Chapter 3. The current scale and potential scalability of circular business models

This chapter moves from describing different circular business models to assessing their potential scalability. Each of the headline business models considered in this report is analysed in terms of, i) their current market share, and ii) their ability to significantly scale up. The former draws upon existing market data from a variety of sources, while the latter is based on a review of the literature relating to these business models. The chapter concludes by summarising the current market penetration of circular business models, and by identifying several fundamental barriers to their future adoption.

3.1. Introduction

This chapter moves from describing different circular business models to assessing their potential scalability. Scalability is important. Achieving a genuine transition to a more circular economy – with significant decoupling of economic growth from natural resource extraction and use – will be unlikely if circular business models continue to occupy small economic niches in a limited number of countries.

Most of the circular business models identified in Chapter 2 are not new. The resource recovery and product life extension business models have existed in the form of recycling, re-use, and repair for many millennia. As will be shown in this chapter, these activities are relatively mature in most sectors; the key question is therefore what kinds of technological, policy, or behavioural change could stimulate more widespread adoption. Other circular business models are emerging rapidly in response to one or more underlying drivers. In the case of the circular supplies business model, increased environmental awareness along with a higher willingness to pay for green products seem to have been important. In the case of sharing business models, the availability of the internet, and the development of referral and reputational systems, have been key drivers. For these business models, the key questions are, (i) whether continued scale up is feasible once significant market share is attained, and (ii) whether they are potentially applicable to sectors other than those currently involved (e.g., how much potential do sharing models have beyond the accommodation sector?).

The current scale, and potential scalability, of individual business models and business model sub-types will vary according to the economic sector considered. Potential scalability of a particular business model will also vary according to the extent that related business models have already emerged. In some cases, this will involve synergies. The adoption of PSS business models will tend to provide manufacturers with incentives to design more modular and recyclable products, with clear benefits for material recovery activities further downstream. In other cases, there will be trade-offs; widespread investment in material recovery facilities may increase demand for secondary raw materials to the point where product repair or remanufacturing becomes less attractive. Assessing the scalability of all business models in all sectors, and the interactions between them, is beyond the scope of this work. This chapter aims to provide insights through the use of four key examples: recycling in the metals sector, product remanufacturing, sharing in short term accommodation sector, and product service systems in the transport sector.

Predicting the market penetration of a particular business model beyond the immediate future is a necessarily subjective exercise. Business model adoption will be driven by the attractiveness of the underlying business case which, in turn, will depend on the evolution of an array of technological, policy, and behavioural factors. The approach taken in this chapter is to document current rates of market penetration and then, on the basis of the respective business model characteristics and the existence of any fundamental barriers to scale up, develop a view of potential future scalability.

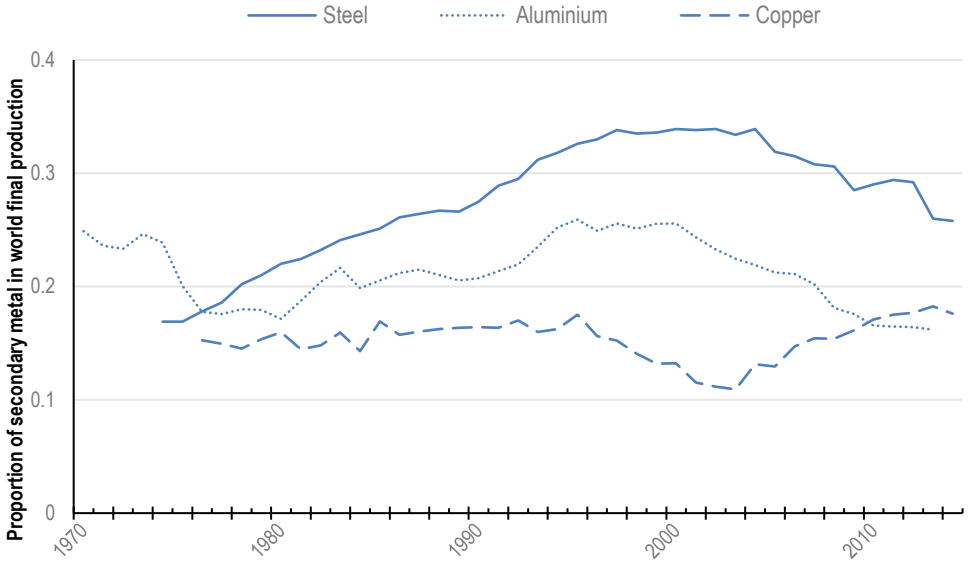
3.2. Resource recovery business models: the example of metal recycling

3.2.1. Current market penetration

Secondary metal production – producing finished metal products from recycled scrap – accounts for around 15% to 30% of the global production of the most widely used metals:

steel, aluminium, copper (Figure 3.1). This figure has fluctuated over the last 50 years, but with a notable recent decline for steel and aluminium, and an equally notable increase for copper. For less common, but nonetheless strategically important metals such as lithium and the group of rare earth elements, secondary production accounts for a negligible share of total output (UNEP, 2013[1]). Although this situation may be slowly changing with the recent increase in demand for these materials, there remains little data available. Given the low market share of secondary metal producers, there seems to be considerable potential for the scale up of the resource recovery business model in the metal sector. A similar conclusion could probably be drawn for other recyclable commodities with similarly limited market shares (plastics and paper for example).

