assimilated consumables. As so often, the work of Zygmunt Bauman is a reliable source

for anyone attempting to get to the essence of this claim. In today's 'liquid modernity', he asserts, durability has long given way to transience as a foundational principle across all walks of life. Consumerism, for him, is explicitly not about the collection and accumulation of possessions, but about instant gratification and the search for transient sensations (Bauman 2013). While the search for uniqueness still represents a powerful engine in the production and consumption of material possessions, this is now measured along an axis between the 'up to date' and the 'out of date' rather than by differences in the style or functionality of goods (Bauman 2005).

Few analysts today would go as far as Bauman in calling out the arrival of something like a 'post-durable' era. Durables are far too pervasive for this. What is interesting about this account, then, is not the empirical accuracy – or inaccuracy – of its predictions, but the consequential theoretical shift it facilitates by turning attention away from differences across products towards their *collective* absorption in what Bauman assumes to be increasingly fast-paced cycles of consumption and production. The issue that makes this shift so significant is that it effectively renders the distinctions between durables and consumables pretty much useless, at least as far as their analytical value for explaining the growth in resource demand is concerned. Furthermore, any analyses of variations in the use, appropriation, or circulation of products that may still exist would only distract from the more fundamental issue of accounting for the accelerating pace of their obsolescence and destruction.

Notions of consumption and production have long played a key analytical role in accounting for such dynamics of acceleration. Arguably, and possibly as a consequence of this framing, accounts of acceleration have become more balanced with respect to the attribution of causes and responsibilities in the domains of consumption and production. Today, such accounts tend to be less about manipulation or insatiable desires and more about dynamics marked by co-dependencies and processes of mutual reinforcement (e.g. Crocker 2017; Jackson 2016; Rosa 2013). Tim Jackson's modern classic *Prosperity without Growth* (2016) offers a particularly elegant example of how consumption and production are mobilised to explain the historical growth in resource use. The analytical framework he offers is a system driven by a self-perpetuating, circular flow of production and consumption. With respect to consumption, Jackson stresses the significance of material goods as carriers of meaning and signifiers of social status. In modern consumer culture, materials are tangled up in fast-changing, unpredictable, and infinite processes of social comparison and identity formation, driven as much by a desire for novelties as by anxi-

eties about falling behind. In Jackson's model, this is all propelled further by a profit-driven imperative of growth on the production side, which pressures businesses to innovate at all costs, even if this means reducing product quality and durability. Alongside various psychological and social dynamics, consumerism thus appears as a historically specific mode of capital accumulation in which profits are closely tied to the pace of 'creative destruction'. As a consequence of this 'iron cage of consumerism', Jackson argues, product lifetimes have plummeted, fuelling the relentless growth of material throughput.

The model of circular flows of consumption and production allows Jackson to make a strong case for the *systemic* nature of consumerism, as an outcome of varied logics and tactics and the interactions of a multitude of actors. Ultimately, this also helps him to evade possibly futile debates over the attribution of individual responsibilities and to focus on the main issue of collective concern: the volumes of resource throughput. Jackson has thus been able to provide an attractive explanation that addresses two core issues of scholarship concerned with 'strong' sustainability of resource use: a balanced consideration of both consumption and production, and a narrative that puts absolute levels of resource use centre stage. However, this flow-based model, like any other account of acceleration, effectively treats all objects as if they were consumables, thus side-lining any processes that might disturb the linear passage from product to waste. To better understand the consequences of this assumption, we need to turn to analyses of material flows and consider what they look like when their duration is considered.

1.3 The material histories of durables

The analysis of durables in the form of infrastructure, machinery, and household goods has moved to the centre of social ecologists' recent efforts at reconstructing the biophysical resources that are extracted from the natural environment and taken as inputs to social and economic activities, the composition of resources and their uses, and the various outputs of waste and emissions – in short, the 'socioeconomic metabolism' (Haberl et al. 2017, 2019; Krausmann et al. 2017a). In the language of social ecologists, durables represent the 'in-use stock' or 'manufactured capital' that, alongside humans and livestock, makes up the stock within any given system. Durables are recognised for their crucial role in facilitating a wide range of services that are key to well-being, such as shelter or transport. Although the explicit consideration of durables

is conceptually well established in social ecology, it is only thanks to recent methodological advancements in material flow accounting that their significance can be expressed in quantitative terms (Krausmann et al. 2017a). In material flow accounting, resources are considered as durables or part of stocks when they remain in use for a minimum of one year. More short-lived products and consumables constitute material flows that either serve as inputs to operate durables or are consumed directly. Resources thus consist of materials serving as inputs in the construction and maintenance of durables, technical energy that is needed in the manufacturing and use of durables, and other consumables such as food, feed, and fertilisers. The division of social metabolisms into these broad categories makes visible some key patterns in resource use.

Beginning with the most environmentally favourable trend, studies of material flows show that, even on a global level, energy demand from manufacturing and operating durables has gone down significantly. For much of the twentieth century, the energy intensity of durables – that is, the demand for primary energy per material unit – was subject to fluctuations anddid not experience lasting improvements. Since the 1970s, however, the energy intensity of durables has declined at an average rate of 1.6% per year, which translates into a stock of durables whose production and use are about twice as energy efficient as they were during the first half of the twentieth century (Krausmann et al. 2017b). In countries where the expansion of the service sector and offshoring of industrial production have a long history, this trend set in much earlier.

Examining material flows in the United Kingdom, social ecologists were able to reconstruct the evolution of the country's socioeconomic metabolism from 1800 to 2017 (Streeck et al. 2020). The long-term perspective reveals that 1899 was the turning point in a major transition from nineteenth-century industrialisation heavily fuelled by fossil energy to a development pathway characterised by steady improvements in the energy intensity of durables' production and use. Due to the high proportion of energy from non-renewable resources, the CO_2 intensity of durables has changed more or less in tandem with energy intensity. However, despite more than a century of efficiency improvements in the production and use of durables, absolute levels of energy use and CO_2 emissions did not decline until the beginning of the new millennium. The main development counteracting energy and CO_2 savings from efficiency gains was the immense growth in material stocks: the increasing volume of durables. In the United Kingdom, the stock of durables more than doubled be-

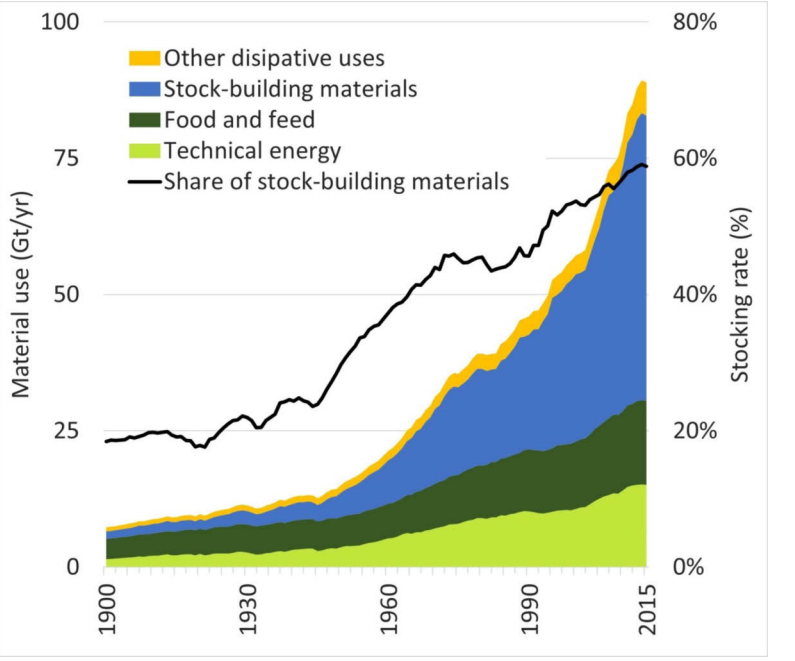
tween 1960 and 2017, thus offsetting more than half of the CO_2 savings that could have been realised from efficiency improvements (ibid.).

On a global scale, resource demand for the expansion and maintenance of durables was far more pronounced, experiencing growth rates of 2.9% per year between 1900 and 2010. In the same time span, the weight of the global stock of durables has increased 23-fold (Krausmann et al. 2017b). Today, the total weight of human-made mass stands at roughly 1,000 gigatons, exceeding the collective weight of all living beings (Elhacham et al. 2020; Haas et al. 2020; Wiedenhofer et al. 2019, 2021). The reductions in energy use that could have been achieved more recently in countries such as the United Kingdom have thus proven illusionary amidst the rapid growth in material stocks when considered from a global perspective. Throughout the twentieth century, resource demand has risen across all use categories, notably for stock building, technical energy, and food (see Figure 1.2). As a result, the global volume of annually extracted and processed materials skyrocketed from 12 gigatons in 1900 to 89 gigatons in 2015. Crucially, however, this growth has predominantly been driven by efforts to build up and maintain stocks of durables. While only 23% of globally processed materials were used for the expansion and maintenance of stocks in 1900, this share increased to 59% in 2015 (Krausmann et al. 2018). The rates of change vary across time and space, of course, but this general pattern can be observed across all continents and, so far, there has been no reversal of the trend (Wiedenhofer et al. 2021).

