Melanie Jaeger-Erben, Harald Wieser,
Max Marwede, Florian Hofmann (eds.)

DURABLE ECONOMIES

Organizing the Material Foundations of Society

[transcript] LABOR AND ORGANIZATION

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Editorial

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Contents

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 anxieties 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.

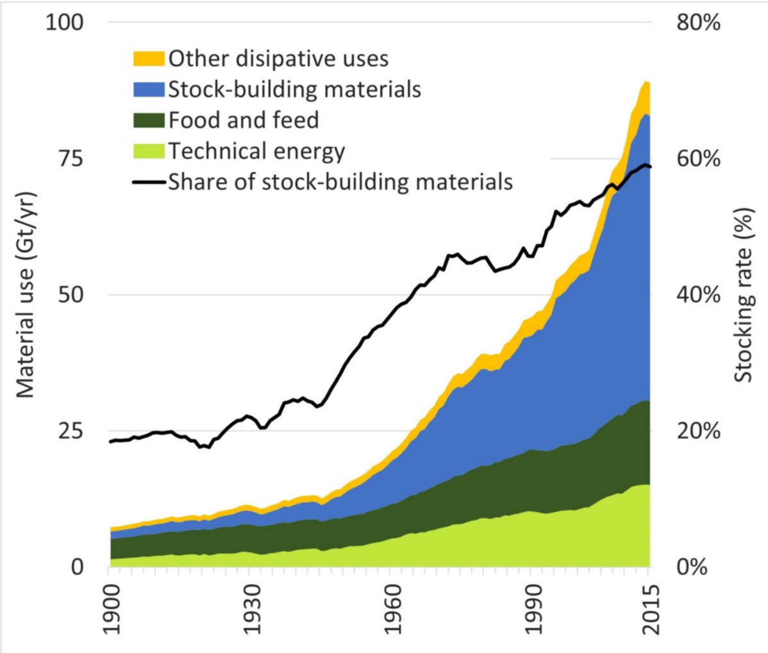
Beginning with the most environmentally favourable trend, studies of material flows show that, even on a global level, energy demand from manufacturing and operating durables has gone down significantly. For much of the twentieth century, the energy intensity of durables – that is, the demand for primary 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 between 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.

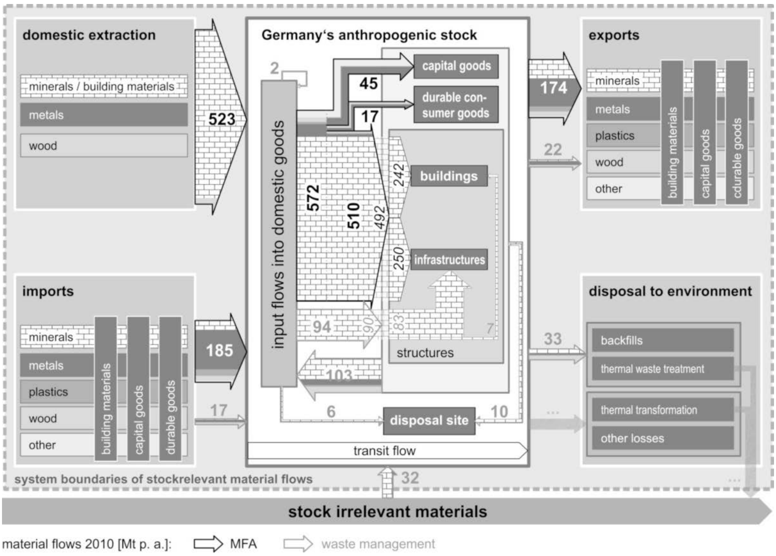
Figure 1.2: Globally processed materials by major use category in gigatons per year.



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-consuming 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.

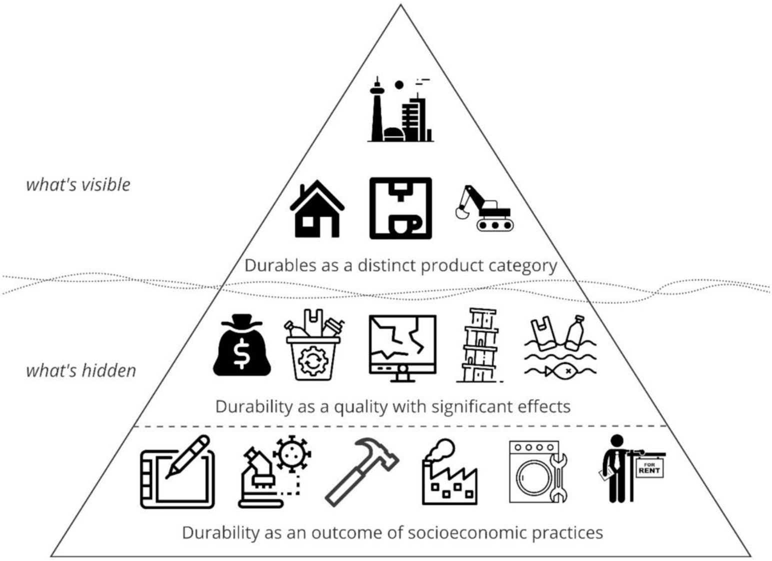
Following Boltanski and Esquerre, commodities that increase in value – in particular, assets and collectibles – have been at the centre of a growing 'enrichment economy' that has specialised in the exploitation of resources that were created a long time, often centuries, ago. For example, heritage sites, 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 complementary, 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 counter-perspective. 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.

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2. Mitigating durable bads: trichloroethylene contamination in Silicon Valley

Josh Lepawsky

> [I]t may help to call 'what to do?' a political question. The term *politics* resonates openness, indeterminacy. It helps to underline that the question 'what to do' can be closed neither by facts nor arguments. (Mol 2002: 177)

2.1 Introduction

Today's consumer electronics are sometimes classed as a type of 'fast-moving consumer goods' (FMCGs). As implied in the name, FMCGs are defined by rapid turnover and consumption (see, e.g., Hawkins et al. 2015 on bottled water). Today's consumer electronics market is valued in excess of US$ 1 trillion (Statista 2022) and brands in the sector typically rely on multiple tiers of hundreds or thousands of contract manufacturers whose facilities are unevenly distributed globally, although they are strongly concentrated in Asia. While the electronics manufacturing industry has been part of the global economy for a lengthy period of time – at least 60 years – the devices produced by it have an increasingly fraught relationship with durability. On the one hand, brands are (rightly) criticised for making devices that break easily or are forced into obsolescence by the vagaries of fashion or the end of software support. On the other hand, the chemistry of materials out of which electronics are made means that chemical pollution from the industry can remain a problem for centuries or even millennia. In the electronics manufacturing sector we find the paradoxes built into enacting 'durable economies'.

Consider the complications of trichloroethylene (TCE). TCE is a chemical product. It exists only as a consequence of industrial technoscientific manufacturing. It is produced for use as a commodity, typically as a solvent and cleaning agent. It is also the main contaminant in a plume of groundwater seeping through part of what is today called Silicon Valley. TCE has wildly variable relationships with durability. Chemists had to find ways to stabilise it if it were to be of use for industrial applications. When exposed to variable combinations of air, light, certain metals, chemicals, and heat, TCE can break down very quickly, in seconds (Doherty 2000b; Russell et al. 1992: 6). But outside laboratories and in the wild, the '[h]alf-lives' of TCE 'are on the order of days to centuries' (Russell et al. 1992: 3; Barbash and Roberts 1986: 344). Distinctions between the technical life and the useful life of TCE are mixed up. Without making it stable, TCE is not useful for industry. But, once stabilised and it escapes containment, TCE's endurance is a problem again. It lasts too long. There's more: TCE has been commercially manufactured for at least a century by now. But, prior to its synthesis by chemists and its manufacture in industrial facilities, TCE did not exist on Earth. In this sense, TCE is brand new. And so, the question that introduces the issues addressed in this chapter, is 'Are durable economies "good"?'

To help answer this question I draw on Mol's (2002) notion of a 'politics-of-what'. A politics-of-what explores the differences between various enactments of a particular version of things. By this, Mol is making the argument that a politics-of-what is not a question of different perspectives on a singular reality having to be reconciled. Instead, it is literally a question of different realities (ontologies) being at stake. A politics-of-what asks several linked questions: what 'goods' are sought? What 'bads' are fought? How are 'good' and 'bad' set up or framed as such to start with? How the good and bad are set up in the first place helps methodically approach what kinds of claims, reasons, and evidence a particular set-up permits and how this or that framing is justified in a contested – that is, political – field. How a framing of good or bad is set up means that different forms of reasons and evidence will be deemed relevant and others not. The distinction between 'goods' and 'bads' is less like a sliding scale and more like patchy, distributed, and not necessarily coherent or reconcilable archipelagos of possible ways of being, of doing the good and the bad, of enacting them. As such, some ways of being may find ways to coexist and flourish, others may clash, and still others may be extinguished (Liboiron et al. 2018). As Mol writes:

> In a political cosmology [a vision of the world as a well-ordered whole] 'what to do' is not given in the order of things, but needs to be established. Doing good does not follow on finding out about it, but is a matter of,

indeed, doing. Of trying, tinkering, struggling, failing, and trying again. (Mol 2002: 177)

I open the chapter with a brief discussion of the complications of TCE as a durable manufacture of the industrial chemicals industry. That discussion proceeds via a synopsis of the geography and history of TCE manufacturing and use; it is a story that helps illustrate how the durability of manufactures are situated, partial, and particular rather than an intrinsic property of products-in-themselves. Initially, the durability of TCE was a problem to be solved due to TCE's chemical instability. Once solved, however, the durability of TCE became a problem again. By the 1950s in the United States, industrial conditions were in place that would generate TCE as a durable 'bad', as a toxicant that could persist and leak beyond its industrial confines to harm human life. One case where these harms became acute is the landscape now called Silicon Valley. By the 1980s, the toxic effects of TCE use in the electronics sector of Silicon Valley could be ignored no longer. Something needed to be done. The chapter then turns to an analysis of regulations that began to emerge in the 1980s to mitigate those toxic consequences of TCE use in the Silicon Valley electronics sector. Here, the question is raised anew of how the 'goods' and 'bads' of durability as they relate to TCE are framed. I pay particular attention to regulatory documents and how they define alternative solutions to managing the toxicity of TCE. These regulatory solutions rely on various criteria, including calculations of economic cost and toxic harm, as well as unstated assumptions about the permission to pollute. Through this analysis, I show that the desirability of durability is partial and situated, rather than automatic and inherent. By extension, a desire for durable economies more broadly, then, is one to be enacted with circumspection.

2.2 Enacting trichloroethylene and durability

Trichloroethylene (TCE) is a member of a class of chlorinated chemical compounds known as halocarbons. These compounds have very wide-ranging applications. By the time TCE was being applied to electronics manufacturing, it had been in economic use for half a century or more. Specifically, TCE is or was used in everything from anaesthesia and wound cleaning to printing inks and paints, and it was used in the textile industry as a solvent and cleaning agent for waterless dyeing and finishing. It came into use in electronics manufacturing as a solvent and metal degreaser. By 1975, TCE was known to be carcinogenic (Doherty 2000b, citing a National Cancer Institute report).

The economic geohistory of TCE manufacturing is intimately bound up with the emergence of the synthetic organic chemical industry in the nineteenth century and military applications in both world wars. A fuller industrial geohistory of this sector is not the point of this chapter (for those sorts of stories, see, e.g., Unattributed 1929; Hamilton 1929; Doherty 2000a; 2000b; Thornton 2000). However, a synoptic discussion of that geohistory helps us analyse TCE's relationship with durability. Mol's notion of a politics-of-what is a useful analytical concept for understanding the geohistory of TCE's production as an economic commodity and its effects as a toxicant. As I will discuss, the chemical instability of TCE meant that the question of how to stabilise it and, thus, make it more durable was an important early problem for industrial chemists. However, long after ways were found to stabilise TCE for industrial applications, durability would again emerge as a problem but now in the form of a chemical toxicant that lasts too long.

TCE can be manufactured in a number of different ways. Early methods involved the chlorination of acetylene, a hydrocarbon compound. The acetylene method was developed by Austrian chemists between 1903 and 1905 and was in use for over 70 years. In the 1960s, Pittsburgh Plate and Glass (PPG) filed patents for new methods of TCE production via oxychlorination, a process that reacts the hydrocarbon ethylene with air and other compounds (Vancamp and Deppe 1968; Schaschke 2014).[1] Eventually, these other methods came to prominence as the cost of acetylene rose. By 1978, the last plant using the acetylene process – operated by Hooker Chemicals in Niagara Falls, New York – was closed.

TCE was in use for a long time before it became a prominent chemical input in the electronics sector. By 1912 it was being used as a cleaning agent for commercial laundry and textile industries. It was also briefly used to defat soya bean-based animal feeds, particularly in Europe, but by 1916 it was identified as a toxicant that poisoned herd animals. Nevertheless, the use of TCE continued in other parts of the food-processing sector to extract fats and oils from sources such as palm, coconut, and soya beans.

1 'Production of trichloroethylene and perchloroethylene', GB1144842A, filed 22 December 1966 and issued 12 March 1969. Available at https://patents.google.com/patent/GB1144842A/en?q=oxychlorination+trichloro&assignee=PPG+Industries&oq=PPG+Industries+oxychlorination+trichloro.

Prior to the First World War, the US depended largely on foreign supplies of chemicals or facilities owned by foreign business interests, especially from Germany (Doherty 2000a). When the US entered the war, it used the Trading with the Enemy Act to confiscate German-owned facilities on US soil. After the war, TCE would go on to find a wide range of uses. Although TCE would not become of strategic military significance until the Second World War, commercial applications of TCE proliferated from the 1920s onwards, much of it produced in US-based factories that had been expropriated during the First World War.

Applications for TCE were found in medicine for pain management, as well as it being a major chemical for use in dry cleaning. By the 1930s, manufacturers making metal or products with metal components found TCE to be an excellent degreasing agent, in part because of its low boiling point that made it possible for it to be almost completely recovered and reused. However, as more uses of TCE were found, so was more evidence of its toxicity.

Demand for TCE rose sharply during the Second World War and the Korean War due to its utility as a metal degreaser. It was important enough that US-based production by companies such as Dow, Du Pont, and Westvaco Chlorine was controlled to meet military requirements, with commercial applications following. By 1952, in the midst of the Korean War, over 90 per cent of TCE produced was used for vapour degreasing applications – essentially, the removal of water-insoluble oil and wax compounds from surfaces of various kinds (Doherty 2000b). By 1960, US domestic production capacity for TCE reached almost 220,000 metric tonnes annually.

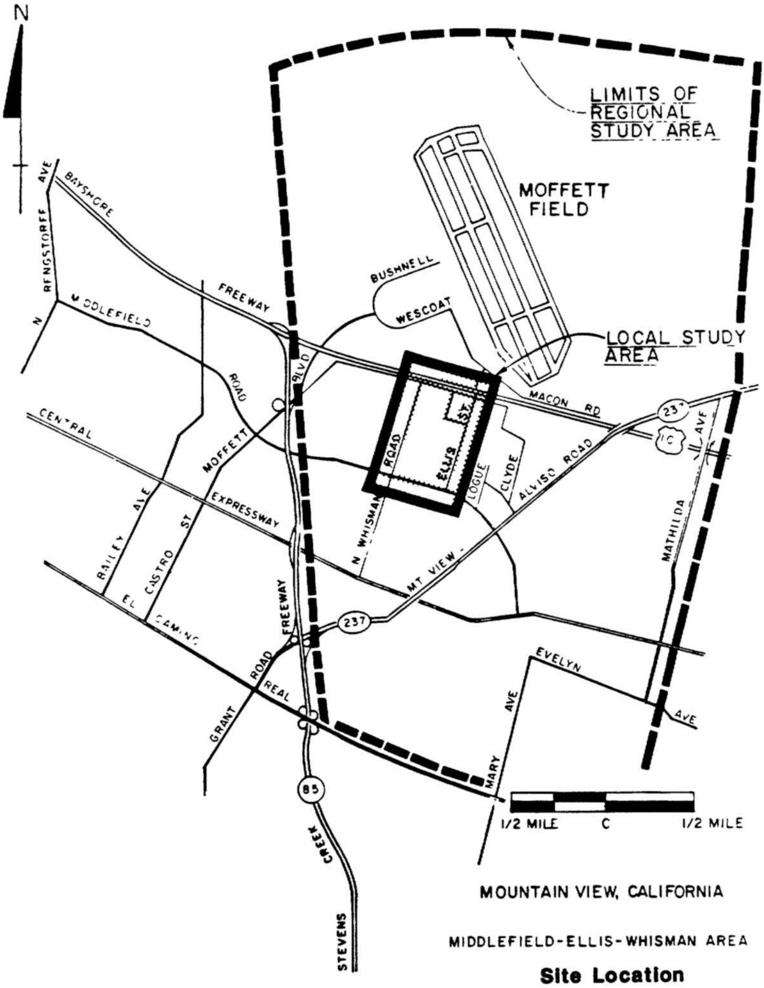
2.3 Durability: from good solution to bad problem

The Middlefield-Ellis-Whisman Superfund Study Area (MEW) is a zone comprising a regional study area of roughly 25 km^2 surrounding a smaller local study area of approximately 1.3 km^2 (US EPA 1989: 1, imperial measures converted to metric and areas mapped by the author; see Figure 2.1). The zone is some four kilometres east and north of the geographic centre of Silicon Valley (Madrigal 2013). It is a site that in many ways embodies the contradictions and paradoxes of what is now sometimes packed into terms such as 'the military-industrial complex' (see Lécuyer and Brock 2010: chapter 1) and, more recently, 'Big Tech'.

Three of what might be called the roots of Silicon Valley's 'family tree' (Siegel 1982: 15) had manufacturing sites in the MEW: Fairchild Semiconductors, Intel, and Raytheon. I focus on these 'roots' because in 1989 they became three 'Superfund' sites designated by a decision of the Environmental Protection Agency (EPA) that created the MEW. 'Superfund' is the colloquial term given to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which was passed by the US Congress in 1980. The act empowers the EPA to extract clean-up costs from liable parties or, when such parties no longer exist (e.g. after a merger or bankruptcy), to use public funds derived from a tax on chemical and petroleum companies to cover the costs (US EPA 2017). The responsibilities of Fairchild, Intel, and Raytheon under the Superfund programme stem from the release of volatile organic compounds (VOCs), of which TCE is deemed to be of primary concern (US EPA 2010: 8), into soil and groundwater from these companies' manufacturing operations within the MEW. The specific origins of the plume of pollutants in the MEW have been traced to the entwined histories of US Navy operations in the area from the 1930s onwards and, later, to the manufacturing of semiconductors and integrated circuits in the area starting in the 1950s. The case of the MEW demonstrates durability as a political question in Mol's sense. TCE is durable in use and, in that sense, its durability is 'good'; but the case of the MEW illustrates that when TCE leaks beyond its industrial infrastructure, its durability becomes a problem again. Long after use, TCE can persist as an environmental toxicant.

Today, the MEW encompasses a landscape that is a mix of corporate office locations (including some operated by Google) and residential areas. It is a landscape that has become almost a cliché of urban design under the aegis of the 'corporate campus'. The design was a deliberate decision to which the facilities operated by Fairchild Semiconductors, Intel, and Raytheon had to conform. As environmental historian Aaron Sachs writes: 'By the time Silicon Valley got its name … its companies had to follow strict building codes, which included "complete concealment" of things like smokestacks, generators, transformers, ducts, storage tanks, and air conditioning equipment' (Sachs 1999: 16; see also Madrigal 2013).

Figure 2.1: The MEW plume and Vapour Intrusion Study Area showing TCE concentrations.



Source: US EPA 2010: 14.

This designed occlusion of infrastructure would go on to play a constitutive role in the making of the MEW as a Superfund site. Prior to the passage of relevant environmental regulations, 'semiconductor companies routinely released acids and solvents into storm drains and sewers. The acids ate through the pipes, and the solvents leaked out and spread' (Siegel 2013: 5). The legacy of leaks, seeps, and spills led to the formation of a plume of toxicants in the subsurface geology of the zone.

The EPA designated the MEW regional study area in 1989. Initially, the problems associated with the plume of toxicants was understood solely in terms of contamination of soil and groundwater (i.e. subsurface geology). Later, however, as knowledge evolved about how toxicants can migrate from one medium (e.g. groundwater) to another (e.g. air), a third form of exposure risk was identified; this is known as the 'vapour intrusion pathway' (US EPA 2010: 9; US EPA et al. 2009: 2). The latter pathway directly impacts people who live and work in the MEW, including today's information workers at companies such as Google (Rust and Drange 2013).

2.4 Eleven versions of the good

In 1989, when the question of how to remediate the pollution problems at MEW was initially raised, several possible alternatives were identified (US EPA 1989: 9). These alternatives were evaluated against six criteria plus an additional three cost-related criteria (see Table 2.1). The assessment criteria are left without explicit definition in the original 1989 record of decision: for example, 'short-term effectiveness' is not given a definite period of time; 'implementability' is left implicit as if it speaks for itself. More explicit definitions of these criteria appear in the 2010 amendment to the record of decision; this responded to the recognition of the vapour intrusion pathway (this pathway essentially refers to the migration of VOCs, such as TCE, out of the groundwater matrix as vapour that can seep into buildings via basements, crawl spaces, and similar environments; see US EPA 2010). Tracking the definition of these criteria between the 1989 record of decision and its amendment in 2010 is an important part of understanding the evolution of the goods sought and bads fought at the MEW site.

These alternatives can be interpreted as different versions of the goods sought and the bads fought by the various interests at the site. Mol's concept of the politics-of-what offers an approach to analysing the list of alternatives and the criteria used to evaluate their desirability.

Table 2.1: Criteria used to evaluate alternatives in US EPA 1989: 39.

Criteria	Definition
Short-term effectiveness	'period of time needed to implement the remedy and any adverse impacts on workers, the community, or the environment during construction and operation of the remedy until clean-up levels are achieved' (US EPA 2010: 31)
Long-term effectiveness and permanence	'the expected residual risk, the ability of a remedy to maintain reliable protection of human health and the environment over time once clean-up levels have been met' (US EPA 2010: 30)
Implementability	'a remedy's technical and administrative feasibility from design through construction and operation' (US EPA 2010: 31)
Compliance with Applicable or Relevant Appropriate Requirements (ARARs)	Legal requirements under CERCLA that remedies 'at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations, unless such ARARs are waived under CERCLA section 121(d)(4)' (US EPA 2010: 30)
Long-term protection of human health and the environment	'Long-term' is replaced by 'Overall' in the 2010 definition, which 'addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls' (US EPA 2010: 29–30)
Additional capital cost ($) / Annual operation and maintenance costs ($) / Present worth ($)	'Cost' becomes an amalgamation of the three original meanings of 'cost' in the 1989 record of decision; the latter are amalgamated into 'present worth' of 'existing and future' commercial and residential buildings and assume wide margins of uncertainty in which dollar estimates 'may be within –30 per cent to +50 per cent of the final project cost' (US EPA 2010: 32)

The EPA's 1989 record of decision for the MEW identifies and evaluates nine alternative remediation possibilities, divided into two broad classes: those relating to soil and those relating to groundwater in underlying aquifers. One category of alternative possibilities cut across both classes: the option of 'no further action' (US EPA 1989: 9). Despite the name, it was not synonymous with 'do nothing'. 'No further action' would include ongoing monitoring of the soil in various subsections of the MEW. It would entail between US$82,000 and US$310,000 in one-time capital costs and between US$187,000 and US$685,000 in ongoing annual operations and maintenance costs (ibid.: Table 12–1). The 'no further action' option would mean that considerable sums would be spent to monitor the plume under the MEW, but nothing would be done to reduce the pollution from it.

A second alternative was to install specialised wells in the soil that would pump VOCs out but leave the soil in place. Technically called in-situ vapour extraction and treatment, this alternative would use carbon-based filters to remove contaminants as they moved from water to gas in the soil matrix and pump them out via the well system. This alternative was understood to meet the criteria for effectiveness in both the short and the long term by reducing the presence of toxicants in the MEW over time (although, as I discuss below, the temporality associated with different alternatives was understood to be wildly indeterminate even in the 1989 record of decision). This alternative would have higher costs, surpassing US$1 million in capital costs and ranging between US$638,000 and US$863,000 in annual operations and maintenance costs.

A third alternative was to excavate soil in place to deliberately volatize the VOCs into ambient air inside 'controlled atmosphere enclosures' (US EPA 1989: 10), and then to return the soil to the ground. A drawback of this approach was that polluted soils under existing building footprints could not be excavated and would continue to be sources of soil and groundwater pollution in the MEW. This problem could be mitigated to a certain extent by combining soil excavation with in-situ vapour extraction at sites with building footprints where full excavation of soils was not feasible. This alternative was estimated to cost over US$6.6 million in upfront capital costs with indeterminate annual operation and maintenance costs. It was also noted that if this approach were used it would be difficult to control emissions of VOCs into the ambient air and it would leave some contaminated soils at least partially untreated.

A second class of remediation alternatives related to mitigating contaminants in groundwater. The main distinguishing feature of this class had to do with the vertical depth of the aquifers in question, whether 'shallow' or 'deep' (those approximately 50 metres below the surface; US EPA 1989: 2). The deep aquifers were already used for drinking water in the region whereas the shallow aquifers were not (although the EPA anticipated that they might be in the future).

Two different forms of groundwater extraction and treatment were contemplated, one involving hydraulic *control* and one devoted to hydraulic *remediation*. Both would entail pumping water out of the ground and treating it, but with different ends in mind. The former would pump and treat water at a rate to maintain the plume in equilibrium – that is, neither expanding nor shrinking it. In both systems, water would be extracted and treated to below a threshold of contamination. Treated water would then be discharged to storm sewers that empty into Stevens Creek on the east side of the MEW. Stevens Creek ultimately flows into San Francisco Bay. Hydraulic control was estimated to require over US$2.7 million in upfront costs and over US$1.6 million in ongoing operations and maintenance costs. In contrast to hydraulic control, hydraulic remediation would pump out water faster than the rate of groundwater recharge and thus shrink the contaminant plume over time (how much time, as we will see, is a major matter of concern). Hydraulic remediation was estimated to be almost twice as expensive as hydraulic control.

Additional alternatives relating to groundwater included installing impermeable barriers, creating and maintaining an inward and upward hydraulic pressure gradient in the plume, and flushing. Barriers would entail physical structures to impound the plume, although those barriers would reduce neither the plume's size nor its degree of contamination unless they were used in conjunction with other measures, such as hydraulic remediation. The barrier option was also almost five times more expensive in terms of upfront costs than the next most expensive option. Creating and maintaining a pressure gradient would move contaminated water out of the aquifer and across the extant slurry walls of the Fairchild, Intel, and Raytheon facilities, where the water would be pumped out and treated; this option would require over US$5.5 million in upfront costs and over US$2.5 million in annual operations and maintenance expenses. Flushing would involve a complex process of extracting water from saturated soil, treating the water and then reinjecting that water into unsaturated soil; over time, this would move contaminants out of the underlying soils and groundwater. This option was estimated to cost less than US$1 million for upfront costs and for annual operation and maintenance.

Ultimately, a combination of two alternatives was chosen for soil remediation and one option was selected for groundwater (US EPA 1989: 22). Soil was to be decontaminated via in-situ vapour extraction and by excavation and treatment with a goal of reducing contamination to below '0.5 ppm [parts per million] TCE for all soils outside slurry walls and 1 ppm TCE for soils inside the slurry walls' (ibid.: 22). Groundwater, meanwhile, would be handled by hydraulic remediation – that is, pumping it out and treating it with the goal of reducing TCE contamination of the plume to 5 parts per billion (ppb) for the shallow aquifers and 0.8 ppb for the deep aquifers (i.e. those already used for drinking water).

In 2010, the EPA amended the original 1989 record of decision relating to the MEW to include mitigation measures to reduce the chance of human exposure to VOCs present in the ambient air of homes and workplaces (US EPA 2010). The decision to do so arose from a complex combination of community activism (Smith et al. 2003; Siegel 2009) and evolving scientific understanding about how VOCs such as TCE can phase change (e.g. by shifting from solute in groundwater to airborne vapour) and move from one environmental medium to another (e.g. groundwater to ambient air). That complex situation led to the recognition of what was dubbed the 'vapour intrusion pathway'.

The recognition of another route of exposure to TCE meant that another set of alternative mitigation measures was to be considered. These alternatives included no action, active ventilation of indoor air, passive ventilation beneath building foundations (called 'passive sub-slab ventilation'), and active ventilation beneath building foundations (called 'active sub-slab ventilation'). Two categories of additional mitigation measures were mandated out of four alternatives. The alternative mitigation methods for vapour intrusion were evaluated against the same set of criteria as those for the 1989 record of decision, but with two additions: 'state acceptance' and 'community acceptance' (US EPA 2010: 33). In this case, 'state acceptance' meant that a given alternative would be approved by a California regulatory body (the San Francisco Bay Regional Water Quality Control Board); meanwhile, 'community acceptance' meant that a given alternative would be favourable to a group of people, as defined by their attendance and comments at a public meeting held by the EPA in the MEW and written comments received by the EPA.[2]

Ultimately, a combination of two of the four alternatives were selected to deal with vapour intrusion: active indoor ventilation and active sub-slab ventilation. Existing buildings in the MEW were then categorised into tiers of prioritisation for implementing the selected mitigation methods. Those buildings found to have indoor concentrations of TCE exceeding 'outdoor (background) concentrations' and beyond a threshold of 0.4 $\mu g/m^3$ would be prioritised for

2 Full transcripts of those verbal and written comments are available in US EPA (2010), but a fuller analysis of these comments is beyond the scope of this chapter.

mitigation (US EPA 2010: 35). Moreover, future buildings would have to include the costs for operating the same mitigation methods.

What might the selected remedies suggest about the politics-of-what as they pertain to the durability of TCE in play in the MEW? The 11 alternative approaches to remediating the toxicants illustrate 11 possible arrangements of people, places, and things that could have cohered into the making of an actual ordering of the world. A combination of five alternatives – two for soil, one for groundwater, plus two for vapour intrusion – was ultimately chosen. The goods sought include reducing (but not eliminating) human exposure to toxicants, especially TCE. The bads fought include cancer and the 'potential human health hazard for noncancer toxicity to the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus' (US EPA 2011: xlii). These goods and bads are set up as such through both explicit criteria (see Table 2.1) and two premises that hide in plain sight: threshold theories of harm and the permission to pollute.

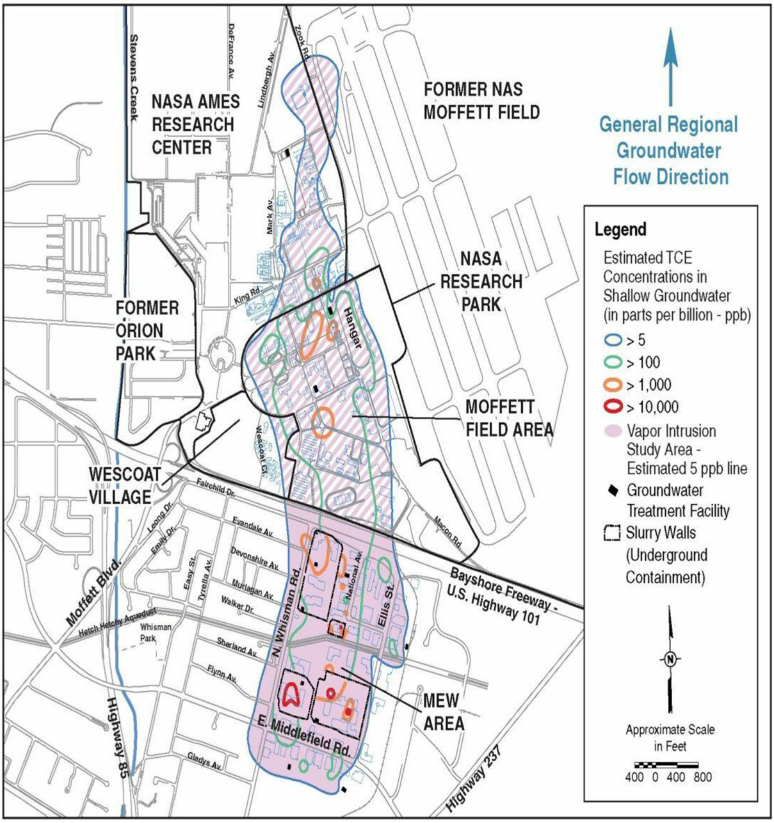
The idea that there is a definitive line separating harm from harmlessness is a particular way of setting up 'goods-as-good' and 'bads-as-bad' – that is, it is an answer to the question 'What to do?' This is a question of politics in Mol's sense of that term. As Mol claims, the question remains open and cannot be shut once and for all by either facts or arguments. Liboiron's (2021) work on pollution as colonialism demonstrates that the effects of attempts to act *as if* a threshold theory of harm *can* be definitively determined once and for all, always, and everywhere (i.e. universally) are, in contrast, provisional and contingent achievements whose presumptions of universality do not hold always and everywhere.

The EPA defined 5 ppb and 0.8 ppb as the thresholds beyond which pollution to shallow and deep aquifers respectively would be considered unacceptable in its record of decision for the MEW (US EPA 1989). Moreover, the EPA's record of decision notes that it multiplied two metrics to derive 0.8 ppb as an acceptable threshold. Those two metrics are the lifetime average daily dose (LADD) and the cancer potency factor (CPF). The LADD was determined by 'multiplying a concentration by 2 litres [of water] per day and dividing by 70 kilograms' (ibid.: 20).

Similar, but not identical, quantitative approaches were used to answer the question of 'What to do?' with respect to the vapour intrusion pathway. The answers to that question, as in the original record of decision of 1989, manage a line (i.e. a threshold) between good and bad forms of contamination by toxicants. The answers to what to do about vapour intrusion came down to two formulas: one for 'residential settings' and one for 'commercial indoor workers' (US EPA 2010: 20; see Figure 2.2).

What do the different quantitative definitions of thresholds of harm for soil, groundwater, and vapour intrusion in the MEW suggest about what goods are sought, what bads are fought, and how the good is set up as such in the first place? What might they also have to say about 'durability'?

Figure 2.2: Formulas used to calculate thresholds of harm for the MEW vapour intrusion pathway.



Source: US EPA 2010: 20.

