MOVING BEYOND THE CIRCULAR ECONOMY

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ABSTRACT: The production model, which currently underpins our material prosperity, remains highly resource-intensive, and the volume of minerals, ores and fossil fuels consumed annually is set to triple by 2050 unless economic growth is decoupled from resource consumption [1]. One response that has been attracting significant attention is the idea of a circular economy (or close loop economy), in which waste is transformed into value rather than disposed of to landfill [2]. While acknowledging potential benefits to businesses of a circular economy, this paper critically reviews the model and proposes an approach that addresses concerns that even recycling processes have energy impacts through transportation, reprocessing and subsequent manufacturing, and that in practice it is impossible to have a complete circular system in which there is no use of virgin materials and no final waste. It presents an overarching framework that responds to such concerns, built by studying different circular models in a macro-level perspective and then tailoring tactics for different sectors in a micro-level perspective [3,4,5,6]. The paper explains how the framework was built and how it is applied to the large household appliance (LHA) sector, through developing two emerging models based on product-service systems (PSS). The paper presents findings from a workshop in which the two models were presented to industry representatives, revealing their responses regarding the opportunities and challenges to implement the proposed models to go beyond the circular economy.

1. INTRODUCTION

Proponents of the circular economy advocate new business models as a means of bringing about a necessary change [6]. The strength is that these models may offer businesses opportunities to move towards more service-driven structures through which the economy continues to flourish and jobs are created. What the proposition does not fully account for, however, is the complexity of the supply chain, which is often spread across geographical boundaries and leads to the problem of information flows about the quantity and quality of material [2]. To be successful these new models will require collaboration between businesses and, importantly, stronger consideration of the role of the end consumer in this process. Infrastructures, products, services and systems must be designed to keep value in products and their component parts (through, for example, repair, remanufacturing, upcycling and reuse) and information flows must deliver greater transparency between actors. The latter is considered in this paper, which proposes a framework and two emerging models that could go beyond the circular economy.

2. THE CIRCULAR ECONOMY: A VIABLE PROPOSITION FOR REDUCING MATERIAL DEMAND?

Developed economies are driven by a resource intensive production model that demands the excessive consumption of products [7]. The predominant manufacturing model favours a linear system of take, make and disposal. In this system materials are extracted and made into products, which are purchased by consumers and then eventually disposed of [5].

The current model of ever-increasing production has been encouraged by the availability of cheap resources over a number of years [2]. However, with the increasing fears over material scarcity and volatility in supply, commodity prices have significantly increased. Resource security has become an urgent concern for the economy and the environment [8]. The need to reduce material

throughput is critical and to achieve this a shift from a linear to a circular model (or closed loop system) is required [9].

Businesses though are structurally 'locked in' to a system, which requires excessive consumption to meet their objectives of growing capital. However, a model that can ensure continued prosperity whilst minimizing environmental impacts is required [10]. This problem is further exasperated by the fact that consumers are locked in to an 'iron age of consumerism', where products have short replacement cycles as consumers just keep buying more [11].

The UK Government undertook a review of waste policy in 2011 and found that the use of virgin raw materials through UK manufacturing was unsustainable [12]. Similar to other developed nations the UK economy is dependent on some finite materials and resource security has become a pressing issue [5]. Resource efficiency specialists at WRAP have estimated that approximately 540 million tonnes of products and materials enter the UK annually, but only 117 million tonnes get recycled [13]. Despite some improvements in recent years valuable resources are still being lost to landfill. Local governments have focused on dealing with waste rather than concentrating efforts on the extraction of materials and their return as value to the economy [14].

In response the circular economy advocates that the value of waste is realised as value ensuring that resources are kept in the economy for longer and thus reducing energy and water use [2]. The 'cradle to cradle' model of Braungart and McDonough proposed a radical shift to the linear economic system through a closed loop production model where materials are recycled whenever possible to minimize waste [15]. Their approach has evolved into the model of the circular economy [4,6,16,17]. The origins of a circular economy also lie within industrial ecology, which suggested that industrial systems should be restructured according to ecosystems [18]. It is therefore not a new approach but research and interest has increased in recent years as industry recognised the need to address environmental concerns [19].

The circular economy's prime focus is material recovery and recycling. Research has suggested that adopting a circular approach would bring growth and create employment opportunities as manufacturers move towards repair and maintenance models [6, 16, 17]. The Ellen MacArthur Foundation has reported that shifting to a circular economy could save European manufacturers $630 billion a year by 2025 [19]. This is a significant figure; however, while the circular economy proposes opportunities for reducing material, it has been open to critics who question whether the circle can remain closed [20].