Figure 3.1. Evolution of secondary market share for finished steel, aluminium, and copper



Source: USGS (2016[2]), *Minerals Information Commodity Statistics,* https://on.doi.gov/2OyIuAU; World Steel (2016[3]), *World Steel Association Statistics,* https://bit.ly/2pg71Qj; ABREEE (2016[4]), *Resources and Energy Statistics,* https://bit.ly/2D6vuBp

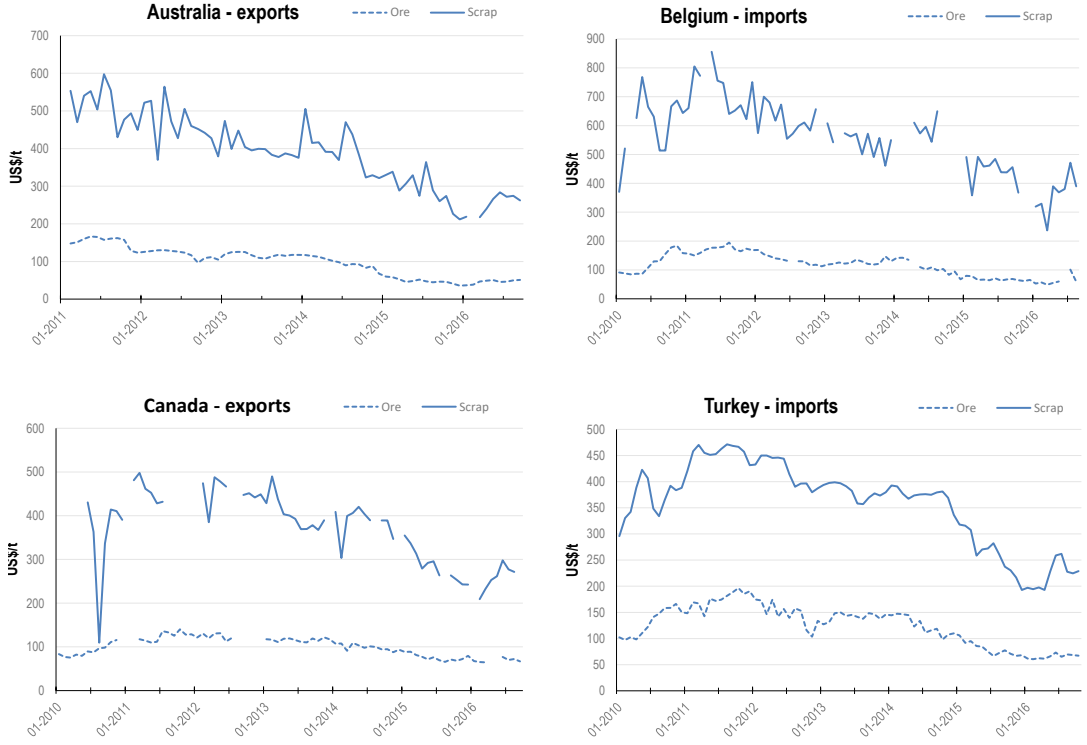
3.2.2. Future scalability

One fundamental constraint on the scalability of the resource recovery business model is the limited availability of scrap feedstock at a given point in time. In contrast to the primary metal production, where additional demand can be reliably met through the exploitation of known ore reserves, the amount of scrap available for processing each year is constrained, both by the decommissioning of long lived capital goods (e.g. buildings and vehicles), and by the disposal of short lived consumer goods (e.g. food packaging). In practice, this means that, even if recycling rates for a particular metal did approach 100%, it is unlikely that secondary production could satisfy more than half of total metal demand in the foreseeable future. This issue is currently most relevant for steel, where global recycling rates are thought to be around 80% (UNEP, 2013[1]), while the proportion of secondary output in total production is only around 25% (Figure 3.1).[1]

For the vast majority of other metals, recycling rates are typically lower than 25% (UNEP, 2013[1]), and it is a lack of economic competitiveness that currently holds back

the resource recovery business model. Producing finished metal products from recycled scrap is not cost competitive with doing so from virgin mineral ores. There are a number of underlying reasons for this, ranging from the labour intensity of product disassembly, sorting, and recycling on the supply side, to concerns about the performance of secondary materials in high performance applications on the demand side. Market failures and policy misalignments are also important; one example of the latter concerns the government support that is provided to extractive and processing industries in a number of countries (OECD, 2017[5]). These issues hold back the development of well-functioning and liquid secondary materials markets, and this in itself has negative implications for secondary competitiveness (both by hindering the realisation of scale economies in production, and by contributing to the relatively high price volatility (Figure 3.2) that restricts investment in secondary production capacity.