The thresholds for harm from toxicants defined for soil, groundwater, and vapour intrusion in the MEW tell us that some quantum of toxicants is too much (i.e. 'bad') for humans to be exposed to. At the same time, they also tell us that some amount of exposure to toxicants *is* acceptable (i.e. 'good' or at least 'not so bad'). Yet, note some of the effects of specifics in these calculations. To arrive at 5 ppb and 0.8 ppb for groundwater contamination, for example, multiplication factors are used: 70 kilograms represents a person of a particular mass, one that excludes people who are heavier (for whom risk is, by this metric, presumably lower) and also people who are lighter (for whom risk is, presumably, higher). One obvious category of persons who typically weigh less than 70 kilograms is children. The metric also excludes all sorts of other factors that might influence cancer risk: age, gender, and cumulative doses from other sources, for example. The bracketing out of risk from cumulative doses is especially noticeable in the way in which residential and commercial exposure risks are calculated. Among other specificities, the ostensibly generic 'human' imagined in those calculations is either at home or at work, but not both. There is no variable that connects the two calculations (one formula for 'residential settings' and one for 'commercial indoor workers'), so they remain separate. Notice, too, that it is risk of cancer that is being calculated to determine harm. It is not hard to accept cancer as a 'bad' one might want to avoid, but recall that exposure to TCE also entails risks of non-cancerous harms to 'the central nervous system, kidney, liver, immune system, male reproductive system, and the developing fetus' (US EPA 2011: xlii). So, while risk of human exposure to TCE is defined in the calculations of thresholds for soil, groundwater, and vapour, this is *not* some free-floating, acontextual universal 'human' whose exposure risk is being calculated. The EPA arrives at a metric (i.e. a number) of carcinogenic risk it deems 'acceptable', but these numbers are not simply out there waiting to be plucked out of context-free 'nature'. These numbers are made – not in the sense of being 'made up' but in the sense of being 'built'.

Something that is built needs a foundation. A key foundation on which the numerical exposure risks of TCE are built is the idea of a threshold theory of harm. That theory itself is derived from studies by two engineers, Earl B. Phelps and H. W. Streeter, who in the early twentieth century studied organic contamination of rivers in Ohio (Liboiron 2021). Phelps and Streeter eventually derived an equation that could mathematically describe how biological oxygen demand changed in relation to the relative concentration of biological pollutants in water (e.g. faecal matter). Yet, as Liboiron shows, the idea of a threshold theory of harm that arises from the Streeter–Phelps equation is poorly suited to managing other types of pollutants, such as carcinogens. Carcinogens, such as TCE, are part of a class of toxicants for which harm is a '[l]inear nonthreshold' – that is, harm arises 'immediately upon contact' (ibid.: 92, 93). As Liboiron (ibid.: 92, footnote 46) writes, 'threshold-thinking is so strong that even in the case of carcinogens and radiation, policy uses risk analysis that allows for a certain amount of population death (or acceptable loss)'. In the case of the EPA's record of decision for the MEW, that acceptable loss associated with 0.8 ppb 'corresponds to a cumulative estimated carcinogenic risk of $1.0(10)^{-6}$' (US EPA 1989: 20) or, said differently, one excess cancer case per million people.[3]

The thresholds of harm calculated for the toxicants in the soil, groundwater, and vapour of the MEW are initial steps in answering the question 'What to do with the MEW?' These calculations are political in Mol's sense of the term. The EPA makes explicit what *is* included in those calculations (e.g. body mass, volume of drinking water, average lifespan, time at home or at work). The explicit inclusions also suggest an indeterminate array of excluded questions that some people (e.g. people who live and work in the MEW) might argue *ought* to have been asked: for example, should the measures of cancer risk from TCE include measures of mass that would include children and the elderly who may be particularly vulnerable? Cumulative doses from more routes of exposure than drinking water alone? Exposure in utero? These sorts of questions are indeed part of the public record of community organising around environmental exposure to TCE and other VOCs in the MEW (Siegel 2009, 2020; Smith et al. 2003). All of these questions can be answered, but not definitively or once and for all. They are and will remain constantly open to contestation (i.e. political).

Threshold theories of harm are part of what sets up the good as good with respect to mitigating human exposure to TCE and other toxicants in the MEW. Yet, as Liboiron (2021) documents, threshold theories of harm are themselves grounded on another premise: the permission to pollute. Much of the regulatory authority in which the EPA is situated is premised on parcelling out the permission to pollute (Davies and Mazurek 2014; see also Liboiron 2021). This regulatory role of the EPA had been in place for almost 20 years by the time TCE and other toxicants were found to be leaking from the facilities of Fairchild, Intel, and Raytheon in the MEW. The permission to pollute is ultimately underwritten by the legal frameworks and associated infrastructure of power of

3 'Introduction to Risk Assessment', p. 5. Available at https://ec.europa.eu/health/ph_projects/2003/action3/docs/2003_3_09_a23_en.pdf (accessed 15 February 2022).

the United States as a settler state. None of the mitigation measures recommended for the MEW eliminate TCE or other pollutants completely. Some of the remedies explicitly presume the use of nearby bodies of water to transport and receive water treated to the point of being at or below prescribed thresholds from the MEW via storm sewers that ultimately lead to San Francisco Bay. Polluting in this mode is colonialism – that is, the axiomatic assumption of settler access to Indigenous land as sinks for toxicants.[4] The presumption of access colonises both the present and the future. In the initial 1989 record of decision, the EPA bluntly states that the soil remedy 'is expected to be in operation between 1 to 6 years. The groundwater remedy for the shallow aquifers may be in operation for as long as 46 years or into the indefinite future' (US EPA 1989: iv). As scientific understanding of how TCE and VOCs behave in the wild have evolved, a more recent analysis of the groundwater remedies selected for the MEW indicate that it will require 700 years before 90 per cent or more of the current groundwater pollution plume under the MEW reaches the target threshold of 5 ppb. An 'optimised' remedy could reduce the time required to 500 years (Gallinatti et al. 2012: 27). These are temporalities and spatialities of durability that must be reckoned with by those who ask 'What to do with the MEW?'

2.5 Conclusion

In many ways, the MEW is an allegory for broader concerns relevant to durable economies. The example of TCE contamination at the site demonstrates a need to approach durability with circumspection. The example of the MEW shows that durability is not inherently good. Instead, durability is political. If, as Mol claims, the politics-of-what is a perennially open question that neither facts nor argument can close once and for all, what then to do? There are concrete interventions that could be implemented beyond the mitigation measures already in place at the MEW. Within the North American Free Trade Agreement (NAFTA) region, companies are already required to disclose what pollutants are released at their facilities that are located within the region (Lepawsky 2022). That such cross-jurisdictional requirements for disclosure already exist tells us

4 See Liboiron (2021) for important discussions of the meaning of Land/land in the context of pollution as colonialism.

that extending those requirements is possible. For example, electronics manufacturers could be required to disclose the same releases of chemical pollutants that they are already required to disclose in the NAFTA region throughout their entire supply chain, wherever their suppliers are located. There is some evidence that suggests that the mere requirement to disclose such pollutant releases can lead firms to find ways to reduce or even eliminate them (Ma Jun et al. 2018). Precedent for such an approach already exists. The Dodd–Frank Act of 2010, passed in the wake of the global financial crisis, also contains a requirement for US manufacturers to disclose whether conflict minerals derived from Congo occur anywhere in their supply chains, no matter what national jurisdiction those supply chains may crisscross. A similar approach could be taken with the requirement to publicly disclose releases of chemical pollutants from the electronics manufacturing sector.

Another approach is that of the EU and its Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation. Unlike the EU's Reduction of Hazardous Substances (RoHS) legislation, which applies only to electronics, REACH will be much more expansive. It is intended to reduce or eliminate the manufacture and use of toxicants in any products sold in the EU. Due to the size of the European economy, REACH will have effects well beyond the EU since many manufactures sold in the region are sold in others as well.

As the EPA records examined in this chapter show, there are various measures for mitigating the harms of TCE that either could be or are being pursued. However, those same records also show that the question of what to do with TCE in the MEW is one that has yet to be fully closed. Ongoing concerns are expressed by residents (Siegel 2020) and workers (Rust and Drange 2013) in or adjacent to the MEW about the toxic consequences of TCE and other VOCs released from the legacy of electronics manufacturing in the region. Those ongoing concerns premised on lived lives and working lives are also tangled up with chemical lives of toxicants. As I have shown elsewhere, the electronics manufacturing sector is a chemically intensive one that is responsible for some 366 million kilograms of toxicant releases and transfers in the NAFTA region between 2006 and 2017 (Lepawsky 2022). Yet, as that work also demonstrates, TCE exists in a chemical galaxy comprised of well over 160 million chemical substances available for industrial use, less than 1 per cent of which have been tested for toxicity. Indeed, the number of chemicals already available for industrial use exceeds all toxic testing capacity on Earth. There is no solution to a problem like this, if by 'solution' we mean some kind of 'clean-up' (Gray-Cosgrove et al. 2015). A world of effectively permanent pollution is a world of harm reduction, rather than harm elimination.

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3. Doing business with durables

Max Marwede and Florian Hofmann

3.1 Introduction

A profound transformation in the mode of market-based value creation, capture, and distribution seems inevitable to ensure the preservation of the essential human life-supporting systems of nature. As highlighted in Chapter 1 of this volume, one of the problem clusters triggering the current Earth crisis has been the massive level of production and accumulation of things, which has obviously been accompanied by a steady increase in demand for natural resources in the last decades. From a durable economies position, the current so-called value chain is based on a take–make–stockpile value creation (and destruction) logic that starts with the extraction of finite natural resources, which are transformed into human artefacts, followed by distribution, and a use phase that finally culminates in stockpiling and storage. There are plenty of reasons why people in the global North accumulate masses of things. These include not only the increasing temporal and spatial flexibility of work and private life or the flaunting of material wealth, but also the perceived change in sociotechnical time structures in post-industrial societies (Reckwitz 2019; Rosa 2005). It seems that flexible access to products and their functions (even if the temporary benefits sometimes last only fractions of a second) has led to people being willing to use resource-intensive space (renting bigger apartments, building larger houses, and heating garages, basements, and attics) in order to store their just-in-case items. In the larger metropolitan areas, we can observe that even the business of renting storage containers is booming, despite horrendous prices for 15 square metres of storage capacity.

Most companies still operate according to a largely stockpiling economy, with business models that are designed for fast-paced consumption and little responsibility for the use and reuse of the products they sell. In this article, we assume that firms that incorporate business model patterns that support the creation, capture, and delivery of economic value by using and offering products and components that pass through multiple-use cycles contribute to a decrease in overall consumption levels and a reduction in anthropogenic pressure on nature. We assume that the products required to do this kind of business need to be durable. There are, of course, several definitions of product durability. We rely on the definition of the common standard on environmental management systems, ISO 14009 (ISO 2020), which defines durability as the 'ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached'. A limiting state can be a failure or a wearing out – that is, a primary or secondary function is no longer delivered. The limiting state can be changed to a functional state by maintenance or repair. If this is no longer viable due to technical or socioeconomic factors, the limiting state can change to an end-of-life status (CSN 2020). Durability can be expressed in units appropriate to the part or product concerned, such as calendar time, hours of use, or operating cycles. Thus, we also consider a product to be more durable if it withstands a higher use intensity over a specified timespan compared with an alternative product – although both products might have the same calendar lifetime. Both 'conditions of use, maintenance and repair' and the 'limiting state' need to be defined for each product group.

Durables can be commercialised in a sales business model – combined with after-sales services such as maintenance and repair – or in a products-as-a-service business model (PaaS), where products and services are combined in a system to deliver a specific benefit. PaaS business models include economic activities such as renting, leasing, pay-per-service, and sharing. In theory, the combination of alternative product designs (design for reparability, maintainability, reliability, etc.) and PaaS business models can result in products and components being used for longer and/or more intensively (e.g. by several users). However, no matter how good companies are at showcasing their new PaaS business model portfolios – and some pioneers have started to experiment with such new models – the reality is that only a limited percentage of products are shared or pass through multiple-use cycles successfully.

We followed two research approaches in order to identify characteristics and typical practices of companies doing business with durables. In the first approach we conducted two in-depth business case studies on companies providing PaaS. To complement this information, we analysed the webpages of companies known to produce and sell durable products (sales business model). We combine the insights of both approaches in a so-called operating model; this is a visualisation that explains how the organisation operates in order to deliver value to its different stakeholder groups (Hewes et al. 2019). It indicates which structural, procedural, and personnel aspects are necessary for the implementation of innovations based on producing, distributing, and providing durables.

We look only at companies producing and providing consumer goods. We do not consider companies operating and maintaining socially essential infrastructures (e.g., electricity grids, water networks, schools, health infrastructures), nor do we incorporate companies that have been in the market for a long time and can therefore be regarded as 'durables' in the sense of being resilient and long-lasting social systems (e.g. old family-run businesses).

3.2 Research approach

To develop our first tentative and practice-relevant ideas on how firms initiate, shape, and manage value creation processes and value propositions that rely on durables and their functions, we conducted two in-depth business case studies. We used polar types (Eisenhardt 1989; Eisenhardt and Graebner 2007) by sampling cases that differ in size, industrial contexts, and economic scope but nevertheless share the objective of achieving innovation through PaaS business models running on durables, to generate comprehensive insights and to identify co-occurring patterns across firms that exhibit significant differences in their business attributes. An overview of each case is illustrated in Table 3.1.

Table 3.1: Case study description.

Attributes	Case I: KitchenStar[1]	Case II: GreenMountain
Company description	Developing and manufacturing products for cooking and baking, dishwashing, cooling and freezing, washing and drying, and digital home connection applications	Developing, producing, and distributing outdoor equipment: functional outdoor clothing, backpacks, bags, sleeping bags, tents, shoes, and camping accessories
Industry	Home appliance industry	Outdoor and textile industry
Founded	1967	1974
Size	Approx. 60,000 employees worldwide.	Approx. 530 employees worldwide.
Operating radius	Global	Europe
Sustainability concept	Advocate of the triple bottom-line approach – they want to prove that nature conservation, social responsibility, and economic performance are not mutually exclusive, but that their interdependence is the basis for a prosperous business	Pioneer company of the common good economy – sustainability is the omnipresent core of business operations
Motivation /guiding principle	'We want to be the first choice for consumers worldwide. We grow responsibly and contribute to protecting our natural resources.'	'As the most sustainable outdoor outfitter in Europe, we contribute to a world worth living in.'

1 The names have been changed to ensure the anonymity of the companies.

Attributes	Case I: KitchenStar[1]	Case II: GreenMountain
Product durability activities	Investing in different business experiments that explore various forms of value creation processes focusing on and using durables: · Instead of selling washing machines and dryers, offering their functionality by equipping and running common shared laundry rooms · Renting highly efficient home appliances at a fixed monthly fee embedded into a PaaS · All appliances used in the PaaS and the common shared laundry rooms are returned to KitchenStar for a second life (selling them on a second-hand online platform or harvesting spare parts for reuse and remanufacturing)	Investing in different business experiments that explore various forms of value creation processes focusing on and using durables: · A PaaS that offers the functionality of backpacks, tents, camping mats, saddlebags, and trolleys by temporary access through rental contracts · Establishment of new alliances, e.g., with the internet platform iFixit, which provides repair and care instructions for GreenMountain products · Collaboration with digital platforms operating second-use marketplaces · Establishment of a repair index for all products in the portfolio – the higher the index score of a product, the faster and easier it is to repair

We complemented the case study analysis with an investigation of the websites of companies that produce and provide durables (see Table 3.2). We selected companies from different industries and of different sizes based on our knowledge of 'typical' companies producing and providing durables. We screened the website of each company to identify company values and practices related to the creation and provision of durable products.

As a first step, we collected information by company; second, we clustered the information and identified overarching categories. We are aware of the limitations of using publicly available information: the information might represent merely a narrative about the company's values and practices; internal processes and strategies that are not intended for the public are not published on the website; and the website describes only the current state of the company (there is no evidence that values and principles were also followed in the past). Nevertheless, we assume that the information given to interested stakeholders has a relation to the company's internal values and practices.

Table 3.2: Case studies for website screening.

Attributes	**Company**					
	Vitsoe	**Thonet**	**Miele**	**Moccamaster (Technivorm)**	**Vorwerk**	**Original Glashütte**
Company description	Producing and selling a shelving system, a chairs and tables	Producing bentwood and tubular steel furniture	Manufacturing kitchen and home appliances	Manufacturing filter coffee machines	Manufacturing home appliances (kitchen appliances and hoovers)	Manufacturing high-quality watches
Industry	Furniture	Furniture	Home appliances	Home appliances	Home appliances	Luxury
Founded	1960	1849	1899	1964	Approx. 1890	1990 (historical roots in 1845)
Size	SME	SME	Large enterprise	SME	Large enterprise	Large enterprise (brand of Swatch Group)
Operating radius	Based in UK, direct sales worldwide	Production in Germany, sales worldwide	Worldwide	Production in the Netherlands	Production in Germany and France, direct sales worldwide	Production in Germany, sales worldwide

Attributes	Company					
	Vitsoe	**Thonet**	**Miele**	**Moccamaster (Technivorm)**	**Vorwerk**	**Original Glashütte**
Product sustainability concept	Produce product with a long lifetime to reduce the environmental impact to a minimum	Strive for a balance between profitable growth, protection of the environment, and responsible actions towards all shareholder groups	Make better, smarter appliances so the homes and businesses they serve become more sustainable, from one generation to the next	Made by hand in the Netherlands from sustainable and recyclable materials	Carefully examine the recyclability of used materials, the share of machining and environmental friendliness, and the sustainability of materials	Focus on high quality (no dedicated product sustainability concept)
Motivation/ guiding principle	Living better, with less, that lasts longer	Pioneering furniture design with a long tradition	Forever better	Life is too short to drink bad coffee	Commitment to high quality, family company taking the long view, openness to innovate, designed for human connection	Innovative watchmaking art that meets the highest standards

Attributes	Company					
	Vitsoe	**Thonet**	**Miele**	**Moccamaster (Technivorm)**	**Vorwerk**	**Original Glashütte**
Product durability activities	· No price reductions · Lifelong service · No change in models · Modular systems of high quality: simple, flexible, robust, simple to construct, change, repair, and dismantle · Item is designed and built to last as long as possible · Goal to allow for reuse of systems · Spare part provision	· Physical and aesthetic longevity of products ('heirloom quality') · Products produced on demand · Models stay in portfolio (over centuries) · Use of high-quality materials · Repair service · Care instructions provided	· Household appliances tested up to 20 years · Fast and efficient after-sales service	· Sustainable and high-quality materials that last a long time · Modular construction · Each product tested twice at factory · Spare parts provided	· Certified quality management · High-quality components facilitate long-lasting high performance with minimal wear · Repair service	· Own tool development and manufacturing · In-house production of nearly all parts · Manual assembly · Intensive testing · Maintenance service

Source: www.glashuette-original.com/de/; www.miele.de; www.moccamaster.eu/; www.thonet.de; www.vitsoe.com; www.vorwerk.de/.

3.3 Doing business with durables: experiences from practice

It is apparent that small modifications of product attributes, such as using recycling input materials or biodegradable packaging, are incremental changes that may lead to eco-efficiency gains, but they do not shift prevailing core business rationales that promote PaaS based on durables. But how can incumbents radically rethink and rearrange their business activities and explore new and suitable approaches to tackle the stockpiling of valuable durables?

As a pioneer company of the common good economy, GreenMountain has set its business motivation as developing durable and nature-friendly outdoor textiles and outdoor equipment. Nature protection, transparency, and respect for human rights across its business ecosystem are GreenMountain's guiding principles for action. Through its new PaaS business model, iShareIT, outdoor enthusiasts have the opportunity to rent equipment such as bike bags, tents, or backpacks for a limited period of time. GreenMountain steps into the role of a product steward – that is, they provide only the functionality of the products offered for rent and thus take responsibility for their use phase. The products can be rented via an online platform in the company's own stores or at the main production site. With iShareIT, GreenMountain offers an infrastructure to ensure that outdoor equipment is used as intensively as possible, for as long as possible, and throughout the entire year, instead of lying around unused in a closet, cellar, or garage for 50 out of 52 weeks a year. The items available through iShareIT, and malfunctioning products sent in by customers, are maintained and repaired by the in-house repair division. To align products developed, produced, and offered with durability, they have established a repair index. The higher the index score, the quicker and easier it is for the product to be repaired. Further, they collaborate with digital ecosystem platforms to provide repair instructions, spare parts, and care instructions, as well as operating a second-use marketplace. Hence, GreenMountain is engaged in intensive community building and strengthens a culture of using durables in mass consumer markets.

GreenMountain has institutionalised 'doing durability' as a strategic investment aim for corporate development; this can be observed in, among other things, the introduction of the repair index, the establishment of the new PaaS business model iShareIT, and strategic alliances with digital platforms pushing forward ecological sustainability. Furthermore, they try to initiate a discourse about repair and durability in the public and political field. Through the support of the 'right to repair' movement, by launching awareness-raising campaigns to reduce consumption, and in its environmental positive lobbying, GreenMountain strives to performatively transform the market and social conditions in order to abolish the stockpiling mentality. This idea of ecological and social performativity (Hofmann and Jaeger-Erben 2020; Hofmann and Knyphausen-Aufseß 2022), which goes hand in hand with corporate awareness about solving ecological wicked problems, does not imply adapting to stakeholder demands in a reactive mode; rather, it involves a proactive contribution to a sustainable transformation of society.

KitchenStar builds its durability efforts on keeping products and materials in use. It aims to reduce the use of natural resources, any type of emissions, and energy consumption across its entire business ecosystem to a minimum. An innovation spin-off called BlueHousing has successfully established a new PaaS business model focused on renting highly efficient home appliances at a fixed monthly fee. BlueHousing owns the appliances, and the subscription covers maintenance, repairs, and replacements – ensuring a hassle-free household. If the devices cannot be repaired, they are returned to BlueHousing, which salvages reusable parts for remanufacturing processes. Another in-house start-up at KitchenStar, BetterTogether, is running shared laundry rooms for serviced apartments, multi-unit residential dwellings, and dormitories instead of selling washing machines and dryers. Digitising everything from booking the machines to paying for the washing and drying cycle simplifies the entire laundry process. According to KitchenStar, BetterTogether's shared laundry rooms have the potential to reduce the number of washing machines and dryers needed in residential facilities by 70 per cent. Besides repairing services, BetterTogether takes back appliances after several years of service, checks, refurbishes, and returns them, after hygienic cleaning, so they can enjoy a second lifecycle.

To avoid unidimensional silo solutions and simultaneously encourage cross-functional collaboration, a diverse team of employees developed a roadmap that directs strategic investments to boost business activities promoting durables, among other things. The interdisciplinary team is responsible for the whole strategic road mapping process, from developing to realising it and then to reflecting on it. The roadmap was communicated within and across company boundaries with a clear mission statement from the top management. In the case of KitchenStar, the purpose of internal cross-functional collaboration is to combine many perspectives and enable collective testing, sharing, and elaboration of ideas about how novel value creation activities can emerge that culminate in innovative PaaS business models based on durables.

3.4 Doing business with durables: public image

To complement the in-depth case studies above we analysed the websites of several companies that focus on creating and providing durables (see Table 3.2). We identified typical company values, value propositions, and practices and strategies related to product design and manufacturing.[2]

3.4.1 Values

Statements on companies values often relate to excellence, superiority and high quality, continuity, trustworthiness, authenticity, and reliability as well as modernity, innovation, and creativity. It is stated that a combination of expert knowledge, passion, and creativity lead to high-quality products. Often, companies refer to their legacy and heritage. In order to create durables, several strategies seem to be relevant:

- long-term planning – this includes continuity of values and long-term relationships with partners;
- partial independence of shareholders in family-owned companies;
- extensive product development and intensive product testing;
- promotion of the exchange of skills and capabilities among employees, such as the teaching of craftsmanship; and
- cooperative and fair relationships with partners and stakeholders.

3.4.2 Value proposition

Much of the information on the website focuses on the value proposition for the customers. Here, the reliability of the product, the quality, and the services provided take centre stage. Messages imply that if customers choose these products, they will have taken the right, 'carefree' decision. Products are supposed to increase the consumer's quality of life, because they are easy to use, simplify everyday tasks, and are reliable. They represent modernity, individuality, and quality and as such should reflect the purchaser's values. Sometimes there are options to individualise the products: for example, by

2 The websites analysed were: www.glashuette-original.com/de/; www.miele.de; www.moccamaster.eu/; www.thonet.de; www.vitsoe.com; www.vorwerk.de/.

choosing colours, materials, or different modules. Furthermore, the companies promise reliable services such as competent and personalised advice and professional repair services.

3.4.3 Practices

3.4.3.1 Product design

A 'long life' is combined with a timeless and sometimes iconic design, which means that products do not become out of date and can be (re)used in different settings. The design combines form, function, and aesthetics. High-quality recyclable materials are combined with a 'simple' repairable and precise construction to achieve physical longevity. The choice of the materials should also minimise deterioration and/or enable 'graceful' ageing. Products are also advertised as being resource-efficient and environmentally sustainable due to being repairable, reliable, or recyclable.

3.4.3.2 Manufacturing, quality management and internal learning

Companies emphasise their in-depth knowledge and capabilities in engineering and handcrafting combined with modern production technologies. All companies have their own manufacturing facilities in their country of origin and they usually have a high level of vertical integration. Some companies also state that they still produce and assemble items (partially) manually in order to achieve a 'hand-made' quality. They emphasise that they developed the know-how to produce high-quality products sometimes over decades and that their capabilities and manufacturing technologies are continuously optimised. Thus, knowledge transfer between young apprentices and experienced employees is extremely relevant. Companies also focus on a close collaboration between research and development (R&D), production and quality management. They have their own testing capabilities, and their requirements are usually set above industry standards (e.g., testing household devices for a 20-year lifetime). They usually follow quality management standards (e.g., ISO 9001 on quality management systems) and also request that suppliers adhere to their own quality standards.

3.5 Synthesis

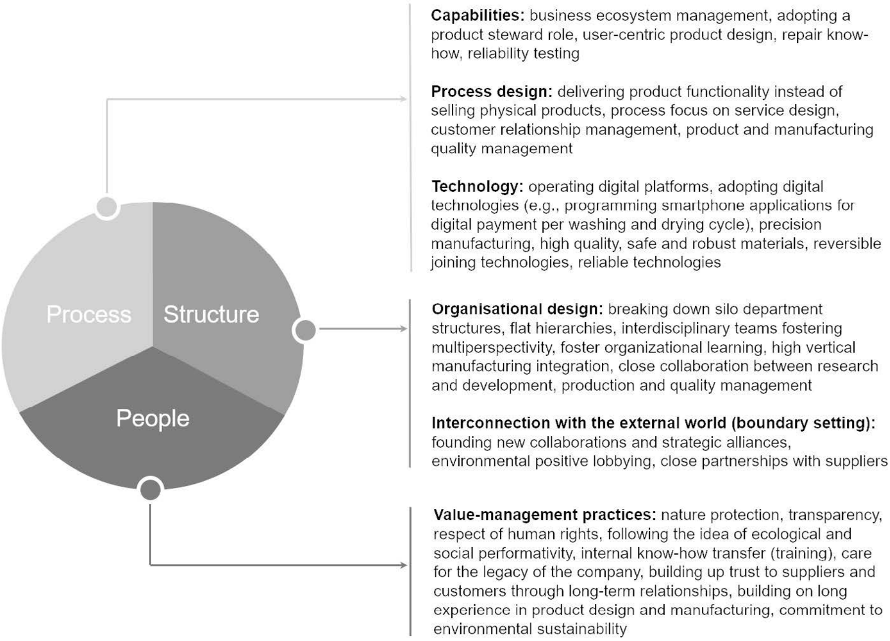
In the face of the massive devastation of nature, companies need to transform their mode of value creation more rapidly and more extensively than ever before. In almost every sector of the economy, complex and dynamic changes occur that have a profound impact. Therefore, it is even more important to have instruments and frameworks that allow companies and their members to find and follow possible paths through this plethora of complexity. An operating model is one widely used approach that supports decision makers in identifying, interpreting, and analysing the interdependencies of business value creation. The image of the operating model contours the essential elements of a company and serves as an instrument for reducing complexity. When done right, it functions as a source of consistent and coherent guidance to all the constituents of a company. We use an operating model as a framework to summarise, structure, and cluster the insights we have gathered.

There is a wide range of ideas on how an operating model should be constituted. A tool for visualising an operating model is the template developed by Hewes et al. (2019); this template is well known and widely used in business practice. It is not designed for a specific industry or economic organisation; rather, it is universally applicable and a cross-sectoral, usable instrument. It consists of three core elements – structure, processes, people – that are mutually connected, and taken together they shape the value creation architecture:

- **Structure:** Defines decision-making processes and segmentation into different working areas. Furthermore, it sets out the framework that balances stakeholder interests and draws the boundaries between the organisation and its environment.
- **Processes:** Sets of activities to transform scarce organisational resources into products and services. Organisational resource refers to tangible or intangible assets that are needed for (re)producing the outputs that an organisation develops, owns, controls, or has access to.
- **People:** Defines the key attributes and behaviours the organisation strives to infuse within its people. It covers working norms and organisational culture issues.

We use the approach of an operating model to synthesise the findings from the two case studies and the website content we collected and have presented above. One of the crucial properties of an operational model is its functional nature as a 'conceptual map'. In other words, it proposes how a certain category of corporate value architectures could be designed to fulfil its purpose. Referring to our case, we present in Figure 3.1 a potential business operating model that has as its purpose a sustainability-oriented use of durables. It serves as a conceptual map for practitioners, indicating which structural, procedural, and personnel aspects are necessary for the implementation of innovations based on producing, distributing, and providing durables. As with all conceptual models, the final model presented below necessarily abstracts social life by drawing a simplified picture of reality. However, we do not intend this to be complete; rather, we sought to identify the main influencing parameters that appear to be important for doing business based on durables.

Figure 3.1: Operational model for companies doing business with durables.



Our findings show that companies doing business with durables have a strong focus on creating user-friendly high-quality products and services in close relationships with suppliers and business ecosystem partners. To do so, they need reliable hardware but also advanced digital technologies and strong internal collaboration between R&D, manufacturing, and quality management. Thus, internal and external organisational design focuses on collaboration and learning. The companies analysed here are driven by their own legacy and values such as transparency and sustainability, and they focus on having a fair and equal relationship with employees and business partners.

3.6 Conclusion

The proposed operating model and the case studies can give a first tentative guide to the ways in which companies have to be organised to provide durable products. However, there are many assumptions regarding what such a business constitutes. The information required to determine the characteristics of businesses providing durables was gathered via two different research approaches, which lead to inconsistencies in the insights obtained (e.g., what type of information was collected). Thus, the proposed operational model is a first attempt to grasp the most important characteristics of companies providing durables. This model needs to be tested with companies: for example, by assessing the status quo and practices within companies in more detail. Furthermore, each model is an abstraction of reality and thus cannot cover all aspects of the actual context. This might lead to blind spots. Certain aspects are not covered within the model: for example, specific governance structures (e.g. incentive systems) and detailed procedures (e.g. supplier management systems and requirements).

Furthermore, the two research approaches had a slightly different focus. The case study analysis looked especially at companies that provide PaaS business models, whereas the website screening focused on companies producing long-lasting and reliable products. In both cases, however, there is no guarantee that the products are in fact used for a long time or very intensively, as stated in our definition of durability. Actual user practices were omitted from the analysis and thus the picture is not complete.

Moreover, we could not assess whether businesses focusing on durable products will lead to environmental (and social) sustainability. Here, indicators need to be developed that link, for example, the longer lifetime of a product to the socio-ecological benefits created – if any. Besides, in many cases durability is not a desirable quality: for example, plastics that end up in the ocean or persistent chemicals in nature and the food chain. Here, a better differentiation is needed of what needs to be durable in which context. Furthermore, different levels of durability can also be addressed: for example, how 'durable' a company is in the sense of it being resilient and long-lasting. What are the characteristics of those companies? Also, to be examined are innovation cycles or the maturities of certain technologies: that is, how long has a certain technology been on the market and undergone development cycles? Taking the material perspective, one could also ask how many times a material can be recycled and retain the same quality (for the same or similar use). All these different aspects of durability need to be analysed to understand what supports or hinders the creation of durables and the positive or negative social or environmental effects this has.

To conclude, doing business with durables still fulfils the capitalistic paradigm that knowledge and assets belong to the company. In the long run, we envision businesses that are shaped by modern ways of collaboration between stakeholders to tackle the environmental (and social) challenges which lie ahead of us. This means that roles and responsibilities between producers, consumers, associations, interest groups, and politicians must be newly negotiated – especially opening up company's internal processes, knowledge, and assets. In the future, the provision of services fulfilling the needs and attending to the well-being of the people might lie in all our hands; instead of working to consume goods and services, we might take an active part in a global networked economy that shares assets and knowledge to provide goods and services catering to the needs of local communities – and thus creating resilient and durable economies.

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4. Curating information for durability

Eduard Wagner

4.1 Introduction

This chapter elaborates the role of information and digitalisation for durability, starting from the question: which factors influence product durability? This apparently simple question is often approached from technical, social, or economic disciplines, but less from a digital perspective. The EU Commission recently stated that 'there is no Green Deal without digital'.[1] Emerging digital technologies and digitally generated data are driving the digital transition, which itself is supposed to support the transition towards a circular economy; together, these are called the 'twin transition'. Digitalisation enables a global connectivity that potentially allows for the steady exchange of information throughout the entire product lifecycle and among stakeholders along the value chain (Neligan 2018). For example, in 2020 global data traffic of 50.5 zettabytes was reached; for comparison, to achieve this volume a movie has to stream 50 trillion times in standard resolution, which would take about six billion years. This is an increase in global data traffic of 25.5 times compared with 2010, when there were 2.1 zettabytes of data traffic (BMWi 2020). However, not all information is 'gold' – as Kroes's phrase 'data is the new gold' (2011) – which means that a rise in the quantity of information is not necessarily related to a rise in quality.

Why is information relevant for the circular economy? The theory of information asymmetry, which was developed by Noble Prize winners George Akerlof, Michael Spence, and Joseph E. Stiglitz (Akerlof et al. 2001), gives a general answer to this question. The theory describes the imbalance between stakeholders of the information available to make an informed decision on a trans-

1 See https://joinup.ec.europa.eu/collection/better-legislation-smoother-implementation/event/uniting-twin-transitions-there-no-green-deal-without-digital.

action, such as the purchase of a product (Bergh et al. 2019). In this scenario, one party has more or better information than another. Projecting this theory into the circular economy context, this gap prevents consumers from informing themselves about the labour or environmental production conditions or durability of a product. In particular, downstream stakeholders at the end of the product lifecycle lack information: for example, recyclers lack the information required to determine the best recycling strategy based on the material composition and value of a product (de Römph and Van Calster 2018).

The 'market for lemons' theorem was introduced in the 1970s by George Akerlof, who aimed to provide a context for the 'economic cost of dishonesty' (Akerlof 1978). Imagining a second-hand market for cars in which only good or bad cars exist, that can only be new or used, that information asymmetry is present: buyers cannot differentiate between good cars and bad cars (utility) when acquiring a car in the second-hand market. This leads to a decreased perception of used cars and thus a decreased utility in buying a used car, which in turns lowers the willingness to spend, which in turn disincentivises used car owners from selling their cars, despite the cars being in good condition. A result of these findings was the Magnuson–Moss Warranty Act in the USA, which passed through Congress in 1975; this required product manufacturers to 'provide consumers with clear and detailed information about warranty coverage' (US Government 1975). In short, information asymmetry and linear information are leading to a decrease in product quality and circularity.