Allwood challenges the feasibility of the circular economy, as with the advancement of technology it may not be possible to make new products from materials extracted from old products [20]. Moreover, the primary focus on recycling would require much energy, which causes other environmental impacts. Rather than making circulatory the goal, Allwood proposes strategies that focus instead on material efficiency [20]. These could include switching to longer lasting and more efficiently used products, reuse and remanufacturing and reuse that would facilitate a closed loop system [21]. Research undertaken by Cooper and the Great Recovery Project at the RSA highlights the significance of design in achieving a goal of material efficiency as many products can be designed to last longer [5,22]. Research by the Green Alliance's circular economy task force concluded that businesses should privilege reuse over recycling as it offers greater value, this is, however, dependent on there being a relevant market available [23].

A circular model could be further developed to show the value that product longevity, sharing goods, reuse and remanufacture would have in reducing resource throughput while benefitting the economy. Research into product service systems (PSS) demonstrates that such an approach could enable dematerialisation of the economy as consumers are able to buy the use of the product rather than the product itself, and in the context of the circular economy this may encourage products to be kept in use for longer [24].

The opportunities for shifting to a more material efficient future will require significant transformations in business practices and organisation. Research has identified barriers that may impact on the transition to a circular economy. These include the transaction costs involved in change and the complexity of supply chains in terms of geographical spread and the flows of information between the various actors [2,19]. In view of this and the fact that different sectors will have different structures and practices, an overarching framework has been developed which can be unfolded to illustrate sector specific business models. These specific models have evolved from current research into methods for a dematerialised future and propose ways of shifting business practice towards low material demand. A limitation of the circular economy is that its primary focus on industrial

processes means that it does not fully consider the role of the consumer. For the models to be successful the role of the consumer in this process was given due consideration.

3. DEVELOPING THE OVERARCHING FRAMEWORK

The proposed framework (figure 1) builds on the existing research into the circular economy [3, 4, 5, 6, 13, 14 16, 17, 19]. The Ellen MacArthur Foundation has developed a circular model that demonstrates how technological and biological nutrient based products and materials circulate through the economic system [6]. The Great Recovery project has further developed a circular model (with four design models), which illustrates the significant role of design in implementing a more effective circular flow and explaining how products, should therefore be designed for longevity [5].

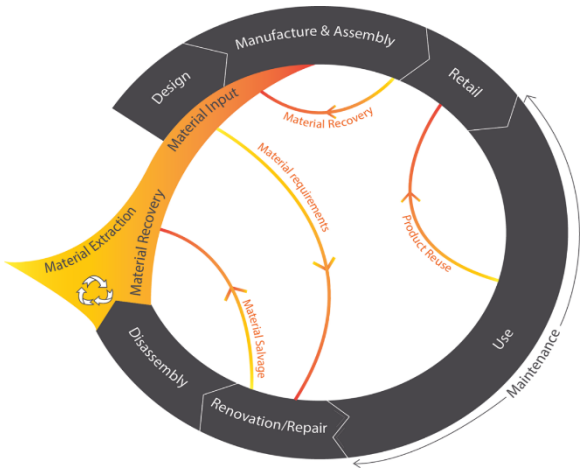

Figure 1 Overarching Framework

The overarching framework responds to these models while taking into account the more sceptical views over the desirability and viability of a completely circular flow [20]. This framework has been designed to show the complete lifecycle of a product whether it be a building, car or large household appliance (LHA) and it displays the material flows across the lifecycle that are needed to bring about reduced material demand.

The framework acknowledges that complete circulatory may not be a realistic goal and instead illustrates how reductions can be achieved through the different life stages of a product to ensure minimal environmental impacts. The framework moves through the key stages of the product's life from design, manufacture and assembly, retail, use, renovation and repair through to disassembly where materials can be extracted and reused for the creation of a new product. Each stage on the framework has been proportioned according to the anticipated timeframe of material flows within that phase, with the use cycle having the highest proportion.

While demonstrating the importance of maintaining a circular flow, the framework emphasises that the circle cannot be closed, as with the current production model there will be some materials, which cannot be extracted and reused, and future products may also require the 'injection' of new materials [20]. The objective of the overarching framework is to present different industry sectors with realistic methods to shift towards business models that will reduce material demand. The framework gives particular consideration to the stage of consumption where the flows of materials are most significant and proposes opportunities for reducing material demand through this stage of the lifecycle.