To get a better idea of where the material demand for stock building comes from, social ecologists have found ways to separate out different types of durables and the immediate purposes of material inputs. A look at the composition of existing stocks of durables shows that the bulk of processed materials is stored in road infrastructures and buildings, in particular concrete, asphalt, and other material aggregates used for construction and maintenance. Further, a significant share of materials is used for the production of machinery (see Figure 1.3 for an illustration of the relative weights of different materials and goods in Germany). Somewhat more surprisingly, however, existing evidence suggests that the same categories of durables have also experienced some of the fastest growth rates over the past decades (Han et al. 2022; Hertwich 2021; Liu et al. 2020; Schiller et al. 2017; Tanikawa et al. 2021). By contrast, the total mass of home appliances has stabilised or has even started to decline in many countries. Except for private cars, which have been experiencing high growth rates in emerging economies, especially in China, the main sources of continuous growth in the global demand for material

resources are thus not to be found in either the expansion of consumables or in the many durables used in the domestic sphere, but in the material structures that are meant to last the longest: infrastructures, buildings, and capital goods.

Figure 1.2: Globally processed materials by major use category in gigatons per year.

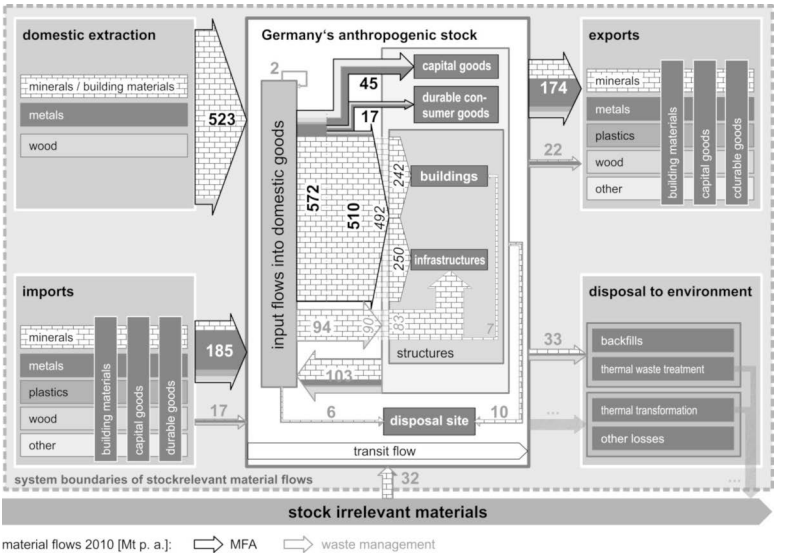


Source: Krausmann et al. 2017b; updated based on Krausmann et al. 2018.

Long-lasting durables can cast a long shadow on the future, creating path dependencies that may lock people into unsustainable and energy-intensive practices and requiring regular investments for their repair and maintenance. The massive accumulation of durables increasingly affects the demand for material resources. In deindustrialised countries and the 'old industrial world', material stocks have long been experiencing declining or, more recently, negative growth rates, with the prospect of reaching saturation point by 2035 (Wiedenhofer et al. 2021). While materials are being invested

less and less in the expansion of stocks, demands relating to their replacement and maintenance have been increasing steadily. Today, the deindustrialised world uses more resources to maintain the present level of durables than for their expansion (ibid.). Analyses of stocks in the deindustrialised economic context thus reveal a world that escapes any generic attributions of liquid and solid qualities. It is a world in which people increasingly surround themselves with more stable and lasting material objects and infrastructures, but it is also a fragile world that requires more and more inputs – in terms of further material resources, energy, and work – to maintain its stability.

Figure 1.3: Material flows into and out of Germany's manufactured (anthropogenic) stocks in 2010, by type of material and goods.



Source: Schiller et al. 2017.

Precisely how this stability of durable stocks is maintained – whether through maintenance work, renovation processes, or the replacement of entire products – is, of course, highly relevant in terms of environmental sustainability, but it is also the current limit of the state of the art of economy-wide material flow analysis. Without knowledge of the historical evolution of

product lifetimes, it remains unclear whether and to what extent the ageing of material stocks can be attributed to a shift in the composition of durables (e.g. from short-lived home appliances to long-lasting houses) vis-à-vis increases in the average lifetimes of products. To date, few studies have attempted to reconstruct the historical information on product lifetimes that is needed to disentangle these potential dynamics (Wieser 2017). Given the centrality of trends in product lifetimes in the material histories of accelerationist accounts, the paucity of robust evidence is noteworthy. But what does the collected data tell us?

Japan is the country for which long-term estimates are available for the widest range of products. Oguchi and Daigo (2017) used three different methods to calculate the average lifetime of six categories of household goods for the period 1970–2015: refrigerators, washing machines, air conditioners, televisions, mobile phones, and cars. Their analysis reveals that all categories except televisions experienced significant *extensions* of product lifetimes throughout the period studied. Televisions followed the same path until analogue devices were rendered obsolete due to an enforced transition to digital broadcasting. Further studies show that the lifetimes of buildings have also increased (Daigo et al. 2015; Kayo and Tonosaki 2022). However, it is unlikely that these trends have been uniform across countries or for the many other product groups not covered in previous studies: for example, building lifetimes had been decreasing for decades in China (Cao et al. 2019). Exceptionally low building lifetimes constitute a core driver of Chinese resource demand and waste generation (Wiedenhofer et al. 2021). A comparative analysis of country-level trends in the lifetimes of cars finds that they have increased at different speeds in different countries and have remained stable in some places (Oguchi and Fuse 2015). Future research will be able to provide a far more detailed dynamic picture of how long durables remain in use. But, as things stand, it is highly unlikely that 'plummeting product lifetimes', if such a trend occurred at all, were the major source of rising resource demand in the past couple of decades, not even in the deindustrialised world.

Material histories based on material flow accounting thus convey a picture that diverges significantly from the prevailing narrative of an expanding resource throughput being driven by ever shorter cycles of production and consumption. Both global emissions and end-of-life waste have increased sharply over the past decades and centuries, but the assumption that there is a direct link between mounting piles of waste and growing emissions on the one hand and the material processes that fuel, feed, and equip societies on the other has

proved to be wrong. There were indeed times when production and consumption almost went hand in hand, but those times were many decades ago. From a material perspective, consumption *sensu stricto* and the disposal of things were defining features of the early twentieth century, far more than they are for today's so-called 'consumer society' or 'throwaway society'. The notions of 'resource throughput' and 'levels of production and consumption' may be useful categories for historians investigating societies' relations with the material world in the past, but as the gap between inflows and outflows has widened and the global economy has shifted from a 'throughput economy' to a 'stockpiling economy' (Haas et al. 2020), employing the same concepts in analyses of contemporary patterns of resource use risks obscuring some of the core dynamics that have underpinned both growing resource demand and rising environmental pressures.

As shown in the previous discussion, durables have been mediating resource use in three distinct ways, and the dynamics behind each of these are vital for appreciating the material histories of past decades. First, durables demand energy for their operation. The ongoing transition towards more energy-efficient durables has been instrumental in reducing energy demand, especially in the deindustrialised world. Second, durables need material resources for their construction and expansion. With respect to the growth in resource demand, the massive global accumulation of durable stocks has been the defining material trend of the twentieth century. Third, durables require material inputs for their replacement and maintenance. The growth in resource demand for replacement and maintenance purposes has developed largely in parallel with the accumulation of stocks. There are clear indications that this growth, at least in some deindustrialised countries and in some important product categories, has been predominantly driven by the resource requirements of maintenance operations rather than the replacement of entire products.

Path dependencies that lock societies into energy-intensive mobility patterns, the management of harmful substances that take centuries to decay, exploding costs for repair and maintenance of infrastructures, or the revival of formerly forgotten artefacts have become common in a world populated by durables. In *The Shock of the Old*, David Edgerton (2007) argues that the histories of technologies are predominantly considered from a perspective centred on processes of invention and change at early points in their lives at the expense of the ways in which technologies are then used. Such a perspective clearly risks overlooking the long-term consequences of any decisions taken in the early lives of technologies, but, as Edgerton highlights, it also fails to recognise the

frequently long, varied, unpredictable, and truly global lives of many artefacts (cf. Lepawsky and Mather 2011). In the following section, we turn to studies of material cultures that have looked beyond first encounters in an effort to build a better understanding of how contemporary societies relate to durables.

1.4 The material cultures of durables

There are arguably few better places to start this reflection on material cultures of durables than the contributions of Bruno Latour, John Law, and Michel Callon to the field of science and technology studies (and more specifically actor-network theory). It is our impression that explicit references to durability have become rarer in this field of work; this may be linked to its popularity for making sense of highly dynamic and unstable settings (Sovacool and Hess 2017). Be that as it may, the concept of durability occupied a central position in the early developments of this stream of research (see Law 2009). A key problem that proponents of this approach sought to tackle related to the generation and stabilisation of social order. Instead of resorting to foundational sociological concepts such as 'social norms' or 'society', they wanted to describe the concrete relations that would create specific stable conditions. In so doing, they have ascribed material artefacts and the durability they afford a pivotal role in stabilising social relations. Latour expressed the view that long-lasting relations and conditions almost always require some material artefacts, especially if they are to be made durable: 'no tie can be said to be durable and made of social stuff' (2005, p. 66; see also Latour 1996).

The social significance of durables becomes apparent with reference to a classic study that resulted from an ongoing collaboration between Latour and primatologist Shirley Strum. Comparing social interactions among baboons and humans, Latour (1996) notes that primates make little use of objects in their interactions, whereas in humans it is almost impossible to identify an interaction that does not refer to things and associated techniques. The durability of material objects enables humans to benefit from two critical functions that do not apply to baboons: to endure beyond the present (e.g. by writing a book) and to interact at a distance (e.g. by buying a shirt manufactured abroad). Because baboons lack material objects that would give structure to local interactions and the associated ability to extend the spatial and temporal reach of their interactions, individual baboons are constantly confronted with unexpected and complex social situations that they need to work out anew every time. The

world of humans, by contrast, is populated by countless durables that frame interactions, generating situations that are far easier to predict.