Curating information for durability by finding the right data and combining it to provide something meaningful entails several challenges. These challenges are elaborated in the following sections, starting from the question: which information is useful to whom in order to improve product durability? Are there technical boundaries imposed by data infrastructure and quality? The research is based on a literature review. According to Rivera and Lallmahomed (2016), it is important to provide an overview of involved stakeholders and goals relating to product durability, instead of providing a segmented description of single barriers and how they could be overcome. Therefore, the aim is to provide an overview of relevant information by stakeholder group (designer, consumer, and repair professional). This differentiation is used to structure the analysis.

4.2 A demand for information to improve durability

In 2020, the German consumer and testing organisation Stiftung Warentest conducted a non-representative survey of 10,000 users concerning the age of devices at first breakdown and whether this age was what they expected (Stiftung Warentest 2020). Users stated that they expected a longer durability for several items, including washing machines and smartphones:

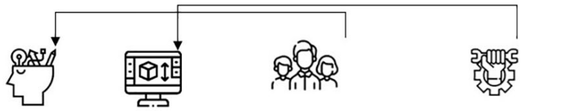
- **Washing machines:** expected 15 years, first breakdown after 5 years (averages).
- **Smartphones:** expected 5 years, first breakdown after 1 year (averages).

This gap between expectation and experience leads to the assumption that the items' durability was faulty by design (product development) or that they were not used as intended (usage) or not maintained properly (business model). The literature focuses on these three areas to analyse product durability and longevity barriers (see, e.g., Jensen et al. 2021). This chapter dives into the information gaps in these three areas that need to be closed to improve durability.

The overview in Table 4.1 shows the stakeholders involved, goals, and information needs, as well as the data flow between them, that are used to structure the sections below.

First, at the product development and business model stage, strategic designers and product designers have a major influence on product durability by either extending the product's lifetime through predictive maintenance (section 4.3.1) or harmonising component lifetimes (section 4.3.2). Information on durability at the point of sale is relevant for consumers when buying products; this information includes comparable indicators (section 4.4.2) and C2C data (section 4.4.3).

Table 4.1: Overview of goals and information needs by stakeholder.
Note: Information feedback from user and repair (downstream stakeholders) back to designers creates a circular information flow.



	Upstream information		Downstream information	
Stakeholder	Strategic designer	Product designer	User	Repair
Lifecycle stage	*business model development*	*product development*	*usage*	*usage*
Goal	Cost-efficient leasing by increasing lifetime	Harmonising and prolonging lifetimes of components	Purchasing durable products for intended use	(Improving ability to be dismantled and repaired)
Information needs	Usage data (e.g. use cycles, age, sensor data)	Repair statistics (frequent failures, successful repairs)	Comparable information (e.g. durability label, maintenance) Feedback to designers (usage data)	Repair information Feedback to designers (failure statistics)

The notion of durability in this chapter follows the definition set out in European Norm 45552 from 2020 (EN 45552:2020); this describes durability as the '[a]bility to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached'.

Figure 4.1: The relationship between reliability, repair, and durability.

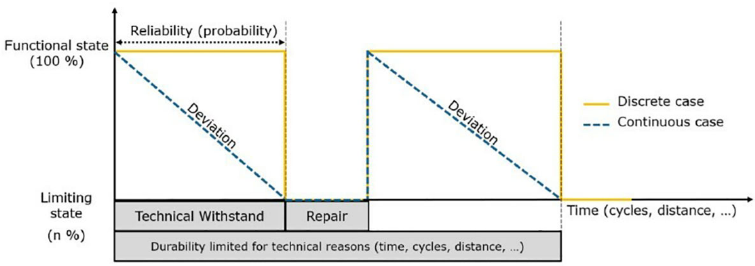


Figure 15: Relationship between reliability, repair and durability (adapted from EN 45552:2020)

Source: Adapted from EN45552:2020.

Figure 4.1 shows the limiting factors to durability as time, cycles, and distance. These are examples of measures and data that are used to determine the product condition. Hence, durability is not only determined by reliability, which is statically inherited in the design of the product; it also depends on repair and use. In the following sections, the term 'durability' is taken to mean a product's lifetime until its first breakdown.

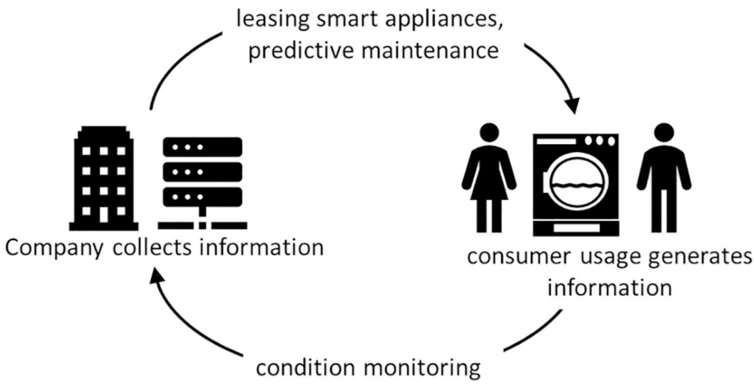
4.3 Upstream durability information

4.3.1 Durability by strategic design: predictive maintenance and leasing

Renting out products and sharing resources are both seen as major enablers in resource decoupling (Manzini et al. 2001; Kjaer et al. 2019). Durable products that require minimum maintenance effort and cost for the companies that rent them out are a prerequisite. Rejeb et al. (2022) argue that the Internet of Things (IoT) enables a fine-grained and continuous tracking of assets, including consumer products. IoT allows products' use and condition to be tracked and monitored, enabling servitisation, product–service systems (PSS), and circular business models through condition monitoring, predictive maintenance, and reuse (Cagno et al. 2021. This can be achieved by the collection of data points by different sensors, hoisted and elaborated by Big Data analytics. As 'smart objects', IoT devices can gauge their local situation, process information, and interact with their users (Kortuem et al. 2010).

More specifically, academia showcases the methodology of smart objects with relation to servitised business models, in which usage-focused models leverage IoT and Big Data ultimately to prolong the lifetime of products (Rejeb et al. 2022; Cagno et al. 2021. For instance, a household appliance retailer operating in Northern Europe provides customer subscription-based access to washing machines, dishwashers, and tumble driers. With the digitisation of their product line (through IoT), the company benefits from lifecycle information about the products' usage, their components, and failure rates. This gives rise to circular economy business models through preventive and predictive maintenance.

Figure 4.2: The basic principle of condition monitoring – companies leasing smart appliances that provide information on their usage.



Similarly, BlueMovement,[2] a start-up powered by a large electronic manufacturer, offers a subscription for household appliances such as fridges and freezers, washing machines, driers, and dishwashers rentable on a monthly basis; pricing ranges from €13.99 to €18.99 per month, depending on the appliance. The company's mission statement advocates circular economy strategies such as refurbishment, thereby following the trend of servitised business models empowered by the information discussed above. As an example, the company Grover offers subscription-based access to consumer electronics such as phones, laptops, tablets, and cameras. The company agrees to cover 90 per cent of the repair costs for product damages and aims for circularity through refurbishment. In 2018, the company Fairphone announced a new pilot to offer customers the opportunity to rent a Fairphone instead of owning one.[3] In their research paper, the authors document the aim of increasing circular value by gaining access to and analysing user data relating to their components, thereby maximising their longevity. Performance and use data, as well as repair history, is used as a basis to evaluate residual value and refurbishment options. Moreover, the authors note that users are incentivised to act in ways that elicit

2 See www.bluemovement.com/de-de.

3 'The Circular Phone: Legal, Operational and Financial Solutions to Unlock the Potential of the "Fairphone-as-a-Service" Model', Fairphone (2018).

information on the product's lifetime. This is exemplified by the diagnosis of Fairphone components, such as the audio port, at the end-of-use stage.

Within PSS, companies that rent out products have an interest in reducing usage costs by increasing product durability (cf. Annarelli et al. 2016; Tukker 2015; Aurich et al. 2006). Data to improve durability by predicting maintenance is a key enabler for this concept. Sharing resources is often seen as a means to realise resource decoupling. However, rebound effects are found that might reduce the overall environmental performance of PSS (Chierici and Copani 2016). As product ownership is not with the consumer, the usage intensity increases (Kjaer et al. 2019). 'Don't be gentle it's a rental' is a common phrase that reflects not only the decoupling of ownership from usage but also less conscious handling (Liu et al. 2022).

4.3.2 Durability by product design

It can be assumed that the product design determines how long the product can be used and thereby defines a product's environmental impact. Ecodesign principles are fundamental to engineers designing products that are circular and thus durable in terms of their intended use time. In the perspective of the twin transition, there are approaches that are driven to a great extent by data. In order to understand how and where data drives durable design, three different guiding approaches are used to direct, regulate, and mandate durability requirements for products:

- company or research-based guidance: ecodesign principles (including feedback from repair);
- third-party guidance: norms, labels, indicators, and standards; and
- legal guidance: mandatory ecodesign directive requirements.

From an information perspective, all three pillars share the strategy of optimising durability by harmonising the technical and useful lifetime. This means that the product should be designed in a way which ensures that all components have the same duration to fulfil their function. Furthermore, the technical lifetime of all components should match or exceed the time during which a product is used by its owner – its useful lifetime. It should be noted that, by definition, the useful lifetime includes a second use or multiple uses within a sharing model; this results in more intensive usage. However, the number of uses does not affect the type of information that is necessary to optimise durability.

According to EN 45552:2020 (General method for the assessment of the durability of energy-related products), an assessment should take account of:

- environmental and operating conditions;
- the product's priority parts (and test methods to assess their reliability);
- the events leading to limiting states (potential end-of-life states);
- being dropped, stress, etc.;
- wearing out and ageing;
- missing software updates; and
- cleaning mechanisms.

An analysis of limiting factors is essential to show the reasons for failures and their underlying causes. Each product group comes with different functionalities and therefore has different failure causes (failure modes) at different times: for example, large and stationary product groups (washing machines, refrigerators, etc.) will have different requirements to portable devices (smartphones, electric toothbrushes, etc.). Information on those failures comes either from early tests (before market release) or from repair statistics. While laboratory tests try to replicate real-world conditions, repair statistics are a valuable source of field information. Within the repair process, some information is usually generated (Wagner et al. 2021), such as repair success rate, frequent failures, and costs for repair, including spare parts, labour, and logistic costs.

Of particular relevance in analysing and improving durability are frequent failures. A documentation of failures is a basis to determine priority parts – those parts that are likely to be replaced or upgraded within the useful lifetime. However, designers usually have access to repair statistics only from the warranty phase, the two-year liability period for the manufacturer. Long-term data, especially from independent repairers, is rare and data quality low (Wagner et al. 2021). Upcoming research and policies on digital product passports will provide information on the product throughout its lifecycle, offering the potential to provide data upstream in the value chain, from repairers to designers, on short information feedback loops (see section 4.5). In this regard, the digital product passport could provide information that assists the design phase with suggestions on component failures, potentially facilitating the harmonisation of component lifetimes and therefore enabling a durable design by default.

4.4 Downstream durability information

4.4.1 Pre- and post-purchase information for consumers

A recent representative consumer survey in Germany (UBA 2023) showed the relevance of electronic and textile-specific product information: a large majority of respondents (82 per cent) indicated that they always or often deem information on performance to be important (e.g. information about capacity, functionality, etc.). Durability and longevity information are second most relevant (79 per cent), followed by energy consumption (73 per cent), and price (70 per cent). The manufacturer's brand (70 per cent) was mentioned as indicating quality and durability. Environmental labels play a minor role (34 per cent) for electronic products; respondents described them as not transparent or comparable (ibid.).

With the specific focus on metrics for use and maintenance, the survey revealed information to be crucial and important in user manuals (75 per cent) and for product care (69 per cent). This indicates the necessity of information on how to use the product and its intended use. This is in line with other research indicating a positive significant relation between the quality of the user manual and the perceived product quality (Renaud et al. 2019). Moreover, Gök et al. (2019) convey that product manuals sometimes assume that the consumer has pre-existing knowledge on how to use the product without reading the manual. Additionally, the authors argue that the person writing the product manual may not have experience of the product.

4.4.2 Metrics and indicators for consumers

Information on durability is a significant factor influencing consumers' purchasing decisions (UBA 2023). However, comparable and widely available information is currently limited to product price and product performance characteristics (e.g. processor speed). But with price as a main criterion, high-quality products have difficulty competing with low-quality products.

While a few labels, such as EPEAT, TCO Certified or the German Blue Angel, try to indicate durability or lifetime, a general challenge is their lack of comparability. The independent website Siegelklarheit approaches this challenge by using a standard set of indicators to compare different labels. In the ideal scenario, all products would show the same durability label. There is currently an aim to make this mandatory in France, rather like the repairability index. A durability index will be introduced that gives the consumer a standardised instrument as a basis for comparison, based on the EN 45552:2020 standard already mentioned. The TCO Certified label, one of the few existing labels, includes criteria on product lifetime extensions for electronic notebooks and information on several aspects of durability:

- warranty – a standardised and comparable indicator that implicitly states that the product is durable, as it assumes that the manufacturer designs its products to be durable within the warranty phase;
- standardised connectors;
- battery longevity and information on protection;
- secure data removal; and
- external power supply compatibility.

The consumer survey mentioned above further shows the relevance of independent information sources to consumers, which they use to gather information before purchase. These sources could include independent testing organisations (such as the German Stiftung Warentest), performance and technical details, in-store advice, and customer reviews.

The website Siegelklarheit.de evaluates the label themselves. It considers specific evaluation criteria regarding durability, including the durability of specific components, modular design, the availability of spare parts, battery properties and usage, expansion facilities for the product, information concerning reparability, availability of upgrades, and an additional lifetime guarantee.

4.4.3 Customer reviews as a source of information prior to purchase: customer-to-customer information (C2C)

An alternative, relevant source of assumed-to-be-trustworthy information are platforms that provide feedback from other product users. The internet comprises a constantly available and growing platform that enables users globally to exchange information and express opinions, in particular on products. Google, Amazon, and eBay have become critical information hubs for customers. The majority of consumers read product-related reviews online to inform themselves prior to a purchase.[4] However, from a scientific perspective, the nature of non-professional, customer-written feedback limits its comparability and significance. Subjective, exaggerated, fake, digressive, and one-dimensional reviews (e.g. reviews of the delivery time instead of the product) are just some examples that need careful evaluation to gauge the significance of the review (Mukherjee et al. 2012). With methods such as 'natural language processing', research is trying to systematically synthesise information from the written text. This is very challenging since algorithms have to cope with grammatically and syntactically incorrect or unstructured sentences, ambiguity, sarcasm, etc. (Johri et al. 2021). One potential approach to this challenge would be a stronger, unified review structure; this would increase the analytical potential, but it might decrease the motivation of reviewers to provide feedback.

If one considers repair as part of the durability definition, the consumer is facing an information gap on reparability possibilities and costs and the potential time till the next failure – in short, the consumer lacks information on the total cost of ownership. Calculating these costs is nearly impossible when one considers improvements in energy consumption. The technological evolution of devices might generate an improvement in the energy efficiency class they belong to. As energy consumption contributes significantly to the environmental impact of most devices, it is therefore necessary to support users with information about whether the device should continue to be used (UBA 2016). This, for example, is relevant for older fridges or vacuum cleaners with poor efficiency.[5]

4.5 What's next? Green information systems – new ways to share knowledge

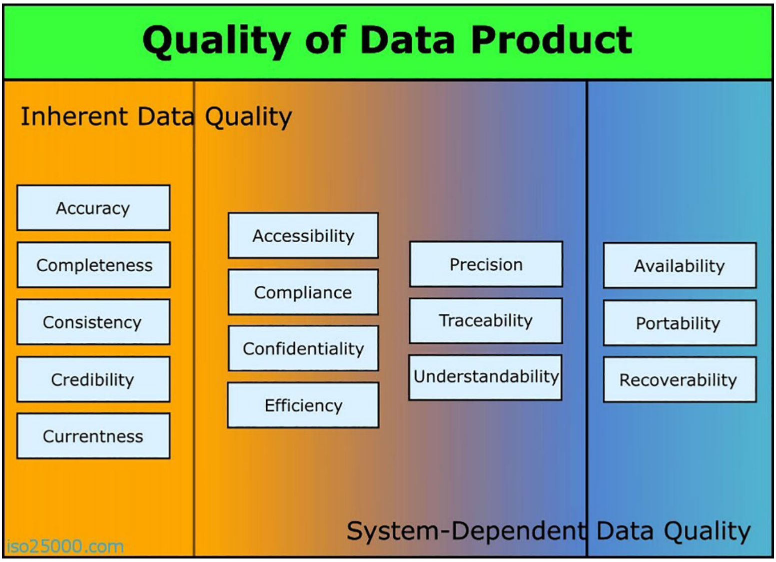
Information gaps and demands (see Table 4.1) might result from a lack of technical infrastructure. For example, usage data is often provided only with modern devices that count the usage cycles or age and transmit this information

4 See www.statista.com/statistics/623685/visual-ugc-access-prior-to-purchase-usa/.

5 See www.test.de/Defekte-Haushaltsgeraete-Wann-sich-eine-Reparatur-lohnt-5157064-0/.

to the designers. There is no harmonised technical infrastructure to report usage history (similar to the mileage of cars). The options available to communicate sensitive information in a reliable way – by upstreaming the value chain from the recycler to the manufacturer, for instance – is limited. Besides intellectual property interests and privacy considerations, several technical and data-related challenges have to be overcome within such an information-sharing system. These challenges typically include data diversity and heterogeneity of type and format, distributed data from several sources, security, data ownership, and liability. This topic is systematically covered within the data quality research.

Figure 4.3: Aspects of data quality aspects.



Source: ISO 25000.

The digital product passport offers various potential benefits. It will become mandatory on an EU level and will address the challenges noted above. Its goal is to provide the technical boundaries to reduce information asymmetries and gaps within the product lifecycle and to develop unused circular potential for the actors involved. The digital product passport is intended to determine product-specific properties such as composition, structure, pollution, functionality, mode of operation, repair and recycling instructions, and product lifecycle and to provide the relevant stakeholders within the lifecycle with the information they need. As an information carrier, it offers potential not only for resource conservation and better recycling but also for circular business models. Although there are already numerous sector- and topic-specific instruments, what is innovative about the product passport is its ability to bundle the various information sources and relevant data in a recording system and make them available on a user-specific basis (Götz et al. 2021).

Depending on the several definitions available in literature (for an overview, see Barricelli 2019), the digital twin shows some similarities to the product passport. A digital twin is a copy of a real object but in the digital world. The digital and real world are connected via data exchange. Data about the real object is transferred to the digital one to investigate consequences, and simulations of the object's behaviour in the virtual world help improve real-life operations. Digital twins are used in manufacturing or during use to improve processes and to document changes in the product. They have a time-critical element, which allows faster changes during the lifecycle, and can deliver almost real-time data about materials, processes, or other elements.[6] The digital twin is currently used to duplicate information that can be either static (purchase date, model number, etc.) or dynamic (usage conditions). For example, potential car buyers can use the digital twin to design and visualise the car and choose additional functionalities or features prior to purchase. During use, the digital twin can be used to diagnose and maintain the car by replicating real-life information (mileage, breakdowns, etc.). In future scenarios, the digital product passport might take the place of the twin by conveying non-time-critical information for consumers, while the digital twin focuses on real-time information (e.g. health, like an electrocardiogram for machines) to prevent failures and expensive downtime.

4.6 Summary and conclusion

This chapter has characterised durability in the context of information in two main areas: upstream and downstream. Designers and manufacturers are up-

6 See https://ec.europa.eu/research-and-innovation/en/horizon-magazine/how-digital-twins-are-guiding-future-maintenance-and-manufacturing.

stream stakeholders that can influence the product's durability either by improving the product design and the technical characteristics of the product itself or by providing services such as condition monitoring to prevent major failures and downtime. Both the strategic designer and the product designer require downstream information from the usage phase. Downstream users comprise individuals who provide feedback on the product's use or repair professionals who provide failure statistics. At the same time, downstream stakeholders also need information in their daily practices. Users require durability information such as labels that allow for sustainable purchases and provide maintenance information after purchase. However, an information asymmetry prevails, with information available for designers and manufacturers while users lack durability information. To create a market for durable products, information transparency needs to be increased. There is therefore a high potential for information-driven durability practices, with some limitations:

- Data protection and privacy have to be balanced with the potential benefits. Currently, data gathering is dictated by manufacturers. Approaches exist to use failure statistics to improve reliability. However, whether this information is used in practice by manufacturing companies to improve product durability is opaque and subject to management decisions, business ethics, etc.
- Little durability information is available. Some labels include such information, but these are not available for a broad range of products. The comparability of information is essential here.

Digital product passports are currently being developed with the goals of increasing transparency and allowing circular information flows between downstream and upstream stakeholders. Therefore, they have a disruptive potential to close information asymmetries. Users are provided with the information required to make an informed decision. Thus, the digital product passport will enable the democratisation of products and reduce the systematic disablement of users. Users in turn are important in sharing data and contributing to the 'data added value'. With the potential of a digital product passport to reach consumers and have an impact on their purchase decisions, the development of a durability indicator and usage might be stimulated.

However, the digital product passport will be a decentralised tool, with information distributed to the stakeholder that generates it. Most information will come from the manufacturer. Strong regulatory enforcement is necessary to gather information with a high impact on durability and sustainability in general.

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5. Durability and retail

Erik Poppe and Vivian Frick

5.1 Introduction

The public debate about short product lifetimes and planned premature obsolescence has been widely publicised in recent years and has involved many stakeholders. The focus of the debate has been mainly on manufacturers, which lay the foundations for product longevity in the design phase (e.g. Poppe and Longmuß 2019). In addition, research shows that consumers can have a significant impact on product lifetime and useful lives through their behaviour (see, e.g., Jaeger-Erben and Hipp 2017). One player that has received little attention to date and still manages to escape attention in debates on product lifetimes and premature obsolescence is the retail sector. As the point of sale, retail plays a central role in mediating and steering supply and demand. Retailers not only decide what products to put on their shelves and what product assortment to present to potential customers. They are also the direct contact and contractual partner for the customer. Consequently, retailers are thought to have an arsenal of practices and strategies that can have a direct impact on product quality and customer behaviour. The aim of this chapter is to uncover these practices and to ask what influence retail can exert within the supply chain. The chapter discusses the role of retail for durability and how its position and retailing practices in the supply chain exert influence over the lifetime and durability of products.

Recent research has identified production and consumption characteristics that influence product lifetime. On the production side, time and budget constraints are central factors determining product lifetime (e.g. Longmuß et al. 2019). On the consumption side, motives such as the desire for new products, societal norms, but also environmental concerns influence product lifetime (e.g. Jaeger-Erben et al. 2021). As another example, it has been found that consumers use products longer when they perceive them as 'workhorses' (e.g. washing machines) than when they perceive them as modern or status products such as information and communication technology (ICT) (Cox et al. 2013). Although research on product lifetimes and obsolescence has grown considerably in recent years, there has been comparatively little dedicated work on the role of retailers. There are several reasons for this. On the one hand, the term 'retail' encompasses a wide range of actors operating in a variety of ways. On the other hand, retailers are often described as mere intermediaries between supply and demand, and their potential to influence product quality and consumer behaviour is often underestimated. But are retailers really subordinate to the evolution of supply and demand? Offensive retail strategies such as offering low-priced private brands, 'cash for clunkers' and trade-in programmes, as well as regular sales promotions such as 'Black Friday' or 'Cyber week', paint a different picture. For example, it has been argued that the desire to consume the latest products and conspicuous consumption are fuelled by marketing activities, a significant part of which comes from retailers (e.g. Kasser and Kanner 2004; Thøgersen 2014). The role of such retail strategies in obsolescence is examined in more detail in the following sections.

The issue of obsolescence generally focuses on what are known as durable goods. In contrast to non-durable goods, such as food and other perishables, durable goods are more complex technical items and processed goods that are not consumable but can be used over a long period of time. We therefore examine the role of retail in the longevity of such durable goods. Examples include electronic devices, textiles, and furniture. We identify positions of power and practices along the supply chain through which retailers can have a direct and indirect impact on product durability.

5.2 Retail as a gatekeeper for durability

The word 'retail' is an English term derived from the French *retaille*, in its origin meaning 'a piece cut off'.[1] It describes the practice of various economic agents of selling goods in relatively small quantities to consumers. Retailing has a long and diverse history. While research on consumers and consumption has steadily developed, dedicated reviews of the history of retail are lacking so far (Jacques and Sandgren 2018). There are several reasons for this gap. On the one hand, retailing is shaped by national and geographical characteristics that

1 See www.lexico.com/definition/retail (accessed 10 February 2022).

make it impossible to draw a universal picture of retailing across countries or regions; on the other hand, the diversity of retail formats and actors means that it is not always easy to analytically distinguish it from other forms of business or to pin a common label on it. Retailing has been defined as a specific economic practice that is prototypically characterised by three factors:

1. In contrast to wholesaling, retailing involves offering end customers a specific product range in small sales quantities.
2. The retailer usually acts as an intermediary between different manufacturers and customers.
3. The retailer buys low and sells high to make a profit from the transaction.

Retail actors vary widely in size, scope, and market strategies. Individuals may act as merchants in public marketplaces or on the internet, offering a range of goods. Corporations may engage in retailing on their own or as part of large conglomerates. Today, we encounter a variety of retailers in the form of supermarkets, fashion stores, hardware stores, electronics stores, and the bakery around the corner. In addition to these 'bricks and mortar' stores, internet-based stores or e-commerce have become increasingly popular in recent decades. Online and offline retailing are also sometimes combined as hybrid concepts ('clicks and bricks').

In addition, retailers can sometimes act as wholesalers, manufacturers of private labels and brands, or non-profit cooperatives. In their economic role, however, retailers essentially act as merchants whose central economic motive is to make a profit from their transaction between the producer of the product and the customer, without adding any functional value to the product, a practice that can also be described as 'rent seeking'. The faster and the more goods are traded, the higher the turnover – also known as 'rotation' in the language of retail.

Beside their economic interests, retailers fulfil a key economic distribution and coordination function. Around 35 per cent of private consumer spending in Germany is spent in the retail sector, with local stores still accounting for the majority. In contrast to local retailing, online retailing has a share of around 13 per cent of private consumer spending in Germany (HDE 2021). This applies not only to complex electronic products and textiles, the so-called durables, but also to food and other perishable goods, the so-called non-durables, which in the past could increasingly be made durable by new technologies such as preservatives and refrigeration, making them available to consumers in remote locations and for longer periods (Dobeson and Kohl 2020). Globalised supply chains and modern distribution systems provide customers with an enormous choice of products across all commodity groups. Supermarkets in Germany more than tripled their average range of products from 3,200 to 11,600 between 1965 and 2015 (LZ 2015). At the end of 2016, online retailer Amazon had more than 200 million items on its website (Jordan 2020). Other surveys even speak of over 500 million products,[2] making it one of the largest product databases in the world.

Retailing took a central role in the development and emergence of the capitalist economy because it facilitated the commodification, distribution, and mass production of products. Although merchants were held in low esteem by authoritative institutions such as the church due to their practice of rent seeking until the early Middle Ages (see also Mazzucato 2019), retailing made certain products accessible to broad sections of the population for the first time. Retailing was less discriminatory than other forms of social interaction, as all individuals could participate if they had the financial means (Trentmann 2017). Even in centrally organised economic systems, market-based informal retail plays a central role in supplying the population. Without the many informal retailers and the 'grey market', supply in countries such as North Korea would simply collapse (Tudor and Pearson 2015).

In addition to its many benefits and achievements for society, retailing is also associated with environmental and socio-structural problems that have become increasingly apparent as a result of the consumerism that has evolved since the early 1950s. Until the middle of the twentieth century, the primary task of the economic system was to eliminate scarcity in all areas of life; but since the early 1990s there has been a growing saturation of demand, especially for durable goods in the industrialised countries (cf. Kostecki 1998). In a linear and growth-oriented economic system, however, saturation of demand can become a problem for companies and retailers if the majority of business models continue to be based on the profitable sale of new goods. As an intermediary between supply and demand, the retail sector plays a central role in the supply chain and can control the flow of goods in terms of quality and price, market availability, and target groups. First, in their role as purchasers and producers, they influence production-specific aspects of durability. Second, they influence consumption-specific aspects; as marketers, they influence the

2 'How Many Products Does Amazon Sell?', Scrapehero.com, January 2018, www.scrapehero.com/many-products-amazon-sell-january-2018/ (accessed 21 April 2022).

purchasing behaviour of consumers who may shorten the life of existing products through premature replacement. These influences on the production and consumption sides are the subject of the following analysis. The concluding discussion raises the question of how retailers can meet future challenges that may encourage the extension of products' lifetimes and use.

5.3 The role of retail on durability and obsolescence within the supply chain

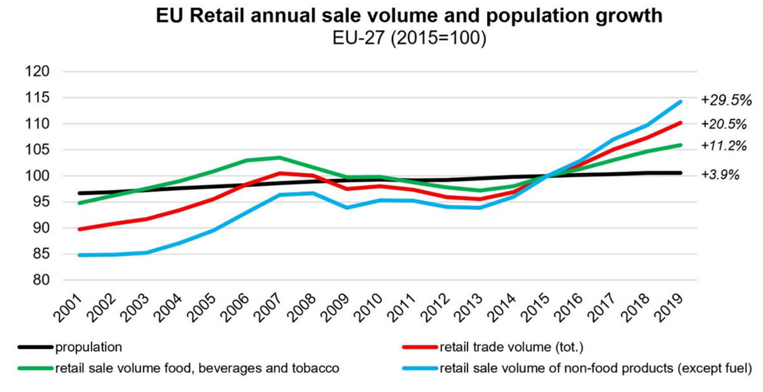
In the following section, selected practices and strategies in the retail sector that may have an impact on product life and useful life are presented. A typical retail supply chain is used as a simple analytical framework to identify key positions and relevant practices. Due to the limited scope and lack of research in this area, it is not always possible to empirically validate the impact and relevance of the identified practices for the product lifecycle. The aim of this chapter is to draw a broader picture of the potential for retailers to influence product obsolescence, durability, and lifetime.

5.3.1 Purchaser role: curator and gatekeeper of supply

Consumers in Germany spend 35 per cent of their income in retail outlets, making it the dominant point of sale for private spending on consumer goods. On average, German households spend around €385 (15.5 per cent) per month on food, beverages, and tobacco; €93 (4 per cent) on textiles and shoes; and €160 (7 per cent) on furniture and other household appliances (Statistisches Bundesamt 2021a, b). Whether in local stores or online, retail is the most important touchpoint for the majority of consumers when buying products.

Despite low population growth in Europe of only 3.9 per cent between 2001 and 2019, the European retail sector has managed to increase its product sales by more than 20 per cent on average over the same period, and by as much as 30 per cent for consumer durables (see retail sales of non-food products in Figure 5.1). Sales figures here refer to product volumes calculated on the basis of deflated turnover, which gives a more quantitative picture of how many products people consume in the EU. The figures show that product sales per person have increased significantly over the last two decades. There may be several structural economic reasons for this growth effect. The purchasing power of consumers is growing due to continuous productivity gains, while the EU central bank has ensured cheap credit with a zero-interest rate policy since 2015. However, in addition to consumer purchasing power, additional consumption has also been stimulated by the expansion of physical infrastructure and marketing, areas in which retailers play a key role.

Figure 5.1: Annual sales volume in retail and population growth in the EU-27 from 2001 to 2019.



Source: Own calculation based on Eurostat (online data source codes: STS_TRTU_M; DEMO_GIND)

To ensure continuously high sales rates, retailers are under pressure to constantly offer customers new consumption options; this manifests itself in a wide differentiation of product qualities. The fact that retailers can sell low-budget toasters for as little as €9 and designer toasters for up to €500 is not only due to the manufacturer that manages to produce such a range of qualities and varieties, but also to the retailer that offers them. Put simply, if retailers were more demanding about the durability and longevity of products, many short-lived products would never make it into the hands of consumers. Unfortunately, some retailers, such as the fast fashion industry, have put low-quality products and fast market cycles at the heart of their business models (Mehrjoo and Pasek 2014). Between 2000 and 2011, the average number of collections by European textile companies doubled every year (Remy et al. 2016). The Spanish fashion retailer Zara launches 65,000 different clothing items per year, which corresponds to an average of 200 models per day (Alliot 2020). It is not easy to prove the extent to which retailers intend premature obsolescence and rapid product replacement cycles, but, as curators of supply, they bear a great deal of responsibility for the overall product quality level in the market.

In contrast to this, retailers are sometimes motivated to strategically withhold certain product innovations to serve other profit interests. When engineer James Dyson invented the first vacuum cleaner that did not require a separate dust bag, no retailer wanted to stock his product because it would disrupt the replacement dust bag market (White 2020). Also legendary is the story of the Phoebus cartel, in which leading lamp manufacturers conspired in the early 1920s to limit the life of lightbulbs on the market (Krajewski 2014). But there are also more day-to-day practices that retailers can use to control which products are on the market. As the largest purchaser, retailers are in constant contact with manufacturers and producers regarding the introduction of new products and the sale of older stock. If retailers are struggling to sell their older stock, why should they risk selling a manufacturer's new products? In this case, retailers have developed a number of strategies to exploit their position of power and minimise their risk in the supply chain. For example, if a particular manufacturer's older products are not selling, they can financially participate in sales promotions or even receive compensation for permanently discounting the older inventory.[3]

The close cooperation between manufacturers and retailers in planning prices and timing market cycles is not well researched and often not visible to the public. However, experts are observing a trend: in times of globalised supply chains and increasing digitalisation, retailers are gaining more and more power in the vertical supply chain. This no longer includes just scouting new products and selling them to customers, but increasingly product development, pricing and timing of market cycles, sourcing of materials, and all kinds of other fulfilment services for manufacturers (Zentes et al. 2012). By far the largest company in the world today in terms of sales and number of employees is the retailer Walmart, followed by Amazon.[4] Obviously, any product-related decision taken by the major retailers can have an impact on the general market.

Besides their position of power, it is also crucial to understand the economic drivers of retailers and the economic trade-offs between product rotation and long product life. As the demand for durable goods in developed

3 Based on personal interviews with purchasers and product category managers in the retail sector for consumer electronics in 2021.

4 See https://fortune.com/global500/2021/search/.

countries is generally saturated and growing at low rates (Sohl and Rudolph 2012), retailers have to compete primarily for market share in replacement or improvement purchases by customers. Storage, shelf space, and consumer attention are the limiting factors in retailing, and retailers' revenues depend on the volume and speed of sales. Retail has developed a key performance indicator called 'product rotation rate', which quantifies the speed at which products are sold. The shorter the time products are in stock and the faster they are sold, the better the product rotation rate. High rotation rates are particularly important for perishables, the 'fast movers'. However, research on traditional 'slow movers', such as fashion items and electronics, has found that these products have also moved to faster rotation and consumption modes over the past two decades (e.g. Cooper 2010; Wieser and Tröger 2015; Kostecki 1998). From an economic perspective, retailers benefit from faster product rotation by customers, which is not necessarily beneficial for long product use cycles. Given the importance of fast product rotation, retailers are the least likely to complain about premature obsolescence and are currently in a very comfortable position, as they can shift responsibility to manufacturers or consumers.