The design enables the framework to be unfolded to reveal further diagrams relative to specific sectors which focus on the interlinks between the different stages and proposes routes to more material-efficient business opportunities. This paper focuses on developing specific diagrams for the Large Household Appliance (LHA) sector, with the objective of understanding the barriers and drivers that various sectors may face when shifting to these new business models.

4. BEYOND THE CIRCULAR ECONOMY: PROPOSED MODELS FOR THE LARGE HOUSEHOLD APPLIANCE SECTOR

Two models are proposed for the LHA sector focused on washing machines, as WRAP has identified them as one of the five priority products that contribute the greatest to resource impact in the UK market [25]. In addition, a report commissioned by the Department for the Environment, Food and Rural Affairs (Defra) categorised LHA as 'workhorse products' because they are purchased on relation to their function [26]. Thus, these models were designed specifically for washing machines but it is expected that they could be applied across other product categories within the LHA sector, where possible.

WRAP has estimated that some LHA including washing machines and refrigeration products, and some electronic products such as computers and TVs, contribute to 40% of the embodied energy impacts of all electrical and electronic products sold in the UK [25]. Consequently the designed models were based

on how to extend the lifetime of household appliances through developing two different models of product service systems (PSS). PSS could help to extend the life of a product by improving the service performance to keep products in longer use [27,28]. In addition, Defra estimates that up to 20% of household expenditure on material goods could be shifted to services [29].

The two proposed models are: 'upgrade and leasing model' and 'community laundry model'. Both set up a different scenario for the near future based on past literature, in which changes are needed in each stage of the life cycle of a product depicted in the overarching framework. Both also reflect the need for input of material extraction and processing, but advocate for a minimal input.

4.1 Upgrade and leasing model

This model (figure 2) is focused on the design of upgradable and high efficiency machines, localised distribution centres, a leasing scheme based on a partnership between retailers and manufacturers, and the recovery and refurbishment of lower energy efficiency rated machines. The material use and material recovery flows are depicted in grey and in gradient colour accordingly, and correspond to the material flows depicted in the overarching framework.

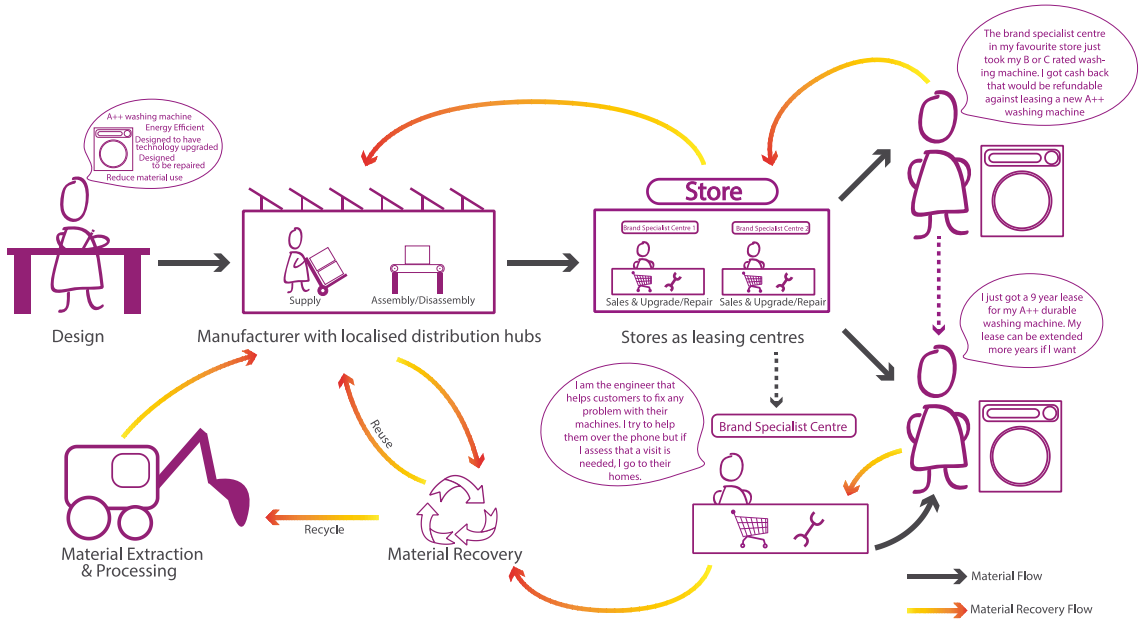

Figure 2 Upgrading and leasing model

For the design stage, Botsman and Rogers proposed that designers must create products with the potential for dynamic longevity, and not to build-in obsolescence [28]. By dynamic longevity, it can be understood that products should be designed with durable materials and also designed to be updated, reused, resold or repaired [28]. To design large household appliances with a significant energy performance in mind is also essential, but in the future, energy efficiency improvements may be small, and this could help to support increases lifetimes [30]. In addition, design with product longevity in mind can deliver cost-effective changes to the whole supply chain. Both of these design considerations were taken into account for the model [29].