For Latour (2005), the fascination with material objects is rooted in their somewhat paradoxical qualities, being at once tangible and omnipresent yet for the most part invisible and taken for granted. From his descriptions of material objects and the examples he gives, it is clear that Latour was predominantly concerned with the roles of durables in shaping social relations. Without some degree of durability, it would be difficult to delegate specific tasks or work to objects. To use one of Latour's famous examples, a shepherd can let a wooden fence do the job of protecting the sheep instead of staying up all night to watch over the flock. If it were not for the durability of wood and the fence's construction, the shepherd would not enjoy much sleep. Durables relieve people from specific tasks and, crucially, make people forget about the same tasks. The more material things are defined by their durability, the more they are able to disappear from view. For most materials, as we have learned from material flow accounting, this means that they become part of the infrastructures of everyday lives, built into roads, buildings, and machinery. Such objects are, most of the time, largely invisible to users in the sense that they do not invite reflection on their existence, functions, or roles in shaping users' lives. Once they are transformed from 'matters of concern' into 'matters of fact' (Latour 2004), durables can become 'second nature' to people.

By paying close attention to the social effects generated by material objects, scholars in the field of science and technology studies have been able to shed light on the power of durability. The durability of objects makes it possible to extend interactions far beyond local and time-bound contexts, while also being critical in rendering the origins of such interactions largely invisible to the users of those objects. For those with control over durables, this creates huge possibilities to exert power over people in different times and places (Latour 1990). Yet, as Law (2009) warns us, durability, like any other quality, is not an inherent property of things. Durables are only as stable as they are made to be. Durability is an ability that relies on 'investments in form' (Thévenot 1984), certainly in design but typically also through careful use, maintenance, being passed on, or through some means of valorisation. This brings us back to the dynamics of resource use.

The notion that the demand for durables is rooted in their ability to stabilise social relations provides a good starting point for thinking about the mechanisms of material cultures underpinning rising resource demand. Of course, durables are not necessarily acquired just because of their durability. There is

no value in something that is *only* durable. However, it would be equally wrong to leap to the conclusion that, as accounts of consumerism and acceleration imply, people are interested in all kinds of product qualities *other than* durability. Over the past two decades or so, studies of material cultures have significantly extended the spectrum of mechanisms driving demand for goods and services. While approaches to material culture have frequently been discussed in opposition to the studies of 'consumer culture' that have informed much of the debate on the rise of consumerism, the new perspectives do not render the theoretical contributions of cultural studies obsolete but should rather be read as a corrective to an overemphasis on aesthetics and communication (Evans 2020; Warde 2022).

The environmental rationale for such a correction was eloquently laid out in an early contribution from Shove and Warde (2002), in which the authors critically revisited the explanations for escalating levels of demand that sociologists of consumption referenced at the time. They note that most explanations focus on individual decision making, specifically in relation to the acquisition of new possessions. Some of the key mechanisms linked to purchasing decisions are related to processes of social comparison, the formation of identities, the desire for the new, efforts to sustain a coherent lifestyle, and the diversification of social activities. Whereas the predominantly cultural explanations associated with such mechanisms may do a fair job of accounting for the demand for items such as cars and smartphones, at least when they were still novel and shiny, Shove and Warde argue that they are ill-suited to demands for resources such as water or energy, which can hardly be interpreted as expressions of status- or novelty-seeking behaviour. This call to consider the environmentally significant, yet 'unglamorous world of consumables' (Shove 2016) in social theory may appear contradictory to the claims we have made so far. Their call should not, however, be mistaken for a plea to pay greater attention to consumables. The central message is that the demand for consumables cannot be accounted for in the same terms as the demand for durables precisely because the former are mediated by durable relations. To understand where the demand for consumables such as energy comes from, researchers thus need to focus on ordinary, day-to-day routines of everyday life and the various sociotechnical (and durable, we might add) infrastructures and devices that shape those routines (Gronow and Warde 2001; Shove and Warde 2002).

Empirically, this shift towards ordinary and inconspicuous forms of resource use has inspired a thriving research agenda that looks beyond the acquisition of artefacts; specifically, it focuses on the use of various energy-con-

suming infrastructures and devices such as freezers, cars, and heating systems (see Rinkinen et al. 2020). This research thus sheds light on a particular relation to durables that has been largely overlooked in cultural studies yet remains environmentally highly relevant (see the previous section on the energy intensity of durables). The proliferation of studies of material culture has also been significant in theoretical terms. Most notably, the turn to theories of practice has marked a decisive step in the development of an alternative perspective on consumption.

Practice-theoretical accounts effectively displace consumption as a core analytical concept in making sense of resource use in favour of (social) practices. Proponents of this perspective argue that people rarely engage in consumption activities per se, or at least they do not consider themselves to be consuming. Instead of being a practice itself, consumption is thus better interpreted as a moment in practices (Warde 2005). Consumption, then, emerges as a consequence of how people are recruited to and involved in socially shared practices rather than of individual decisions. While theories of practice have been most influential in relation to the study of resource demand, several other interesting theoretical perspectives have been developed that hold great promise for illuminating people's relations with durables. In part, those perspectives are able to address some of the deficiencies of theories of practice, in particular their emphasis on use and routines. For example, the field of market studies has brought the insights into the roles of material objects presented at the beginning of this section to bear on the study of how people form attachments to things (e.g. Cochoy et al. 2017). Although the focus was initially on processes of market exchange and acquisition, more recent studies have also considered the detachment from things and associated processes of obsolescence, reuse, and recycling (see Wieser 2021).

Studies of material cultures have also developed their own methods that are particularly useful for the study of durables. Approaches such as 'broken world thinking' (Jackson 2014), 'infrastructural inversion' (Bowker 1994), 'follow the actors' (Latour 2005), and 'biographies of artefacts' (Hyysalo et al. 2019) share the common aim of directing the researcher's attention to the processes and relations that brought artefacts into being and continue to sustain them, especially those that are often rendered invisible in the discursive realm, such as the many engagements with artefacts occurring between their acquisition and disposal. Such methods demand that durability is not seen as a continuous stable state but as an outcome that must also always be restored, through practices that are often just as invisible as the durable things themselves.

Ethnographic repair research associated with these traditions, for example, assumes a fundamental fragility of things, which require constant care, maintenance, and repair (see Denis et al. 2016). Going a step further, the philosopher Elizabeth Spelman (2002) declares humans to be '*homo reparans*', who are constantly under the compulsion to repair everyday things as well as emotions, social structures, and social relations so that the social and material order can be re-established. If we follow Latour in comparing humans with baboons, Spelman's claim will likely need to be relativised. Spelman nonetheless has a point when she attributes a hugely significant role to repair in contemporary societies. Recalling the insights from material flow accounting presented in the previous section, this diagnosis likely also remains true – and perhaps even more so – in relation to material objects. Historians of technology lack the methods of social ecologists to estimate the changing levels of repair and maintenance, but those who have looked deeper into the histories of repair have similarly cast doubts on the accuracy of widespread assumptions of declining levels of repair. Krebs and Weber (2021) note that the most significant changes in the twentieth century may not have been in the growth or decline of repair, but in shifts in the modes, appearances, sites, and actors of repair. They highlight three historical trends in particular. First, repair has shifted towards the global South. Second, the focus of repair has moved from industrial consumer goods to infrastructures and production facilities. And third, repair today seems to be less about patching and mending than about replacing entire parts.

Accelerationist accounts, in particular the thesis of a throwaway society, have also been challenged by scholars of material cultures who have been examining how durables are moved on through processes such as gifting, selling, storing, and wasting (e.g. Gregson et al. 2007; Holmes and Ehgartner 2021; Woodward 2015). In an early study of what British households do with possessions they no longer want or need, Gregson et al. (2007) found that the vast majority of durables did not directly enter the waste stream but were given away in some form. The research group suggests that people are frequently riddled with various anxieties in relation to unwanted possessions, rather than exhibiting careless behaviours or a throwaway ethic. As a result, people frequently went to great lengths to avoid throwing things away and to find a person for whom the thing would still be useful. Furthermore, when things were thrown away, this was often linked with social dynamics that were far removed from the motives implied in the throwaway society thesis, such as breakups of couples or house moves.

'Non-consumptive' practices such as storing, saving, and hoarding are often neglected in studies of consumer culture. The accumulation of things in homes has been researched extensively by a team from California's Center on the Everyday Lives of Families, who regularly visited 32 families in their homes and apartments over several years (Arnold et al. 2012). The team illustrates how the escalating demand for durables in twentieth-century America is reflected in people's domestic environments, as 'mountains of possessions' accumulate, fill homes, and spread to more and more spaces, such as garages and front yards. Using their approach of visual ethnography, they illustrate how families, on the one hand, store memories in assemblages of images and objects, and, on the other hand, seek to simplify their daily lives, which are filled with many activities, through material arrangements. It is noticeable that through the accumulation of many different things – books, games, gardening tools, but also durable and pre-produced food – an attempt is made to always keep as many options for action open as possible and to keep the necessary material equipment available. Many things linger for years, practically on standby, before being forgotten due to the inability of households to maintain a regular flow of objects in and out of the home.

The resulting attentiveness to material realities and the development of a distinct set of theories and methodologies have thus allowed scholars of material cultures to develop accounts of resource demand that, although largely rooted in the study of local and situated actions, are very much complementary to the economy-wide patterns studied by social ecologists. In particular, the diverse stream of research presented in this section reveals the deficiencies of theories of linearity, which assume that things, once purchased, quickly and unproblematically turn into waste. What is mostly missing from studies of material cultures, however, are considerations of how these fit into wider economic processes. In the following section, we turn to work from a political economy perspective to get a sense of how durables are incorporated within processes of valuation and appropriation.