5.3.2 Producer role: the hidden business with private label brands

As part of their vertical integration, every major retailer, from supermarkets and DIY stores to electronics and fashion retailers, offers what are known as 'private labels'; these are products produced and marketed exclusively on behalf of the company under its own label. E-commerce retailer Amazon, for example, offers the private label brand 'AmazonBasic', with a range of products from displays, office chairs, and vacuum cleaners to frying pans and toasters. In terms of volume, the market share of private labels in the European food retail sector is between 20 and 50 per cent (Nielsen 2020), while estimates for the retail of consumer durables such as electronics and fashion are in the lower range (Bluemont 2020), making it highly relevant for sustainable market management. Aside from its significant market penetration, private label deserves special attention for at least three reasons:

- It is not always clear to customers whether a brand is a private label or an independent brand.
- Retailers can present their products in a way that discriminates against other brands that may be better value for the customer.

- Most retailers place their private label brands in the lower price segment, which can be associated with lower quality compared with higher-priced products.

Private label brands are not always as transparent to consumers as in the case of Amazon. The German electronics retailers Mediamarkt and Saturn, for example, offer the brands PEAQ, Koenig, ISY, and ok[5] without indicating direct brand ownership at the point of sale. Some retailers expect to gain a market advantage over other brands by masking their own brands and it is debatable to what extent consumers may be deceived by this practice. Consumers tend to be insufficiently informed about the market (cf. Clark 1918; Nelson 1970) and this enables retailers, for example, to use the appearance of independence to recommend their own brands over others or to place them in a better position. The placement and pricing of private labels can go so far as to specifically disadvantage other brands at the point of sale. In a recent antitrust investigation, the US Federal Trade Commission cited Amazon's practice of prioritising items on its website in favour of its own products and those of manufacturers that use Amazon's fulfilment services.[6]

So far, the practice of product discrimination at the point of sale is not well researched and it is not clear to what extent it causes avoidable societal costs (i.e., violation of antitrust law, cut-throat competition). Nevertheless, it is striking that private labels are often placed in the lower price segment. This does not mean that they are of lower quality than other brands in the same price category (Boyle et al. 2018), but private label brands are often the cheapest products in the market, and it seems important to ask how durable and sustainable an electric hand blender costing less than €10[7] or a washing machine for less than €200[8] can be. Although not entirely uncontroversial, research suggests that there is a strong relationship between the quality and price of durables, implying that the lower the price, the lower the quality of the product (see Mitra and Golder 2006), which can have a negative impact

5 See www.mediamarkt.de/de/specials/eigenmarken.

6 See https://crsreports.congress.gov/product/pdf/R/R45910/3.

7 See, for example, 'OK. OSB 2019 W Stabmixer Weiß (200 Watt)' for €9.99 at www.mediamarkt.de/de/product/_ok-osb-2019-w-2606520.html (accessed 26 April 2022).

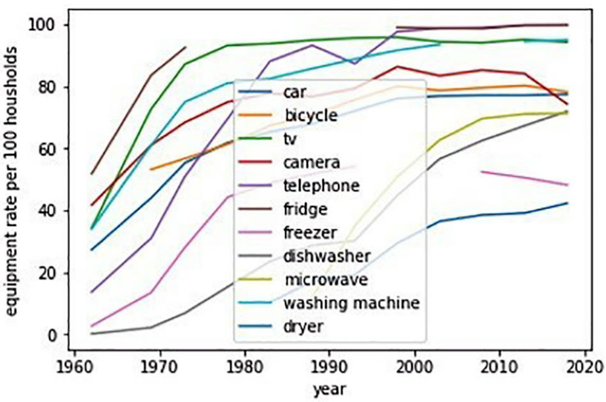
8 See, for example, 'OK. OWM 5112 D Waschmaschine (5 kg, 1000 U/Min., D)' for €199.99 at www.mediamarkt.de/de/product/_ok-owm-5112-d-2665050.html (accessed 26 April 2022).

on the durability of the product. In addition, the lower prices of the retailer's own brands may put pressure on other competitors and brands to lower their prices as well, thereby reducing their budgets for quality and leading to cut-throat competition that reduces overall quality in the market. As noted above, retailers have an interest in rapid product rotation and replacement, and lower-priced private labels would offer them two advantages. First, the profit margins are much higher than from selling other brands (Bluemont 2020); and second, the lower quality of low-priced private labels could correspond to faster replacement cycles by the customer. Unfortunately, there is no research yet to support these conjectures, even though private labels are the best evidence that retailers have a direct influence on the quality and durability of products.

5.3.3 Marketer role: between profit increase and liability

Without question, retail is one of the most important supply systems for the population. Retailers now make an abundance of durable goods available to everyone, all year round. As a result, consumer demand for durable goods has become increasingly saturated in recent decades (see Figure 5.2).

Figure 5.2: Household equipment per 100 households in Germany from 1962 to 2018.



Source: Illustration based on data in Statistisches Bundesamt 2020.

Market saturation poses a problem for retailers and their business models: if everyone already has everything, who is going to buy new products? Not least because of this 'paradox of the plenty', manufacturers and retailers have been accused of planned obsolescence (London 1932; Packard 1960; Slade 2006; Guiltinan 2009). In planning for premature product replacement, the retail sector is subject to strict limits – at least in theory. After all, the retail sector is liable for the contracted quality and condition of the products sold. When products fail prematurely, the seller is legally obliged under European law to replace or repair the item for the customer.[9] Although retailers may benefit from shorter product lifetimes and lower durability in the short run, such strategies may become a liability later. However, research provides evidence that many consumers tend to replace their products prematurely without any defect or failure due to symbolic or psychological obsolescence (Prakash et al. 2016; Jaeger-Erben and Hipp 2017; Cooper 2004), an effect that retailers can exploit to boost their sales. Current literature (e.g., Bala and Verma 2018) reveals several marketing practices that retailers have developed to actively encourage customers to increase their purchases and thus potentially replace their old products with new ones:

- **'Cash for clunkers':** Manufacturers and retailers offer customers a discount on new products if they bring in their old products, thus incentivising early product replacement (Xu et al. 2019).
- **Upselling and cross-selling:** Retailers offer various marketing techniques such as discount and bonus schemes that are designed to encourage customers to make additional purchases that were not previously planned (Pandya and Dholakia 2021).
- **Variety seeking:** Marketing research supports companies in the assumption that consumers generally welcome a certain level of product variety and selection (variety seeking) (Kahn 1995, 1998; Stasiuk et al. 2018). Although an excess of product selection can put people off (Schwarz 2016; Iyengar and Lepper 2001), a highly differentiated and changing assortment of products can incentivise consumers to look for better products in terms of brand, price, quality, and functionality (Beath and Katsoulacos 1991).

9 Directive (EU) 2019/771.

- **Novelty seeking:** New products are often valued higher than older or currently used products (Frick et al. 2020).[10] Marketing strategies can reinforce this belief by portraying the new as technologically superior, more convenient, and easier to use, encouraging early replacement or additional purchases.

These marketing strategies show that retailers do not have to degrade the quality of products to induce premature replacements and additional consumption. The quantitative effect of these practices is difficult to examine. There are studies that show a correlation between marketing activities and consumption levels (e.g. Frick et al. 2021; Gossen et al. 2022), yet causal relationships are difficult to prove empirically. Retailers use marketing for a variety of reasons: to build brand awareness, introduce new products, enhance their image, or increase sales. It can therefore be assumed that retailers are evaluating and optimising their marketing practices very closely.

The importance and influence of marketing also shed new light on the issue of environmental and social responsibility. From a narrow business perspective, it might be expected that retailers would seek to encourage premature replacement and additional consumption, as their business model is often based on the rapid rotation of products in the marketplace. However, the question remains as to what extent retailers are aware of their active role in premature obsolescence and the negative consequences of overconsumption. In discussions on degrowth and consumption reduction, retailers have tended to stay out of public debates (with some prominent exceptions, such as Patagonia; see Hwang et al. 2016). At other times, their key position has been overlooked in public and scientific debates. However, as this contribution has hopefully shown, the retail sector plays a central role in enabling and accelerating consumption. Therefore, the chapter concludes with a discussion of how retail can decelerate consumption.

10 'NEWISM. Why More Than Ever, Consumers Lust After the New. And Why That Spells Heaven or Hell for Brands', Trendwatching.com, July/August 2012, https://trendwatching.com/trends/newism/ (accessed 4 November 2020).

5.4 Discussion: circularise consumption through retail

Retail holds a key position in the supply chain, which can have a bidirectional influence through the control of material and information flows. On the supply side, it coordinates, bundles, and distributes the products from many different manufacturers. As a gatekeeper and curator, it can determine the type, volume, and speed of products on the market. On the demand side, retailers can influence consumer behaviour through a variety of marketing practices, giving retailers great power to influence the overall speed and scope of consumption. The following section takes a closer look at both power positions in the supply chain to discuss the potential for more sustainable production and consumption patterns.

5.4.1 Supply side: reduce and decelerate

There is an inherent problem with the idea of endless economic growth: 'The more goods we produce, the more bads we generate, in the form of waste and pollution' (Wiese and Mayrhofer 2020). Overproduction and overconsumption are not only problems of a linear economy, but can also become issues in a circular economy. Every production requires the transformation of energy and materials, which creates entropy and can have a negative impact on the environment by increasing the overall level of entropy (Georgescu-Roegen 1971; Rapf and Kranert 2021). As the problem of entropy cannot be avoided in any kind of sustainable future scenario (Jackson 2021; Corvellec et al. 2021), it becomes increasingly important to reduce or at least limit the overall level of production and consumption in the economy. In economics, these approaches have been discussed for some time in the debates on degrowth and the steady-state economy (Kallis et al. 2018), but what would this entail for the retail sector?

One way to immediately cap the supply side would be through selective product bans and the introduction of supply quotas for certain consumer products. Both are tools that are already used to regulate markets. Quotas on the supply side, for example, are used to prevent the overfishing of oceans and other natural resources. Today, product bans can exist for any type of product in the EU that does not meet minimum safety, environmental, and social standards (EC 2022a).

Regarding the retail sector, one could consider imposing selective limits on product variety in the market, at least in problematic product areas such as the ultra-fast fashion sector, whose business model is based on rapid product changes and low product quality (Mehrjoo and Pasek 2014). Another way to put the brakes on the supply side would be to introduce selective speed limits on the market cycles of certain products. This could include consumer electronics such as smartphones, whose short usage cycles of around 2.5 years are not in sustainable relation to their environmental impact. A study of the market cycles of smartphones shows that online retailers in Germany change 40 per cent of their product range within a year, while 16 per cent of smartphones are sold for a period of only 100 days (Poppe 2019).

There are many reasons for short usage cycles, but one of them is that the devices are usually not designed by the manufacturer to be used for long periods, and therefore they have short support cycles for software and spare parts, as well as generally poor repairability. The reasons for this lie in the business models of the manufacturers and retailers themselves, which want to keep the wheel of consumption turning by changing the models on the market every year and constantly introducing new models. But what would happen if major manufacturers such as Apple or Samsung started releasing a new smartphone model only every three years? The annual sales of new devices would certainly decrease, but it is also likely that manufacturers and retailers would be forced to shift more of their value creation to after-sales activities and services, where the focus would be on product preservation and life extension, which could lead to an overall increase in useful life (Ertz et al. 2019). The potential for retail could be to better differentiate itself from the competition by focusing more on the downstream part of the value chain. This could include better customer service and a better shopping experience, which is increasingly important to customers. It could also include more circular activities, helping consumers to make more sustainable choices, offering them maintenance or refurbishment services, and organising reverse logistics for better reuse and recycling of used products.

Reducing product variety and extending market cycles could play a more important role in sustainable market governance in the future. In its ecodesign directives,[11] the EU has already started to set legal requirements for minimum support periods for software and spare parts for some product groups. Specifically, the support period is set in relation to the market cycle of a product, which is an innovation in environmental product law. For example, for dis-

11 Directive 2009/125/EC.

plays, manufacturers and retailers are obliged to provide software updates for at least eight years after the sale of the last model.[12]

5.4.2 Demand side: demarketing and sufficiency-oriented consumption

Retailers can use their unique position to influence both upstream suppliers and downstream customers (Vadakkepatt et al. 2021). As customer-facing stakeholders, they can encourage and incentivise consumers to be more sustainable, not only by improving the sustainability of their products, but also by influencing consumer behaviour (Gossen et al. 2019). However, promoting sustainable and sufficiency-oriented consumption is not without its challenges, as retailers are usually interested in the rapid marketing and sale of products. Why, then, should retailers advise their customers to buy less and buy more responsibly? Fortunately, research shows that some of the trade-offs between economic self-interest and sustainability can be partially overcome.

Gossen et al. (2019), as well as Bocken and Short (2016), provide overviews on business and marketing practices and approaches that promote sufficiency-oriented consumption, which they define as the avoidance of over- and under-consumption in affluent societies. One example is the anti-consumption campaign of the fashion label Patagonia, which advertises its clothing with slogans such as 'Don't buy this jacket'. In general, research suggests that brands can benefit from marketing aimed at reducing consumption by improving the image of a product's quality (Hwang et al. 2016). This could also be applied to the retail of durable goods, where the benefits of long-lasting and high-quality products can be communicated to customers. A prerequisite for this is to provide customers with more information on the durability of products at the point of sale. To this end, the EU has already taken several measures in recent years as part of its Green Deal. Under the so-called EU Sales Directive (Directive 2009/125/EC), customers should expect products to have a reasonable lifespan, and retailers must provide information on support periods for software and spare parts, especially for electronic products. In addition, the European Commission plans to introduce a digital product passport for all products, which will include information on durability, repair, and other information relevant to the product's lifetime (EC 2022b). Consumers should have access to all the information they need at the point of sale to make informed and

12 Regulation (EU) 2019/424.

more sustainable purchasing decisions. Of course, not every retailer will benefit from more transparency in the marketplace, but, given the need for more sustainable consumption and production patterns, the measure seems reasonable and overdue. Although surveys clearly show that most consumers want information about the durability and repairability of products (Gnanapragasam et al. 2018), the impact of more transparency is not always clear and does not guarantee that consumers will switch to more durable products. However, increased transparency on product durability offers the potential to disadvantage short-lived products at the point of sale; this approach could go even further and include the deliberate demarketing of short-lived products on the market.

The concept of pro-environmental demarketing aims to suppress demand for certain products that are either scarce (e.g. electricity or water) or not desired by market authorities (e.g. drugs and counterfeits) (Ramirez et al. 2017; Kotler 2011). For retailers, this could include better placement and active recommendation of more durable products, or even excluding items from the store that do not meet certain quality criteria. Although customers highly value information on the durability of products, leading retailers in the durable goods market do very little to meet this specific customer need. While grocery retailers have been successful in implementing a variety of rating and labelling systems that indicate a product's sustainability and environmental profile, retailers in the durable goods sector are still lacking in initiatives that provide greater transparency regarding the repairability, durability, and longevity of products.

5.5 Conclusion: from product rotation to deceleration and circularisation

According to market research, sustainability is one of the biggest value drivers in retail (Deloitte 2021). Although rapid market cycles, immense product proliferation, and the ongoing discount battles show that retailers still rely heavily on the traditional 'make, take, and dispose' business model, there is a great opportunity for retailers to become key players and operators in a circular economy.

As the nexus for hundreds of millions of products and billions of customers worldwide, retail is in the best position to organise the bidirectional flow of materials and information along the supply chain that is necessary to make a circular economy work. Retailers are experts at sourcing and distributing products and materials, so why not use their skills to bring material back into the loop? Some deposit schemes are already in place, such as the generally successful bottle deposit scheme in Germany. In addition, retailers selling electronic equipment in Europe are required by law to take back old electronic equipment for disposal.[13] A revised law in Germany, ElektroG3, even requires food retailers to take back electrical equipment. Others, particularly fashion retailers, have successfully established take-back schemes on a voluntary basis. Some retailers have already started to offer used goods alongside new goods (Höfler 2021). According to market studies, the second-hand market and re-commerce are among the fastest-growing retail sectors (Deloitte 2022). These are all good developments that are slowly becoming mainstream.

In recent decades, retailers have become increasingly integrated into the vertical supply chain and have expanded their product and service offerings. In doing so, they have not only gained a great deal of knowledge about how markets work, but they have also become an important data hub for all product-related information. The flow of information is important in creating and providing opportunities for sustainable practices and in helping supply chain members to coordinate (Vadakkepatt et al. 2021). As part of the European Green Deal, retailers will be more involved in market surveillance to ensure that products meet all environmental and social standards. This includes the introduction of a digital product passport that must be accessible at the point of sale (EC 2022b). Ultimately, the question remains whether all this is enough for retailers to build economically successful circular business models. As the previous analysis has shown, most retail business is based on the rapid and highly competitive rotation of products in the market, which is inherently opposed to the idea of longevity, with retailers constantly under pressure to introduce new products more quickly. In contrast, retailers are in a unique position to benefit from any type of emerging circular business model, and they have a great opportunity to provide better products to people.

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6. Valuing electronic devices? User narratives and their role for durability

Tamina Hipp and Daniel Fischer[1]

> My grandfather has a washing machine that's 30 years old, and I think it's a bit mean because you can make these machines nowadays so that they're indestructible, so to speak, but it's not done because then the economy suffers because the company then says, 'Well, then I'll only sell one washing machine in a lifetime to everyone. That's not profitable.' (female interview participant, 29 years old)

6.1 Introduction

Why do some electronic devices remain in use for a short time and others for much longer? The durability of electronic devices, in addition to their robustness and reliability, is decisively influenced by how they are used. This chapter argues that everyday narratives about the use of electronic devices play a significant role regarding durability. We argue that narratives contain value judgements about objects that act as mediators between user practices and product life.

Narratives about the everyday use of electronic devices are often addressed in everyday conversations and are conveyed in the media. Whether they are about someone's grandparents' long-lasting washing machine, the printer that broke down prematurely, or a cherished kitchen appliance that has seen other devices come and go. Such stories are based not on facts but on the plausibility of events and their connections. Narratives about the everyday use of electronic devices are not only 'sediments of experience' (Haker 2010: 8); they also shape how people interact with electronic devices, as they provide orientation and a

1 A sincere thank you to Paul Lauer for his diligent proofreading of this article.

specific perspective. Moreover, users' experience, memories, and discussions about how they have used products – and for how long – take place within a narrative structure, as there is a temporal sequence and a connection between events.

Which practices of electronic device use are meaningful are revealed by the sequence of narratively coupled events. As electronic devices are becoming more and more technically complex and their inner processes more and more impenetrable to the user, using them is increasingly fraught with uncertainties. Against this background, we are interested in the stories that users tell us about electronic devices and the role those stories play in relation to durability.

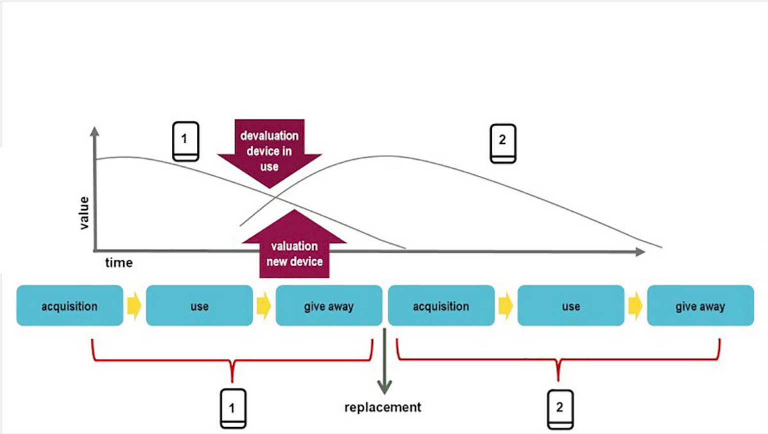
There is ample research showing that users tend to act inconsistently when it comes to their attitudes towards products in the different phases of use, from purchase to disposal (Echegaray 2015; Evans and Cooper 2010). These inconsistencies suggest that approaches that assume that users have fixed norms and value systems have only limited explanatory potential. For example, practices that are relevant to how long products are used for are strongly based on routines, but they are also dependent on context (Jaeger-Erben et al. 2016).

Wieser et al. (2015b, 2015a) propose that the narrative of planned obsolescence – the assumption that manufacturers shorten product lifespans by design – contributes to reinforcing practices associated with a shorter useful life, in that users who believe this assumption may prefer low-cost electronic devices and view repairs as pointless. However, there has been no systematic investigation into which narratives about the use of electronic devices in everyday life are relevant to their durability, and what function they may play in social practices that support or hinder practices relevant to durability. This study aims to contribute to closing this research gap by examining the relationship between practices of talking about the everyday use of electronic devices and use practices that are relevant to their durability. This chapter also helps identify starting points for consumer-focused sustainability communication (Fischer et al. 2021) to promote longer useful product lives as a contribution to achieving durable economies.

6.2 Theoretical background: value assignment by practices of sayings

Narratives are understood differently in different academic fields and traditions. Our approach is informed by theories of practices, which emphasise the materiality of the social and cultural on the one hand, and the implicit, informal logics of social life on the other (Reckwitz 2003). Following Schatzki (2000), practices can be differentiated into those of doing and those of saying. Narratives are thus conceived as verbal expressions in concrete settings, and although they are related to doings, doings and sayings are not mutually determinative. Durability-related practices can be seen as a nexus (Hui et al. 2017) of social practices that include material arrangements and social meanings as well as user competencies (Hipp and Jaeger-Erben 2021). In this context, the electronic devices themselves fulfil the function of linking these practices together over a period. According to practice theorist Warde (2005), consumption is a prerequisite for performing practices. Following Warde, acquisition is followed by appropriation, in which the user becomes familiar with the object, and appreciation, in which the object is used as intended. Evans (2019) adds another process, in which processes of devaluation and divestment occur before an item is discarded. Devaluation refers to the process of depreciation during use. During the phase of divestment, the object is not used, and an emotional and physical separation occurs until it is passed on in the final phase (Encino-Muñoz et al. 2021; Ortega Alvarado et al. 2020). Ortega and colleagues suggest combining these six phases to achieve an integrated understanding of product lifetime (Ortega Alvarado et al. 2020). Hipp and Jaeger-Erben (2021) recommend that the process of product usage should not be divided into distinct phases but should be conceptualised as a continuous process of value assignment. In addition, the replacement of electronic devices should be set in relation to the value assignment of new devices, as shown in Figure 6.1. Following Dewey (1939), a classic of valuation sociology, valuations are understood as processes in which value emerges from interaction. In short, 'value emerges from what people do' (Arnould 2014: 130). This perspective implies that value is also assigned through what is *not* done, such as a lack of product care. Since in the present study actions are not directly observed, the assigned values are reconstructed from practices described in the narratives of interviews analysed.

Figure 6.1: The change in value over the course of electronic devices use.



To understand the value assignment process more precisely, narratology offers helpful starting points. Brian Richardson (2000) defines a narrative as a representation of events that are causally connected. Other definitions of narrative emphasise that attributions of meaning are inherent to narratives (Bruner 1986; Ricoeur 1984). Unlike fictional narratives, everyday narratives are more deeply rooted in people's experiences. Through the process of remembering, narratives are reflected on, organised, and transformed into structures of meaning (Haker 2010). According to psychologist Laurel Richardson (1990), narratives are a part of sense making, and by conveying values and emotions they influence the ways in which the world is perceived. In line with these understandings, we define a narrative as a sense-making story that describes how a subject engages with and interprets the world. This emphasises the function of narratives as a frame of reference for practical everyday action. Narratives about the use of electronic devices reflect everyday life arrangements (Bødker et al. 2014; Middleton et al. 2014) concerning how often and how intensively devices are used – and especially for what purpose. This can yield insights that are important in reconstructing practices relevant to the durability of products (e.g. avoiding defects). However, according to the distinction of practices of doing and saying, narratives do not simply express individual consumption practices. They emerge in social structures, reflect material arrangements, and are shared collectively; as such, they entail social and cultural references (Rahmanian 2021) and reproduce and influence cultural patterns of interpretation that legitimise the meaningfulness of ways of using electronic devices.

From a practice theory perspective, it is of fundamental interest how communication is enacted physically and habitually. Following John Austin and Ludwig Wittgenstein, Schatzki (2000) considers speaking to be a social act, which thus emphasises the action of the speaker. According to Wagenaar (2011, quoted in Bueger 2014), narratives give temporal and spatial coherence to social practices. They offer an understanding of situations by presenting interpretations about intentions and the consequences of actions. Narratives can reduce complexity, give direction, and allow us to act with greater certainty by providing the basis for judging actions. As Schatzki puts it: 'Sayings and texts contribute to what makes sense to people to do and the intelligibility of things in the world' (Schatzki 2017: 134). Therefore, from the perspective of practice theory, we are not primarily interested in whether a narrative is true or false, or what the intention of the narrator was, but rather in the function a narrative has within the nexus of practices (Bueger 2014; Neumann 2002) – that is, the performative quality of a narrative (Rivera and Nanz 2018). Specifically, we ask which social practices are favoured or disfavoured by narratives and to what extent.

6.3 Research design

This study is exploratory and inductive in nature, following the methodology of reflexive grounded theory (Breuer et al. 2018; Bryant and Charmaz 2011; Mey and Mruck 2011; Strauss and Corbin 1996). It employs problem-focused interviews with users. The findings are supplemented with quotes from 'device stories' on durable electronic devices that were collected in the context of an online campaign.[2]

A special feature of grounded theory is that data collection and data analysis are not conducted as two separate phases, but iteratively. After the first interview was conducted and evaluated, the next interviewee was selected based on the results. It is of crucial importance in this procedure to continuously check theorising approaches that arise in the process, especially through theoretical sampling of contrasting cases. Hence, respondents in this study were purposively selected for specific characteristics to drive theory building. In our

2 See https://langlebetechnik.de/Aktion.html.

case, we were particularly interested in our respondents' experiences with using electronic devices, their usage intensity, and equipment, as well as their concern about durability. Fifteen problem-focused interviews lasting approximately 90 minutes each were conducted with electronic devices users (aged 14 to 78 years) from all over Germany. In addition to the interviews, users kept diaries to document their use of smartphones and washing machines over a period of two weeks.

The interviews were transcribed and analysed using the coding paradigm of Strauss and Corbin (1996) as previously adapted to our research question. The coding paradigm analyses social phenomena in terms of four aspects: conditions, contexts, actions/interactional strategies, and their consequences. The coding of the material was done in three methodological steps: open coding (identification of categories), axial coding (connections between categories), and selective coding (recoding regarding the central category). The method of constant comparison was used. The lead author repeatedly explored the data material based on the questions inspired by the coding paradigm. The paradigm explored which action strategies the interviewees deemed appropriate taking contexts and intervening conditions into consideration. These questions directed the analysis to explore how value was attributed to electronic devices. The analysis showed that users assign a value to their devices in the process of using them and that this value shapes future ways of using devices.[3] During the analysis, we coded all passages in which a positive, negative, or neutral value was assigned to the devices. The analysis revealed the central role played by experiences with devices as well as by stories from others or in the media. From a practice theory perspective, it was crucial to understand the functions a narrative assumes within a network of practices. Therefore, in a second phase, we analysed how social practices are favoured or disfavoured in experienced, narrated, and media stories. In an iterative process, ten narratives were identified that featured prominently in user stories about electronic device use. As is common with grounded theory, interpretations were discussed in research colloquia. We acknowledge credibility as an important criterion of rigour in qualitative research (Tracy 2010) by including extensive excerpts of the material below to allow readers to evaluate the accuracy of our interpretations.

3 These findings have already been published in an article (Hipp and Jaeger-Erben 2021).

6.4 Classification of narratives

Narratives about the everyday use of electronic devices that are relevant to durability often exert an orientating function for everyday actions in concrete situations. People justify their own actions through action strategies that have proven useful in the past.

When talking about their devices, many respondents referred to narratives they know from the media to justify their actions, addressing such issues as successful and unsuccessful repairs, planned breaking points in devices (planned obsolescence), technological innovations highlighted in advertising, television shows about decluttering, and documentaries about the consequences of mass consumption. During the analysis process, we identified ten narratives about the everyday use of devices that are relevant in the context of durability. We classified these into three groups, based on whether the narratives frame the devaluation of the electronic device as accelerated or decelerated, or whether the devaluation was context-dependent – that is, the devaluation could be both accelerated and decelerated depending on additional conditions. In Table 6.1, the ten narratives are assigned to the three groups. The table represents narrative types as ideal constructs. In practical application, narratives are combined and contrasted with each other, as shown in the explanation below.

Table 6.1: Classification of narratives based on their inherent valuation of electronic devices.

Classification	Narrative
Depreciative	'Devices are unmanageable'
	'Repair isn't worth it'
	'The new is appealing'
Ambivalent	'My daily life depends on my electronic devices'
	'High-quality electronic devices last longer than cheap ones'
	'Manufacturers intentionally manipulate the lifespan of electronic devices'

Appreciative	'I don't need anything else'
	'I'm not part of this throwaway society'
	'My device is my companion'
	I have someone to help me'

6.4.1 Depreciative narratives

Narratives that were associated with an accelerated devaluation of electronic devices in everyday life refer to processes of devaluing the device currently in use and valuing a new device. These are often narratives about devices being unmanageable, maintenance and repairs not being worthwhile, and new devices being more attractive. Table 6.2 contrasts key characteristics of these three narratives.

Table 6.2: Characteristics of depreciative narratives.

	'Electronic devices are unmanageable'	'Repair isn't worth it'	'The new is appealing'
Subject of narrative	Regular technical malfunction, spontaneously or in the wrong situations	Repairs are expensive, time-consuming, and associated with risks, while buying something new is easy and safe	More innovative electronic devices are more attractive than old ones
Valuation of device	Complete devaluation of the device possible		Accelerate valuing new devices and devaluing used devices

Practices favoured or disfavoured by narrative	Favour premature product replacement, although the device may have been operated incorrectly or could be repaired Disfavour obtaining fault diagnosis or repair	Favour replacement of devices that are (partially) defective Disfavour checking repairability or carrying out repair	Favour justifying a replacement purchase for a working product and replacement for partial defects Disfavour caring for and repairing older devices

The narrative 'electronic devices are unmanageable' includes stories about electronic devices that malfunction and have defects. Malfunctions can occur from the beginning of the device's use, regularly or spontaneously, and can lead to a complete devaluation of the device. The narrative makes it seem reasonable to replace devices even though they still mostly work, could be repaired, or do not work as expected due to a lack of user competence. Frequent elements of such narratives are attributions of responsibility for (partial) defects. Malfunctions and defects are attributed either to one's own bad luck or lack of competence or to poor product design or faulty production. When devices do not work in situations perceived as important, this can be associated with annoyance, frustration, and anger by the interviewees, as the following quote from a geriatric nurse illustrates:

> I never had mobile phone reception. And text messages and things like that arrived much too late … For example, I once didn't get a message that a patient had died. But I went there and got totally involved in the mourning scene, where all the relatives were there … And then, when I was sitting in the car again, completely dejected, the news came. And then I was also pretty fed up with it. (w, 34 years old)

Users describe that the device is replaced when the hassle becomes too much, as happened after the experience described above. The 'devices are unmanageable' narrative is often reported along with narratives about how repair efforts are not worthwhile.

The narrative 'repair isn't worth it' goes hand in hand with a complete devaluation of a device if it has malfunctioned or has a defect. The expression 'worth it' refers to a subjective, relative assessment that evaluates buying a new device as better than repairing the old one. The (presumed) monetary costs associated with a repair, the (possible) amount of work involved, the perceived risk of failure, and the expected short time remaining in which the device can still be used are cited as hurdles to a possible repair. Bad experiences of unsuccessful repair attempts are regularly associated with negative feelings such as anger and frustration among users, even after a longer period. Such experiences are used as a reference for not attempting a repair the next time a defect occurs. The narrative can also be disconnected from the user's own experience, as observed with users who state that repairs would never be worthwhile, even though they have never attempted to carry them out themselves or have someone else do so.

Often, in the narratives, a repair is not considered because a new device is described as more attractive. In this combination with the 'new is appealing' narrative, the perceived benefits (features, design) of a new generation of electronic devices are emphasised to justify the purchase of a new device. This narrative may also favour the replacement of functioning electronic devices, as well as disfavour the maintenance of devices perceived as obsolete. The interviewees report that 'new' is communicated to them as attractive at various touchpoints. For them, this includes marketing as well as interactions with other users and social media, such as unboxing videos in which users document how they unpack and try out new electronic devices. Narratives that implicitly accelerate the devaluation of used devices are frequently linked to ambivalent narratives.

6.4.2 Ambivalent narratives

The function of narratives to provide meaning and orientation can also be combined with an ambivalent inherent devaluation of electronic devices, depending on the contexts in which the narratives are used. The three ambivalent narratives – 'not without my device', 'high-quality devices are more durable than cheap ones', and 'manufacturers intentionally manipulate the lifespan of electronic devices' – are described below. Table 6.3 compares their characteristics.

Table 6.3: Characteristics of ambivalent narratives.