Figure 3.2. Price volatility in the iron ore and steel scrap markets: 2010 to 2016



Note: Not all data points are available for Canada, Belgium and Australia.
Source: UN COMTRADE (2018[6]), *International Trade Statistics Database,* https://bit.ly/2jL1FIk

3.3. Product life extension models: the example of remanufacturing

3.3.1. Current market penetration

The global market for remanufactured goods is thought to be worth around €100 billion (Le Moigne and Georgeault, 2016[7]; AmCham, 2017[8]). Data from the United States International Trade Commission indicate that the United States was the world's largest remanufacturing economy in 2011, with around USD 43 billion in remanufactured output

(US ITC, 2012[9]). Production data is also available for the European Union (Parker et al., 2015[10]) and China (Wang, 2016[11]), which in 2015 produced EUR 30 billion and CNY 150 billion (EUR 20 billion) of remanufactured goods respectively.

Remanufacturing remains relatively small in terms of its share of total manufacturing. In both the EU and the US, remanufacturing generally accounts for no more than 4% of the output from any given sector (Table 3.1 and Table 3.2). One exception involves the European aerospace industry, where remanufacturing apparently represents 11% of total sectoral output. Part of the reason for this appears to be that general repair services have been lumped to together with remanufacturing.[2] More generally, it is apparent from the US and EU data that remanufacturing is better established in some sectors – aerospace, heavy duty and off-road equipment, medical equipment, and tyres – than in others – consumer products, EEE, and IT products. This is consistent with more anecdotal evidence regarding remanufacturing; the examples that are frequently cited include Caterpillar (heavy duty and off-road equipment), Siemens (medical imaging equipment), and Michelin (tyres).

Table 3.1. US remanufacturing statistics - 2011

	Production (USD m)	Employment	Market share (%)
Aerospace	13,046	35,200	2.6
Automotive parts	3,212	30,700	1.1
Consumer products	659	7,600	0.1
HDOR equipment	7,771	20,800	3.8
IT products	2,682	15,400	0.4
Machinery	5,795	26,800	1
Medical devices	1,463	4,100	0.5
Retreaded tyres	1,399	4,900	2.9
All other	3,974	23,000	1.3
Wholesalers	-	10,900	
Total	*40,001*	*179,400*	

Source: Parker et al. (2015[10]), *Remanufacturing market study,* https://bit.ly/2NiylMi

Table 3.2. EU remanufacturing statistics - 2011

	Production (EUR m)	Firms	Employment	Market share (%)
Aerospace	12,400	1000	71,000	11.5
Automotive parts	7,400	2363	43,000	1.1
EEE	3,100	2502	28,000	1.1
Furniture	300	147	4,000	0.4
HDOR equipment	4,100	581	31,000	2.9
Machinery	1,000	513	6,000	0.7
Marine	100	7	1,000	0.3
Medical devices	1,000	60	7,000	2.8
Rail	300	30	3,000	1.1
Total	*29,700*	*7203*	*194,000*	

Source: Parker et al. (2015[10]), *Remanufacturing market study,* https://bit.ly/2NiylMi

3.3.2. Future scalability

Given the low share of remanufacturing in total manufacturing output, there appears to remain considerable potential for future scale up. Although there is limited data available, remanufactured output does seem to have grown in recent years. In the US, for instance, remanufacturing expanded at 7% annually between 2009 and 2011 (US ITC, 2012[9]). Projections for the EU suggest that remanufactured output could double or triple during the next decade, perhaps employing as many as 600 000 workers by 2030 (Parker et al., 2015[10]). Achieving these projections will require that a number of important barriers to the further development of remanufacturing be addressed.

There does not appear to be any inherent characteristic of remanufacturing that might limit its future growth. Achieving significantly higher rates of market penetration will instead depend on the attractiveness of the underlying business case. Although there are a number of assessments that highlight the theoretical profitability of remanufacturing (Lavery et al., 2013[12]),[3] it is clear that it continues to be largely uneconomic under current market conditions. Two key costs that are often highlighted are those related to labour inputs and the transport of used cores. With respect to the former, it is generally accepted that remanufacturing, because it cannot be automated to the same extent as traditional manufacturing, is relatively labour intensive. While this is positive from a job creation perspective, the additional costs involved also represent a barrier to market penetration. With respect to core transport, it has been noted that restrictions on cross border flows of used and second-hand products can make it difficult for remanufacturing firms to regain access to their products.

More broadly, it is possible that many traditional manufacturers may be unwilling to adopt remanufacturing, even when external calculations seem to indicate that it makes economic sense. There are at least three reasons.