For the manufacture and assembly stage Defra estimates that the UK imports over 1,5000,000 tonnes of electric and electronic products each year [29]. Increasing product lifetimes of LHA could stimulate a service sector that, in some cases, would only be possible to deliver locally [29]. As a response to this the model suggests regional distribution hubs for the distribution of final goods and spare parts, and for refurbishment of low energy efficiency rated machines (e.g. C rated) if possible. Refurbishment of old machines could bring potential carbon savings across UK households. WRAP estimated that

refurbishing C rated machines and using them for a further 9 years could save 220,000 tons of Co2e per year, compared to replacing them immediately by an A rated machine [30].

For the retail stage, WRAP acknowledged that stimulating the repair and maintenance markets for these products could increase value to the UK economy [31]. According to a study made by WRAP consumers would be willing to get maintenance and repair services from a specialist recommended by the manufacturer, but they would be more keen to lease a LHA from their favourite retailer [31]. In addition, longer-life, quality products are typically more expensive to produce, and low-income consumers simply cannot afford these types of products. As such, the model proposes a partnership with retailers and manufacturers in which the retailer will offer leases instead of selling products, but will allow the manufacturer to offer the maintenance and repair services through an extended warranty and with a personalised service through specialised engineers doing domestic visits when needed. From a business perspective, providing a longer-term service model could enable consumers to afford these products through a service payment, and could help producers to limit the initial cost of purchasing and recover their margins over time [29]. In addition, these types of models could deliver a long-term service relationship with customers, and between producers and retailers [27]. Finally, to recover old machines for refurbishment, the model proposes for the retail stage a scheme in which consumers with old machines could exchange them for cash that could be used to get into the leasing scheme.

4.2 Community laundry model

This model (figure 3) is based on similar considerations for the design, manufacture and assembly phases, but differences are seen in the retailer and use phases. As in the previous model, the material use and material recovery flows are presented in grey and in gradient colour accordingly, and correspond to the material flows depicted in the overarching framework.

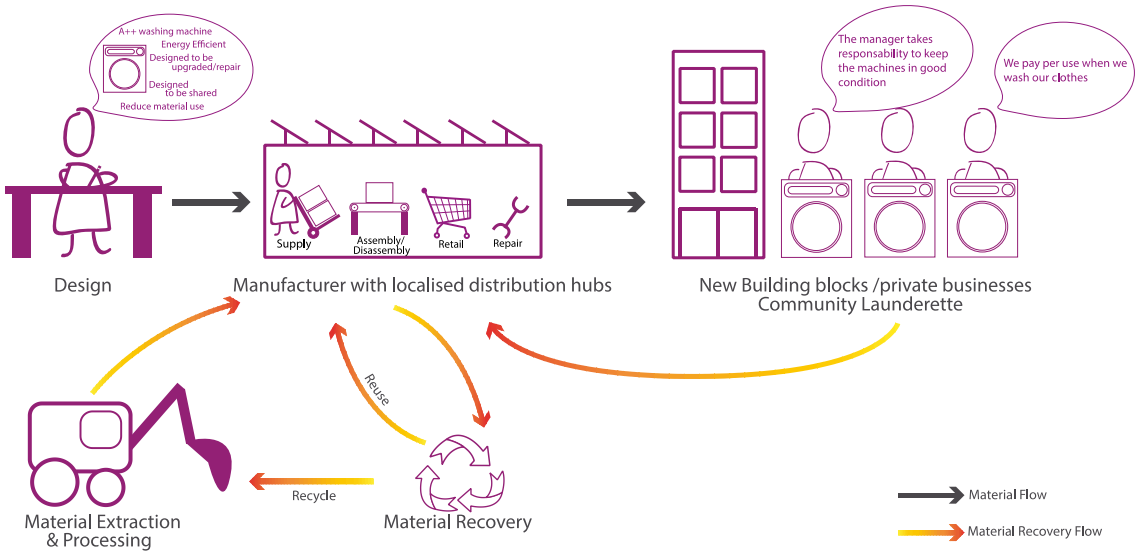

Figure 3 Community Laundry Model

The main differences between this model and the other, is that the retailer is removed from the supply chain and the localised distribution hubs take care of selling the products to new housing blocks or other accommodation types or businesses (e.g. student buildings, launderettes).