	'Not without my device'	**'High-quality devices are more durable than cheap ones'**	**'Manufacturers intentionally manipulate the lifespan of devices'**
Subject of narrative	Devices are indispensable for everyday life	Electronic devices differ in terms of quality and service life	Manufacturers intentionally build breaking points into devices to increase sales
Valuation of device	Valuing the device due to dependency In case of non-usability, potentially complete devaluation	Identify quality (brand, price, country of origin, service) as a differentiating factor for the relative valuation of devices	Suddenly devalue device if broken, but value it if repaired (repair as empowerment and rebellion)
Practices favoured or disfavoured by narrative	Favour caring practices – high intensity of use leads to heavy wear Favour regular new purchases and immediate replacement in case of defects	Favour purchase and repair of medium-and high-quality devices Disfavour purchase and repair of low-quality devices	Disfavour a willingness to buy expensive devices as well as a willingness to make repairs ('everything is rigged') Favour an avoidance of specific brands Favour a commitment to repair

In many stories about everyday product use, users portray electronic devices as indispensable for everyday life. These are grouped together here in the narrative 'not without my device'. Examples of indispensability include temporal comparisons in which life in the past is contrasted with the demands of life today, or descriptions of efforts that users make to be able to use a device (e.g. driving straight home when the mobile phone is forgotten). In this respect, practices that promote durability (e.g. spending more money on quality, using products carefully, repairing defects) appear meaningful. However, narratives revealing a significant dependence on devices are often associated with above-average product use, as a comparison of diaries documenting the intensity of electronic device use reveals. In terms of practices, more intensive product use increases the risk of damage (e.g. from dropping mobile phones). When combined with the narrative 'electronic devices are unmanageable', unexpected malfunctioning can cause annoyance, although the device is nevertheless highly valued; this can lead to ambivalent feelings, as the following quote illustrates:

> Love–hate. The hate is because this thing might send notifications at night, when I don't want it to notify me at all. Some bing sound is activated at night, and you're wide awake and can't sleep for another four hours … but if you forget it at home, that's actually the term for love, if you miss something, then there must be a love there. So, if you forget it at home, it's already a drama. (m, 51 years old)

The 'high-quality devices are more durable than cheap ones' narrative includes stories about how investing in a medium-or higher-quality device is financially worthwhile in the long term compared with low-priced electronic devices, as a longer service life can be expected. The main characteristics for valuing quality are the brand image, country of origin, service, and price. People refer to their experiences and reports from their social environment as evidence of quality. The narrative can thus favour a willingness to accept a higher purchase price and disfavour buying cheap devices. If the device is described as high quality, this also favours a willingness to repair the device instead of replacing it. However, in the interviews, this narrative is often used as a justification for not caring for or repairing cheap devices. The narrative 'repair is not worth it' often frames efforts to ensure durability as useless, because they would not pay off. In this case, the period of time for which a product is used is seen as a question of whether users are capable of selecting and paying for high-quality devices. A temporal comparison is typically made, especially from people in the sample who were socialised in the former German Democratic Republic. In this comparison, 'in the past', devices were produced more robustly and in ways that made them easier to repair compared with devices produced today. Some interviewees expressed the maxim of staying 'in mid-point' of the range of options when buying a device, to neither spend too much money nor buy a low-quality product. In some cases, the expected product service life is derived directly from the purchase price, thus reducing the quality issue to price. Others, however, associate premature product failures as planned obsolescence.

The narrative 'manufacturers intentionally manipulate the lifespan of electronic devices' (publicly discussed as planned obsolescence) describes the belief that users are deceived and pressured to buy new products by manufacturers intentionally building defects into the design of products to shorten their lifespan. As evidence for this manipulation, people rarely refer to their own experience and only sometimes to experiences of friends; mostly, they note that it is a plausible and rational strategy for manufacturers to increase sales. According to the majority of interviewees, only some designers ('the bad guys' versus 'the good guys') would intentionally build in breaking points in selected product groups. In such cases, the narrative may involve avoiding specific brands, especially if people have had bad experiences with these brands before. If planned obsolescence is framed as a common strategy, it does not seem to matter to some interviewees which electronic devices they choose, since they expect to be manipulated anyway; accordingly, additional costs for more expensive devices would not be worthwhile. During the interviews, however, these interviewees also distinguish between quality criteria such as brands. When combined with the narrative 'new is appealing', they conclude that long periods of use for devices with short innovation cycles are not necessarily advantageous because more innovative devices make older versions obsolete. From this perspective, planned obsolescence is not a problem since devices are not intended to be used for long periods of time. More tech-savvy users point out that lifespan would be more subtly manipulated by making repairs more difficult through lack of standardisation and compatibility, cases that are glued shut, and the non-availability of spare parts. Interviewees can only speculate whether premature failures are intentional or due to a lack of competence in design: 'About planned obsolescence ... well, I had a bit of a suspicion, you have to be relatively stupid to do something like that accidentally' (m, 45 years old). In some cases, premature product failures motivated users to repair the devices. If the repair succeeds, this can be accompanied by a sense of self-empowerment and can enhance the device as it acts as evidence of one's skill and autonomy. Overall, the orientation-giving function of the narrative for using electronic devices is low, since there is great uncertainty about whether planned obsolescence exists and how widespread this strategy is. In contrast, people's own experiences and recommendations from their social networks are more important.

6.4.3 Appreciative narratives

In the interviews, many stories were shared that are related to a slowed down devaluation of electronic devices. They may also be accompanied by an appreciation of devices in use or a devaluation of new devices. The stories are about sufficiency, sustainability, faithful devices as life companions, and mutual support for technical problems. A brief description of the narratives is juxtaposed in Table 6.4.

Table 6.4: Characteristics of appreciative narratives.

	'I don't need this'	**'I'm not part of this throwaway society'**	**'My device is my companion'**	**'I have someone to help me'**
Subject of narrative	A (newer) device is not needed because the device used meets the needs of the user	The level of consumption is too high and the environment is harmed by the waste produced Sufficiency makes the user happy	Devices are attributed a nostalgic value because they are linked to biographical events	Support is given by people from the local community and social network in selecting a product, providing tips on use and helping identify problems
Valuation of device	Value old devices and devalue new devices			Slow down the devaluation of used devices
Practices favoured or disfavoured by narrative	Favour all life-extending practices and disfavour all life-shortening practices			Favour compensating for a lack of user competence by a competent environment throughout all phases of use

The narrative 'I don't need this' comprises everyday stories in which users describe that they do not need a newer, more modern, or more innovative product version or device category. It is not about unhappily doing without something but describes the absence of desire to own something else. It acts as a counternarrative to the 'the new is appealing' narrative and is often voiced by users to distance themselves from the consumption of devices they consider unnecessary. In some narratives, the quality of the devices owned is compared with more recent versions and valued as equal. Stories in which older devices are valued address not only repairs but also updates, hacked operating systems, and modifications to technical devices. In some stories, not only the electronic device itself is criticised, but also the intensity with which it is used. Predominantly, people aged 60 and older criticise (perceived) increasing mobile phone use as disruptive to social interaction.

The narrative 'I don't need this' is frequently combined with stories about people throwing away too much. The narrative 'I'm not part of this throwaway society' includes narratives about overconsumption in Western societies. Excessive resource use and ecological damage are morally condemned. Industry is blamed for fuelling mass consumption through marketing, fashion, and oversupply, and people are blamed for allowing themselves to be persuaded that they require more.

Typically, mountains of junk, which are familiar from the media, are described pictorially. In this narrative, narrators distance themselves from people who always want to have the latest thing and exchange their functioning devices for new devices. A reluctance to throw away working devices is found in almost all such interviews. In this context, electronic devices are considered valuable and too good to throw away, as the following quote shows:

> I would like to see more consciousness [in using things], what kind of brainpower goes into some things … With good things, where some people have put a lot of effort into [them]. (m, 45 years old)

This narrative is primarily a criticism of the actions of others; rarely is it connected with the narrative 'manufacturers intentionally manipulate the lifespan of electronic devices' or related to a lack of quality. Premature breakdowns and bogus innovations are criticised not only as consumer deception, but also as an unnecessary waste of resources. The narrative is regularly combined with stories about how people have owned certain durable devices for a particularly long time.

The narrative 'my device is my companion' comprises stories in which certain old electronic devices are linked to biographical events. One example of this is the quotation at the start of the chapter about the washing machine lasting a lifetime. New phases in life – such as beginning your apprenticeship, renting your first flat, or going abroad – may necessitate acquiring new devices. In retrospect, a nostalgic value is then attributed to the devices. Limitations both in usability and in the range of functions are often accepted, as the appreciation that the device 'still works' prevails.

These three narratives are associated with a slowing devaluation of electronic devices and positively emphasise their durability, their ease of use and repairability, and their timeless design. When these narratives are used, a high level of tolerance is typically shown for devices with partial defects; devices with quirks continue to be used instead of being replaced immediately. They support life-extending and overall resource-conserving practices in the context of device use, such as second-hand purchasing, product maintenance, and repair. These narratives also disfavour the desire to replace electronic devices if their basic functions still work or can be repaired.

A fourth narrative, which is associated with slower devaluation, addresses help and mutual support from other people. Nearly every interviewee reported either receiving regular advice on devices in their social circles or providing support to other people, particularly with issues concerning product selection, diagnosis related to malfunctioning, and repair. The narrative 'I have someone to help me' is about how skills are available in one's own community or social network, how one's own skills and abilities continue to develop through learning from one another, and how used appliances are passed on to others. In the interviews, adult children were more likely to pass on information and entertainment electronics to their parents, while parents were more likely to give household appliances to their adolescent children, primarily when they moved out. It is interesting to note that it is not only family members and friends who offer help and advice; there are also extensive support networks.

6.5 Discussion

This study combined practice theories, narratology, and the sociology of valuation to analytically focus on two features of narratives about the use of electronic devices: first, that they distil experiences of human–device interactions; and second, that they thereby also shape users' future engagement with devices. We have reconstructed value assignments to devices as a significant mediating entity between doings and sayings. These value assignments might be conscious to the users, but they do not have to be, since interactions with devices are often routine and thus are predominantly organised through practical consciousness (Giddens 1984). Instead of referring to individuals' fixed norms, values, and attitudes and thus reproducing the discrepancy between attitudes and behaviour (El Haffar et al. 2020; Evans and Cooper 2010) that is frequently found in research, we analysed the function of narratives in networks of practices and thus emphasised their situational dependence. Narratives are anchored in material arrangements, but they are combined and adapted depending on the context (Neumann 2002): 'In reality, individuals, and technologies exist in a "sea of stories" – in the midst of texts, histories, norms, and the constraints and capacities of infrastructures and technologies' (Harmon and Mazmanian 2013: 1059). In this chapter, we examined the functions that frequently occurring narratives about everyday use of electronic devices exert within practice patterns in using those devices. In classifying ten narratives into three groups, a distinction was made between accelerated, decelerated, and ambivalent devaluations of devices currently in use.

Depreciative narratives frame devices as unmanageable in use and consider more modern devices as more attractive in comparison. The effort and expense of repair are not considered worthwhile under the circumstances, so product replacement seems more sensible. Appreciative narratives associated with the decelerated devaluation of the device in use address sufficiency as well as an often moral view of the throwaway society and frame devices as loyal and reliable life companions. They often address mutual help with technical problems and how used electronic devices are passed on in communities. These differences are important in relation to expected product lifetimes, which are shaped by experience (Cooper 2004; Hennies and Stamminger 2016; Knight et al. 2013). The expected lifetime, in turn, shapes user practices: if a longer lifetime is expected, users are more willing to pay higher prices for devices (Ihemezie et al. 2018; Jacobs and Hörisch 2021) and to invest money and effort in repairing them (Okada 2001). With a shorter expected remaining lifetime, electronic devices are replaced more quickly because they are thought to have already amortised their cost (Berge et al. 2020; Nes and Cramer 2006; Okada 2001).

The interviews suggest that negative experiences are remembered more intensely than positive ones, and that premature failures are therefore more mentally present than devices that have functioned flawlessly for decades.

This is in line with Baumeister et al.'s analysis that 'bad is stronger than good' (Baumeister et al. 2001), according to which negative feelings or fears motivate action more strongly than positive feelings and hopes. They state that the overall impression remains negative when there is an equal number of events rated as good and as bad. Therefore, it takes several positive experiences to compensate for a single negative one. In this analysis, the approach often used in sustainability communication – presenting premature product failures as a strategy of manufacturers (planned obsolescence) – appears problematic, even if this approach receives attention due to its emotional appeal. Instead, a narrative framing devices as valuable might be more useful in strategic communications to support durability-enhancing practices. Practice theorist Spaargaren also advocates a 'positive view' on sustainable consumption (Spaargaren 2011: 820). Instead of portraying electronic devices as overly complex and as ticking time bombs, devices could be framed as faithful companions or intelligible machines, thus reinforcing lifespan-favouring practices, as some NGOs are already doing (Persson and Klintman 2022). Positive visions of a future circular society – for example, with ecological, social, and economic benefits, but also an increased joy in life – could also help make sufficiency practices appear meaningful.

In addition to appreciative and depreciative narratives, a third type, ambivalent narratives, was identified. These need to be considered in a more nuanced way: depending on the context, they can be associated with both accelerated and decelerated devaluation. The 'not without my device' narrative can both support lifespan-extending practices (such as choosing high-end devices and care practices) and encourage premature product replacement to prevent potential functional failure. Such ambivalent relationships have also been described as characteristic of technology use more broadly. One example is Mazmanian and colleagues' (Mazmanian et al. 2013) description of the autonomy paradox, in which technology on the one hand supports the perception of personal autonomy, as users can use technical devices to transcend temporal and spatial boundaries. On the other hand, constant accessibility makes it almost impossible to preserve self-determination. The narrative 'high-quality devices are more durable than cheap ones' can be invoked both to not repair devices because of their inferior quality and to justify the purchase of high-quality devices. Although studies prove that more expensive devices generally last longer than less expensive devices, devices are often used for shorter periods than expected (Hennies and Stamminger 2016).[4] However, the expected lifespan is not transparent for the consumer. Results of this study show that the narrative 'manufacturers intentionally manipulate the lifespan of electronic devices' is used to legitimise the choice of inexpensive appliances and of not repairing appliances, as suggested by Wieser et al. (2015b). On the other hand, it has been shown that the narrative can also favour repairs if they are understood as an act of rebellion against immoral product policies. Furthermore, according to Ackermann (2018), the fact that manufacturers make repairs more difficult can be a motivation for users to repair electronic devices. Various studies indicate that repairing devices can evoke positive emotions and stimulate product loyalty (Ackermann et al. 2018; Desmet 2012; Page 2014; Scott and Weaver 2014; Wieser and Tröger 2018). Overall, the present study found few connections between beliefs about planned obsolescence and accompanying actions, which may also be due to uncertainties about whether manufacturers are tampering with electronic devices. Experiences and personal advice from the community and social networks are considered to have a greater orienting function. Because this narrative has a strong potential to arouse anger, it is often used by NGOs as a mobilisation strategy. The results of the study suggest that it may be more appropriate for NGOs to value rather than devalue electronic devices in communications in order to support desired user practices.

However, from the perspective of consumer-focused sustainability communications (Fischer et al. 2021), to which this study set out to contribute, the narratives about the everyday use of electronic devices identified in our research can be viewed from several perspectives, three of which are briefly highlighted here: an interpretive-reconstructive, a critical, and an interventionist perspective. From the interpretive-reconstructive perspective, the narratives can be interpreted as manifestations of overarching discourses on achieving sustainable consumption, as exemplified by the distinctions between status quo, reform, and transformative-oriented understandings of sustainability (Hopwood et al. 2005); the juxtaposition of strong and weak conceptions of sustainable consumption (Hobson 2013); and strategies of efficiency, sufficiency, and consistency (Huber 2000). For example, the narratives 'new is appealing' and 'I'm not part of this throwaway society' can be interpreted as poles of tension between technologically oriented approaches to ecological modernisation and approaches such as degrowth. Against this background, what is intriguing about the narratives is that they show connections to various ideo-

4 'Schon kaputt? Geräteverschleiß', Stiftung Warentest press release, September 2013.

logical positions in sustainability discourses, which can also be strategically utilised for sustainability communications.

From a critical perspective, the narratives about the everyday use of electronic devices could be examined in terms of their underlying power relations. In such a perspective, questions about the social validity of knowledge, agency, and attribution of responsibility (responsibilisation processes) would come to the fore (Fuchs and Di Giulio 2016; Giesler and Veresiu 2014; Leipold and Winkel 2017). In these perspectives, narratives provide a lens to understand how sustainability concerns are framed in terms of what the problem is and what are its causes, as well as which solutions are to be preferred (Luederitz et al. 2017). In contrast to the interpretative perspective, the emphasis here is on how actors strategically shape collective understandings of and preferences for desirable transition pathways. The findings show that narratives of transitions into 'durable economies' can take different positions in terms of how they attribute responsibility and agency to users, producers, and state actors when it comes to electronic device use. In the mobility sector, for example, such aggregated, collectivised 'grand narratives' revolve around notions of consuming less (low mobility societies), consuming differently by sharing (collective transport 2.0), or producing differently (electric mobility) (Holden et al. 2020). The narratives identified in this study contain similar building blocks in relation to durable economies in their focus on extending usage and delaying new purchases (consuming less), maintaining and repairing (consuming differently), or holding producers responsible for designing for durability (producing differently).

Finally, from an interventionist perspective, one can ask how narratives can be used to promote longer product lifetimes. Studies suggest that, at least in specific circumstances, narrative argumentation structures have a greater persuasive power than facts alone. For example, Hamby et al. (2015) conclude that product valuations in narrative form have a stronger influence on purchase intention than argumentative structures. In terms of strategic communication, the results of this study offer starting points for counteracting narratives that promote accelerated devaluation processes. Depending on how the narrative is positioned – for example, user competence in the narrative 'electronic devices are unmanageable' versus attractiveness in the narrative 'new is appealing' – various tried-and-tested approaches to sustainability communication seem suitable: for example, messages targeting cognitive-analytical, affective-experiential, or social-normative dimensions (see Linden 2017).

The study presented in this chapter suggests that it could be fruitful to focus on how value is assigned to electronic devices in narratives. Narratives that assign high value to devices may also support product longevity. There should be a focus on narratives about how investing in high-quality devices pays off, devices are durable, care practices and protecting devices are worthwhile, repairs are successful, help can be found in the community and social networks, and sustainability is an important principle for action to support resource-conserving device consumption. In addition, stories about positive experiences with sufficiency and collaborative consumption might help strengthen people's willingness to share, borrow, and exchange used electronic devices and their interest in doing so. It would be interesting to first investigate the effect of narratives on consumption in an experimental study designed to answer the question of how narratives affect actual product use and durability. Further research could go deeper and also ask what role narratives about the everyday use of electronic devices play in (behaviour-changing) learning processes or in (behaviour-stabilising) justification processes, and how problematic narratives can be reinterpreted in terms of sustainability (reframing; see Weder 2021) to support durability-enhancing practices.

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7. Regulation with a lasting impact? Policies for product durability

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Poor people cannot afford cheap things. *(Finnish saying)*

7.1 Introduction

Extending the lifetime of products and components has the potential to slow down the overall flow of resources in the economy (Bocken et al. 2015) and support the circular economy (CE). A CE is promoted as a conceptual model towards a more sustainable system of consumption and production (Sustainable Development Goal 12) (see, e.g., Khajuria et al. 2022). The lifetime of most products can be extended through the use of more robust materials, design for durability, care, maintenance, repair, and reuse, thus reducing waste and the need to extract materials for manufacturing. These strategies, and the importance of product lifetimes in a CE context, also mean that there is a strong correlation between: 1) product policies that support a CE; and 2) the concept of product durability (i.e. products that – in some way or another – maintain their function, form, and attractiveness over time). While different product groups face different interpretations of durability and different challenges – for example, the implications of durability for textiles will differ from those for electronics (see, e.g. Klepp et al. 2022) – there is still a common overarching issue of overproduction and overconsumption, even of durable items.

The choice of which products to purchase is important as it creates 'lock-ins'. For instance, buying second-hand (or retro) items is increasingly popular in many countries, but if our parents and grandparents had chosen to purchase cheap stuff with limited durability, there would be nothing retro to buy today. In addition, product characteristics are determining environmental impacts in several other ways, such as resource use (purchasing fewer but more durable products leads to using less material), energy use (how energy efficient is the product?), toxic waste (does the product contain dangerous substances?), and plastic pollution (what is the product made of?).

Looking back in time, some authors argue that consumer and professional products were more durable or were used for longer than they are today, and people used to maintain and repair them on their own or by using cobblers, tailors, blacksmiths, etc. (Slade 2006; Strasser 1999). One example, from one of the authors of this chapter, is a shirt inherited from his father: the shirt survived over 40 years of intense use without any need for repairs. The introduction to this book argues that the mass production techniques introduced in the Industrial Revolution made it possible to produce larger volumes of standardised products, as well as increased durability and accumulation. This led to concerns that, if the products had a very long lifetime, demand would not be able to match supply, and not all products that were manufactured could be sold (i.e. overproduction), thus leading to unemployment and economic recession. An important asymmetry between the supply and demand of products is indeed seen as one of the factors leading to the Great Depression of the 1930s. An answer to this problem was thus for manufacturers to shorten product lifetimes through the active planning of product obsolescence, as elaborated by London (1932). In other words, a wide range of products were made to break prematurely, prompting quick replacement and high consumption levels (Slade 2006).

Victor Lebow summarised the implications of what is known as a 'productive economy':

> *Our enormously productive economy … demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfaction, our ego satisfaction, in consumption … [W]e need things consumed, burned up, replaced and discarded at an ever-accelerating rate.* (Lebow 1955)

Obviously, these trends do not apply to all kinds of products, or all markets. There are still examples of well-crafted products in some markets, e.g. for furniture, machinery, and professional clothing, not least in business-to-business markets. Further, 'premature' obsolescence, whereby manufacturers make a product 'good enough', considering consumer expectations and price competition, is increasingly problematic (Dalhammar et al. 2021b). This implies that obsolescence is not necessarily 'planned'. It is nonetheless evident that there are indeed many low-quality consumer products on the market, and poor quality is a key reason behind, for example, e-commerce consumer returns being destroyed by the retailer without the items ever being in use; destruction is less costly than making the returned product available for sale again (Roberts et al. 2023).

It is increasingly understood that public policy interventions are necessary to enable longer product lifetimes as part of a CE, given the existing barriers found in the current 'linear' economy. To this effect, in the last 20 years, both EU and national policymakers have attempted to address growing concerns about the environmental and human health impacts of production, consumption, and waste. Pursuing product durability is part of these policy efforts to realise a CE, with the assumption that slowing product loops can slow the impacts of production and consumption. Required policy interventions for the CE include both the adoption of new policies (e.g. on product design) and changes to existing policies (such as consumer laws) that act as barriers to circular solutions. The literature argues for policy changes in international (Lindahl and Dalhammar 2022), European (Wilts and O'Brien 2019; Milios 2018), national (Circle Economy n.d.; Milios 2016), and regional and local (Circle Economy 2019; Dagilienė et al. 2021) levels. Product-oriented policies, such as design standards, guarantees, public procurement, and lifecycle costing measures, are a key part of the CE policy agenda.

Promoting product durability is part of these policy efforts. However, on its own this would not solve the current problems related to our consumption patterns. Although more durable products may often cost more, both to produce and to purchase, there are many barriers beyond product durability that must also be addressed (such as the primacy of shareholders and other shortcomings in company law, as well as short-term and narrow pressure for the maximisation of returns to investors in financial markets and the banking sector) if we are to achieve a true sustainability transition (Sjåfjell et al. 2019). Otherwise, we risk upholding mass production, overproduction, and the consumerist society, but with more durable products, thus potentially aggravating both ecological and social pressures.

Consumers are also important actors: they must be willing to invest in high-quality products. However, while consumers generally want more durable products, there is evidence that this mainly applies to certain product categories (Dalhammar et al. 2021b), and it is questionable whether consumers in general are prepared to pay more for durable products (Sajn 2022). There is also a gap in policies addressing citizens and consumers.

In this chapter, we consider the concept of 'durability' in relation to the production and consumption of products, and we explore how public policies can promote longer-lasting products through targeted policy interventions. Public policies have an important role in shaping economies; in essence, they influence the rules of the game. We focus on the context of the EU to exemplify the multi-level and multi-dimensional character of such policy approaches. In Europe, several policies have been adopted that address the various lifecycle aspects of products (for an overview, see, e.g., Dalhammar et al. 2021a), including regulating chemicals in products (Alaranta and Turunen 2021), producer responsibility rules that mandate consumers to collect and recycle end-of-life products (e.g. Manomaivibool 2009; Maitre-Ekern 2021), and rules that set minimum energy efficiency standards for products (Dalhammar et al. 2018). This policy mix is complemented by other policies that address several environmental aspects, such as ecolabels and sustainability criteria in green public procurement (Milios 2016; Dalhammar et al. 2021a; Hansen et al. 2021).

In this contribution, we critically examine these policies and discuss additional policy interventions that could promote longer-lasting products and components. The stated research objectives are to:

- describe and analyse emerging European policies that aim to increase product lifespans; and
- relate policy developments to the concept of a 'durable economy' for products.

The methods employed are:

- literature searches using relevant keywords in Scopus, Web of Science, Google Scholar, and LUBSearch; and
- a policy analysis, which in this case involves an analysis of current policies and potential policy outcomes, and the consistency of the 'policy package'. When relevant, references are also made to specific laws.

We mainly deal with consumer products (business-to-consumer), not business-to-business. We have not limited our analysis to specific product categories, but many of the examples are related to consumer electronics and appliances. The analysis is nonetheless relevant for textiles and furniture. Further, we consider various types of policies (i.e. administrative, economic, and informative) and various legal fields (e.g. consumer law and product regulation). The main focus is on EU policies and national policies, but, in some cases, references are made to local initiatives.

Chapter 1 of this book put forward the argument that durability is a contested quality whose definition remains something of a black box, and that there are multiple qualities to durability that contribute to the ability of things to hold their shape, such as robustness, sturdiness, reliability, stickiness, timelessness, and resilience. These qualities, in turn, also influence whether products become prematurely obsolete as well as the length of their lifetimes. In addition, practices of consumption, use, repair, and so on are determinants for durable economies. The production of more durable products does not in itself create a less consumerist society.

In a European standard, durability is more formally defined as the 'ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached'.[1] In this case, we are examining product durability in terms of qualities of robustness and functionality, recognising that these in turn are dependent upon and exist in relation to many factors involved in the conditions of use, maintenance, and repair. While factors such as attractiveness, newness, and product care also play a role in product lifetimes, these are considered less by current policies and are included only in the perspectives of citizens. When discussing functionality, we also refer to the product lifetime. In this chapter, we primarily understand lifetime as technical, or functional, lifetime, which can be expressed as the total period during which an asset or machine can technically perform or function before it must be replaced. Importantly, lifetime is not necessarily measured in 'time'; other possible units include number of cycles, hours in operation, kilometres driven, etc. Some other key concepts, with definitions taken from European standards and laws, are found in Table 7.1.

1 EN 45552:2020.

Table 7.1: Definitions from standards and legal texts.

Concept	Definition
Durability	Ability to function as required, under defined conditions of use, maintenance and repair, until a limiting state is reached (EN 45552:2020)
Reliability	Probability that a product functions as required under given conditions, including maintenance, for a given duration without limiting events (EN 45552:2020)
Maintenance	Action carried out to retain a product in a condition where it is able to function as required (EN45552:2020)
Repair	Process of returning a faulty product to a condition where it can fulfill its intended use (EN 45554:2020)
Spare part	A separate part of an EEE [product] that can replace a part of an EEE. The EEE cannot function as intended without that part. The functionality of EEE is restored or is upgraded when the part is replaced by a spare part. (RoHS Directive, Article 3)

A significant difference between durability and reliability is that the latter concept does not include repairs. Thus, the reliability of a product may be five years of normal functionality but repairing restores the durability of the product and can extend the product lifetime.

In the next section, we discuss why products become obsolete as a starting point for our investigation into the ways in which durability can be addressed through policy. This is followed by an analysis of the potential gains from durability and longer product lifetimes, from both an environmental and a consumer perspective, and a review of the main strategies that can be employed for achieving longer product lifetimes. We then discuss existing and emerging policy approaches at the EU level, at national levels, and at local levels, to support longer lifetimes through durability, repair, and refurbishment. This is followed by a section on the role of citizens, in which we examine how they can be engaged to support longer product lifetimes as well as barriers to them playing a more active role. We then discuss policy strategies and the latest developments in light of the concept of a 'durable economy'. Finally, we end with concluding remarks on how current policies should be even more progressive to support longer-lasting products, and why we need to further question the way current markets work.

It should be noted that the European policies primarily aim to bring about longer product lifetimes. While longer product lifetimes can obviously be associated with the concept of 'durability', they are not necessarily the same. In our final discussions we consider these issues.

7.2 Reasons for premature obsolescence

It should be noted that it is hard to obtain good information on how durable products have been in the past. Furthermore, many products sold today are quite durable, and product lifetimes have not necessarily become shorter for all product categories (Dalhammar et al. 2021b). Still, there are clear indications that the lifespan of some product groups is shrinking (Huisman et al. 2012; Prakash et al. 2016; Stamminger et al. 2018). Although in most product categories there are a few so-called 'champions' – i.e. very long-lived products – there is nonetheless a need and potential to increase the lifespan of more products. Thus, while we may not aim – at least in the short term – for very durable items, or for lightbulbs that last over 100 years, it should be possible to make most everyday products longer-lasting than they currently are.

Moreover, the literature highlights that people want products to last longer (Echegaray 2016; Cooper 2004; Wieser et al. 2015; Sajn 2022), or be repairable (Perzanowski 2021), although the age of the consumer influences how long some products – like mobile phones – are used for (Wieser and Tröger 2018). Further, consumers are more interested in longer lifetimes for certain product categories (e.g. so-called workhorse products such as white goods) than others ('up-to-date' products); reasons for this include long lifetimes effectively 'locking in' consumers to owning a product considered to be outdated (Dalhammar et al. 2021b; Jaeger-Erben et al. 2021).

The main reasons for product obsolescence include the following (for a deeper discussion of these issues, see Proske and Jaeger-Erben 2019; Kahlin McVeigh et al. 2019) :

- **Product failure or breakdown:** This is often due to specific components breaking down. Product failure can be the result of in-built obsolescence (e.g. printer cartridges that are made to stop functioning before they are fully empty) or the use of low-quality materials.

- **Lack of access to repair:** In particular the lack of access to spare parts, tools, and manuals, or services for repairs outside the repair service network authorised by the product manufacturer.
- **Economic obsolescence:** Repair services or parts are available, but expensive or inconvenient, or generally considered inferior to buying a new product with a guarantee.
- **Technological or functional obsolescence:** 'Outdated products', e.g. a lack of software updates or support, or software updates that impede the functioning of the product.
- **Symbolic obsolescence:** Obsolescence driven by marketing campaigns and social expectations, abundance, and a search for 'newness', etc.

Current policy approaches primarily focus on the first three categories above. It is usually more difficult to address technological and symbolic obsolescence through policy: if people want novelty, there is little point in adopting policies for prolonging the lifetime of old products they will discard anyway. In addition, it is also important to note that sometimes obsolescence can be planned for safety and other reasons: for example, products and components become obsolete if they are found to be defective or unsafe (e.g. they contain toxic materials), or undesirable for other reasons (e.g. inefficient appliances that may still be functional).

Manufacturers can make use of one or more of the following three key strategies to stimulate repetitive consumption (i.e. shorter consumption cycles): 1) the limitation of material or component durability; 2) lack of repairability; and 3) design features that stimulate rapid replacement (Guiltinan 2009).

Consumers often believe that companies engage in 'planned obsolescence'. This has been defined by French legislators as: 'A group of techniques through which a manufacturer or a marketer seeks to deliberately reduce the lifecycle of a product in order to increase its replacement rate.'[2] However, while planned obsolescence does occur (Kahlin McVeigh et al. 2019), there is limited evidence that it is commonplace, at least as a deliberate act; products may have a rather short lifetime, but this is not planned per se (e.g. Longmuss and Poppe 2017). Instead, other market factors can explain why products are not as durable as people expect, or as durable as their designers intended. These factors include

2 French Consumer Code Articles L441-2.

increased product complexity, cost pressures, and shorter time to market (ibid.).

Nevertheless, even if planned obsolescence is not common, there is evidence that producers adopt strategies that make it difficult or even impossible for users to repair their products (Svensson-Hoglund et al. 2021; Dalhammar et al. 2021b; López Dávila et al. 2021b), thus effectively shortening product lifetimes. Strategies to reduce repairs notably include product designs that make repairs difficult and expensive, expensive spare parts, and intellectual property rights and contracts that stop independent repairers and citizens from engaging in repair activities.

Many consumer products – from electronics to clothes – have a strong aesthetic design element. New designs of the same product or product category are released regularly, with new aesthetics and functions emphasised in their marketing. Also, fundamental functions are 'extended' in new product models by way of attracting attention to their symbolic meanings (Eisenman 2013). Such practices stimulate the replacement of products before failure. Thus, even a 'durable' product can in practice have a short lifetime because a newer model has prompted its disposal.

Since planned obsolescence is rare, the preferred term for strategies that effectively limit product lifetime is 'premature obsolescence'. The term has no formal definition, but it describes a situation in which products break down faster than expected and/or cannot be repaired due to design or cost reasons. Whether the breakdown of a product is 'premature' can be measured against a standard: for instance, a consumer guarantee, a legally set requirement on product lifetime, or reasonable consumer expectations (Dalhammar et al. 2021b).

7.3 Encouraging longer product lifetimes and durability: rationale and strategies

Durability is generally seen as a key strategy towards a sustainable CE and is largely linked to initiatives to increase product lifetime. Extending product lifetimes can be achieved in many ways; not all strategies will necessarily be linked to product durability, particularly if longevity is to be achieved through reuse or repurposing; in that case, the product may have a 'first life' and a 'second life', and the durability of the first life and/or the total lifetime can be relevant. While these issues are complex, what we really want in the context of the CE is to maintain the value of a resource.

Thus, longer functional lifetimes are very much associated with durability. An important question is whether longer product lifetimes are always beneficial in terms of achieving sustainability. A recent literature review (Dalhammar et al. 2021b) found the following:

- Longer lifetimes are generally positive for 'passive' products, such as furniture and textiles, as well as for products that have their most significant environmental impacts in the extraction and production phases, such as ICT and consumer electronics.
- For high energy-consuming products, such as white goods, there can be a trade-off between energy use (and thus climate change impacts) and resource gains (which are connected to various environmental impacts). Then, the optimal lifetime depends on, inter alia, how much more energy efficient a new replacement product is compared with the old product and how often it is used. The electricity mix of a country also has an impact: in countries with a high share of renewables in the electricity mix, it is less environmentally beneficial to switch to a more energy-efficient product.
- As more and more product groups are coming closer to the technical limits of energy-efficiency improvements, it makes more sense to prolong their lifetime, as new models do not provide much in the way of energy-efficiency gains. Further, if people buy more efficient products but do not use the 'eco mode' – perhaps because the eco mode programme of a dishwasher takes several hours – the potential gains from a more efficient product are not materialised.

Generally, it is agreed that it does make sense – from an environmental perspective – to prolong the lifetime of most products. The next question is what 'lifetime' really means. This is not necessarily straightforward, especially for more complex products such as lightbulbs, where lifetime relates not only to how long the product functions, but also to whether its colour and light (lumen) output remain consistent over time.

There are three main strategies to extend product lifetimes: 1) design for long life; 2) handle products with care (maintenance) to extend life; and 3) support the 'R' strategies that focus on keeping the product in use for longer (in particular repair, refurbishing, and reuse) (Dalhammar et al. 2021b). The first key strategy consists of designing for durability: for example, investing in higher-quality materials or making the product more robust or more repairable (i.e. easy dismantling, production of key spare parts, etc.). However, durable or repairable products make sense only if they are used for a longer period of time. That is where the second strategy, which aims to ensure that products are continuously maintained and serviced, comes in, with the objective of increasing the product's lifetime in use. The third strategy relating to 'R' activities (see Table 7.2) effectively postpones the moment when products and individual components reach their end of life. For instance, direct reuse and repair, done together or separately, can enable continued usage of an older product. Refurbishment or re-manufacturing can be applied to products and components to restore functionality, or even enhance it. It should be noted that the exact definitions of several of the 'R' activities are not agreed upon in laws or standards, and they are often used in different ways (for more discussion on the terminology, see, e.g., Gustavsson et al. 2021; IRP 2018; EC 2020).