- There may be concerns about product cannibalisation (Agrawal, Atasu and van Ittersum, 2015[13]). Many traditional manufacturing firms market a suite of products within a given product category, often ranging from entry level versions with limited functionality to high end versions with more functionality. It may be that sales of remanufactured products – necessarily priced at levels below those of premium products – displace sales of traditionally manufactured premium products, thereby reducing overall profits.
- Manufacturers may be unable to capture all of the value associated with designing products that are amenable to remanufacturing (those that are relatively modular and easily disassembled). For example, the entry of low-cost third party repair, refurbishment, and remanufacturing firms can mean that end of use products do not find their way back to the original equipment manufacturer. This lack of certainty reduces the attractiveness of adopting remanufacturing.
- Although remanufacturing produces products that are "as good as new", it does not necessarily follow that consumers are willing to pay "new", or even "near-new" prices for them. In some cases, this is because the performance of the remanufactured product is not as good as that for a contemporary version of the same product, even if it is as good as that for the original version. In other cases, prices are probably lower because consumers are unprepared to pay for a product that is perceived as being as old or out of fashion. This may be a partial

explanation for why remanufacturing appears to be less common in consumer goods sectors (personal electronics for example) than in B2B applications.

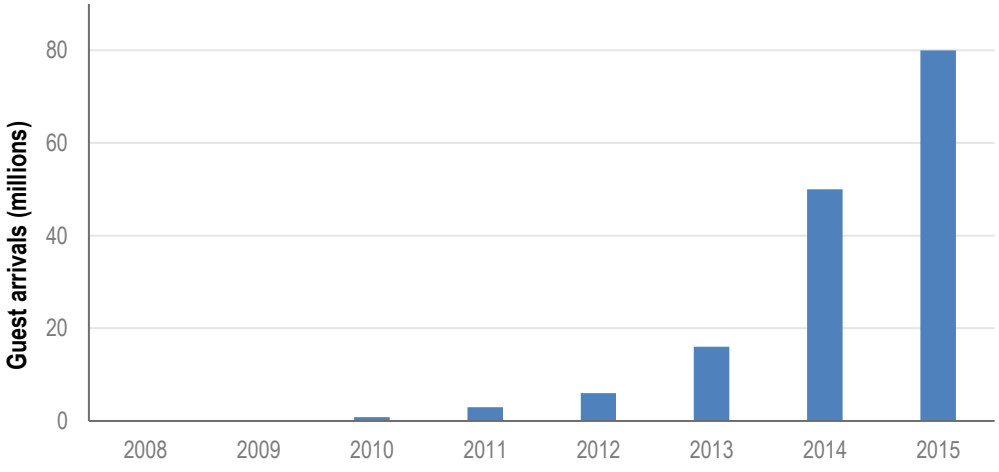
3.4. Sharing models: the example of short-term lodging

3.4.1. Current market penetration

Airbnb is perhaps the best known platform for marketing short term lodging. It was founded in 2008 and has experienced exponential growth since.[4] By November 2016, Airbnb had around 1 million individual listings, giving it roughly the same capacity as the largest traditional hotel providers (STR, 2017[14]).[5] This growth can be largely attributed to the price competiveness of Airbnb relative to traditional providers. According to several recent assessments, the average price of an Airbnb listing was between 15% and 20% lower than a traditional hotel equivalent (STR, 2017[14]; Statista, 2017[15]). Figure 3.3 shows the growth in annual Airbnb guest arrivals (or individual bookings – regardless of their length) between 2008 and 2016.

Although Airbnb's growth has been dramatic, its relative share of overall bookings remains small. Recent analysis indicates that it only accounts for 1-6% of short stays in a cross section of ten major North American and European cities (STR, 2017[14]). Similarly, CBRE Hotels estimates that Airbnb hosts in New York generated $450 million in revenue for the year ended September 2015, only around 5% of the $9 billion in lodging revenue generated in the city that year (Travel Weekly, 2016[16]). Given these figures, there appears to be clear potential for the continued scale up of sharing models in the short-term lodging sector.

Figure 3.3. Airbnb guest arrivals: 2008 – 2015



Source: Recode (2017[17]), *Airbnb is on track to rack up more than 100 million stays this year,* https://bit.ly/2uBH9Cj

3.4.2. Future scalability

The increased consumer choice and price reductions that are facilitated by sharing models will tend to encourage their continued growth, both within the short term lodging sector

and elsewhere. That said, the availability of spare capacity and the introduction of additional regulatory restrictions represent barriers that could curtail scale up.

In most cases, shortages of spare capacity are probably of limited relevance since there will always be a proportion of individuals unwilling to lease their assets. Similarly, and particularly with respect to short term lodgement, it seems likely that there will always be a proportion of travellers who prefer the relative familiarity of traditional hotels. Preferences for traditional forms of consumption[6] also tend to be reinforced by the transaction costs that are associated with participating in sharing business models. Sharing of existing assets introduces a variety of time costs – the search for an appropriate product, contacting the owner to arrange pick-up times, pick-up and return of the shared good – that can collectively render sharing less attractive unattractive. Importantly, both of these issues are likely to be partly mitigated if sharing models continue to emerge. Trust in platforms like Airbnb tends to increase as they become more widespread, and this may result in individuals becoming more willing to share their assets.[7] Similarly, the transaction costs associated with asset sharing are likely to decrease as more people take part; increased participation increases the likelihood that an available asset is located nearby. These effects highlight the catalytic nature of sharing models, a feature that partly explains their rapid recent growth.