1.5 The political economies of durables

Broadly speaking, durables can fulfil two key economic functions: they can store both value and work. In combination with markets in which things can be exchanged and thereby 'liquidised', durability can turn things into assets to build up wealth, whether through saving or speculation. Durability is thus

foundational to the exchange value of things. Putting durables to work, they can be used to meet human needs such as shelter or communication, but they can also be mobilised as means of production for the manufacturing and sale of commodities. The durability of things here is vital for their use value. By thinking of durables through political economies, we can examine the exchange and use values of durables, or what kind of durable 'goods' and 'bads' are being mobilised in the creation and destruction of value and how the organisation of such processes occurs. Here, we focus on the specific context of capitalist economies and discuss a selection of works that provide explanations of why durables have not 'melted into air', to paraphrase Marx's famous proclamation, but instead have attained increasingly significant roles in the accumulation of capital.

For Marx, the accumulation of capital rests on its circulation through processes of production, exchange, and consumption. In the industrial production process, which is organised around the production of mass-manufactured, standardised commodities, the mechanisation of manufacturing processes through the mobilisation of 'fixed capital' in the form of machinery and other physical infrastructures is of critical importance. Economic competition, which forces the owners of such fixed capital to constantly revolutionise the means of production, leads to a relentless economic pressure to increase sales volumes in order to maximise returns on investment made on the quickly depreciating stock of fixed capital. The rapid depreciation and obsolescence of industrial equipment remain central challenges for manufacturers to this day. In its annual report to investors, Apple, the world's most valuable corporation, lists among the key risk factors faced by the company the need to write off its assets and inventories in response to unpredictable product obsolescence. Across industries, large quantities of products are being discarded before they even enter circulation (Roberts et al. 2023). It would be historically inaccurate, however, to link industrialisation to a decline in durability. As historian Ferdinand Braudel remarked, at least initially and compared with pre-industrial times, 'the industrial revolution was above all a transformation of fixed capital: from now on, it would be more costly but more durable: its quality would be improved and it would radically alter rates of productivity' (Braudel 1982: 247, cited in Dobeson and Kohl 2020). Indeed, before a complex industrial and institutional framework of quality control was established, uncertainties over the quality of products and their durability were a ubiquitous problem and prevented the circulation of products and materials through second-hand sales or recycling (Casson et al. 2023).

For as long as population growth, rising incomes, and the global expansion of the market increased the customer base, durability did not represent a major problem from an economic point of view. Indeed, it was only when markets began to show signs of saturation that durability came to be viewed as a hindrance to capital accumulation. The emerging struggles over saturated markets and the celebrated discovery – in marketing and business circles – of 'planned obsolescence' as a response to stalling sales have received a fair amount of attention in studies of the rise of consumerism and the throwaway society (see Weber 2018; Wieser 2021). Researchers and activists have uncovered a wide range of practices through which manufacturers have sought – sometimes successfully – to curtail the durability of products in order to speed up the circulation of capital (e.g. Slade 2006). Today, Marx-infused theories of planned obsolescence form a central pillar of the accelerationist accounts of resource use discussed earlier in this chapter. Such accounts of the ways in which manufacturers react when faced with the 'durables problem' (Guiltinan 2009) undoubtedly have some currency in explaining key historical trends such as the rise of 'Sloanism' and the associated stylistic revolution in the world of automobiles. However, as we argued in the previous section on the material histories of durables, product lifetimes did not uniformly decrease, and in many cases they underwent lengthy periods of extension. A focus on product lifetimes would therefore miss the key development of the twenty-first century: the unprecedented accumulation of durable stocks.

In the previous section, we explored social and cultural factors that may go some way in explaining how longer product lifetimes and increasing accumulations of highly durable artefacts such as material infrastructures, roads, and buildings come about. Once we recognise that acceleration is not the only alternative strategy to the expansion of markets, it becomes clear that durability does not necessarily represent a problem; rather, it can become a key resource for generating profits and accumulating capital. Perhaps nowhere are the consequences of a related shift in accumulation strategy more evident than in the real estate sector. As Piketty's (2014) long-term analyses show, in the (de)industrialised or old industrial parts of the world, capital has completely changed its form over the past centuries. Whereas a major share of capital, in monetary terms, was stored in agricultural land until well into the nineteenth century, housing emerged as the dominant type of capital in the second half of the twentieth century. Since around 1990, virtually the entire addition of capital has been led by the housing sector.

Aalbers and Christophers (2014) offer a political economy reading of this trend, noting a marked shift away from the traditional role of houses as sites predominantly used for social reproduction. They argue that a key driving force behind this shift was the immersion of housing into a growth economy based on expectations of continuously rising prices, a process that has been accompanied by a massive rise in private debt. According to Aalbers and Christophers, government support for debt-led financing of house purchases has become a cornerstone of Keynesian demand-side policymaking, following the idea that increasing house prices compensate for stagnating income levels and spur demand for products and services more generally. Furthermore, they suggest that houses and urban infrastructures have also become – by virtue of their durability, we might add – attractive stores of value for over-accumulated capital. This trend to use houses as deposits of wealth and investments rather than residential properties is particularly visible in the expensive real estate of cities such as London and New York (Fernandez et al. 2016). In many countries, the state and public administrations have been playing an important role in compensating for rising real estate prices by redistributing wealth through the provision of subsidised housing, thereby stabilising the growth model.

As well as realising profits from higher resale values, housing has also become a focal point through which social relations manifest themselves. This is particularly clear in the division between owners and renters, a division that has given rise to its own 'housing classes' that cannot be entirely reduced to people's position in the labour market (Aalbers and Christophers 2014). Aalbers and Christophers suggest that private property rental is particularly prone to social exploitation due to the monopolistic qualities of residential properties, which can make housing a financially highly attractive form of investment in times of deregulated rental markets. The opportunities for extracting high and long-term rents may be even greater in the case of large-scale infrastructures. Examining the political economy of energy infrastructures, Schaffartzik et al. (2021) argue that, due to their enormous scale and high durability, investments can often be realised only by a combination of large corporations, states, and banks. They suggest that the long-term lock-in effects and longevity of energy infrastructures, as well as their ability to lock out competitors, make such investments particularly appealing to financial actors seeking safe rents. The durability of infrastructures plays an important role here in contributing to long-term lock-in effects.

In terms of economic size, housing certainly represents the most significant sector; it is a sector in which a mode of capital accumulation has been

established that, at least in a Western context, relies not so much on the expansion of the customer base or on an accelerating pace of replacement, as on the increasing economic value of the existing material stock. However, housing may be far from the only sector where profit making has become linked to the increasing economic value of commodities. In Boltanski and Esquerre's (2020) seminal analysis of contemporary capitalism in countries such as France and Italy, the authors argue that the decades since the decline of old industries saw the emergence of a new form of capitalism that they characterise as 'integral'. Whereas industrial capitalism rested predominantly on the commercialisation of standardised objects, an integral capitalism is able to capitalise on a wider range of commodity forms and associated ways of creating value. In exploiting more fully the commercial opportunities provided by the universe of commodities, profit-seeking actors increasingly turn to things that increase in value over time, whereas the traditional focus was on mass-produced goods whose value typically declined throughout their lives.

Following Boltanski and Esquerre, commodities that increase in value – in particular, assets and collectibles – have been at the centre of a growing 'enrichment economy' that has specialised in the exploitation of resources that were created a long time, often centuries, ago. For example, heritage sites, which may attract tourists from across the globe, are significant sites of enrichment. Such heritage sites are not just there, however, but need to be actively preserved and marketed. Boltanski and Esquerre note that recent decades have seen a proliferation of monuments, artisanal products, folklore stories, and traditional festivals being 'rediscovered' as significant expressions of a place's cultural heritage. By developing narratives around how particular objects relate to some significant event, person, or practice from the past, owners and local stakeholders are able to present objects as unique and culturally significant. The enrichment economy thus draws heavily on two groups of workers. The first group works in the cultural industries, from advertising to craft, tourism, and artistry, and their aesthetic sense, cultural awareness, and creativity are vital for the valorisation of objects. The second group, albeit less considered by Boltanski and Esquerre, consists of workers who are active in the restoration and maintenance of the material stocks on whose durability the enrichment economy rests. The enrichment of objects can work irrespectively of whether they are centuries-old or new, and it has become a common practice across sectors as diverse as cultural tourism, art markets, and luxury products. It is easy to see why France and Italy, with their rich and storied pasts, are key sites for the growing enrichment economy, but younger cities such as Dubai, with its

spectacular architecture and art exhibitions, show that this economic model is also being embraced to build a *lasting* heritage elsewhere.