Table 7.2: The 'R' activities explained

Term	**User**	**Definition**	**Level**
Repair and maintenance	First user	Extends the life of a product during its first use by retaining or restoring its functionalities with maintenance and minor repairs that can be done by users, manufacturers, or professional service providers	Product
Reuse	Second-hand	Extends the life of a product or part by having a second-hand user utilise it for the same original purpose with no or only minor enhancements and changes Can be combined with refurbishing	
Refurbishment	Second-hand	Extends the life of a product by replacing a few major components, which restores its functionality and provides a good or acceptable performance for a second-hand user (also known as reconditioning)	

Term	User	Definition	Level
Compre-hensive refurbish-ment	Second-hand	Extends the life of a product by undertaking refurbishment activities (see above) within industrial or factory settings, with a high standard and level of refurbishment to enable the product to meet applicable technical standards or regulatory requirements, with the result of making a fully functional product to be used for its originally intended purpose	
Repurpo-sing	Second-hand in another applica-tion	Extends the life of a product or part by using it for a purpose than the one it was originally produced for (sometimes also known as cascaded or second use)	
Remanu-facturing	Second-hand	Enables a full new service life of a product via a standardised industrial process that takes place within industrial or factory settings, in which cores are restored to original as-new condition and performance, or better The re-manufacturing process is in line with specific technical specifications, including en-gineering, quality, and testing standards, and typically yields fully warranted products (and per agreement of global industry members)	Compo-nent
Recycling	Same industry (closed) Any other industry (open)	Closes material cycles by retrieving raw ma-terials from the product and returning them to the production process of new products in lower-quality uses or in other products (down-cycling or open-loop), similar products with the same quality (closed-loop), or higher quality and functionality (upcycling)	Material
Recovery	Any	Only the energy is recovered, through, for example, incineration, while the material is lost (but the material replaces another fuel)	Energy

Source: Based on Albertsen 2020, with amendments.

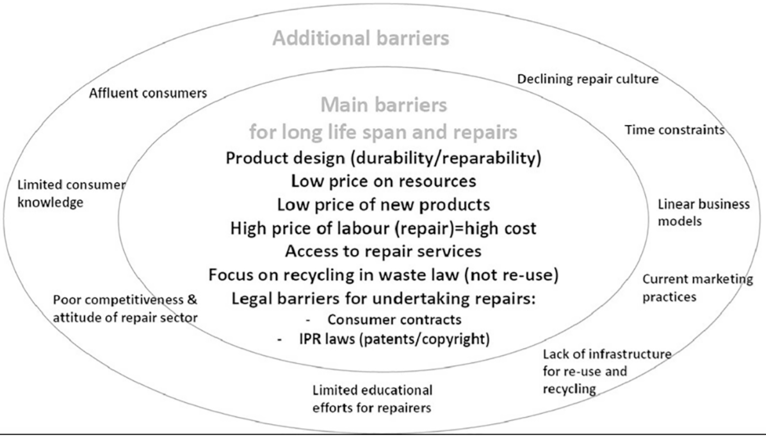
The 'R' strategies involving restoration of functionality can be related to supporting durability. While these strategies refer to products and com-ponents, they are dependent upon practices, which involve capabilities, knowledge, and routines and ultimately depend on social and material arrangements. While many 'R' strategies focus on the product, it is also necessary to consider the role of components within product-focused strategies. For example, harvesting components from end-of-life or obsolete products can enable reuse and repair at the product level, as the harvested spare parts may allow for a less costly repair process (Richter et al. 2022). The policies that aim to increase the lifespan of products and components do so by incentivising design for longer life and/or support the 'R' activities in various ways.

It should be noted that the various 'R' activities in Table 7.2 are not equal from a consumer perspective: a consumer would prefer to buy a product that is 'durable' rather than one that is 'repairable' (Dalhammar et al. 2021b). When buying a new product, durability is associated with quality, whereas a reference to it being 'repairable' could be interpreted as it being of poorer quality, because it seems to imply that repair will be needed. From an environmental perspective, durability is also superior to repairability, since repair means that new components will be needed and existing ones will be discarded. Plus, in practice, many repairable products are discarded because repair is not attempted or proves unsuccessful (see, e.g., Jaeger-Erben et al. 2021). However, policymakers do not necessarily prioritise durability over repairability policies (Dalhammar et al. 2021b). For instance, requirements in the Ecodesign Directive (2009/125/EC) more commonly address repairability than durability. The main reason for this is that it is easier to enforce rules on repairability, whereas it is more complicated to define – and thus enforce – durability.

7.4 Policies promoting longer functional lifetimes and durability

The emergence of the CE as a distinct area of policymaking has provided momentum for new policies that promote longer lifetimes, and we now see several such policies – adopted or proposed – at European, national, regional, and local levels. Importantly, given the many barriers to longer product lifetimes and the 'R' activities, a substantive policy mix is required (see Figure 7.1).

Figure 7.1: Summary of barriers for longer lifetimes, reuse, remanufacturing, and repairs.



Source: Dalhammar et al. 2021b.

In this section, we first discuss the policies related to durability and longer functional lifetimes through design, repair, reconditioning, refurbishment, and re-manufacturing more specifically. We end this section by discussing existing policies that create barriers to durability and longer product lifetimes.

Several recent policy proposals address product lifetimes. The European Commission presented its package of policy proposals under the Sustainable Products Initiative (SPI) in March 2022 (for an overview, see EC 2022c). It proposes the introduction of digital product passports that may be used to transfer data on lifetime and repair activities. Further, the proposal for a new ecodesign regulation will cover new products groups such as furniture and textiles, where lifetime and repairability requirements will most likely be discussed.

The Commission package also included an initiative on 'empowering consumers for the green transition' (EC 2022a). It contains proposals to ensure that consumers obtain reliable and useful information on products, including on their lifespan and repair options, and to prevent sales of products with a covertly shortened lifespan (ibid.). Furthermore, a Commission proposal on 'right to repair' (R2R) is expected in 2023.

There are also national proposals for changing marketing practices. In France, the NGO HOP (2020) has proposed: 1) introducing an obligation for advertisers to mention repair, reuse, and the second life of products, as well as recycling opportunities of the products they advertise; 2) regulating green claims in advertising and marketing to avoid green-washing by banning the use of certain wording that minimises a product's impact on the environment; and 3) imposing the display of environmental indicators in advertising (such as ecolabels).

Table 7.3 gives an overview of different adopted and proposed policies at the EU, member states, and local or regional level that address longer product lifetimes.

Table 7.3: Overview policies for longer product lifetimes.

	European Union	**EU member states**	**Other (local/regional)**
Adopted	*Ecodesign Directive*: new mandatory requirements on products on the EU market; related to durability, repairability, provision of spare parts, etc. *Standardisation* activities to develop new product standards on concepts such as durability, reuse, repairability, and recyclability; these standards will make it easier to regulate these issues in future laws (ongoing process) *Change VAT rules* *Digital product passports*	*Criminalising planned obsolescence* (France) *Fines for planned obsolescence due to software updates* (competition authorities of Italy and France) Strengthening *legal* (mandatory) *product guarantees* in consumer law (several EU countries) *Tax relief for repair* (e.g. Sweden) *National accreditation* of reuse organisations (e.g. Belgium) *Repairability index* (France) *Ban on destruction of unsold/unused products* *Better regulatory frameworks for sharing and leasing* *VAT changes to support reused goods, sharing, and leasing*	*Public procurement* of re-manufactured ICT and furniture (e.g. Sweden) *Reuse centres* and similar infrastructure; diverting end-of-life products to reuse *Networks for reuse*, including infrastructure, quality controls, and marketing (e.g. the Flemish reuse network), *repair networks* (e.g. Vienna), and *repair cafés* *Subsidies for repairs* (e.g. repair vouchers in Vienna) *Encouraged use of re-manufactured spare parts* for federal government vehicle fleet maintenance (e.g. USA) *Government support for private reuse firms* (e.g. Sweden) *Quality labels for reused goods* to instil consumer confidence (several EU countries)

	European Union	EU member states	Other (local/regional)
Proposed	*Consumer law* changes to ensure that consumers receive trustworthy information on product lifespan, the availability of repair services, spare parts, and repair manuals *Mandatory changes of marketing practices* *Mandatory labelling on expected product lifetimes* *Additional measures to promote R2R* *Public procurement criteria* for remanufactured goods	*National public procurement criteria* for re-manufactured goods such as furniture and ICT products (under development) *Standards and quality labelling* schemes for reused products (under development)	*R2R laws* proposed in several US states, with provisions to enable consumers to repair their products and allow independent repairers to access the after-sales market

Source : Dalhammar et al. 2021c.

In addition to the initiatives outlined in Table 7.3, there is also untapped potential; legal norms could have an impact on stakeholder attitudes and behaviours, directly and indirectly, when it comes to product durability, not least individuals' attitudes and expectations regarding product lifespans. However, even though EU law stipulates that sustainability should be considered across EU policies and activities,[3] not all policies with influence on product longevity do so appropriately. For example, EU consumer law[4] fails to include durability in the requirements on product quality (Pihlajarinne 2022: 120–1, 125).

7.4.1 New European standardisation activities

The European Commission made a standardisation request (M/543) to the European standardisation organisations CEN, CENELEC, and ETSI in 2015. The aim was to develop standards on material efficiency that would support future legal requirements for energy-related products, most notably those set under the Ecodesign Directive. Most of the standards are not intended to be directly applied to a specific product group, but rather to be used as a framework for the development of product group-specific standards. The topics covered in the standardisation request are linked to the following material efficiency aspects of energy-related products:

- product lifetime extension though design for durability, repairability, and remanufacturing;
- ability to reuse components from products at their end of life (which in turn could support repair and re-manufacturing); and
- promotion of the use of secondary (reused) components and/or recycled materials in products, which could also promote durable design of components.

The most relevant standards in the context of this chapter are outlined in Table 7.4 below. Some researchers argue that the new standards on material efficiency can be a 'game-changer' and support future ecodesign and labelling regulations (Schlegel et al. 2019), but this remains very uncertain as there are several barriers associated with regulating specific product groups (Dalhammar et al. 2021b).

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3 Treaty on the Functioning of the European Union, Article 11.

4 EC Directive 1999/44/EC.

Table 7.4: List of European standards relevant for the durability and repairability of products.

Standard	Main purpose
EN 45552:2020 General method for the assessment of the durability of energy-related products	Contains definitions of concepts such as 'durability' and 'reliability' Provides a framework comprising parameters and methods for assessing the reliability and durability of energy-related products
EN 45554:2020 General methods for the assessment of the ability to repair, reuse, and upgrade energy-related products	Defines parameters and methods relevant for assessing the ability to repair and reuse products; the ability to upgrade products (excluding re-manufacturing); the ability to access or remove certain components, consumables, or assemblies from products to facilitate repair, reuse, or upgrade; and lastly by defining reusability indexes or criteria (supporting a 'repairability scorecard')
EN 45556:2019 General method for assessing the proportion of reused components in energy-related products	Deals with the assessment of the proportion of reused components in energy-related products, on a generic level, which can be applied at any point in the life of the product
EN 45553:2020 General method for the assessment of the ability to remanufacture energy-related products	Provides a general methodology for assessing the ability to re-manufacture energy-related products and elaborates on the assessment and process of re-manufacturability in a horizontal, cross-product way – however, product group-specific standards are needed to properly assess individual product groups

7.4.2 Policies for more durable design

Some policies provide incentives for manufacturers to design more durable products. At the EU level, the Ecodesign Directive has been used to set design (functional) lifetime requirements for two product groups (for more details, see Maitre-Ekern and Dalhammar 2016):

- **Vacuum cleaners:** Rules relate to the minimum lifetime of engines (hours in operation) and durability testing of the hose; these are the two components most likely to break on a vacuum cleaner.

- **Lighting products:** Lamps have been regulated with minimum lifetime requirements related to several dimensions, including 'lamp survival factor at 6,000 hours', 'lumen maintenance' at 2,000 and 6,000 hours, 'number of switching cycles before failure', and 'colour rendering' consistency over time.

In the case of vacuum cleaners, one reason for the standards was that relevant standardisation for testing already existed, making it possible for manufacturers to prove legal compliance. Often, such testing standards are not available, which makes it difficult to introduce mandatory durability requirements. Another problem is the assessment of very long-lived products, conducted by market surveillance agencies; indeed, such items can hardly be tested for 15 years in a laboratory to mimic daily use, as once the tests were completed, the model would no longer be sold on the market (Dalhammar et al. 2021b).

Another way to incentivise more durable product design is to extend the legal guarantee period. The EU set some minimum rules for consumer guarantees, but several European countries have gone further, introducing longer guarantee periods and changes in the 'burden of proof' (Maitre-Ekern and Dalhammar 2016; Keirsbilck et al. 2020). There are, to the best of our knowledge, no evaluations done on whether these rules have the anticipated effects or not. For this policy to have the desired effect, 'R' strategies must also be the preferred remedy for product faults under guarantee (see, e.g. Svensson-Hoglund et al. 2021).

France is also planning to introduce a mandatory durability index in 2024. The idea is that the repairability index that is already in place (discussed in the next section) will be incorporated into the new durability index, together with two new criteria:

- **Reliability:** This may include aspects such as durability/robustness, correct maintenance of the product, and related consumer information, as well as requirements adapted to each product group.
- **Upgrade:** This may include aspects related to software and hardware upgrades, as well as requirements adapted to each product group (ADEME 2021).

France announced at the end of 2022 a proposal for how the scheme would work and what product groups should be covered (ADEME 2021), but the plan appears to be delayed.

An additional challenge is that some products are not even used: their commercial lifetime never starts, as they are thrown away and discarded by retailers or e-commerce actors before use (in the case of overstock and returns) (e.g. Pourhejazy 2020; Napier and Sanguineti 2018; Roberts et al. 2023). This relates to the issue of accumulation highlighted in the introductory chapter to this book. This is a tremendous waste of resources, which France in particular has started addressing by introducing a ban on the destruction of unsold goods; under Article 35 of the French Law No. 2020–105 from 10 February 2020, destruction of unsold goods is no longer permitted. The law stipulates that companies must prioritise the following actions (in line with the waste hierarchy): ensure that the products are reused (second-hand markets), redistributed (e.g. through donations), or recycled. The law covers several product groups and entered into force on 1 January 2022 for some product groups; successive regulations covering more product groups are underway (Dalhammar et al. 2022b). However, the rules do not, at this point, have a strong impact on practices due to exemptions, lack of transparency, and limited enforcement, among other factors (Roberts et al. 2023). Now, the European Commission has included transparency obligations relating to discarding and destroying unsold goods in the proposed Ecodesign for Sustainable Products Regulation that was released on 30 March 2022 (EC 2022b). Chapter VI of the proposed Regulation would require large companies to publicly disclose the number of unsold products they discard and the reasons for discarding them. In addition, the Commission sets itself the mandate of adopting delegated acts prohibiting the destruction of unsold products in certain conditions.

However, while these policies point to objectives of using and redistributing existing stocks better, there is still uncertainty about the effects of these policies in terms of overproduction and overconsumption.

7.4.3 Policies for supporting durability through 'R' strategies

In the last couple of years, many consumer NGOs and independent repairers have lobbied for R2R policies. Such policies serve a number of objectives – in particular allowing citizens to repair their products, including through independent repairers (outside the original equipment manufacturer's (OEM) authorised network), and allowing both citizens and independent repairers to access necessary repair manuals and tools and purchase spare parts. Politicians have started to support these objectives, both in the USA and the EU.

In the USA, this has led to several R2R bills being introduced at the state level. With some variations, these initiatives mainly aim to force OEMs to allow independent repairers and product owners to access manuals, tools, and spare parts (Svensson-Hoglund et al. 2021). In June 2020, New York State was the first to pass such a bill. The bill is expected to have a national effect, similar to the R2R bill for automobiles passed in Massachusetts in 2012; following the latter, the stipulations were implemented nationwide through a voluntary agreement between car manufacturers and repair service providers (Wiens 2022; Svensson-Hoglund et al. 2021). In addition, the US Federal Trade Commission has some existing rules in place that aim to protect citizens from repair restrictions; it is also considering new rules as well as enhanced enforcement (FTC 2021; Svensson-Hoglund et al. 2021).

At the EU level, the legislative solution has been to mandate producers that want to put products on the EU market to comply with specific R2R obligations. These R2R provisions have mainly been adopted for products that come under product-specific regulations within the Ecodesign Directive. Table 7.5 provides an idea of 'typical' requirements. There is a notable difference in the 'repair rights' bestowed on professional repairers compared with those that apply to non-professional repairers (e.g. DIY or community repair cafés). Non-professional repairers are not guaranteed access to the same range of information and spare parts as professional repairers. For example, common citizens and non-professional repairers are guaranteed access to spare shelves for a refrigerator, but not spare parts for the electrical components of a refrigerator; the latter are guaranteed only for professional repairers.

Table 7.5: Examples of R2R standards set under the Ecodesign Directive.

Product group	Examples of criteria applied
Refrigerators, electronic displays, washing machines, washer-dryers, dishwashers, refrigerating appliances with a direct sales function, welding equipment	**Spare parts** Making key spare parts available for all professional repairers and some parts for all users Maximum delivery time for spare parts Replacing spare parts made possible with commonly available tools Obligation to provide information on, for example, access to professional repair, ordering spare parts, minimum duration of producer guarantee, and minimum period during which key spare parts are available Information on (some of) the above should be publicly available **Information** Making repair and maintenance information available to qualified repairers Providing information on the availability of software and firmware updates (for some product groups) Making software updates available for a minimum number of years, at no, or limited, cost **Dismantling** Product design: dismantling of key components and materials should be possible with commonly available tools

Source: Dalhammar et al. 2021b.

At the national level, we have seen several interesting policy initiatives (Almén et al. 2021; Dalhammar et al. 2022b). The most notable is certainly France introducing a mandatory repairability index in 2021, which applies to five product groups so far. The index is a type of scoring system for product repairability based on five criteria: 1) how long the producer provides independent repairers and citizens with technical documentation; 2) the product's ease of disassembly; 3) the availability of spare parts in years and delivery time; 4) the price of these spare parts; and 5) sub-criteria specific to each product group (Dalhammar et al. 2022b). France has also proposed repair funds, whereby producers will pay part of the costs for repairing a product. The system is currently being set up, and the idea is that it will be organised through producer responsibility schemes (Thompson 2022). Making producers pay for some of the repair costs could provide incentives to design durable and even repairable products. However, to date, the costs and producer responsibilities have not been high or ambitious enough to drive significant ecodesign changes (Maitre-Ekern 2021).

A national policy that can support the repair sector more directly is tax reductions for the repair sector. One example is Sweden, where the VAT rate (which is high in Sweden, at 25 per cent for most businesses) was halved from 2017 for some repairs; the government recently proposed that it should be halved again (Almén et al. 2021; Dalhammar et al. 2022a). The effect of these approaches has not been evaluated.

At the local level, two Austrian cities have introduced local repair networks, which are open to independent repairers who fulfil certain criteria (Lechner et al. 2021; Almén et al. 2021; Dalhammar et al. 2022a). When citizens undertake repairs at these repairers, they are subsidised via public funds. For instance, in Vienna, citizens can download repair vouchers online, which provide them with a 50 per cent discount on the repair cost up to a maximum amount.

Regarding reconditioning, refurbishment, and re-manufacturing, it is often hard to differentiate between these practices, so here we treat them together and generally define them as a third party (i.e. after the product's end of use) conducting a wide range of repair or preparation for reuse efforts deemed necessary in order to make the product available on the second-hand market. The EU has provided financial support to set up the European Remanufacturing Network, but it has not adopted many policies to directly support re-manufacturing and reconditioning, except for general recommendations to support such activities through public procurement. Some parts of the re-manufacturing sector, however, are growing quickly without any need for policy support, such as the re-manufacturing of cars, trucks, and heavy machinery (US International Trade Commission 2012).

At the national, regional, and local levels, re-manufacturing is supported especially through public procurement. In Sweden, the public sector can support ICT re-manufacturing by, for example, selling used computers to re-manufacturers or purchasing re-manufactured ICT products (Crafoord et al. 2018). Furniture re-conditioners and re-manufacturers have received some support through public procurement of reconditioned furniture (Öhgren et al. 2019), an approach that has recently been scaled up.

7.4.4 Current policies that act as barriers to longer lifetimes and repairs

Even though an impressive number of new policies are emerging to support longer lifetimes and the 'R' strategies, they also need to overcome many barriers. These are not only major economic barriers related to the low pricing of primary resources and business models geared towards new products, but also existing policies that hinder circular solutions. Legislation is often a key barrier for 'R' strategies such as reuse, re-manufacturing, and repair (Gustavsson et al. 2021; Hansen et al. 2021; Rizos et al. 2021; Svensson-Hoglund et al. 2021; Lindahl and Dalhammar 2022). Among the key legal barriers, we find the following:

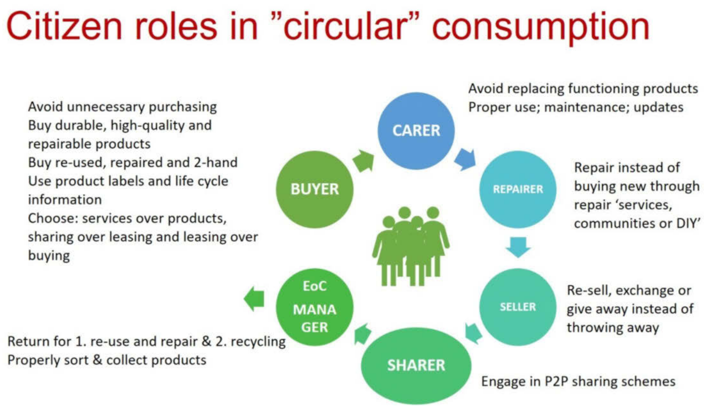
- Current waste legislation and rules on shipment of waste make it difficult for reuse and preparation for reuse activities (including repair and re-manufacturing) of potentially functional waste products and components to occur because of the administrative burden of rules and bureaucratic procedures required to transport waste for such processes.
- Waste management targets, and the way in which producer responsibility schemes are implemented, lead to the recycling of functioning (or potentially functioning) products and components.
- If a product is refurbished or re-manufactured and is considered a 'new' product (rather than the same 'old' product), it has to comply with rules relating to the introduction of a new product on the market. Examples of such rules include taxes and chemical laws regulating content.
- Rules on substances may act as a barrier to repair, re-manufacturing, and recycling.
- Intellectual property laws – including patents, trademarks, and copyrights – often constitute barriers to repair and re-manufacturing, for instance by making it harder to reuse products or to access spare parts and repair manuals.
- In some countries, such as the Netherlands, the reuse of harvested spare parts is not allowed without certification, which is a barrier for many re-furbishers.

Although the EU aims to address some of these barriers with CE policy packages, current proposals do not seem sufficient to successfully overcome all the barriers that stand in the way of durability. For instance, solutions for overcoming barriers stemming from intellectual property laws are still largely missing from the policy efforts.

7.4.5 Policies addressing durability and citizens

Durability is not just a question of producing longer-lasting and repairable products, it is also – and most importantly – an issue of purchase and use. The life of a durable product will be extended and have a positive environmental impact only if its user invests in it, uses it with care, undertakes repair when needed, and shares or passes on what they don't use to avoid accumulation and waste (Figure 7.2).

Figure 7.2: Citizens' roles in durable economies.



Source: Adapted from Maitre-Ekern and Dalhammar 2019; Camacho-Otero et al. 2020.

As depicted in Figure 7.2, from a durability perspective, the ideal role of the citizen is to choose to acquire fewer, more expensive, and longer-lasting products that they use for longer periods. This is crucial not only to create a demand, but also to enable durability-related activities later on in the cycle shown in Figure 7.2; for example, the repair of low-quality items is often not feasible. Moreover, citizens should avoid unnecessary purchases and instead use and care for what they already have (i.e. through repair, repurposing, or borrowing). This is also likely to be the outcome if durable products are made more expensive. Where the acquisition of a product is necessary, citizens will prefer products that have a longer expected lifetime and can be repaired (i.e. create demand and enable the rest of the cycle shown in Figure 7.2), or they will choose items from the reuse and resale (second-hand) market (i.e. to capitalise on unused durable items, again to avoid accumulation and waste – see the arrow from 'Reselling' to 'Acquiring' in Figure 7.2).

During the use phase, the product is treated with care and maintained as needed. Unused items are ideally made available to others in the form of sharing or borrowing to maximise their utility. If the device becomes unwanted, it is passed on to others, through either informal or commercial channels. Where failures occur or products lose their function, citizens will attempt to repair them to make use of the durable properties of the product. At the end of use – when the product has become unwanted – it is put into the second-hand market directly (reuse) or, if necessary, after re-manufacturing, reconditioning, or refurbishing.

These behaviours are quite remote from the common consumption behaviour in Western countries. In a society with a free market, it is still difficult to envisage forcing citizens to adopt any given role. However, policies can be adopted that contribute to making it easier, more attractive, and more clearly beneficial to assume more sustainable roles, and less obvious, economically sound, and socially acceptable to continue with the more unsustainable ones. For example, labelling and other information can guide citizens in making decisions based not only on the price upfront, but also on long-term costs. Likewise, tax rebates for repair activities provide incentives to attempt repair rather than discarding items at the first sign of failure. However, a real break from wasteful consumption patterns and habits of accumulation and discard is bound to require going further than this, notably to address so-called rebound effects where consumers buy new products from the 'gains' made from efficiency or less replacement (Sorrell 2007). A true sustainability transition requires promoting sufficiency (i.e. reducing consumption), which demands even tougher interventions on consumer choice.

In addition, a more durable economy could be imagined as one where citizens actively participate in the value chain, from design and production (e.g. as prosumer) to technological and social innovations (e.g. repair cafés) and open source. Finally, a key aspect in changing the roles of citizens occurs through education, from kindergarten and primary school and all the way through to, and during, adult life. Currently, repair and maintenance of products that are owned are usually not the norm. This could be changing. One study shows that

Finnish citizens are increasingly seeking better alignment between their values and consumption patterns, and thus they are willing to pay more for something durable (Green and Korkman 2022). However, the emergence of a 'repair norm' seems to be absent in the field of electronics; buying a new product rather than repairing the old, broken one is still seen as the normal thing to do in wealthier nations (López Dávila et al. 2021a).

While citizens and consumer NGOs claim that people want more durable products, it is fair to question whether they are in fact willing to pay for them. People may hesitate to pay double or triple the purchase price they are used to paying or expect to pay for a very durable product, even with the promise of long-term economic gains. Generally, people do not properly calculate the 'total cost of ownership' (i.e. the cost per year, or per month, over a longer period), which would support the purchase of the more expensive product from a purely economic point of view (Dalhammar et al. 2021b). However, a higher upfront purchasing cost is difficult or impossible to meet for some consumers, thus leasing and sharing options need to be considered.

The durable economy faces a steep uphill battle; its realisation hinges on citizens and consumers overcoming the current logic of the market that too often is in contradiction with not only their personal economic interests, but also the goals of sustainability. The linear model has created a system in which individuals lack information and skills to make sustainable purchase and recovery choices. Moreover, people are often steered by habits and ideas of what is the 'common thing' to do. For the time being, resources and new products are relatively cheap (often due to cheap labour in countries where components are sourced or manufactured) and under-priced in relation to their environmental impact. On the other hand, activities such as repair are expensive in high-income countries because they are labour intensive, and salaries and labour taxes are high. Thus, it often makes more economic sense to buy a new product rather than repair the old one (Dalhammar et al. 2021b). This is exacerbated by other factors, such as the fact that a new product often comes with a three- to five-year commercial warranty, whereas warranties on repairs are usually much shorter, if they exist at all.

7.5 A critical discussion of policies and their relation to a 'durable economy' for products

Although an important focus on recent CE policies is on extending product lifetime, durability will not necessarily be achieved with upcoming regulatory changes. For example, repair is a highly prioritised strategy in CE policy developments. The proposed ecodesign regulation includes it as one of its priorities. However, design for repair may affect other aspects of durability. Whereas durability may favour gluing together the casing of a smartphone or a laptop to make them waterproof, repairability would call for using screws, which decreases waterproofness (see Chapter 8). Generally, durability and lifetime, although closely related and overlapping, are not one and the same. The broad and complex policy mix relating to the CE in the EU and in the various member states can lead to unintended effects – or rather, the expected benefits may not materialise – because other factors are not addressed properly. In this section, we therefore critically discuss some of the main points of tension in Europe's emerging sustainable product policy in light of the broader conversation about transitioning to a 'durable economy'.

In this chapter, we have established that regulators are increasingly aiming to promote longer product lifetimes, mainly for environmental reasons, through CE policies. This is very apparent in the sustainable product initiative of March 2022, which notably aims to introduce ecodesign requirements for durability, but also for upgradability and repairability. It will certainly prove challenging for the Commission to develop ecodesign requirements that will reconcile all the priorities of the future regulation.

In addition, such legal rules are effectively achieving 'choice editing', increasing the regulatory hurdles that products must pass to be allowed on the market. Corporations that are forced to redesign their products may consider changing business models – from selling to leasing or providing services, including maintenance and repair, for example – to reap the benefits of more durable design (Dalhammar 2016). Changes in business model are an expected and desirable effect of policies aimed at product durability, but the benefits for the environment will materialise only if both producers and consumers align in their behaviours. Restricting the supply of poor-performing products through regulations may prove very effective in changing design and production patterns, but they do not necessarily guarantee sustainable consumption in terms of conscious purchasing and careful use. In fact, consumers may end up behaving unsustainably with more durable products, for instance by replacing or discarding functioning ones if they look for novelty. In that case, regulating the supply of more durable products could even be a case of over-engineering – that is, designing a product to be more robust or have more features than is typically necessary for its intended use – and this would be a waste of resources.

Changing consumption habits is hard, and there is growing recognition that information and educational measures will not be enough. Not giving consumer choice top priority appears to be necessary, along with empowering consumers in their choices. In sum, product regulation is not straightforward. Although consumer habits, business models, and markets are in constant interaction with each other, changing one variable will not necessarily lead to desired changes in others. Trade-offs must be explicitly explored and discussed in policymaking.

When it comes to norms regarding product longevity, publicly visible repair initiatives, such as repair cafés, can normalise the idea of not accepting breakage as the end of an item's life (Madon 2022). Research on consumer attitudes to repair also show that people would like to see public messaging on the importance of repair, similar to what has been done in Sweden with regard to reusable grocery bags (López Dávila et al. 2021a), a form of messaging which presumably also apply to keeping products in use for longer. The most important factor, from the perspective of policies, is perhaps how legal norms impact social norms; if the message is that innovation and the sale of new products is more important than repair – which is the case in current intellectual property laws – then the public will internalise such a mindset (see Pihljarinne 2022). Given the many barriers to the emergence of more durable consumption practices, it appears appropriate to adopt an approach of 'choice editing' for consumers, whereby legislators impose rules designed to achieve durability. Change is indeed unlikely to take place without strong policy and legal measures to lead the way.

Another important but unpopular topic is that there is a need to make products of higher quality, as well as a need for consumer products to be more expensive. This may sound counter-intuitive when we have established that people will usually make decisions based on their immediate economic interests. However, there are indications that people are better at maintaining and repairing expensive products, and that the number of repairs increases for more expensive products. Indeed, people are more willing to invest in repair for products on which they have invested money, and the repair of products is gaining traction as innovation rates slow down (e.g. for mobile phones).

In order to get and keep consumers on board, expensive products must have better guarantees to make durability and care attractive in the long term.

As for the industry's arguments that we 'price the poor out of the market', there are solutions to be pursued, including instalment contracts or leasing (Hammond and Prahalad 2009). In fact, getting access to higher-quality products would often be the best option for low-income individuals when the 'total cost of ownership' is considered (see the discussion in Dalhammar et al. 2021b). Such regulations should be combined with educational and information initiatives to make consumers more aware of product quality and its relation to environmental impacts, and to the total cost of ownership. These initiatives should possibly be combined with more visionary ideas on involving citizens in creating more sustainable products, and preparing them to better engage in maintenance and repair activities. Research shows how hard it is to change consumer behaviour; it is certainly easier to regulate the products. The question is, can worsening environmental crises wait for consumers to change their behaviour, or should regulations be used even more ambitiously?

If we are serious about transitioning to a sustainable future, the price of products should reflect their true cost, including ecological and social externalities. A green tax reform could completely change the rules of the game in current markets, making products more expensive while making labour for repair cheaper. However, this is not likely to materialise in the near future. Thus, the most viable way to achieve longer-lasting and more expensive products is to set regulations – such as ecodesign requirements – that make products higher quality and more expensive. Policies need to engage consumers and citizens in a way that stimulates consumption of fewer products of higher quality, and consumer choice should be complemented with a sense of responsibility for the products bought and for maintaining them for as long as possible. However, such a strategy is yet to emerge, and consumption patterns show no sign of changing at the pace needed to respond to the crisis we are facing.

Current policies are based on a rather 'technocratic' approach: setting standards and regulating lifetimes, making repairs more attractive, and using lifecycle assessments and economic calculations as tools for finding the right balance between benefits and costs. However, they appear to fall short of enabling a different approach to consumption and changing social norms. Striving for genuine durability requires craft and vision to create something unique. Current policies aim to support the CE by addressing a resource challenge, but they fail to fully engage with the paradigm shift necessary to achieve a sustainable economy. Too often, current ways of designing and consuming products are unchallenged, even when there may be other ways of satisfying human needs.

7.6 Conclusion and outlook

In this chapter, we have presented the emerging policy landscape for product regulation as part of the CE, which includes a mix of very different policies, with focus on achieving durability. We have established the following points:

- Policies can address durability by addressing the lifetime of products in design or by extending product lifetimes through 'R' strategies.
- Policies are adopted at different levels (e.g. at EU, national, and local levels).
- Quite different regulatory frameworks are applied, including those relating to product legislation, criminal law, and consumer law.
- The policies address different aspects and thus different producer 'responsibilities', such as information requirements, design requirements, and requirements to support independent repair with manuals and tools.

One key finding is that policymakers are now determined to intervene in current markets, as the market has proven unable to deliver sustainable outcomes. As part of the transition to sustainability to which Europe has committed, more durable products must be placed on the market. If producers do not step up to the challenge, policymakers are showing that they will. Likewise, policymakers are increasingly intervening to end particularly unsustainable practices, such as single-use plastics. In 2019, the EU legislator banned ten single-use items as part of the EU's commitment to fight marine litter and plastic pollution.[5] In line with France's recent anti-waste legislative package, the next target for the EU is unsold products that are often destroyed, evidence that the incentives of market actors are not in line with societal objectives.