Regulatory restrictions could represent a more significant barrier to the scale up of sharing models (Box 3.1). For example, in the context of short term lodging, a number of city authorities (in London, Amsterdam, and San Francisco among others) have placed a cap on the maximum number of nights that an Airbnb host can offer each year (AirBnb, 2018[18]). Authorities in other cities have imposed other restrictions. For example, in 2015, city authorities in San Francisco made it illegal for hosts to offer short term leases for residences other than their primary address (San Francisco Business Portal, 2018[19]). Similarly, authorities in New York have made short term (less than 30 days) sub-lets of any type illegal unless the owner of the residence is living there during the time of the lease (The Herald, 2017[20]). Although it is unclear how city rules will evolve in the future, it seems likely that any continued increase in stringency will affect the scale up of sharing models in the short term lodging segment.

Figure 3.4 shows the reduction in Airbnb's year-on-year revenue growth in New York since 2011.

Box 3.1. Social concerns and the growth of sharing and other platform based business models

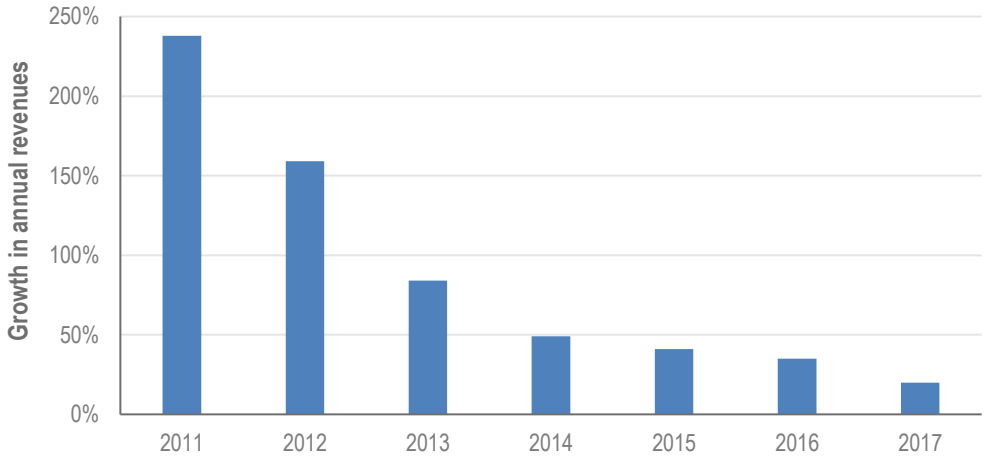
The recent emergence of sharing (e.g., AirBnb) and other platform based business models (e.g., Uber and Amazon) has provided consumers with a number of clear benefits (in terms of financial savings, convenience, and product diversity). At the same time, the emergence of these business models has triggered concerns about lost profitability and jobs in traditional service activities, foregone government tax revenues, and increasing housing prices and rents.

The diversity of these business models, the speed at which they have emerged, and uncertainty about their costs and benefits has led to a fragmented policy response. Some

governments have taken a relatively "hands off" approach while others have intervened more strongly (see the above examples relating to AirBnb for example).

At the centre of the debate lie concerns about consumer protection and, relatedly, fair competition. Should "peer producers" of goods and services be regulated in the same way as traditional providers? Or do the reputational and referral systems embedded in most online platforms render certain forms of traditional regulation no longer fit for purpose? To what extent should the incomes accruing to "peer producers" be subject to taxation – are there thresholds below which the administrative costs become excessive? The answers to these questions are far from clear, but there is a significant body of ongoing research that will help to provide new insights. Interested readers may refer to the ongoing OECD's Going Digital project and, more specifically, the work streams on online platforms in the context of taxation (OECD, 2017[21]), regulation (OECD, 2018[22]), and consumer protection (OECD, 2016[23]).

Figure 3.4. Airbnb revenue growth in New York City: 2011 – 2017



Source: Statista (2017[15]), *Airbnb – Statistics and Facts,* https://bit.ly/2D8LqDc

Although sharing models are currently most visible in the short term lodging segment, it is also relevant in other sectors. Analysis undertaken for France indicates that sharable goods – those characterised by high upfront costs and infrequent use – account for about 25% of household expenditure (IDDRI, 2014[24]). The major product categories that are highlighted include vehicles, clothing, furniture, household appliances, and tools. Although there is little data available, and perhaps with the exception of vehicles, the practice of sharing these goods via online platforms is probably less widespread than it is for short term lodging. Clearly, the behavioural barriers highlighted above for lodging – the willingness of asset owners and leasers to participate in sharing – are relevant. Transaction costs may also be particularly important, especially for bulky goods like furniture which are difficult to transport even locally.