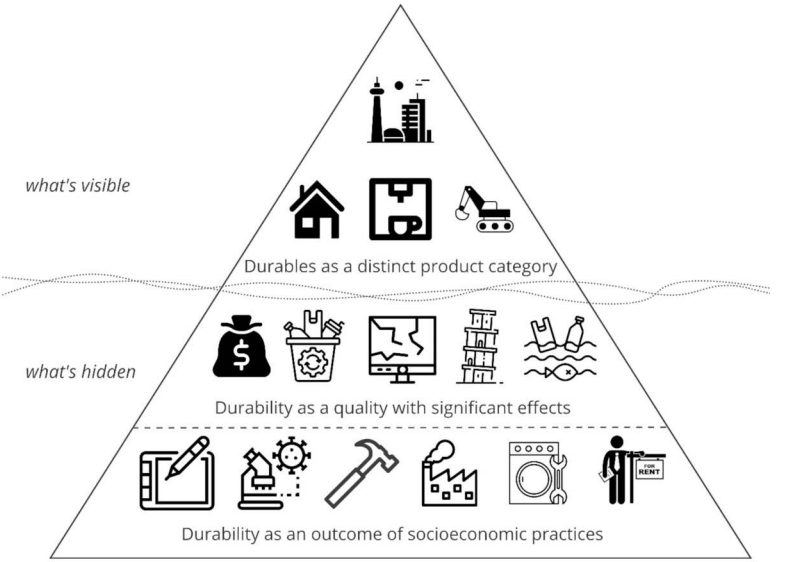
The discussion so far shows that the durability of artefacts has been implicated in the accumulation of capital in different ways. Looking at the big picture of historical developments characterised by the industrialisation and deindustrialisation of economies, the positioning of durability as a core economic problem, which is frequently at the heart of accelerationist accounts, appears to be exaggerated. Instead of reducing durability to curb sales of replacements, contemporary economies have also found ways to generate profits from the exploitation of the existing stock of durables. It is worth emphasising a central parallel between the historical dynamics sketched out here and the characteristics of 'alternative' durable economies that are hailed as more sustainable economic models. The focus on renting rather than selling together with the continuous maintenance and valorisation of things are fundamental pillars of the 'circular economy' as envisaged by its leading proponents (e.g. Stahel 2016). A historical perspective that is sensitive to the ways in which durables have been incorporated in capitalist relations reveals that such economic processes have been at the centre of capitalist development in Western countries for several decades. Perhaps even more importantly, however, such a perspective cautions against naïve promises of a 'win–win–win' solution for businesses, society, and the environment. This is conveyed most powerfully in the dual sense in which Boltanski and Esquerre use the notion of an enrichment economy. While this economy relies on the contributions of cultural workers and repair professionals to enrich objects, such work ultimately enriches those in possession of these objects – that is, the wealthy elites who own the vast majority of real estate and cultural artefacts. In a context where durables proliferate and store huge amounts of wealth, their distribution and questions of who benefits from practices such as repair and maintenance thus need to be taken far more seriously.

1.6 Contours of the research programme

In the introductory paragraphs to this chapter, we formulated the claim that durability represents a core quality in contemporary economies, a quality that should be placed at the centre of analyses of patterns of resource use. Following the previous discussion of the material histories, material cultures, and political economies of durables, we are now in a better position to substantiate this

claim and outline some possible avenues forward. One way to approach this is to turn the claim on its head and ask what is to be gained from paying closer attention to durability. We suggest that there are multiple layers where durability can be considered, from recognising and studying durables as a distinct category in their own right, to focusing more specifically on the effects of durability and how durability is enacted (see Figure 1.4).

Figure 1.4: Three layers in studying durable economies.



A first step is to recognise the significance of durables vis-à-vis consumables. As we have shown with reference to the latest findings from analyses of economy-wide material flows, contemporary patterns of resource use can no longer be plausibly captured using frameworks that treat all objects as if they were consumables. Locating environmental problems in increasing 'levels of resource throughput' or 'levels of consumption' not only hides crucial differences in the dynamics of resource use, and thus the origins of rising demand, but also generates false expectations regarding the fates of manufactured objects and infrastructures. Instead of a linear and short-term passage from product to waste, vast amounts of materials are embedded in durable

infrastructures, production facilities, and household goods, which frequently last many decades or even centuries. Following years of massive stockpiling, societal relations with the material world have become predominantly defined by durables, or at least mediated by them. This matters greatly in environmental terms, for durables can lock societies into long-term commitments to expand stocks even further, consume energy for their operation, and make continuous investments in their maintenance. Studying societies' relations to durables and the various mechanisms through which durables are linked to growing resource use should therefore be considered a key priority within the scientific community.

To appreciate the full significance of durables, however, it is necessary to go beyond durables as a category and recognise the specific effects that their durability creates. Durability allows things to become part of the material infrastructures that shape everyday lives. The ways in which people relate to such objects in their everyday lives are very different from their relationships with consumables and require distinct theoretical and methodological research approaches (cf. Shove 2016). By enabling the spatial and temporal expansion of interactions (as discussed in the section on material cultures), durability is also vital to processes as diverse as the preservation of memories, manufacturing, and the accumulation of wealth. We should also mention here the extraordinary durability of some materials – think of nuclear waste, plastics, or asbestos – and the durability of products that have been designed with little regard to their ability to degrade and be recycled as key environmental problems of our times (Bensaude Vincent 2018; see also Lepawsky, this volume). Another important effect of durability, however, is that experiences with durables are marked by regular interruptions due to failures, processes of decay, or other forms of deterioration. As contemporary societies surround themselves with more and more durables, repair and maintenance represent vital and omnipresent practices. Recognising the durability of artefacts and their frequently fragile qualities thus opens up and reveals the significance of a much wider spectrum of engagements with the material world than could be appreciated if the durability were taken for granted.

The third layer concerns durability itself. We know, for example, that durability ranks highly as a product quality among many people (e.g. Jaeger-Erben and Hipp 2017) and plays an important role in product design (see Mesa et al. 2022). However, durability is also a contested quality whose definition has long been subject not only to scholarly debate but also, for instance, to legal disputes (Maitre-Ekern and Dalhammar 2016; see also Dalhammar et al.,

this volume). While durability is clearly a widespread matter of concern, this quality remains something of a black box. A look at how durability has been discussed in scholarly debates reveals that there are multiple *qualities* to durability, such as robustness, sturdiness, reliability, stickiness, timelessness, or resilience (e.g. Cooper 2010; Fletcher 2012; Haug 2018). Each of these qualities (and more) may contribute to the ability of things to hold their shape, but they do so in different ways and with different implications for the lives of artefacts and possibly also for how they are used. While this part of our claim is thus more difficult to substantiate based on existing evidence, we contend that opening this black box by developing a better understanding of the specific concerns and processes that make things durable will be crucial to appreciate why durables have become such a dominant force and to develop more sustainable alternatives to current patterns of resource use.

In making a case for durability to be considered across these different layers, we have already outlined what should be a key ambition of a research programme on durable economies. It should be a programme that recognises the distinctiveness of durables and is attentive to how durability comes about and the effects this quality creates. An important implication of this multi-layered perspective is that durable economies cannot be understood through formalist economic approaches or with recourse to economic forces alone. In directing attention to economies, we are certainly not advocating a return to economistic explanations that are characteristic of critiques of planned obsolescence, for example. As we have argued, durability has economic as well as social and technical dimensions and is shaped by a multitude of actors, from businesses and households to regulatory institutions and governmental bodies, all of which form part of durable economies. A research programme on durable economies thus necessarily relies on insights from a wide range of different disciplinary perspectives.

Durable economies also comprise different processes of resource use: both production and consumption as well as various engagements with durables that neither create them nor destroy them and are thus better conceived in terms of practices, care, use, or valuation, to name just a few. In the previous sections, we have presented theories and methodologies that have been brought to the study of durables with great effect and will likely continue to be highly relevant. However, as already noted, the research landscape that relates to the study of durables is highly fragmented. Furthermore, while many perspectives presented so far share common ground in being influenced by the 'materialist turn' and have produced valuable insights that are largely comple-

mentary, research communities put very different emphases on the various aspects of durability, with separate groups forming around topics such as repair and maintenance, discarding, waste, or product lifetimes. As the previous sections hopefully demonstrate, we see great value in establishing links between these communities and bringing their insights together to develop a more realistic perspective on societies' relations to the material world. In the concept of durable economies, we see a promising vehicle for creating links between situated practices and wider (political) economies and for adopting a symmetrical perspective on the stability and instability of durables.

Finally, perhaps one of the areas where the concept of durable economies is most productive is the critical analysis of how durables are made and given value to. In the environmental discourse, durability still has a predominantly positive connotation. Confronted with the huge burdens associated with durables, material flow accountants have adopted a decidedly more critical perspective that explicitly problematises durables (e.g. Vita et al. 2021). Boltanski and Esquerre's (2020) analysis of the enrichment economy, which is outside the environmental discourse, provides another welcome counterperspective. Applying such critical perspectives on durability has great potential for illuminating the promises and limitations of different conceptions of 'new' sustainable economies. Viewing the 'circular economy' from a durable economies perspective, for instance, reveals some fundamental inconsistencies in how the durability of artefacts is supposed to be addressed (see Holmes et al. 2021). It would also likely show that the circular economy debate has been centred on the lifecycles of individual artefacts at the expense of attention to their volumes as well as to larger infrastructures – the most significant drivers of resource use. Furthermore, such an endeavour might critically examine how a circular economy would differ from a dystopian enrichment economy, in which a minority exploits the high durability of circular products for its own financial gains. In our view, an important aspect of the project of engaging with durable economies is overcoming generalisations of durables as 'goods' or 'bads' and providing space for critical reflection on their environmental implications as well as their distributional effects. We return to this project in the final chapter of this book.