Current approaches show that policymakers increasingly engage with 'choice editing' for consumers, who can buy only the products that pass through the 'regulatory needle'. The EU ecodesign scheme effectively limits consumer choice by removing the worst performers from the market, and allows for competition to take place based on factors related to durability rather than just price.

5 Directive (EU) 2019/904.

In addition, the various indexes, labels, and other information schemes that are in place today or are about to be adopted can contribute to creating 'spill-over effects': even if people today seldom consider product durability and repairability when they purchase an item, the citizens of tomorrow may start paying more attention as they receive more and better information of this kind (Dalhammar et al. 2021b).

Regarding the intended effects of policies, most policies are recent and have not been evaluated yet. Some desired effects may be achieved for 'workhorse' products (e.g. some white goods), but policies will probably work less well for product categories where consumers look for novelty or trends. The question is whether policymakers and other societal actors should address the underlying causes: consumers' need for and expectation of 'the next best thing'. We might even start questioning some innovations per se: do we need another new version of a smartphone? Is 'fast fashion' at all justifiable?

Neither producers nor citizens can in themselves change a paradigm that has been in place for several decades. A combination of more durable products, more access to repair, and better infrastructures for reuse and other recovery activities, coupled with clear information, strengthened guarantees, and targeted incentives, can trigger a lasting change in both production and consumption patterns and bring us one step further on the road to a more durable future.

More progressive policy approaches are needed to transition to a CE that supports durability. This involves:

- considering the prospect of products becoming more expensive in order to have higher quality, durability, and repairability integrated into product design;
- considering not only the durability of products but also the durability of components, so that these might be used for repair, or as parts of modular designs that enable longer product lifetimes; and
- reviewing marketing practices, as these often promote unsustainable behaviours and choices that undermine policies for more sustainable production and consumption.

Ultimately, the important societal and political role of material wealth and product acquisition needs to be addressed as a consumption challenge. This requires sufficiency policies that address the limits of the 'consumption space' of each individual and the need to divide the Earth's resources more equally

(Raworth 2018; Hickel 2018; Newell et al. 2021; Dalhammar et al. 2022b). In a sustainable durable economy, the production of durable products would be the norm and consumption would be careful and mindful.

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8. Scalability and durability, or: is modular the new durable? The case of smartphones

Melanie Jaeger-Erben, Marina Proske, and Sabine Hielscher

8.1 Introduction

Few modern electronic devices are as frequently discussed in terms of their ephemerality as smartphones (see, e.g., Tröger et al. 2017). The smartphone has become a symbol of an accelerated modernity where multifunctionality meets multitasking and a fast market meets fast consumption. Thinking of a smartphone as a durable product seems like thinking of a racehorse as a turtle: slowness and a robust temperament do not seem to suit the smartphone as a highly equipped performer. But the smartphone race comes at a price. Even though the carbon footprint of a single smartphone is in the range of a few kilograms of meat (40–100 kg CO_2e (e.g. Apple 2022) compared with 22 kg CO_2e per kilogram of meat; Reinhardt et al. 2020), the rapid increase in global smartphone production has led to, among other things, high pressure on unrenewable resources such as gold, cobalt, tin, tantalum, and tungsten, as well as to long-lasting social-ecological damage in mining areas. From a sustainability point of view, further exponential growth of production in combination with short replacement cycles is not desirable, and thus questions of longevity and durability are brought into focus. The smartphone is an exemplary product for a discussion of the potential and limits of durability strategies, since it has evolved into a very convenient item due to high integration, but at the cost of durability-enhancing strategies such as repair and refurbishment. Taking smartphones as an example can help to clarify what shape(s) durability can take and which forms of durability are desirable from the normative perspective of sustainability. Is a durable thing something that is preserved as a whole, with all its (expected) functionalities? Or is it an entity that is adaptable or scalable in relation to changing needs and technological innovations and therefore can change its form or composition?

Since the acceleration of the smartphone market in 2007 following the introduction of the first iPhone, the device and its various features have undergone rapid technological progress. Immature technologies often have high failure rates and short lifecycles in the first phase after market entry. But, despite their increasing technological maturity, smartphones still have short production and replacement cycles and are used for only two to three years on average, with the majority of devices still working when they are replaced (Jaeger-Erben and Hipp 2018; Wieser and Tröger 2018; Schischke et al. 2021; Watson et al. 2017).

Technically, smartphones could last much longer than two to three years, particularly if small repairs (replacements of a broken screen or a weak battery, for example) took place and the software stayed up to date (Proske 2022). Considering this in relation to the usually highly intensive use of smartphones (on average, 3.5 hours a day spread over the whole day; see Statista 2020), the smartphone would qualify as a long-lasting product if it weren't for the short replacement cycles.

Short replacement periods have been considered one of the core issues when examining the sustainable use of smartphones and have been investigated in a few studies linked to product replacement, repair/maintenance, and the reuse of phones (see Wieser and Tröger 2018 for an overview). Since 2015, replacement cycles have steadily become longer, from an average of 23.8 months in 2014 to 33.6 months in 2020 (Statista 2021). It has been argued that reasons for this increase include a lengthening of smartphone contracts, mature markets, and higher prices (see also Wieser 2021). Still, most smartphones are being replaced before the end of their useful lifetime. Moreover, Benton et al. (2015) have found that if a smartphone is used for an additional year, the overall carbon footprint of the phone is reduced by 31 per cent. An overall benefit still exists if spare parts are needed for repair or if peripheral parts (display, camera, etc.) are upgraded to achieve this longer use time, as long as the mainboard is kept in use (Proske et al. 2020a). Summarising some of the literature on the reasons for replacing smartphones, Proske et al. (2016: 5) found that 'the main reason for replacement is that new devices have more functions combined with the opportunity for new devices through service contracts, the second reason are technical failures and breakage'.

In general, the reasons for replacement are related to a combination of usage patterns, use expectations, market developments, and (technological) device characteristics (see also Proske et al. 2016; Jaeger-Erben and Hipp 2018; Wieser and Tröger 2018). For example, users replace their still functioning devices when unsatisfied with storage space (e.g. after not regularly emptying the memory) or with the image quality of the camera (e.g. after a new smartphone with a better camera has been introduced). Another typical reason for replacement is the decreasing capacity of the battery; this is among the weakest points in a smartphone's technical durability, but the battery's durability is also related to or impaired by the high intensity of average smartphone usage. Thus, the 'durability problem' mainly seems to concern the performance of smartphone components, such as the capacity of the memory and the quality of the battery and camera, which then affects the evaluation of the smartphone as a whole. Therefore, component repairability and replaceability might be key to durable smartphones.

Backed by these ideas, modular product architectures became a promising design strategy. Modular architectures decouple products into components that can be independently and easily replaced or reused (Schischke et al. 2019, Proske et al. 2016, Agrawal and Ülkü 2013). Modular product designs have been around for over 50 years (Starr 1965) and have been touted as a means to offer customised products to the masses. It was only with the arrival of the circular economy debate in the last decade that modular product design became seen as a possibility to enhance longevity and sustainable consumption (e.g. Revellio et al. 2020). From the perspective of producers and product providers, modularity allows for the extension and simplification of services, since modules can be replaced more easily in case of malfunction, they can be upgraded if customer needs or technology changes, and their storage and redistribution can be more straightforward than for the entire device. Instead of an understanding of innovation that is based on the development of ever new technologies to constantly create new incentives to buy smartphones, modularity allows innovation to be thought of in smaller terms and to relate to the constant improvement of components or services geared to replacement and second life. Innovation through modularity also enhances user innovation by enabling the re-combination of modules.

As highlighted in Chapter 1, durability and scalability are important features of a durable economy. We understand scalability as the ability of an entity (e.g. object, system, or network) to change its boundaries – that is, to grow or shrink or to enlarge or decrease its reach or functionality. The creation of scalable things ensures the long-term functionality of singular products and of networks of connected things in the case of infrastructures such as railway or communication networks. In digital devices, scalability means the ability of a system of hardware and software to increase performance within a defined range by adding resources, such as further hardware. Modularity (as a quality of an entity) and scalability (the ability to extend beyond boundaries) are connected but independent features. A modular entity, such as an extendable crib, is scalable if modules are added or removed. Modularity can help to extend the functionality or reach of an entity beyond its initial boundaries; thus, it is one – but not the only – possibility to allow for scalability.

This chapter investigates the assumption that modular product design has the potential to connect durability with environmental sustainability by keeping one of the shortest-used digital devices in use for longer. This is important since modular product design can also lead to an explosion of resource use and an even faster market (this time for components), since it promises an ideal synergy between a never ending (cultural) need to improve individual consumer performance, the (capitalist economic) need to maintain or, better, constantly expand sales markets, and the (engineering) drive to reinvent and innovate technological systems. Therefore, we analyse the various relations between durability and modularity or scalability on the one hand and environmental impact on the other, and we discuss possible challenges and trade-offs. We highlight that in-depth knowledge of smartphones as popular cultural artefacts and everyday multifunctional companions is a prerequisite to design a durable and sustainable combination of product and services (or a 'product–service system') with modular smartphones. We present a typology of smartphone usage patterns based on a qualitative study and develop different durability scenarios. Based on this, we reflect on which form of modularity, and thus scalability, provides the optimum durability.

8.2 Modular smartphones: potentials, challenges, and tensions

Our chapter deals with touchscreen smartphones, which became the dominant design from the late 2020s (see Proske et al. 2020b), and focuses on the smartphone as the basic material entity. We also consider parts of 'smartphone systems', in the sense of bundles of phones, apps (software), and services. Hardware-focused modular designs for touchscreen smartphones became popular with the design experiment Phonebloks, which was created around 2013 by the Dutch designer Dave Hakkens.[1] The study describes the idea of a fully modular and upgradable smartphone, primarily to reduce electronic waste. Phonebloks essentially consists of a motherboard (called a 'base') onto which individual modules ('bloks'), including a battery, camera, or antenna, are plugged. If a component breaks, only this component needs to be replaced or repaired instead of the entire smartphone, and so less electronic waste is produced.

Although the design idea received much attention and inspired other attempts to develop modular smartphone concepts, it was never technically realised or commercially implemented. Other attempts have focused on upgradability and personalisation, such as project ARA, a prototype modular phone from Motorola that was later taken over by Google. The design was quite similar to Phonebloks; besides waste reduction, the objective was to offer a cheaper phone since only the modules had to be replaced in order to stay up to date. The modular device was developed to a high degree but never entered the market (Statt 2016; Hankammer et al. 2018).

The first devices with a modular design that entered the market were Fairphone 2 and SHIFT6m. Both designs were developed by start-ups that were driven by the motivation to develop a more sustainable phone. The two companies stated that they were founded to create an alternative to the fast-moving market and to maintain social and ecological standards. Longevity is also intended to compensate at least to some extent for the high and not entirely avoidable social and ecological costs. These designs mainly focus on easy reparability and thus the restoration of the device's functions, as well as possible upgrades. In contrast, a more dynamic modularity design strategy would allow for a flexible use of a diverse set of parts and modules (as intended by the Phonebloks concept).

Even though extensive modularity is still a niche phenomenon in the smartphone market, it can be assumed that modular devices will become increasingly important as the circular economy movement progresses, especially for fast-moving products, since modularity enhances possibilities for repair and refurbishment instead of replacement (see Revellio et al. 2020).

However, the relationship between modularity, durability, and sustainability is complex and by no means clear-cut. The decisive question is, first, what durability refers to: to the smartphone as a whole with all its (expected) functionalities, to the possibility of adaptation to changing needs and technological

1 See, for reference, www.onearmy.earth/project/phonebloks.

innovations, or to the robustness of all devices. If the first is foregrounded, then a 'simple' modularity that is limited to those parts that break down most often or wear out fastest, such as batteries and screens, is sufficient. If the second is intended, then modularity must be more pronounced and extend to those components that are most likely to be affected by technological innovations, such as the camera, memory, or possibly the sensors. Both interpretations of durability can have a positive or negative impact on the environment, because the more complex and elaborate the device, the higher the ecological costs. These decrease the longer the device and its components last, but only if repairs are made and upgrades are not too frequent. If, on the other hand, the focus is on durability, then modularity is often rather weak, because the more integrated the individual parts of the device, the less susceptible to breaking down they are. This can be seen, for example, in the question of water resistance. Liquid penetration is a common type of damage in smartphones (Agrawal and Bellos 2017). If smartphones are waterproof, they (potentially) last longer, but they are more difficult to modularise and repair. Furthermore, touchscreen smartphone designs often aim for a timeless, smooth, and seamless appearance, which can make them less susceptible to falling out of style, but the high integration of components again decreases the rate of repair and hardware upgrades.

Table 8.1 provides an overview of different durability strategies, the dominant features of the design, and their relation to sustainability. Depending on the durability strategy, the design focuses on robustness and resistance, repairability, adaptability, or expandability. Each level of modularity shares the sustainability risk that the more fragile design is more susceptible to failure and therefore more repairs and replacements are needed. Furthermore, higher degrees of modularity run the risk of inviting a (too) fast replacement of new components.

Table 8.1: Relations between modularity, durability, and sustainability.

Durability strategy	Designed for…	Modularity	Sustainability challenges and risks	Examples
Persevere	Robustness, resistance, and timelessness	Low modularity and high integration	Reduced lifetime in case of failure, since repair options are small	Rugged smartphones and premium smartphones (e.g. Apple or Samsung)
Repair	Repairability	Medium modularity with exchange of few parts (battery, screen)	Reduced lifetime if repair is not done or available Reduced lifetime through fragile design	Repairable: Fairphone 2, SHIFT6m Exchangeable battery: Fairphone1/2, most 'conventional' smartphones
Adapt	Adaptation and customisation	High modularity with exchange of several parts for customisation and adaptation to personal needs and adjustment to up-to-date performance parameters	Fast consumption of fast-moving upgrades Reduced lifetime through fragile design	Google ARA, LG G5
Upgrade and expand	Expandability and upgrades	Open modularity, expandable to up-to-date feature spectrum and add-on functionality	Fast consumption of fast-moving add-ons Reduced lifetime through fragile design Overconsumption of components	Google ARA, Moto Z (+ Moto Mods)

The key aspects for sustainable durability of modular smartphones relate to how the more fragile design is embedded in a 'robust' service system. While for non-modular devices it is primarily the design of the device that matters, for the different levels of modularity it is primarily the relation between developments in consumer expectations, technology, and the market on the one hand and, on the other, the product–service systems that determine whether durable is also sustainable. Durability through repair is about quick and easy availability of spare parts and repair services. A high level of modularity that allows consumers to exchange parts – or even expand existing parts if newer, more efficient, or faster components are available – can also increase consumption if the new components appear regularly and aspirations and user expectations rise at the same time.

Furthermore, the success of circular and durable design and business strategies relies on the development of appropriate usage practices. In the case of modular designs, the first issue is to understand which social practices in the context of smartphone use can ensure that modularity and durability go hand in hand and lead to a better lifecycle assessment overall. Second, it is necessary to investigate how much 'desirable' modularity-relevant practices differ from current smartphone usage practices. But, as mentioned earlier, the idea of durability through hardware modularity must accommodate a device that has become more and more integrated during its evolution until it is now something like a Swiss army knife, offering a wide variety of options to users as well as a high level of convenience. Smartphone designs and user practices have come together in a way that might make modular hardware design much less likely to succeed. We therefore start our investigation into the potential of 'durability through modularity' with a review of the evolution to the smartphone into a highly integrated device – not only technically but also socially.

8.3 Smartphone research

8.3.1 Touchscreen smartphone as a popular cultural artefact

The introduction of the iPhone by Apple marked a turning point for the concept of the mobile phone. The iPhone had an integrated operating system (OS), a web browser, and the iTunes store for downloading audio and video files. It had a touchscreen (instead of a keyboard) with a software-based keyboard. With the concept of the iPhone, Apple was able to redefine the market's boundaries by combining different industry branches: the mobile phone sector with the internet and portable music industry (Giachetti 2018). It further introduced the concept of an almost endlessly scalable device by means of constantly adding new apps to the available services in the app store. Apple set an example to the rest of the smartphone sector, and even though a multitude of smartphone providers appeared on the market, the design principles introduced by Apple have been adopted by almost all other players. Physical keyboards gradually disappeared, form factors became uniform, and all manufacturers relied on flexible operating systems that could be extended with third-party apps. The historical development of mobile phones shows that performance densities and the integration of parts and features have intensified enormously within the market. Moreover, novel use patterns have been integrated into mobile phones (e.g., clocks and diaries). For most devices, not even the battery or displays can be swapped easily. The architectural innovation of the smartphone (as a converging system of different technologies) was accompanied by an increasing integration of single components that are glued together within the phone.

The introduction of the smartphone transformed not only the market but also the social practices of mobile device usage and their integration into everyday life. While some smartphone studies focus on the negative psychological and health impacts of intensive smartphone usage, such as addiction, depression, anxieties, and various other public health concerns (e.g. Alhassan et al. 2018), others have underlined that people's relations with smartphones in their everyday lives are more ambivalent and complex (Ytre-Arne et al. 2020). In 2019, Daniel Miller wrote:

Has there been an invention so integral to our lives, and so intimate, as the smartphone? Yet they are slippery things. Smartphones are both a step change in the ability of human beings to communicate with each other and become informed, and new point of vulnerability to penetration by the outside world … Apple makes the iPhone, Samsung the Galaxy; these are phones with the capacity to be smart. But what really makes them smart comes from below: from their appropriation by users. (Miller 2019: 1–2)

Mobile technologies have radically altered ways of self-fashioning and being connected to each other. New cultural and social forms arose and new modes of interacting, sharing, and self-organising led to new ways of 'being in the world' (Frömming and Köhn 2015). Like no other mobile device, the smartphone has become an extension of bodies, senses, and minds, something that is used to organise everyday life, to improve the self, to learn about the world, and to assist in social interaction.

Scholars within the fields of media and communication studies have argued that the smartphone 'is not itself a medium but is instead a convergence point for a wide range of media' (Farman 2012: 4), allowing for diverse uses (Boehmer et al. 2011; Ling et al. 2015). Some of these studies are not only about how often and how smartphones are being used, but also about the changing organisation of everyday life and the associated interpersonal relations that are part of smartphone use (e.g. Brown et al. 2002; Katz and Aakhus 2002; Baym et al. 2004; Lapierre and Custer 2021). For example, Ytre-Arne et al. (2020) have examined how people manage and experience time through their smartphone. They have found that, although smartphones promise to make some everyday tasks more efficient, this is not always straightforward to achieve in everyday life. Time management strategies need to be implemented that must overcome several temporal conflicts (Lohmeier et al. 2020; Ytre-Arne et al. 2020).

Similarly, a group of anthropologists have conducted ethnographies into the impacts of smartphones on the experience of mid-life (Miller 2021). They have argued that the smartphone's capacity to be smart does not derive from its design and production, but rather from how it comes into being through people configuring their phone through applications and settings and the phone's ability to learn about its user over time (based on algorithms). As outlined in a recent book description, 'smartphones have become as much a place within which we live as a device we use to provide "perpetual opportunism", as they are always with us' (Miller et al. 2021: 297).

In addition to literature derived from media studies and anthropology, research studies have emerged that examine strategies and ways towards a more sustainable use of smartphones. Studies have looked at, for example, replacement cycles (e.g., Wilson et al. 2017; Wieser and Tröger 2018), energy consumption levels when using smartphones (e.g., Tarkoma et al. 2014), including practices of charging and managing power (Horta et al. 2015), phone hibernation (i.e. keeping a phone even though a replacement has been acquired) (Wilson et al. 2017), and sustainable product–service systems (e.g. Hobson et al. 2018). A UK study has also shown that 'there was little sense that giving users more information about the ethical and environmental dilemmas embodied in the mobile phone would make a difference to purchasing, use and disposal behaviour' (ibid.:155), demonstrating that developing strategies for making the use of smartphones more sustainable might not be straightforward.

8.3.2 Smartphones as scalable and modular devices

Smartphones as multifunctional, integrated, and convenient tools enable or assist a great variety of everyday practices. They can be described as an 'all-round medium' that picks up more and more functions, diversifying how people use their phones in daily life. The scalability of smartphones is mainly due their modular software design, which allows – at least to a certain extent – the inclusion of more and more functions via apps. In the last decade the app market has grown immensely. In 2020, people were able to choose from 2.59 million applications on Google Play and 1.96 million applications on the Apple App Store (Statista 2021). The average user has around 40 applications on their smartphone (Simforum 2021).

Given its software scalability and ability to constantly fulfil new and additional functions, the smartphone can already be described as highly modular. Used with additional items, such as covers, earbuds, external loudspeakers, and power banks, the smartphone can become a 'smartphone system' made up of different modules. However, when it comes to the core item, the smartphone itself, we can speak only of a 'soft modularity', whose scalability requires the most extensive basic hardware equipment possible. The smartphone design is like a Swiss army knife (Satyanarayanan 2005) from the start; it provides the right hardware tool ready for all possible eventualities. Multiple cameras, sensors, microphones, extra memory, and graphics capacity, among other elements, ensure that a wide range of apps can be installed and used. Thus, most smartphones are sold and purchased as an 'all-inclusive device' and may have many more function options than are actually needed.

Thus, it seems obvious that, at present, the scalability of smartphones leads to more unsustainable consumption of smartphones, since the devices might be overequipped when purchased and the user might install more apps than needed. The rapid development of the app market and the increasing use of apps can also lead to a device's hardware reaching its limits more quickly and the device then being replaced sooner. Thus, scalability reduces durability. Nevertheless, the scalability of smartphones also offers the potential to downscale the range of functions (and the hardware required) and to orient consumption towards sufficiency and not extensiveness.

If hardware modularity should lead to more sustainability, because of durable smartphone use, we need to understand better how people make use of the different functions of a smartphone and how much they tend to upscale its functionalities or are likely to downscale software and hardware use. Our first question is: what kind of 'sustainable consumption potential' can we find in existing patterns of smartphone consumption? And how do these patterns relate to (downward) scalability and durability? Our basic argument is that modular devices and corresponding modularity-embracing practices need to be embedded into product–service systems that are geared towards a durability-enhancing modularity that takes different qualities of scalability into consideration.

But current product–service systems are oriented towards extensiveness; they provide 'all-inclusive hardware' and abundant software that are likely to trigger overconsumption. Our second question therefore is: how and what kind of product–service systems can better connect to the sustainability potentials in current consumption patterns? The third question is: how much do the different scenarios of sustainable product–service–consumption systems differ in their ecological benefits and their potential to reduce their environmental impact?

The following analysis mainly focuses on everyday routines and practices around smartphones; this also includes non-consumption practices that are related to maintenance or care. From our point of view, actual practices are more important for more or less modular designs than general attitudes concerning smartphones or the role of the smartphone as a status object.

8.4 Durability through modularity: developing modular designs based on a typology of smartphone practices

8.4.1 Approach and methods

To collect data for our research, 24 in-depth interviews were carried out over the period of one year. The selection of interviewees was based on theoretical sampling: that is, categories of possible contrasting smartphone use patterns were developed based on analysis of the first few interviews and new interviewees were chosen who potentially showed contrasting characteristics (e.g., people with more versus less intensive usage patterns or people with high versus low technical expertise). The interview guide was broadly based on five themes: daily practices linked to the smartphone; a tour of people's smartphones (mainly relating to apps); smartphones set against the wider media context of people's homes; norms and meanings attached to smartphones; and modular smartphones. A total of 24 interviews were analysed based on interview transcripts, open coding, and constant comparison, using ATLAS.ti qualitative analysis software. An inductive coding structure was developed to be able to carry out an initial thematic analysis; codes consisted of topics such as my smartphone and its daily tasks, optimisation of wider media, and changes in smartphone use (e.g., weekends, holidays, and life changes).

After an initial thematic analysis of the in-depth interviews had been conducted, several steps were undertaken to develop a typology of smartphone use and scenarios for modular usage practices.[2] The processed aimed at the development of scenarios for sustainable modular smartphone designs and associated practices (sustainable product–service–consumption systems). Based on our initial research into modes of modular and scalable product–service systems, we developed scenarios that would allow for a long-lasting – hence sustainable – use of smartphones. The developed scenarios were than qualitatively assessed in terms of their positive environmental potential.

8.4.2 Insight into everyday smartphone use

On overall analysis of interviews about everyday life with a smartphone validated the results of other qualitative studies that describe smartphones as everyday multipurpose companions. The list of everyday activities that use a smartphone is long and comprises almost all domains of everyday life – housework, family and social life, paid labour and other forms of work, shopping, leisure and entertainment, and mobility. The smartphone also creates new, virtual everyday spaces where users engage in digital self-presentation via social media apps or self-optimisation via timers and fitness or meditation apps. The smartphone not only supports the organisation of everyday life, but also helps organise past and future, by means of documentation of experiences and archiving of memories or by forecasting and planning. Interestingly, the smartphone is no longer (only) a phone, since calling somebody or receiving calls is sometimes the thing people do least with their smartphones.

In line with the findings of media studies, we could find examples of convergence and de-convergence. The smartphone sometimes replaces other devices, particularly small and monofunctional devices such as alarm clocks or wristwatches, but even though smartphones are often used as cameras or music/movie players, people tend to have an extra camera, television or big screen movie player at home.

2 See Hielscher et al. (2020) for a more detailed description of the research process.

A key insight was that smartphones are mainly 'function carriers' or tools. Even though most people spend a great deal of time with their smartphone and keep it close throughout their everyday lives, they do not develop an emotional attachment to the device as such. In many cases, people value and appreciate the many functions of the phone, but if something is dysfunctional over a longer period, they tend to replace the phone instead of investing time and effort in restoring its functions. This is a possible threat to durability. The smartphone's tendency to be (up)scalable increases users' expectations that they can continuously enlarge the spectrum of functionalities on their smartphone. But the growth of functionalities meets hardware limits eventually, and so it is increasingly likely that people become dissatisfied with their smartphone as a function carrier.

Nevertheless, these more general insights can be further differentiated by our typology of smartphone usage patterns introduced below.

8.4.3 A typology of modularity-relevant usage patterns

This section outlines our empirical findings, by introducing a typology of smartphone usage patterns based on four dimensions that describe a continuum of two opposite poles.

I. Stability-optimisation

This dimension distinguishes use patterns that either keep the functionalities of a smartphone stable over time or continuously experiment with new or altered functionalities. Stability means that a user keeps the apps and the associated functions on the phone stable over time and does not connect it to other devices. With functions, we relate to the different practices a smartphone facilitates by means of apps (software). Since most smartphones have similar hardware, the spectrum or pattern of functions used in the smartphone are mediated by apps. 'Stable users' spend little time organising their phone – for example by deleting unused apps or uploading new ones – and are habitual in their smartphone use. They could probably do without some hardware components of their phones since they never use them (e.g. cameras). Optimisation-oriented users use a diverse set of apps and functions and change the constellation of their apps continuously. Users on this side of the continuum often use their smartphone within a larger media ensemble: for example, together with a smartwatch, a tablet, or a laptop. They regularly (re)organise their phone and media ensemble to find their 'optimal' set-up. Part of this group likes to have the newest phone. They enjoy discovering new apps and functions on their phone.

II. Reduction-extensiveness

In this dimension users can be distinguished according to the extent of their smartphone use. Extensive consumption is characterised by very frequent consumption, using a great variety of apps and functions. Extensive users frequently change and enlarge the apps and functions on their phone to be able to use the phone for every possible situation (i.e. going on holiday). They use the full range of hardware components of their phones and reach the limits of the hardware earlier then less extensive users. Reduced consumption is characterised by a conscious motivation to use the smartphone as little as possible. People actively try to reduce their use time, they delete apps they do not use, and they rarely add new ones. The smartphone is considered to be a tool for particular situations. These users would probably discard not only software they did not need but also hardware components if they realised that they could do without them.

III. Convenience-takeover

This dimension distinguishes users according to their engagement with the smartphone beyond using its functions. Convenient users expect their smartphone to work properly at all times but do not want to engage in maintenance or care activities, for example. They add apps as they see fit but do not want to invest time in (re)organising them, deleting unnecessary apps, or managing storage space or updates. Convenient users would rather buy a new phone than upgrade or repair their old one. 'Takeover' describes practices that actively engage with the phone's settings, by organising apps and settings efficiently, while keeping an eye on the storage space and actively looking for updates. Takeover users might also conduct basic repairs to the software and hardware and/or engage with privacy and data security issues connected to using the phone.

IV. Overwhelm-control

This dimension is closely related to the technical and use competencies of the smartphone user. 'Overwhelmed' users have low technical competencies and often feel stressed and overloaded when they have to deal with any kind of technical problem or demand. They often feel dependent on and ruled by technologies that are at the same time a 'black box' to them. These users have difficulty maintaining their phones properly or diagnosing the cause of a failure. On the other side of the continuum are users with high technological and/or use competencies. These users know how to manage their smartphone to make it work properly and how to deal with most problems. These users would be able to assess the necessity of upgrades, updates, or repairs.

The last two dimensions are related, but convenience–takeover is more closely connected to the patterns of using smartphones (the actual engagement with the device) whereas overwhelm–control is connected to (the lack of) competencies that enable (or disable) certain practices. Very competent users are more likely to show takeover patterns of smartphone use, but they can also be convenience-oriented and uninterested.

Depending on their position within the different dimensions, we were able to identify six different types of smartphone use as described in Table 8.2. Figure 8.1 shows the positions of the types in a multi-field scheme. Since the first two dimensions are more critical to the differentiation of usage patterns, they are presented more prominently. And since we concentrated on actual usage patterns, the durability of the smartphone in amount and length of use did not feature in the development of the typology. Nevertheless, both aspects differ between the identified types and are included in the typology description. The scalability of the phone is mainly relevant to the optimisation, extensiveness, takeover, and control dimensions, as can be seen in the type description on the next page.

Figure 8.1: Position of the six smartphone usage types within the stability–optimisation and extensiveness–reduction dimensions.
Note: Italic letters are used for convenience-oriented users and the font size characterises the use competencies (larger fonts for higher competence).

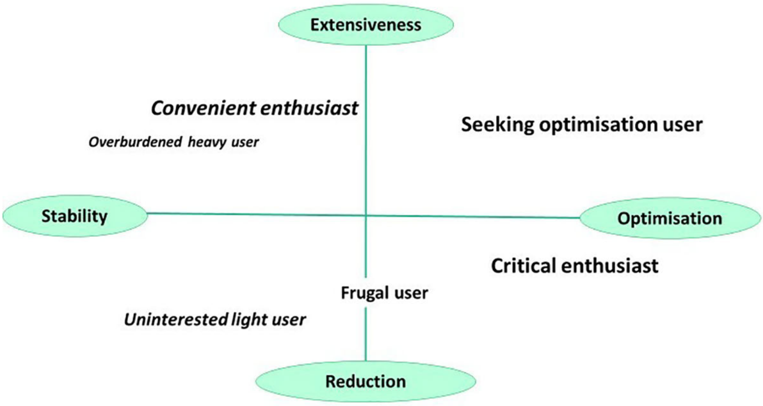

Table 8.2: The six types of smartphone use patterns and their characteristics.

Type and typical quote	**Use patterns**	**Scalability**	**Durability**
Uninterested light user *'I only use a few things linked with my smartphone. Telephone, I am calling people very small amounts of time. I have 100 free minutes and I never use them up. I use WhatsApp a lot.'*	High convenience and reduced use: usage concentrated in particular apps (e.g. social media) High stability: new apps/functions are rarely added Neither competent nor incompetent	Small scale of hardware and software in use Neither up- nor downscaling software and hardware	Durability in terms of long use times mainly due to reduced use but challenged if device does not work as intended
Frugal user *'I try not to install all apps, just because everyone has them … I try to read through things so that there is a level of data security … I turn my GPS off, so that no one can reach me like this.'*	Optimisation and takeover towards reduced use Competence is acquired to make the use long-lasting and sufficient Control is important	Medium and reduced scale of hardware and software in use Downscaling both software and hardware	Durability as part of sufficient long-term consumption
Critical enthusiast *'I serve the device so that it serves me. So especially all these complex things, when you can do more and more with the electronics, it also puts a strain on me. That means I have to learn how to do it, and how to avoid mistakes, all this data protection and what's all connected to it, there's an ever longer tail of rats attached to many devices.'*	High competence, takeover and control, but critical towards issues of security and data protection Tendency to reduce use	Broad but varying spectrum of hardware in use Both up- and downscaling of software in order to fit own standards	Durability and longevity depend on how the device meets own standards (e.g. of privacy, adaptability)

Type and typical quote	**Use patterns**	**Scalability**	**Durability**
Overburdened heavy user *'It's a device that can transmit data, that makes things public, I don't know how it does things. It's hard to describe. You never know what kind of things are stored somewhere, what kind of things are posted, what kind of terms and conditions you haven't read properly, what kind of GPS was on. So, you do not really have control.'*	Extensive use but low competence and tendency to be overwhelmed Dependent on social support and provider's services if device fails	High scale of software and hardware available but not entirely used Mostly upscaling with a tendency to have more apps and functions than needed	Low durability connected to short use times, since device is not well maintained and replaced when not working properly
Convenient enthusiast *'I think, this is because one is used to such a high level, it probably is hard to go down. Because everything is working absolutely fine all of the time and seamless, even when changing the smartphone. This is not a big issue and one can do [it] rather quickly. And I would say that such high content levels one does not want to reduce.'*	High to medium competence but low engagement and strong convenience orientation Smooth and fast operation is important and latest model is preferred Use is extensive and used apps/functions are stable over time	High scale of software and hardware in use Upscaling more likely but more or less stable use	Comparatively low durability, and replacement likely when device becomes less convenient
Seeking optimisation user *'It's great that you now have these cloud services that replicate everything directly, i.e. you have your images in the cloud and don't lose your valuable treasures. So that's the important thing!'* *'I always take the apps down and back on it, depending on where we are and what we need. So when I'm on the road, if we are in Berlin subway network, S-Bahn network, streetcar, on it and if we are in Hamburg, then the port forums and so.'*	High competence, strong orientation towards optimisation Smartphone is connected to cloud services and other devices High importance of control	Broad but varying spectrum of hardware in use Dynamic up-and downscaling	Orientation towards high durability connected with long use time, if optimum is found

8.4.5 Modular product-service systems for different use patterns

The six types show distinctive differences in how they make use of the smartphone as a scalable device. They also differ in the range of hardware they need on their phone. The frugal user, the user seeking optimisation, and the critical enthusiast are more likely to downscale their device in terms of software and hardware and use a durable design to its full extent, but for different reasons and under different circumstances. The frugal user has low expectations and only a few needs that should be fulfilled by a smartphone; they use only some aspects of the smartphone (calling people and browsing the internet but not using the camera, for instance). The other two types of users have high standards and expectations concerning their device and would rather replace a smartphone that does not fit their standards than keep it. They quickly reach their limits with a given smartphone and would benefit from upscaling. Since all three types have rather high competences that make use of the functional (software-related) modularity of a smartphone, they could also profit from a hardware-related functionality that fits their needs at the same time as it builds on their technical or use competencies to control and adapt their phone. The optimisation seeker and the critical enthusiast could both profit from dynamic product–service systems (PSS) that adapt hard- and software services to changing needs and standards. In the case of the optimisation seeker, the PSS should provide help for optimisation; for the critical enthusiast, it is more important that it offer high standards and quality for particular functions. The frugal user could profit from PSS that offer a 'frugal phone' that does not provide more hardware and software than needed. This also applies to the uninterested light user, who might need a bit more help in finding out what their basic needs and expectations really are. The convenient enthusiast and the overburdened heavy user tend to keep their smartphone at an upscaled level; for them, the Swiss army knife smartphone is the best option. In this case, durability and hence sustainability are not reached through modularity-oriented PSS but by high-quality and reliable products and refurbishment or take-back services.