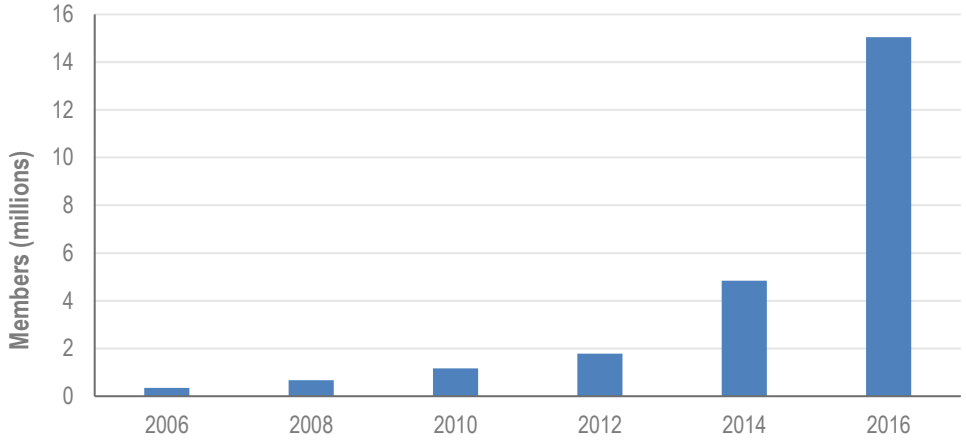
3.5. Product service systems: the example of user oriented product service systems – mobility

3.5.1. Current market penetration

Urban bike and car sharing schemes are examples of user oriented product service systems. The underlying business model involves business to consumer (B2C) transactions and should not be confused with the consumer to consumer (C2C) transactions associated with car-pooling (e.g., BlaBlaCar) or bike (e.g., Peerby) or car sharing (e.g., Getaround). These mobility schemes are also distinct to traditional rental operations. First, rental locations are not limited to fixed locations such as airports, railway stations, and shops. Instead, bikes and vehicles can be accessed throughout urban areas with the use of GPS based mobile applications. Second, pricing schemes and typical usage patterns differ. Urban bike and car sharing schemes generally charge users an up-front membership fee along with a variable fee based on the time (often minutes or hours) that the bike or vehicle is used for. Users have strong incentives to restrict usage to short periods, which partially explains why this type of sharing is primarily an urban phenomenon. The following discussion focusses on urban car sharing schemes. Currently operating examples include Zipcar (privately owned and operated enterprise operating in the United States) and Autolib (government owned enterprise operating in Paris).

Urban car sharing schemes have grown rapidly recent years (Figure 3.5). Between 2006 and 2014, the global fleet of shared vehicles grew from 11 500 vehicles to 104 000 vehicles while membership grew from 350 000 people to 4 800 000 people (Shaheen and Cohen, 2016[25]). That said, as of 2014, the fleet of shared vehicles accounted for less than 0.1% of the almost 1 billion strong global in-use car fleet (OICA, 2015[26]). According to the same publication, the biggest markets for carsharing worldwide are Europe (46% of global members and 56% of global carsharing fleet) and North America (34% of global members and 23% of global fleet). In sum, the market penetration of B2C car sharing schemes remains very low in cities in developed countries, and largely non-existent in cities in the developing world.

Figure 3.5. Global urban car sharing membership trends



Source: Shaheen and Cohen (2016[25]), *Innovative Mobility Car Sharing Outlook,* https://bit.ly/2NMMUXZ

3.5.2. Future scalability

There are no inherent characteristics of urban car sharing schemes that will obviously hinder their continued emergence.[8] To the extent that the mobility provided by such schemes is comparable to that provided by alternative transport modes, both in terms of convenience and affordability, car sharing will probably continue to emerge and capture higher rates of market share. Projections developed by Navigant Research (2015[27]) indicate that global car sharing membership could reach 23 million people by 2024, a fivefold increased relative to today. The same projections suggest that much of the future growth will be seen in Asia, where car sharing has not developed to the same extent as in Europe and North America. At present, Asia, Africa, and Latin America comprise over 78% of the world's population, but only account for 20% of the car sharing market (WRI, 2015[28]). Car sharing could help to prevent or delay the uptake of private car ownership of the growing middle-class in these regions.

The future uptake of urban car sharing schemes will mostly depend on consumer acceptance of the concept, as well as the profitability of the underlying business model. With respect to the former, one potential barrier relates to the availability of parking space in public areas. The convenience of urban car sharing schemes is greatly diminished when it is difficult to find parking at the conclusion of the use period. Another barrier related to consumer acceptance is the value that individuals often appear to attach to vehicle ownership *in itself*. Private vehicles provide a mobility service – often one that is more convenient than shared vehicles – but they also seem to provide other sources of wellbeing. In particular, part of what individuals may be paying for when buying a vehicle is the status that comes with ownership. This is one explanation for why, despite providing much the same mobility service, there is a large price differential between mid-range mass produced cars and high performance sports cars.[9] If vehicles are a status good or, in other words, if individuals buy them for reasons other than the mobility service they provide, then this may become a significant obstacle to the continued emergence of urban mobility schemes.