1.7 'Doing durability': outline of the book

The remaining chapters explore different facets of durable economies from a diverse range of disciplinary backgrounds. There are too many facets to the research programme as set out in this introductory chapter to be covered in a single volume, and a different book might have taken an alternative approach in presenting case studies on various durable economies – or it might have brought together analyses of different historical resource use dynamics from a durable economies perspective. This book originates in conversations held in the context of ongoing research projects on the lifetimes of products. Most of the authors have been part of the interdisciplinary research group 'Obsolescence as a challenge for sustainability', which explored causes of product obsolescence and sustainable alternatives. A common thread in most chapters is thus their focus on how durability is enacted today and the lessons that can be learned for extending product lifetimes. If this strategy is applied to 'goods' and not to 'bads', prolonging the lifetimes of products represents one of the most effective strategies to cut down resource demand (e.g. Wiedenhofer et al. 2021). Most chapters also focus on household goods, especially electronics, and on the enactment of durability in a Western context. Against this backdrop, the following chapters provide a unique glance at how durability is enacted in diverse sites, such as regulatory agencies, retail settings, public discourse, digital infrastructures, businesses, and the home. In so doing, they take an important step towards opening the black box of durability and addressing the 'doing durability' layer of the research programme sketched out here, while also offering reflections on how durability can contribute to more sustainable resource use. In the final chapter, we bring some of the key insights from these explorations together to return to the overall theme of the book and reflect on the conditions under which durable economies may become congruent with lower levels of resource use.

In Chapter 2, Josh Lepawsky examines spaces of durability associated with the manufacture of electronic devices to interrogate the politics of durable economies. The chapter looks at the Middlefield-Ellis-Whisman area (MEW), a site located in Silicon Valley and burdened with trichloroethylene (TCE), which is released from electronics manufacturing. It focuses on the regulatory actions taken in response to community concerns about contamination of the area by this long-lasting toxicant. From the empirical focus on TCE contamination in the MEW and regulatory responses to it, the chapter interprets durability and durable economies conceptually through the idea of the

'politics-of-what'. This perspective allows Lepawsky to investigate what goods are sought and what bads are fought with respect to durable economies and how the 'good' is set up as 'good' in the first place.

In Chapter 3, Max Marwede and Florian Hofmann explore how manufacturers of long-lasting consumer durables align high levels of durability with their business models. By juxtaposing sales-based business models on the one hand and rental-based business models on the other, the authors tease out the specific qualities of durability and the business operations that characterise each model. While there are different modalities for commercialising durability, Marwede and Hofmann argue that they nonetheless share commonalities in the organisational processes, structures, and capabilities needed to do business based on durability.

In Chapter 4, Eduard Wagner engages with the roles of information and digitalisation in durable economies. The author's starting point is that information asymmetries and 'linear' or one-directional information flows frequently inhibit practices that could support higher levels of durability and product circularity. Taking a multi-stakeholder perspective, the chapter provides an overview of key information needs across product designers, providers, and users to discuss the potential and limitations of alternative, 'green' information systems based on the Internet of Things, digital product passes, and digital twins.

In Chapter 5, Erik Poppe and Vivian Frick investigate the role of the retail sector in durable economies. They start from the observation that retailers are remarkably unchallenged in discourses on planned obsolescence and short product lifetimes, even though they exert significant control over the design of marketplaces and the flow of products in and out of points of sale. The authors discuss several strategies employed by the retail sector to prompt consumers to buy more products in shorter periods, thus diminishing the durability of products (in this chapter, durability is equated with the useful life of the product) by offering early replacements. The chapter explores a field of research that has received little attention to date and proposes possible interventions in the retail sector to enable it to contribute to a durable economy in the sense of longer product use cycles.

In Chapter 6, Tamina Hipp and Daniel Fischer focus on everyday discourses to examine how user narratives contribute to the appreciation or depreciation of electronic devices. They classify ten distinct narratives, of which three have depreciative, four have appreciative, and three have ambivalent effects. The authors show how sustainability communication professionals

can mobilise this discursive repertoire and the interactions between different narratives to extend the lives of consumer durables and navigate transitions to alternative durable economies.

In Chapter 7, Carl Dalhammar, Eléonore Maitre-Ekern, Jessika Luth Richter, Sahra Svensson-Hoglund, and Leonidas Milios focus on the political framework necessary for the durability of consumer goods. The authors look at durability from the normative perspective of sustainable consumption. Starting from a legal definition of durability as the 'ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached', durable consumer goods are seen as a more resource-efficient alternative to products with short use and life spans and thus the goal of a sustainable economy. Dalhammar et al. make clear the difficult conditions that prevail for political durability interventions in a productive economy that focuses primarily on the sale and purchase of always new generations of products. At the same time, they identify a broad range of policy approaches and strategies that seek to address the various barriers to enabling greater durability and longer life – such as the low cost of new production and the high cost of maintaining the value of consumer objects. In their comprehensive analyses of 'durability policies' at different administrative levels, they find that policies (still) take a more technocratic perspective on the needs of change and focus on 'classical' approaches such as regulations, standards, and quantitative indicators.

In Chapter 8, Melanie Jaeger-Erben, Marina Proske, and Sabine Hielscher focus on a specific consumer good that is often highlighted as an example of a short-lived product in terms of the length (or rather brevity) of usage and innovation cycles: the smartphone. The authors investigate whether a modular product design has the potential to connect durability with environmental sustainability. Modular product design can increase the availability of repair and upgrades, thus allowing a longer useful life. But it can also lead to an explosion of resource use and an even faster market, this time for components. The chapter discusses the various relations between durability and modularity/scalability on the one hand and environmental impact on the other hand, as well as possible challenges and trade-offs. The authors argue that in-depth knowledge of smartphones as a popular cultural artefact and everyday multifunctional companion is a prerequisite to designing a durable and sustainable product–service system with modular smartphones.

Following up on the individual contributions to 'doing durability' for the development of more sustainable economies, Chapter 9 concludes with some

reflections on the relations between durability and resource use, and the challenges of organising durable stocks. The discussion highlights the importance of attending to three dimensions of resource use – stock-driven energy use, construction and expansion of stocks, and replacement and maintenance of stocks – and the shortcomings of existing conceptions and visions of sustainable economics in addressing these dimensions. In terms of 'doing durability', the chapter discusses some of the key challenges in aligning durability with sustainable outcomes along technical, economic, and social lines.

References

Aalbers, M. B. and Christophers, B. (2014) Centring Housing in Political Economy. *Housing, Theory and Society* 31(4), 373–94. https://doi.org/10.1080/14036096.2014.947082

Arnold, J. E., Graesch, A. P., Ragazzini, E., and Ochs, E. (2012) *Life at Home in the Twenty-First Century: 32 Families Open Their Doors*. University of California.

Bauman, Z. (2005) *Liquid Life*. Polity Press.

Bauman, Z. (2013) *Society under Siege*. John Wiley and Sons.

Bengtsson, M., Alfredsson, E., Cohen, M., Lorek, S., and Schroeder, P. (2018) Transforming Systems of Consumption and Production for Achieving the Sustainable Development Goals: Moving beyond Efficiency. *Sustainability Science* 13(6), 1533–47. https://doi.org/10.1007/s11625-018-0582-1

Bensaude Vincent, B. (2018) Of Times and Things. Technology and Durability. In S. Loeve, X. Guchet, and B. Bensaude Vincent (eds), *French Philosophy of Technology: Classical Readings and Contemporary Approaches*. Springer International, 279–98. https://doi.org/10.1007/978-3-319-89518-5_17

Boltanski, L. and Esquerre, A. (2020) *Enrichment: A Critique of Commodities*. Polity Press.

Bowker, G. (1994) *Science on the Run: Information Management and Industrial Geophysics at Schlumberger, 1920–1940*. MIT Press.

Çalışkan, K. and Callon, M. (2010) Economization. Part 2: A Research Programme for the Study of Markets. *Economy and Society* 39(1), 1–32. https://doi.org/10.1080/03085140903424519

Cao, Z., Liu, G., Duan, H., Xi, F., Liu, G., and Yang, W. (2019) Unravelling the Mystery of Chinese Building Lifetime: A Calibration and Verification Based on Dynamic Material Flow Analysis. *Applied Energy* 238, 442–52. https://doi.org/10.1016/j.apenergy.2019.01.106

Casson, C., Boons, F., Davies, J., Holmes, H., Lee, J. S., and Wieser, H. (2023) Lessons from English Pre-Industrial Times for a Post-Industrial Circular Economy. *Resources, Conservation and Recycling*, 193, 106968.

Cochoy, F., Deville, J., and McFall, L. (eds) (2017) *Markets and the Arts of Attachment*. Taylor and Francis.

Cohen, M. J. (2019) Introduction to the Special Section: Innovative Perspectives on Systems of Sustainable Consumption and Production. *Sustainability: Science, Practice and Policy* 15(S1), 104–10. https://doi.org/10.1080/15487733.2019.1703331

Cooper, T. (ed.) (2010) *Longer Lasting Products: Alternatives to the Throwaway Society*. Gower Publishing.

Crocker, R. (2017) *Somebody Else's Problem: Consumerism, Sustainability and Design*. Routledge. https://doi.org/10.4324/9781351284127

Crocker, R. (2018) From 'Spaceship Earth' to the Circular Economy: The Problem of Consumption. In R. Crocker, C. Saint, G. Chen, and Y. Tong (eds), *Unmaking Waste in Production and Consumption: Towards the Circular Economy*. Emerald Publishing, 13–33. https://doi.org/10.1108/978-1-78714-619-820181003

Daigo, I., Iwata, K., Oguchi, M., and Goto, Y. (2015) Changing Average Lifetime of Buildings Over Time Analysed on the Basis of D-based Distribution. In T. Cooper, N. Braithwaite, M. Moreno, and G. Salvia (eds), *Product Lifetimes and the Environment*. Nottingham Trent University, 88–92.

Daly, H. E. (1977) *Steady-State Economics*. San Francisco.

Denis, J., Mongili, A., and Pontille, D. (2016) Maintenance and Repair in Science and Technology Studies. *Tecnoscienza: Italian Journal of Science and Technology Studies* 6(2), Art. 2.