Reflecting on the six use types in the context of the relation between durability, scalability, and sustainability led us to four different PSS scenarios that seek to optimise a sustainable use of smartphones. These four scenarios mainly relate to the dominant first two dimensions of the use typology (see the two axes in Figure 8.1); the other two dimensions are relevant for variations within the scenarios (see Figure 8.2). Table 8.3 describes the basic characteristics of the scenarios, their potential to foster durable, hence sustainable, consumption, and critical aspects regarding the environmental dimension.

Figure 8.2: Four scenarios for modular PSS.

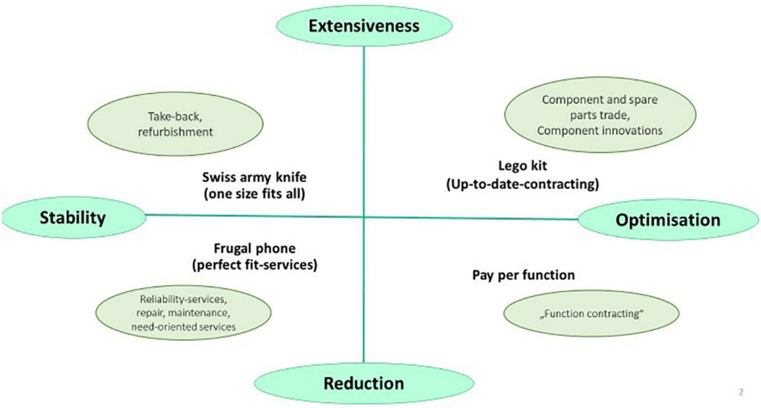

Table 8.3: Description of PSS scenarios.

PSS scenario	**Swiss army knife**	**Frugal phone**	**Pay per function**	**Lego kit**
Description	Product: One (biggest) size fits all, up-to-date technology Services: Take-back, refurbishment	Product: Basic modules Service: Needs-oriented sale, repair, and long-term updates	Product: Basic modules and expanding/upgrading options Service: Professional service at eye level, regular updates, and lending instead of owning	Product: Variety of modules Service: 'Up-to' contract that covers hardware upgrades and new modules
User types (and possible variations)	Overburdened heavy user (needs full service and high support) Convenient enthusiast (could be motivated to engage more, e.g. for maintenance, feedback to service provider)	Frugal user (could be motivated to engage more, e.g. for maintenance, repair) Uninterested light user (needs basic service that requires low engagement)	Critical enthusiast	Seeking optimisation user
Durability requirement	High-quality/high-end hardware, robustness, high up-scalability of hardware (particularly storage space allowing use of many apps)	Sufficiency/basic need orientation, down-scalability of hardware, reliability, fewer functions	High security, adaptability, dynamic up-/down-scalability of software and selected hardware	Expandability, adaptability, dynamic scalability of hardware

PSS scenario	Swiss army knife	Frugal phone	Pay per function	Lego kit
Requirements to reduce the environmental impact	Upgrades of peripheral parts could keep the mainboard in use Long overall product use time ensured through second and third use, main electronics are kept in use (e.g. for frugal users) Easy data transfer to new devices and secure data erasure enhances fast return of devices to enable second-hand use	No need for functional upgrades due to sufficiency orientation, repairability can deliver full potential, maintainability (battery exchange) is necessary to ensure longevity	Efficient connector design (small connector size, low amount of precious metals) Short-term need for certain hardware would not require a full high-end device (e.g. camera upgrade only for holidays) Easy and secure data erasure is needed to support short-term lending	Efficient connector design (small connector size, low amount of precious metals) Optimisation might lead to reduction in other devices (one product for everything)
Critical aspects regarding the environmental dimension	Modularity and PSS might accelerate upgrade cycles, including for main computing parts	Hardware functions might be rarely used but still needed from time to time, so no actual reduction in hardware components Reduced use of smartphone could require other products (e.g. digital camera if no camera is installed)	Short-term availability might lead to accelerated adaptation to new technical features	High frequency of module replacement, high fragility of overall device, resource intense production

8.5 Doing durability with modular smartphones

The aim of this chapter is to explore the potential for sustainable smartphone consumption, considering both existing usage patterns and new technological and service developments. The smartphone has a particular place among modern digital devices, because hardly any other device combines a similar number of functionalities and usage options with a comparatively short usage period. The scalability of a smartphone in terms of the expandability of functions makes the device an 'infinite machine' that is potentially eternally durable, but also carries the risk of reducing durability. This is mainly because this scalability of a smartphone mostly affects the software, while the hardware tends to remain stable. Although there are models of different hardware quality and equipment (e.g. in terms of storage space), once purchased, the equipment usually remains stable. If the usage volume increases due to the number of new apps, the hardware soon reaches its limit, and the device is replaced. On the other hand, the hardware can also be overequipped if users use only a few functions via apps. In this case, electronics are unnecessarily installed, and resources are overused. Both cases – quickly achieved under-equipment and permanent over-equipment – are ecologically problematic.

In this chapter, we have addressed the question of how the scalability of hardware can be increased in such a way that permanent and more ecologically compatible use is promoted. In doing so, we explored the potential of modular product–service systems with respect to different types of smartphone use.

The comparison of the contrasting types of smartphone use reveals a diversity of meanings, competences, and material arrangements that are associated with smartphones in everyday life. Growing old with a phone does not seem to be a straightforward process, given that the smartphone has become an integral part of people's lives and is linked to several daily practices. As argued by Miller et al. (2021: vi), the name 'phone' no longer really applies, 'since traditional phone calls now represent only a small part of usage'. Therefore, it is important to consider what function(s) a smartphone fulfils in the everyday life of a particular user and what type of relation and patterns have evolved between user and object. Our findings show that frugal and uninterested light users would benefit from a 'basic or downscaling' modularity, whereas users seeking optimisation and critical enthusiasts would value upgradable and expandable modularity with dynamic scaling options. Convenience-oriented users would not benefit from modularity but would need other types of PPS to be facilitated in sustainable smartphone consumption.

But downscaling is not a straightforward process. Miller et al. (2021: 104) have referred to the term 'perpetual opportunism' – i.e. 'simply because the smartphone is always with us, it creates the possibility to being opportunistic as a constant'. For example, the use of the smartphone has redefined how we take and store photographs, look at the news, listen to music, etc. Keeping the functions and applications of a smartphone over time is not easily done. A frugal phone requires the user to be extremely reflective about their existing and potential future practices that are enabled by the smartphone to prolong customisation and associated use for as long as possible.

The positive environmental effect of modularity results not only from the modularity of the product but also, as described above, from modular utilisation concepts. The PSS should also be modular in design. In particular, the linking and interaction of several user types within a service platform promises improvements. Quick upgrades for overburdened heavy users will never be truly sustainable, but by sharing devices and modules, this form of usage can be mitigated. While this can happen with the 'Lego kit' within a group of users seeking optimisation, since users rarely all have the same expandable needs at the same time, with the heavy user this would occur primarily through phones being passed on to other user groups with lower demands for technical high performance.

The PSS therefore needs to focus on the products, the modules, and the different users. As for repair in general, upgrades need to be 'easy' to be used. This could mean that a module is easily swappable by the end user, but it could also mean that upgrade cycles are already defined in a basic PSS contract and users do not need to keep track of which modules are available and when. Automatic information (e.g. on the phone) regarding new modules could makes processes easier for the user, but they could also accelerate upgrades as users are made aware constantly about new modules. This could even accelerate the exchange of the whole phone, if users are confronted with a range of new modules for almost all features and decide to ditch the product because of 'so much progress'. On the other hand, successive updates of certain modules in fixed time intervals could extend use time by upgrading the device without adding much acceleration.

Depending on the user and their specific knowledge, online shops and exchange platforms could be efficient means of disseminating new modules. For others, services such as professional exchange and advice on module choices could be needed.

Efficient linking of different user types with the passing on of modules and devices could thus make middle-class and low-end devices unnecessary. 'Yesterday's flagship can out compete today's best seller,' wrote Benton et al. (2015). Utilising used devices to fulfil lower demands instead of producing specific low-end devices would reduce the quantity of permanently required devices in the long term. The problem of functional obsolescence within a certain user group would be significantly lower for another user type. The prerequisites for this are general reliability, the possibility of replacing worn-out parts such as batteries, and the ability to repair damage easily.

Notions of longevity and sustainability are not inherent in smartphones, even if they are modular. These technologies are interpreted and adapted within the existing patterns of people's everyday life. How people use and live with their smartphones is deeply embroiled with, for instance, existing digital infrastructures, media ensembles, family relations, and changes to work situations and lifestyles. Developments towards a 'perpetual opportunism' and integrated smartphone designs (i.e. glued parts) do not necessarily make it straightforward to introduce different types of modularity to prolong a mobile phone's useful life. Thus, a smooth transition seems unlikely from the current, rather unsustainable use of the static modularity of a smartphone to sustainable consumption and a dynamic modularity that enables a circular economy. Modular smartphones (such as Fairphone or SHIFT) are currently niche products that cater for smartphone users who like the idea of such a phone. Within these niche markets, a lot of thinking seems to go into the technological developments of modular smartphones and related business models to increase the potential for more sustainable production and consumption patterns. Considerations of how modular smartphones are being domesticated in people's daily life – that is, what types of meanings are created and how the phone is placed within existing patterns of daily life – often seem to be neglected within these developments.

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9. Organising durable economies for environmental sustainability

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9.1 Introduction

In contemporary societies, where most resources extracted from the environment do not simply flow in and out of the economy but remain in use, pile up in storage rooms, or litter environments for many years or often even centuries, resource use can no longer be reasonably captured in terms of consumption and production only. Once societies start to accumulate and surround themselves with material infrastructures, buildings, and other durable objects, consumption and production become only some of the moments in our engagements with natural resources alongside many others, from use to repair, maintenance, care, or valorisation. As we have argued in the introductory chapter to this book, such engagements have distinct material consequences that, rather than being hidden in increasingly expansive understandings of consumption, should be brought to the centre of analyses of resource use. To appreciate why contemporary societies demand increasing volumes of natural resources and why those resources are processed in ways that create long-term damages to humans and the environment, it is crucial to acknowledge the significance and distinctiveness of objects made durable vis-à-vis materials and energy intended for immediate consumption.

The research programme on 'durable economies' put forward in this book aims to shed light on the social, economic, and technical processes that make durables such foundational elements of everyday lives in the twenty-first century. Moving from the study of inanimate 'stocks' to the varied practical and contested engagements that make things last is vital for gaining a better understanding of the driving forces behind resource use. Furthermore, considering durable economies as ongoing and diverse practical accomplishments creates room for research and debate on the potential benefits and opportunities of transformations towards more *sustainable* durable economies.

Throughout this book, our main concern has been with the environmental consequences of resource use. As Josh Lepawsky illustrated in his discussion of the chemical compound trichloroethylene (Chapter 2), durables that seemed to be 'goods' at some point may turn out to be environmental 'bads' many years later. Other durables may be environmentally hazardous from the very beginning or unsustainable from a social or economic point of view. In making the case for a more neutral approach focused on durables rather than 'durable goods' and problematising the resource and carbon intensity of existing, accumulation-driven durable economies, we have already made clear that, for us, a durable economy is not necessarily desirable. In this final chapter, we first expand upon the relation between durability and sustainability, and we discuss how a durable economies perspective can help in developing environmentally sustainable economies that address the varied consequences of durables. Our main message is that sustainable economies need to attend to the volume, pace, and intensity of durable stocks and that existing concepts do not provide satisfactory responses to each of these dimensions. In the second and final part, we reflect on the arguments and findings presented in the previous chapters to tease out some key learnings on the promises and challenges of 'doing durability'. Considering the massive implications of durables for the environment, mastering the quality of durability will be of vital importance in sustainable economies.

9.2 Durability in sustainable economies

While not everything that is durable is also sustainable (cf. Carp 2020), sustainability is inconceivable without some form of durability. For future generations to be able to meet their needs, natural resources need to be preserved and ecosystems need to be protected for them to retain their capacities to deliver services that are vital for human well-being. It is less evident, however, that future generations need 'manufactured capital' and that sustainability demands that today's generations preserve durable infrastructures and objects. Likewise, making things last may not be the only or even the best sustainability strategy for protecting the environment and resource preservation. Despite such uncertainties, durability evokes mostly positive connotations in debates on more sustainable futures. In several languages, such as Dutch, Finnish, and

French, sustainable is even translated as durable. Against this background, it is not surprising that durability has been put very much at the centre of various conceptions of sustainable economies and more sustainable relations with the material world more generally.

An interesting example of such a conception is the development model that has been advanced for the city of Burlington, Vermont (Phillips et al. 2013; Seifer et al. 2020). Drawing inspiration from McKibben (2007), who linked local, community-based economies with durable futures, Seifer et al. (2020) characterise the development model of Burlington as a 'durable economy'. 'A durable economy,' they propose, 'is one that is nurtured by the community from the ground up and maintains its vibrancy over the long term by consistent attention to the needs of that community' (ibid.: 43). Notably, the authors make scarce reference to material stocks, stressing instead the significance of long-term visions as well as distributed, inclusive, and local action for the durability of the economy. By contrast, durable objects, as with the biophysical world more generally, have long been central to the sustainable economies conceived by ecological economists. Boulding's (2011) 'spaceship economy' and Daly's (1974) 'steady-state economy' are classic examples of this. In his famous essay 'The Economics of the Coming Spaceship Earth', Boulding argued that attention would need to shift from the flow concepts of production and consumption towards the condition of 'stocks':

> The essential measure of the success of the economy is not production and consumption at all, but the nature, extent, quality, and complexity of the total capital stock, including in this the state of the human bodies and minds included in the system. In the spaceman economy, what we are primarily concerned with is stock maintenance, and any technological change which results in the maintenance of a given total stock with a lessened throughput (that is, less production and consumption) is clearly a gain. This idea that both production and consumption are bad things rather than good things is very strange to economists, who have been obsessed with the income-flow concepts to the exclusion, almost, of capital-stock concepts. (Boulding 2011: 11)

Boulding was clear that stocks should not be preserved for their own sake but, at the very least, they should be evaluated from the point of view of their resource requirements. However, for Boulding, the maintenance of stocks was more than a mere matter of resource conservation. He viewed durable objects and infrastructures as foundational to human well-being and saw in their rates of depreciation a more appropriate indication of an economy's (lack of) success than the flow-centred gross domestic product (GDP). The burden of proof would thus be reversed: it would not be maintenance and persistence that need justification but replacement and technological change.

The idea that durables are vital for human well-being and deserve greater recognition in debates on sustainable futures finds resonance to this day. Pauliuk and Müller (2014), for example, suggest that durables play multiple roles in contemporary societies, from 'service suppliers' to 'resource repositories' and 'wealth watchers'. Alongside such perspectives that stress the significance of durables in providing services for the fulfilment of human needs (e.g. Haberl et al. 2017; Whiting et al. 2021), durables also figure centre stage in environmental movements that advance a 'new materialism' (Simms and Potts 2012). Grounded in similar philosophical roots as many of the approaches to material culture studies presented in Chapter 1, 'new materialist' movements bring forth a radically different perspective from the 'post-materialist' approach to environmentalism. Instead of turning towards non-materialist values and lifestyles, new materialism proposes a convivial approach that recognises the importance of the material world for human flourishing. New materialism is about 'a different kind of love affair with "stuff" – a long-term relationship of appreciation, slow pleasures, care and respect' (ibid.: 26). Developing more long-term relations with things is very much at the heart of this perspective, which is practised across the world in repair cafés and workshops.

None of the perspectives presented equate the durability of artefacts with environmental sustainability. Even so, the strong emphasis on the maintenance of durable stocks in conceptions of the spaceship economy, steady-state economy, or new materialism can easily be misleading. Material efficiency strategies for the extension of product and infrastructure lifetimes, such as repair, maintenance, and reuse, will likely need to be core ingredients of more sustainable economies (Hertwich et al. 2019). However, continued growth of durable stocks in the old industrial world means that the reference point against which Boulding made a plea for focusing on stock maintenance has changed dramatically since the publication of his spaceship economy essay. If the global population were to attain and maintain today's level of per capita stocks of industrialised countries, the CO_2 emissions resulting from the expansion of stocks in the remaining world regions alone would use up almost the entire carbon budget available to meet global warming goals (Krausmann et al. 2018). To limit global warming to 1.5–2.0°C, durable stocks will likely need substantial downsizing through higher intensities of use, sharing, light-weighting, and avoidance of unnecessary acquisitions (Krausmann et al. 2018; Pauliuk and Heeren 2021).

Furthermore, as Van den Bergh (2011) rightly points out, energy and materials vary considerably with regard to their environmental impacts. Focusing too strongly on aggregate material stocks suppresses incommensurabilities and eschews important procedures of assigning appropriate weights to different substances. A case in point are light-weighting strategies in aerospace and automotive industries, which can reduce material inputs in production and cut down fuel consumption in use but frequently involve materials with higher emission intensities and lower levels of recyclability (e.g. Liu et al. 2022). A narrow focus on aggregate stocks would clearly overestimate the environmental benefits of light-weighting, possibly leading to detrimental effects in both the short term (higher emissions in manufacturing) and long term (depletion of primary resources). Stock maintenance and downsizing are insufficient and may even be counterproductive in addressing key environmental challenges related to the most energy-and carbon-intensive stocks. Even if no new infrastructures for fossil fuels were to be built and all existing fossil fuel infrastructures were to be phased out according to plans, there would still be a 36 per cent chance that the 1.5°C target could not be met (Smith et al. 2019). Meeting global warming goals thus requires an immediate acceleration of phase-out strategies in this critical domain.

While durability is a necessary ingredient of sustainable economies, the discussion so far shows that there are inherent risks in establishing close connections between durability and sustainability. However, from a research point of view, focusing on durable stocks is not the same as advocating stability – or durability, for that matter. Building on studies of material flow accounting, we suggest that durables mediate resource use in three ways: they demand resources for their construction and expansion (relating to volume), for their replacement and maintenance (relating to pace), and for their operation (relating to intensity) (see Chapter 1). Paying attention to each of these dimensions can help in evaluating the sustainability implications of diverse economies and eliciting their respective blind spots. A coarse review of prominent concepts of sustainable economies is sufficient to reveal that none of them can be expected to deliver significant changes in resource use across all dimensions (see Table 9.1). Moreover, there are significant trade-offs and gaps that remain poorly addressed in existing approaches to reduce the environmental pressures of resource use.

As we tried to show in the introductory chapter, a durable economies perspective is able to provide an account of historical material flows that diverges significantly from prevailing narratives of the rise of consumerism, the throwaway society, and the linear economy with their emphasis on the increasing pace of resource throughput. The resulting reinterpretation of present-day environmental challenges has important implications for the priorities that need to be set in sustainability transitions. The circular economy and the performance economy, for example, may offer effective responses to slow down the pace of stock replacement but they are oblivious to the important roles rental-based business models, repair, and maintenance have historically played in the accumulation of durable stocks, in particular in the housing sector. Similarly, constructing new infrastructures for renewable energies could reinforce existing dynamics of capital accumulation and lead to lock-in effects that impede sustainability transitions in the long run if the links to economic growth and the distribution of capital are not taken into account. Tackling the massive accumulation of durable stocks, which represented the main driver of growing resource use in past decades, will require alternative resource-saving strategies – from downshifting to light-weighting and sharing – that are scarcely considered in prevailing notions of sustainable economies (Hertwich et al. 2019).

Table 9.1: Expected contributions of sustainable economies in reducing environmental pressures across each dimension associated with durable stocks.

Dimensions Reducing environmental pressures	**Volume** Downsizing stocks	**Pace** Keeping stocks in use	**Intensity** Using more environment-friendly stocks
Circular economy	*	**	**
Performance economy	*	***	**
Bio-based economy	*	*	**
Green economy	*	*	***
Sharing economy	**	*	*
Steady-state economy	**	**	*

Note: * = weak, ** = medium, and *** = strong, based on our own judgements of the emphasis put on different dimensions in each framing.

With the steady-state economy and the sharing economy, among others, there are several candidates for addressing the volume of durable stocks. However, it is important to note that considerations of measures that target the volume of durable stocks *directly* are still rare. For example, Daly redefined the steady-state economy in terms of constant flows rather than constant stocks in later years (see O'Neill 2015). Instead of imposing limits on material wealth, Daly proposed that the government should focus on controlling aggregate resource throughput by setting quotas for the use of resources according to ecological and ethical criteria. The allocation of available resources would then be determined by market forces. The basic strategy of setting resource caps in accordance with planetary boundaries and allowing a (relatively) large amount of individual freedom with respect to the use of available resources is widely advocated among scholars concerned with 'strong sustainability' or absolute levels of resource throughput (e.g. Fuchs et al. 2021; Jackson 2016; Raworth 2017). However, by failing to open the black box of resource throughput, particularly with regard to the dynamics of durable stocks, this strategy falls short of explaining the processes that prevent democratic governments from setting strict resource caps in the first place (Smith 2010; Spash 2020). Developing a coherent strategy that tackles volumes of durable stocks head on will thus likely be a core challenge in conceiving sustainable durable economies.

9.3 Doing durability for sustainable economies

Following the discussion of how durability relates to resource use, we can turn to some final reflections on the making or 'doing' of durability. The ambivalent effects that durability can have on resource use make it essential to develop capacities for organising durable stocks in an environment-friendly manner. This is no straightforward challenge. Contemporary economies have become extraordinarily skilled at creating matches between supply and demand, and the proliferation of powerful new 'devices' and 'arts' across production, distribution, and consumption has created unprecedented capabilities at shaping the qualities of products and establishing unique attachments between individual people and things (Cochoy et al. 2017). When it comes to organising and managing the durability of artefacts, however, the economies we know tend to be strikingly inept, creating tons of things that either disintegrate far too quickly or end up cluttering our world. In other words, today's durable economies constantly fail to meet the core expectation of providing goods that serve their purpose until – and only until! – they are no longer needed. Even if one were able to define a *sustainable* use of durables, there would still be major challenges in realising such an outcome.

Approaching the doing of durability from various vantage points, the previous chapters have explored some of the key challenges different actors face and potential solutions for aligning business models, public discourses, regulations, design, and user practices, among other elements, with higher levels of product durability. In the following sections, we review the challenges and approaches to durability from three different perspectives: technical, economic, and social.

9.3.1 Technical challenges: planning and optimising durability

From a technical perspective, doing durability is about predicting the lifetimes of artefacts and implementing the technical procedures and infrastructures necessary for products to perform according to predictions. In debates on product lifetimes, this perspective has informed a growing body of research on the challenges and possibilities of 'planning' and 'optimising' durability. Instead of associating 'planned obsolescence' with the intentional manipulation of product qualities to bring about premature obsolescence, engineers and designers argue that 'planning' is not bad per se but an inevitable element in product development that should be leveraged for sustainability (Burns 2010; Poppe and Longmuß 2019; Satyro et al. 2018). Brian Burns suggests that it is time to acknowledge the inevitability of obsolescence, learn from experiences, and collect necessary information to plan for it:

> Life cycle analysis can help, as will the development of appropriate industry standards and consumer education. We must now attempt to optimize each product's life by planning for the inevitable obsolescence at the end of its life. (Burns 2010: 58)

The idea that product lifetimes and durability can and therefore should be 'optimised' (van Nes and Cramer 2006) has informed, for example, a substantial body of research concerning the environmentally optimal timing of replacements and the development of a wide range of design strategies (see Rivera and Lallmahomed 2016). However, the technical challenges associated with the planning of durability have arguably shifted over the years. This is because previous advances in material sciences and testing methods, which had turned uncertainties about failures into relatively calculable risks, allowing for a fairly high degree of alignment in the durability of product components, are being increasingly undermined by trends that see products experiencing more complex and unpredictable lives (cf. Spring and Araujo 2017). As industrial divisions of production and consumption collapse and a growing number of agencies participate in the co-production of goods, be it through means of personalisation, reuse, or repair, it becomes more difficult for 'original equipment manufacturers' to simulate product lives and plan for durability accordingly. It is in this emerging context of flexible durable economies made of diverse, distant, and asynchronously acting entities that the technical focus shifts from predictive testing methods to digital and modular technologies.

By establishing a virtual copy or 'digital twin' of a product that contains real-time information regarding the product's condition, use, and location across its lifecycle, it may become possible, for example, to predict failures more accurately and implement preventive measures in time (see Chapter 4). Information on use and location could also support the management of material flows by identifying idle resources. Perhaps the revolutionary potential of digital technologies in 'planning durability' is nowhere greater than in relation to the choreography of temporalities. Marketing professionals, for example, have established a massive infrastructure for disrupting everyday routines in various locations, including people's homes, but until recently they had little control over the time when potential customers received their messages. Even the bundling of phone purchases to mobile service contracts with predetermined contract periods – a market device par excellence for calibrating the temporal rhythms of product renewal in the traditional world of marketing – was unable to reliably control the rate at which customers would replace their phones (Wieser 2021; Wieser and Tröger 2018). Digital tools allow marketing departments to get their messages out with much greater precision. For example, British network operator O2 submitted an insightful case study to a national marketing association, in which its marketing professionals explained how they addressed the self-proclaimed challenge of 'identifying the exact tipping point when customers started to itch for a new handset, and being there to catch them':

> It is in O2's interest to lock customers into a new phone as soon as possible. So the team ran quantitative research to identify the moment that, on average, customers started to want a new phone; and at that very moment O2 stepped in to help them get it … This timing was critical, so the campaign needed to identify and use the right channel (email, SMS and outbound calls) for the right customer, based on data insight, with absolute precision … A live countdown timer and fireworks told them precisely when their contract ended, creating a sense of urgency and anticipation that drove immediate renewal … Complex data algorithms allowed the campaign to predict the most tempting phone for each customer, based on brand preference, usage and sales trends. Current contract details informed their upgrade cost and generated relevant incentives, such as a 25% discount or the recycle value of their current handset back. Everything was designed to drive immediate response, get the customer locked into a new contract and get them to feel good about it. (O2 2015)

In O2's efforts to align the durability of the phone with the length of its contracts, timing was key and smartphones, as carriers of digital traces of customer behaviour and as digital communication devices, proved critical in both creating and transmitting a customised message in time. The company reports that this campaign encouraged 130,000 customers to take a new handset early. Digital technologies, in connection with incentives for returning the phones and complementary resale and recycle programmes, enabled O2 to reduce the time periods during which phones would remain in an idle state.

The use of digital technologies for planning durability at O2 highlights their potential but also raises important questions about how such technologies affect existing power asymmetries in economies. In his contribution to this book (Chapter 4), Eduard Wagner puts forth a vision in which tools such as digital product passports are leveraged for the democratisation of production processes, in particular by empowering individuals such as users, consumers, and DIY practitioners, who at present have inferior access to relevant product information compared with designers and manufacturers (cf. Callon and Muniesa 2005). In such a democratic economy, an 'optimal' level of durability would not be achieved through some form of centralised 'planning' but through distributed capacities among diverse economic actors to evaluate the durability of an artefact at any moment during their lives. However, as Wagner points out, important challenges related to intellectual property rights and privacy need to be overcome to realise such a vision of information sharing about product characteristics relevant to their durability. Furthermore, digitalisation may not be the only path for optimising durability through more democratic or distributed production processes.

A key challenge in doing durability is to align the durability of artefacts at different scales. Hand and Shove's (2004) analysis of kitchen replacements offers an intuitive example. To most people, a kitchen is more than the sum of its parts. The value of a kitchen derives from the harmonious configuration of its constituent devices and pieces of furniture, which in turn tend to be informed by wider design trends and expectations of the ideal kitchen, which Hand and Shove refer to as 'kitchen regimes'. As they go on to show, it is not uncommon at all to replace entire kitchens when new ideas and expectations of kitchens emerge. In such cases, the durability of each component outstrips the durability of the shared 'kitchen regime', leading to their (provisional) obsolescence despite remaining perfectly functional. In contrast, irreparable damage to a single appliance or piece of furniture may be sufficient to ruin the current kitchen regime and motivate the replacement of an entire kitchen.

From a technical perspective, it is difficult to avoid misalignments when changing cultural ideals are involved. However, as Melanie Jaeger-Erben, Marina Proske, and Sabine Hielscher show in Chapter 8, it may be possible to reduce co-dependencies between material components by following a modular approach to product design. If co-dependencies can be relaxed, misalignments and different temporalities do not have to lead to the replacement of entire products or product ecosystems.

9.3.2 Economic perspectives: managing and regulating durability

Moving on from the previous discussion of technical challenges to the economic sphere, economic theory suggests that durability poses a series of specific challenges to achieving 'socially optimal' market outcomes. Economic theories of markets for durables generally start from the assumption that durability can be planned with precision. The core economic issues, following Waldman (2003), relate to pricing, the timing of new product releases, and governance of markets for second-hand goods and complementary goods and services. In markets for durables, sellers with sufficient market power have an economic incentive to withhold 'real' innovations and seek ways to reduce competition from durables in use instead (see Chapter 5). Sellers could thus offer lower-quality products or eliminate markets for second-hand items and complementary goods or services such as repair, leading to socially suboptimal levels of durability. As Max Marwede and Florian Hofmann (Chapter 3) illustrate, based on companies that have specialised in high-durability products, economic incentives alone do not necessarily lead to lower levels of durability. Companies that are able to build trust in the quality of their products and communicate the advantages of durability may gain competitive advantages from putting durability at the centre of their sales strategy. However, such companies frequently cater to the needs of specific segments and often struggle to reach a wider range of customers (Hofmann 2019; Niessen and Bocken 2021).

In recent years, growing recognition of a more systemic 'market failure' in relation to product durability has informed a series of public policy interventions. As Carl Dalhammar and his colleagues show (Chapter 7), governmental bodies in Europe are considering various policy measures to regulate business practices on the one hand and empower consumers on the other. As would be expected, such efforts have been met with fierce resistance by business representatives. Ongoing controversies relating to a 'right to repair' are a case in point. Whereas consumer agencies have called for more transparency and better access to repair equipment so that product owners can repair defective items themselves, following a model of 'distributive repair market governance', industry representatives have defended a model of 'centralised repair market governance', lobbying for much more restrictive legislation that would essentially grant consumers only the right to have their items repaired by a manufacturer's authorised professional, potentially solidifying prevailing monopolies of aftermarkets even further (Svensson et al. 2018; Svensson-Hoglund et al. 2021).

In domains where expectations have stabilised and products are relatively homogeneous, standard setting and regulation can be appropriate responses to secure minimum levels of durability and reparability. Therefore, standardisation of durability has been implemented mainly with respect to products such as vacuum cleaners and lighting products, where technological advancements have plateaued. For other domains, where products undergo rapid change, alternative business models are needed that decouple sales volumes from the imperative for profit generation. An ideal typical case is the scenario of the 'seeking optimisation user' of smartphones explored by Melanie Jaeger-Erben, Marina Proske, and Sabine Hielscher (Chapter 8). To address the demand of this user group for frequent hardware upgrades, the authors propose that businesses could switch from a sales-based business model to 'up-to-date contracting', which provides users with the most up-to-date product modules. Such a business model could allow providers to obtain used modules and resell them on the second-hand market. As the authors show, widening the scope from products to wider product–service systems generates new possibilities for developing solutions tailored to user-specific demands and aligning the durability of product modules with different temporalities of product use.

However, irrespective of whether companies pursue a sales- or service-driven model, commercialising durability can be extremely challenging. From Max Marwede and Florian Hofmann's contribution (Chapter 3), we learn that providing products with high levels of durability requires enterprises to develop a set of specific, internal procedures, structures, and human capacities. An additional important challenge lies in the relationship with retailers, whose profits tend to rely heavily on driving sales volumes (see Chapter 5). Manufacturing firms wishing to switch to service-based business models and establish direct contacts with customers are likely to meet resistance from dominant retailers.

9.3.3 Social perspectives: narrating and doing durabilities

In addition to being contested in economic and political terms, durability is subject to various cultural meanings and embedded in a wide range of different social practices. While durability is clearly of economic relevance, it is thus important to highlight that durability may not be at the forefront of people's concerns, or that, in other words, an artefact can be durable without anyone wanting or intending it to be durable per se. Frequently, people care more about specific qualities such as reliability or robustness rather than durability. Studying consumer understandings of product lifetimes, for example, Cox et al. suggest that many of their study participants 'want products to last (i.e. not break) for just as long as they want them to last, but not necessarily any longer than that' (2013: 24). Their point is that when people talk about product lifetimes, they do not express a demand for durability per se, which could be related to economic or environmental concerns, for example; mainly, they talk about 'functional reliability', a quality linked to concerns about being able to perform particular tasks without disturbances or interruptions. While 'workhorses' such as washing machines and dishwashers are expected to last *for some time*, such expectations are very different for 'investment products' including houses or jewellery, where there are no limits to how long they should last – that is, where durability per se matters greatly.

Most of the empirically informed chapters in this book originate in research on product lifetimes. While there was a shared intuition that durability would play a role in relation to product lifetimes when we launched this joint venture, the concrete links between durability and product lifetimes were not self-evident and many authors were confronted with the situation of having to (re)construct how their observations relate to durability. In contrast to research that takes the quality of durability as a starting point, this research strategy makes it possible to open the 'black box' of durability (see Chapter 1) and elicit the *specific* qualities different communities are concerned about.

While the multiplicity of qualities that underpin durability certainly can represent a major challenge in 'doing durability', be it in research or in practice, this multiplicity can also be a key asset that opens up various pathways for achieving higher or lower levels of durability. By examining how various people talk about the lives of electronic devices, Tamina Hipp and Daniel Fischer (Chapter 6) were able to identify a wide range of popular narratives that contribute to the depreciation or appreciation of devices. While all narratives have implications for durability, only some of them make direct links to this quality. The narratives provide a valuable repertoire of communicative tools for shaping the durability of artefacts in various social contexts. The contribution of Melanie Jaeger-Erben, Marina Proske, and Sabine Hielscher (Chapter 8) adds an additional layer by addressing the diversity of user profiles and their varied demands with respect to durability. Again, their analysis focuses on daily practices and expectations relating to smartphones in general, from which the authors are able to derive different durability requirements, ranging from reliability and robustness to storage space, scalability, adaptability, and expandability. From a social perspective, 'doing durability' thus emerges as a practice of manoeuvring a space of multiple durable economies in which durability takes different forms.

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