More generally, the suite of product service system business models – including product-oriented, user-oriented, and result-oriented varieties – appear to be applicable in just about any market involving the use of manufactured goods. As highlighted in Chapter 2, PSS models are already being applied in both B2B and B2C markets in sectors as diverse as apparel, aviation, chemicals, electronic appliances, energy, office furniture, and, of course, transport. They are also being applied increasingly in the context of digital products: e-books, streamed music, digital media, and online education for example.

Despite this broad applicability (which is a significant strength from a scalability perspective), it is clear that the uptake of PSS business models continues to be rare in most sectors. There are probably two main reasons:

- As emphasised by Tukker (2015[29]), B2C variants of PSS business models have historically been held back by a strong consumer desire for product ownership: "for consumers, having control over things, artefacts, and life itself is one of the most valued attributes". This point about ownership is essentially the same as the one made above in the context of urban car sharing schemes.
- It is not clear that PSS business models represent a better commercial strategy than traditional sales models. There probably are advantages in certain situations, such as where there is a considerable supply risk affecting manufacturing inputs, or where the adoption of the PSS model allows manufacturers to signal the

superior quality of their product. But more generally, some costs can be higher, especially if the PSS introduces new labour inputs, or when it involves more networked production systems with associated transaction costs (Tukker, 2015[29]). In addition, the management of ongoing client service relationships is unlikely to be within the core business expertise of manufacturing firms, a factor that also probably hinders adoption.

3.6. Conclusions

Circular business models occupy a peripheral position in most markets (Table 3.3). Recycled pulp and paper, metals, and plastics represent small proportions of global material output, while remanufactured industrial and consumer products represent an even smaller share of global manufacturing. Sharing of under-utilised housing capacity has grown rapidly, but now only accounts for several percent of the annual short stays in most major cities. The same is true for user-oriented product service system models, which account for less than 1% of the market that they are perhaps most well known in: urban mobility. One notable exception to the above pattern is the emergence of result-oriented PSS in the automotive market. European and North American vehicle manufacturers have widely outsourced the chemical coating phase of the production process on a price per-area basis (OECD, 2017[30]).

Although this chapter did not include an explicit focus on geographic differences, it is apparent that some circular business models are more successful in certain contexts than others. In most cases, market penetration seems to have been greatest in developed country settings. Circular supply models, for example, have been successful here, perhaps because of a greater consumer ability to pay for "green" products. Similarly, sharing models involving short term lodging and transport have experienced rapid growth in wealthier cities, probably because of the relative availability of under-utilised assets there. There are also some notable exceptions. One example relates to certain forms of product sharing and leasing, which are becoming more visible in developing countries. Bike sharing schemes are common in large Chinese cities; more than two million shared bikes are available in Beijing alone (BBC, 2017[31]). Another example concerns the resource recovery model. Trade data indicates that a significant portion of the material recovery value chain (specifically the reprocessing of sorted waste back into secondary raw materials) is located in developing countries (Eurostat, 2018[32]).

There remains considerable scope for the future growth of circular business models. However, any such growth will be subject to economic realities – more widespread adoption of these business models will not take place unless there is a solid underlying business case. In some cases, the attractiveness of the business case may diminish as market share increases. For example, in the context of recycling, it is well documented that the unit cost of recovering steel or aluminium from household appliances is significantly higher than recovering them from relatively simple bulky products like vehicle chassis'. In other cases, the attractiveness of the business case will improve as market share increases. This is especially relevant for those business models characterised by network effects; consumer acceptance of platform models and car sharing schemes is likely to increase as the membership base – and services offered – grows. It may also be relevant for other business models that are characterised by some form of path dependence or that benefit in some way from the emergence of related business models.[10] In the context of remanufacturing, addressing the trade rules that hinder cross border

flows of product cores would allow remanufacturing to become more widespread and, perhaps, generate lower costs through either learning externalities or scale economies.[11]

Table 3.3. Summary of current market penetration of selected circular business models

	Sector	Market penetration	Explanation
Waste as value: recycling	Pulp and paper	38%	Of total global output
	Metals	0 - 30%	
	Plastics	13%	
Product life extension: refurbishment	Various	2 - 3%	Of EOL products
	Smartphones	4 - 8%	Of annual manufactures
Product life extension: remanufacturing	Aerospace	2 - 12%	Of total manufactures
	Machinery	3 - 4%	
	Automotive	1%	
	Consumer and EEE	0 - 1%	
Idle Capacity: co-access	Lodging	1% - 6%	Of total short term bookings
PSS: result-oriented (chemicals)	Automotive	50 - 80%	Of manufacturer uptake
	Aerospace	5 - 15%	
PSS: result oriented (digital content)	Music	50%	Of total industry revenues
	Books	25 - 35%	
PSS: result-oriented (lighting & heating)	Various	4 - 7.5%	Of potential ESCO uptake
PSS: user-oriented (car sharing)	Transport	<1%	Of total global car fleet

Source: Plastics and paper recycling data are from Geyer, Jambeck and Law (2017[33]) and in Van Ewijk, Stegemann and Ekins (2017[34]) respectively. Data for smartphone refurbishment is taken from analysis by Gartner, cited in Tech Crunch (2015[35]) and Trend Force (2017[36]). Data for refurbishment of other consumer products are from European Commission (2016[37]). Data for result-oriented PSS in the chemicals, literature and music, and lighting and heating sectors are taken from OECD (2017[30]), IFPI (2017) and the Guardian (2017[38]), and Stuart and Goldman (2014[39]).