Dobeson, A. and Kohl, S. (2020) Why Durability Matters? Towards a Comparative Economic Sociology of Market Organization. *European Journal of Sociology / Archives Européennes de Sociologie* 61(1), 33–64. https://doi.org/10.1017/S0003975620000028

Edgerton, D. (2007) *The Shock of the Old: Technology and Global History Since 1900*. Oxford University Press.

Edwards, P. N., Bowker, G. C., Jackson, S. J., and Williams, R. (2009) Introduction: An Agenda for Infrastructure Studies. *Journal of the Association for Information Systems* 10(5), 6.

Elhacham, E., Ben-Uri, L., Grozovski, J., Bar-On, Y. M., and Milo, R. (2020) Global Human-Made Mass Exceeds All Living Biomass. *Nature* 588(7838), Art. 7838. https://doi.org/10.1038/s41586-020-3010-5

Evans, D. M. (2020) After Practice? Material Semiotic Approaches to Consumption and Economy. *Cultural Sociology* 14(4), 340–56. https://doi.org/10.1177/1749975520923521

Faber, M., Frank, K., Klauer, B., Manstetten, R., Schiller, J., and Wissel, C. (2005) On the Foundation of a General Theory of Stocks. *Ecological Economics* 55(2), 155–72. https://doi.org/10.1016/j.ecolecon.2005.06.006

Fernandez, R., Hofman, A., and Aalbers, M. B. (2016) London and New York as a Safe Deposit Box for the Transnational Wealth Elite. *Environment and Planning A: Economy and Space* 48(12), 2443–61. https://doi.org/10.1177/0308518X16659479

Fletcher, K. (2012) Durability, Fashion, Sustainability: The Processes and Practices of Use. *Fashion Practice* 4(2), 221–38. https://doi.org/10.2752/175693812X13403765252389

Gasper, D., Shah, A., and Tankha, S. (2019) The Framing of Sustainable Consumption and Production in SDG 12. *Global Policy* 10, 83–95.

Georgescu-Roegen, N. (1971) *The Entropy Law and the Economic Process*. Harvard University Press. https://doi.org/10.4159/harvard.9780674281653

Graeber, D. (2011) Consumption. *Current Anthropology* 52(4), 489–511. https://doi.org/10.1086/660166

Gregson, N., Metcalfe, A., and Crewe, L. (2007) Identity, Mobility, and the Throwaway Society. *Environment and Planning D: Society and Space* 25(4), 682–700. https://doi.org/10.1068/d418t

Gronow, J. and Warde, A. (eds) (2001) *Ordinary Consumption*. Routledge.

Guiltinan, J. (2009) Creative Destruction and Destructive Creations: Environmental Ethics and Planned Obsolescence. *Journal of Business Ethics* 89(1), 19–28. https://doi.org/10.1007/s10551-008-9907-9

Haas, W., Krausmann, F., Wiedenhofer, D., Lauk, C., and Mayer, A. (2020) Spaceship Earth's Odyssey to a Circular Economy: A Century Long Perspective. *Resources, Conservation and Recycling* 163, 105076. https://doi.org/10.1016/j.resconrec.2020.105076

Haberl, H., Wiedenhofer, D., Erb, K.-H., Görg, C., and Krausmann, F. (2017) The Material Stock–Flow–Service Nexus: A New Approach for Tackling the Decoupling Conundrum. *Sustainability* 9(7), Art. 7. https://doi.org/10.3390/su9071049

Haberl, H., Wiedenhofer, D., Pauliuk, S., Krausmann, F., Müller, D. B., and Fischer-Kowalski, M. (2019) Contributions of Sociometabolic Research to Sustainability Science. *Nature Sustainability* 2(3dd), Art. 3. https://doi.org/10.1038/s41893-019-0225-2

Han, F., Yang, N., Sun, M., Liu, J., Xu, X., Yang, D., Shi, F., and Zhang, L. (2022) In-Use Stocks Dynamic of Durable Goods in Rural Chinese Households: Spatial-Temporal Patterns and Influencing Factors. *Resources, Conservation and Recycling* 186, 106584. https://doi.org/10.1016/j.resconrec.2022.106584

Haug, A. (2018) Defining 'Resilient Design' in the Context of Consumer Products. *The Design Journal* 21(1), 15–36.

Hellmann, K.-U. and Luedicke, M. K. (2018) The Throwaway Society: A Look in the Back Mirror. *Journal of Consumer Policy* 41(1), 83–7. https://doi.org/10.1007/s10603-018-9371-6

Hertwich, E. G. (2021) Increased Carbon Footprint of Materials Production Driven by Rise in Investments. *Nature Geoscience* 14(3), Art. 3. https://doi.org/10.1038/s41561-021-00690-8

Holmes, H. and Ehgartner, U. (2021) Lost Property and the Materiality of Absence. *Cultural Sociology* 15(2), 252–70. https://doi.org/10.1177/1749975520969007

Holmes, H., Wieser, H., and Kasmire, J. (2021) Critical Approaches to Circular Economy Research: Time, Space and Evolution. In R. Bali Swain and S. Sweet (eds), *Sustainable Consumption and Production. Volume II: Circular Economy and Beyond*. Springer International, 55–74. https://doi.org/10.1007/978-3-030-55285-5_4

Hyysalo, S., Pollock, N., and Williams, R. A. (2019) Method Matters in the Social Study of Technology: Investigating the Biographies of Artifacts and Practices. *Science and Technology Studies* 32(3), Art. 3. https://doi.org/10.23987/sts.65532

Jackson, S. J. (2014) Rethinking Repair. In T. Gillespie, P. J. Boczkowski, and K. A. Foot (eds), *Media Technologies*. MIT Press, 221–40. https://doi.org/10.7551/mitpress/9780262525374.003.0011

Jackson, T. (2016) *Prosperity without Growth: Foundations for the Economy of Tomorrow*. Routledge. https://doi.org/10.4324/9781315677453

Jaeger-Erben, M. and Hipp, T. (2017) *Letzter Schrei oder langer Atem? Erwartungen und Erfahrungen im Kontext von Langlebigkeit bei Elektronikgeräten*. OHA Texte 1/2017. Technische Universität Berlin.

Kayo, C. and Tonosaki, M. (2022) Lifetimes of Buildings in Japan. *Resources, Conservation and Recycling* 185, 106504. https://doi.org/10.1016/j.resconrec.2022.106504

Kostecki, M. (1998) Marketing and Durable Use of Consumer Products. In M. Kostecki (ed.), *The Durable Use of Consumer Products: New Options for Business*

and Consumption. Springer US, 1–28. https://doi.org/10.1007/978-1-4757-2819-4_1

Krausmann, F., Lauk, C., Haas, W., and Wiedenhofer, D. (2018) From Resource Extraction to Outflows of Wastes and Emissions: The Socioeconomic Metabolism of the Global Economy, 1900–2015. *Global Environmental Change* 52, 131–40. https://doi.org/10.1016/j.gloenvcha.2018.07.003

Krausmann, F., Schandl, H., Eisenmenger, N., Giljum, S., and Jackson, T. (2017a) Material Flow Accounting: Measuring Global Material Use for Sustainable Development. *Annual Review of Environment and Resources* 42(1), 647–75. https://doi.org/10.1146/annurev-environ-102016-060726

Krausmann, F., Wiedenhofer, D., Lauk, C., Haas, W., Tanikawa, H., Fishman, T., Miatto, A., Schandl, H., and Haberl, H. (2017b) Global Socioeconomic Material Stocks Rise 23-Fold over the 20th Century and Require Half of Annual Resource Use. *Proceedings of the National Academy of Sciences* 114(8), 1880–5. https://doi.org/10.1073/pnas.1613773114

Krebs, S. and Weber, H. (2021) Rethinking the History of Repair: Repair Cultures and the 'Lifespan' of Things. In S. Krebs and H. Weber (eds), *The Persistence of Technology: Histories of Repair, Reuse and Disposal*. transcript Verlag, 27–48.

Latour, B. (1990) Technology Is Society Made Durable. *The Sociological Review* 38(1S), 103–31.

Latour, B. (1996) On Interobjectivity. *Mind, Culture, and Activity* 3(4), 228–45. https://doi.org/10.1207/s15327884mca0304_2

Latour, B. (2004) Why Has Critique Run Out of Steam? From Matters of Fact to Matters of Concern. *Critical Inquiry* 30(2), 225–48.

Latour, B. (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press.

Law, J. (2009) Actor Network Theory and Material Semiotics. In B. S. Turner (ed.), *The New Blackwell Companion to Social Theory*. Blackwell Publishing, 141–58.

Lepawsky, J. and Mather, C. (2011) From Beginnings and Endings to Boundaries and Edges: Rethinking Circulation and Exchange through Electronic Waste. *Area* 43(3), 242–9. https://doi.org/10.1111/j.1475-4762.2011.01018.x

Liboiron, M. and Lepawsky, J. (2022) *Discard Studies: Wasting, Systems, and Power*. MIT Press.