As highlighted in Section 2.3, the business case for circular business models will also evolve alongside broader societal level trends. Changes in policy frameworks, consumer preferences, and available technologies have the potential to stimulate adoption in much the same way as in the past.[12] The emergence of technologies associated with the so-called Fourth Industrial Revolution seems particularly promising in the context of circular business models. Improvements in robotics, artificial intelligence, sensor technology, and 3D printing will have widespread consequences, particularly when coupled with increasingly pervasive digital networks. The Internet of Things (IoT), which is just one of the potential implications of these developments, will present an array of opportunities for more efficient food and energy use (Jagtap, 2017[40]; Ashman, 2017[41]). Research undertaken by the WEF (2016[42]) in New York city suggests that digital connectivity in concert with smart sensors could also vastly improve the convenience of ride sharing, to the extent that 80% of all journeys could be shared.

Based on the material presented in this chapter, it is also possible to highlight several more fundamental barriers that affect the scalability of each major business model:

- *Resource recovery models* may become constrained by feedstock shortages if recycling rates approach 100%. At present, this is probably only relevant in the steel market, where global recycling rates are thought to be around 80%. Even if there was a business case for recycling the final 20% of scrap contained in waste flows, it is unlikely that secondary steel production could meet more than half of

global of global steel demand. This constraint may be eased in the long term as the materials contained in long lived capital goods and infrastructure are released into waste streams (assuming that future growth in demand for materials is sufficiently low).

- More widespread adoption of the *remanufacturing business model* appears to be hindered by manufacturers' concerns about cannabilisation of premium sales and the entry of third party remanufacturers. More generally, the limited market share held by the family of *product life extension models – reuse, repair, refurbishment, and remanufacture* – may be a result of a strong consumer desire for the "latest" product, an effect which is itself modulated by the rate of product innovation,. This is one explanation for why the *remanufacturing* business model has been more sucessful in a B2B than a B2C context.
- *Sharing models* have emerged rapidly in response to several technological and social innovations, and will probably continue to do so given the network effects that are inherent to these models. One obvious constraint to future growth is the availability of spare capacity, and the proportion of owners willing to make it available. Another issue concerns the longevity of current policy frameworks. In an effort to address equity and competitiveness concerns resulting from the growth of peer to peer sharing, policy makers in a number of cities have implemented new regulations (with respect to short term lodging for example) that may serve to slow scale up.
- *Product service system models* have been adopted across a diverse range of sectors, and have seen some success in applications like chemical leasing (OECD, 2017[30]). Barriers to scale up elsewhere vary significantly according to the sub-model considered (user-oriented vs result-oriented for example) and the sector it is applied in. Generally speaking, one major barrier, particularly in a B2C context, seems to have been consumers' desire for the convenience and other intangible benefits that come with product ownership. Another issue concerns the underlying business case for the adoption of PSS; it often seems to be far from clear.

Notes

[1] Limits on the availability of scrap feedstock will be partially eased in the medium term as an increasingly large anthropogenic metal stock is decommissioned and replaced.

[2] See page 57 of Parker et al. (2015[17]).

[3] These assessments generally highlight the retention of product cores, and the associated avoided material input costs, as a key cost advantage relative to traditional manufacturing.

[4] Airbnb turned its first profit in 2016, and was recently valued at around USD 30 billion (CNBC, 2017).

[5] Airbnb actually had around 3 million listings in November 2016. However, many of them – unavailable, shared, and private rooms for example – are not obviously comparable to a traditional hotel booking. STR therefore excludes these from their analysis.

[6] Individual product ownership in the case of durable goods, and traditional service providers (e.g., hotels) in the case of services.

[7] There may also be a feedback mechanism from the growth of sharing platforms to the overall availability of spare capacity. For example, there is some anecdotal evidence that the emergence of Airbnb has led to investments in the housing stock that may not have taken place otherwise.

[8] One issue relates to the feasibility of car sharing schemes in low density areas. The business case is probably greatly diminished in rural areas where a larger number of stations would be required to serve a given population. This barrier is probably minor given the high proportion of people living in urban areas.

[9] To be sure, some of this differential probably also reflects differing performance levels.

[10] For example, the adoption of product service system model – and the retention of product ownership that goes with it – may well serve to incentivise the parallel adoption of the product life extension model.

[11] Path dependency may also be relevant for the resource recovery business model. Secondary material markets are characterised by high levels of price volatility, and this probably makes investment in secondary processing facilities less attractive. Addressing the barriers that hinder secondary material markets will boost output and thereby lead to more liquid markets with less price volatility.

[12] Consider the role that waste management policies and new technologies have played in stimulating (respectively) higher recycling rates and the sharing of underutilised consumer assets.

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