Liu, J., Wang, M., Zhang, C., Yang, M., and Li, Y. (2020) Material Flows and In-Use Stocks of Durable Goods in Chinese Urban Household Sector. *Re-*

sources, Conservation and Recycling 158, 104758. https://doi.org/10.1016/j.resconrec.2020.104758

Lorek, S. and Fuchs, D. (2013) Strong Sustainable Consumption Governance: Precondition for a Degrowth Path? *Journal of Cleaner Production* 38, 36–43. https://doi.org/10.1016/j.jclepro.2011.08.008

Maitre-Ekern, E. and Dalhammar, C. (2016) Regulating Planned Obsolescence: A Review of Legal Approaches to Increase Product Durability and Reparability in Europe. *Review of European, Comparative and International Environmental Law* 25(3), 378–94. https://doi.org/10.1111/reel.12182

Mesa, J. A., Gonzalez-Quiroga, A., Aguiar, M. F., and Jugend, D. (2022) Linking Product Design and Durability: A Review and Research Agenda. *Heliyon* 8(9), e10734. https://doi.org/10.1016/j.heliyon.2022.e10734

Murphy, J. and Cohen, M. J. (2001) Sustainable Consumption: Environmental Policy and the Social Sciences. In M. J. Cohen and J. Murphy (eds), *Exploring Sustainable Consumption*. Pergamon, 225–40. https://doi.org/10.1016/B978-008043920-4/50016-1

Oguchi, M. and Daigo, I. (2017) Measuring the Historical Change in the Actual Lifetimes of Consumer Durables. *PLATE: Product Lifetimes and the Environment*, TU Berlin University Press, 319–23. https://doi.org/10.3233/978-1-61499-820-4-319

Oguchi, M. and Fuse, M. (2015) Regional and Longitudinal Estimation of Product Lifespan Distribution: A Case Study for Automobiles and a Simplified Estimation Method. *Environmental Science and Technology* 49(3), 1738–43. https://doi.org/10.1021/es505245q

Phillips, R., Seifer, B., and Antczak, E. (2013) *Sustainable Communities: Creating a Durable Local Economy*. Routledge. https://doi.org/10.4324/9780203381212

Piketty, T. (2014) *Capital in the Twenty-First Century*. Harvard University Press.

Princen, T. (1999) Consumption and Environment: Some Conceptual Issues. *Ecological Economics* 31(3), 347–63. https://doi.org/10.1016/S0921-8009(99)00039-7

Rabiu, M. K. and Jaeger-Erben, M. (2022) Appropriation and Routinisation of Circular Consumer Practices: A Review of Current Knowledge in the Circular Economy Literature. *Cleaner and Responsible Consumption* 7, 100081. https://doi.org/10.1016/j.clrc.2022.100081

Rinkinen, J., Shove, E., and Marsden, G. (2020) *Conceptualising Demand: A Distinctive Approach to Consumption and Practice*. Routledge. https://doi.org/10.4324/9781003029113

Rivera, J. L. and Lallmahomed, A. (2016) Environmental Implications of Planned Obsolescence and Product Lifetime: A Literature Review. *International Journal of Sustainable Engineering* 9(2), 119–29. https://doi.org/10.1080/19397038.2015.1099757

Roberts, H., Milios, L., Mont, O., and Dalhammar, C. (2023) Product Destruction: Exploring Unsustainable Production-Consumption Systems and Appropriate Policy Responses. *Sustainable Production and Consumption* 35, 300–12. https://doi.org/10.1016/j.spc.2022.11.009

Rosa, H. (2013) Social Acceleration: A New Theory of Modernity. In *Social Acceleration*. Columbia University Press. https://doi.org/10.7312/rosa14834

Schaffartzik, A., Pichler, M., Pineault, E., Wiedenhofer, D., Gross, R., and Haberl, H. (2021) The Transformation of Provisioning Systems from an Integrated Perspective of Social Metabolism and Political Economy: A Conceptual Framework. *Sustainability Science* 16(5), 1405–21. https://doi.org/10.1007/s11625-021-00952-9

Schiller, G., Müller, F., and Ortlepp, R. (2017) Mapping the Anthropogenic Stock in Germany: Metabolic Evidence for a Circular Economy. *Resources, Conservation and Recycling* 123, 93–107.

Shove, E. (2014) Putting Practice into Policy: Reconfiguring Questions of Consumption and Climate Change. *Contemporary Social Science* 9(4), 415–29. https://doi.org/10.1080/21582041.2012.692484

Shove, E. (2016) Matters of Practice. In A. Hui, T. Schatzki, and E. Shove (eds), *The Nexus of Practices: Connections, Constellations, Practitioners*. Routledge, 155–68. https://doi.org/10.4324/9781315560816-19

Shove, E. and Warde, A. (2002) Inconspicuous Consumption: The Sociology of Consumption, Lifestyles, and the Environment. In R. E. Dunlap, F. H. Buttel, P. Dickens, and A. Gijswijt (eds), *Sociological Theory and the Environment: Classical Foundations, Contemporary Insights*. Rowman and Littlefield, 230–51.

Slade, G. (2006) *Made to Break: Technology and Obsolescence in America*. Harvard University Press. https://doi.org/10.4159/9780674043756

Sovacool, B. K. and Hess, D. J. (2017) Ordering Theories: Typologies and Conceptual Frameworks for Sociotechnical Change. *Social Studies of Science* 47(5), 703–50. https://doi.org/10.1177/0306312717709363

Spelman, E. V. (2002) *Repair: The Impulse to Restore in a Fragile World*. Beacon Press.

Stahel, W. R. (2016) The Circular Economy. *Nature* 531(7595), Art. 7595. https://doi.org/10.1038/531435a

Streeck, J., Wiedenhofer, D., Krausmann, F., and Haberl, H. (2020) Stock-Flow Relations in the Socio-Economic Metabolism of the United Kingdom 1800–2017. *Resources, Conservation and Recycling* 161, 104960. https://doi.org/10.1016/j.resconrec.2020.104960

Tanikawa, H., Fishman, T., Hashimoto, S., Daigo, I., Oguchi, M., Miatto, A., Takagi, S., Yamashita, N., and Schandl, H. (2021) A Framework of Indicators for Associating Material Stocks and Flows to Service Provisioning: Application for Japan 1990–2015. *Journal of Cleaner Production* 285, 125450. https://doi.org/10.1016/j.jclepro.2020.125450

Thévenot, L. (1984) Rules and Implements: Investment in Forms. *Social Science Information* 23(1), 1–45. https://doi.org/10.1177/053901884023001001

Trentmann, F. (2017) Material Histories of the World: Scales and Dynamics. In J. H. Arnold, M. Hilton, and J. Rueger (eds), *History after Hobsbawm: Writing the Past for the Twenty-First Century*. Oxford University Press, 200–22.

Vannini, P. (2009) Introduction. In *Material Culture and Technology in Everyday Life: Ethnographic Approaches*. Peter Lang.

Vita, G., Rao, N. D., Usubiaga-Liaño, A., Min, J., and Wood, R. (2021) Durable Goods Drive Two-Thirds of Global Households' Final Energy Footprints. *Environmental Science and Technology* 55(5), 3175–87. https://doi.org/10.1021/acs.est.0c03890

Waldman, M. (2003) Durable Goods Theory for Real World Markets. *Journal of Economic Perspectives* 17(1), 131–54.

Warde, A. (2005) Consumption and Theories of Practice. *Journal of Consumer Culture* 5(2), 131–53. https://doi.org/10.1177/1469540505053090

Warde, A. (2014) After Taste: Culture, Consumption and Theories of Practice. *Journal of Consumer Culture* 14(3), 279–303. https://doi.org/10.1177/1469540514547828

Warde, A. (2022) Society and Consumption. *Consumption and Society* 1(1), 11–30. https://doi.org/10.1332/GTYE7193

Weber, H. (2018). Made to Break? Lebensdauer, Reparierbarkeit und Obsoleszenz in der Geschichte des Massenkonsums von Technik. In *Kulturen des Reparierens: Dinge, Wissen, Praktiken*. transcript Verlag, 49–84. https://doi.org/10.1515/9783839438602-002

Welch, D. and Southerton, D. (2019) After Paris: Transitions for Sustainable Consumption. *Sustainability: Science, Practice and Policy* 15(S1), 31–44. https://doi.org/10.1080/15487733.2018.1560861

Wiedenhofer, D., Fishman, T., Lauk, C., Haas, W., and Krausmann, F. (2019) Integrating Material Stock Dynamics into Economy-Wide Material Flow

Accounting: Concepts, Modelling, and Global Application for 1900–2050. *Ecological Economics* 156, 121–33. https://doi.org/10.1016/j.ecolecon.2018.09.010

Wiedenhofer, D., Fishman, T., Plank, B., Miatto, A., Lauk, C., Haas, W., Haberl, H., and Krausmann, F. (2021) Prospects for a Saturation of Humanity's Resource Use? An Analysis of Material Stocks and Flows in Nine World Regions from 1900 to 2035. *Global Environmental Change* 71, 102410. https://doi.org/10.1016/j.gloenvcha.2021.102410

Wieser, H. (2017) Ever-Faster, Ever-Shorter? Replacement Cycles of Durable Goods in Historical Perspective. *PLATE: Product Lifetimes and the Environment*, TU Berlin University Press, 426–31. https://doi.org/10.3233/978-1-61499-820-4-426

Wieser, H. (2021) From Throwaway Objects to Premium Platforms: A Biography of Mobile Phones and Their Marketisation in the UK (2000–2018). PhD dissertation, University of Manchester. www.research.manchester.ac.uk/portal/en/theses/from-throwaway-objects-to-premium-platforms-a-biography-of-mobile-phones-and-their-marketisation-in-the-uk-200002018(138aacd6-5807-47bc-b14b-db0acd64bdf8).html

Wilk, R. (2004) Morals and Metaphors: The Meaning of Consumption. In K. M. Ekström and H. Brembeck (eds), *Elusive Consumption*. Berg, 11–26.

Woodward, S. (2015) The Hidden Lives of Domestic Things: Accumulations in Cupboards, Lofts, and Shelves. In E. Casey and Y. Taylor (eds), *Intimacies, Critical Consumption and Diverse Economies*. Palgrave Macmillan, 216–31. https://doi.org/10.1057/9781137429087_11