Centralized community laundries are not a new concept. According to Fletcher and Goggin, community laundries reduce the number of machines in use and thus contribute a reduction in energy use [32]. Their localised locations allows the easy introduction of more sophisticated and efficient machines; and social collaboration and participation within the community can be enhanced using the facilities [32]. Despite the technology and product infrastructure in place to support this model, the social and cultural acceptance and appropriate

consumer behaviour is still something to be considered within such business models, especially for other product categories [32]. Other innovative business models should also be considered. For example, Electrolux in Sweden, launched a scheme in which households were paying per use, based on smart metering applications, which allowed them to develop more expensive, higher quality and more environmentally friendly technologies, which customers could afford as they were paying per unit of function and not for the product [33]. However, this model discontinued as the utility provider stopped the smart metering service [16].

5. METHODOLOGY

The paper presents findings from a participatory workshop with industry representatives in which the overarching framework and the proposed models for large household appliances (LHA) sector were presented. The aim of this workshop was to capture responses regarding the opportunities and challenges that these models could have to go beyond the circular economy. A participatory workshop was thus chosen as a research collection technique as it requires discussion and debate, which encourages participants to suggest and offer insights for a given subject. Visual aids, such as the diagrams depicting the overarching framework (Figure 1) and the proposed models (Figures 2 and 3), were used to engage participants in discussion and to capture knowledge.

The workshop was conducted during an industry seminar held at Nottingham Trent University, UK in June 2014. The seminar had 55 participants in total, of which 22 were involved in this workshop, (as the rest of the participants where engaged in other activities). For this workshop, three tables were formed with seven or eight participants on each table. Participants included, six research consultants with expertise in product lifetimes, two consultants from organisations involved in the circular economy, six academics, seven members from industry (including retailers and appliances manufacturers), and three policy advisors. Each table had a facilitator to guide the discussion and a scribe to record the conversation.

The overarching framework (Figure 1) was used to explain that material input will always be required, and helped to explain how the two depicted models were developed (Figures 2 and 3). The facilitator had a list of questions for discussion regarding barriers, drivers and benefits of these specific models. Participants were asked to numerically rank their top 5 barriers, drivers and benefits, and this was recorded on each table (see table 1) using post-it notes. Participants were also asked to write a reason on the post-it note of why they choose that barrier, driver or benefit.

Table 1 Example of table used to choose barriers, drivers and benefits

Barriers	**Score on post-it notes**
Intellectual Property	
Cost Restraints	
Lack of investment or capital to develop and build new facilities	
Lack of operational capital	
Time constraints	
Current policy requirements	
Lack of knowledge	
Lack of certification procedures for alternative practices i.e. reuse of LHA	
Complex supply chains	
Complex information flows within the supply chain	
Consumer perception	
Consumer behaviour	
Producers consumers locked into the current economic/market system	
The amount of price subsidises on key materials, gas and petrol	
Cultural expectations for new models	
Take back process unknown supply qualities and quantity	
Closed loop supply chains reverse loop supply chain could increase cost of logistics, transportation and energy	

Results were quantified between the three tables, and a ranking was given to each barrier, driver and benefit according to these results. It was considered 'low' if the total was less than 4, 'medium' if it was between 5 and 8, and 'high' it was more than 9. In addition a thematic coding analysis was used to analyse the scripts from the scribes to identify specific reasons for each barrier, driver or benefit [34]. This was complemented with the reasons given by participants on the post-it notes.

6. ANALYSIS AND DISCUSSION OF FINDINGS

As described in the methodology section, the barriers, drivers and benefits were ranked as high, medium and low. Table 2 has a summary.

Table 2 Barriers Drivers and Benefits Ranked as High, Medium and Low

Large Household appliances sector barriers, drivers and benefits			
	High	**Medium**	**Low**
Barriers	- Cost Restraints - Consumer perception and behaviour - Producers and consumers locked into the current economic/market system	- Cultural expectations for new models - Closed loop supply chains reverse loop supply chain could increase cost of logistics, transportation and energy	- Cost restraints: Lack of operational capital - Cost restraints: Lack of investment capital to develop and build new facilities - Time constrains - Lack of knowledge - Lack of certification procedures for alternative practices - Complex supply chains Complex information flows within the supply chain - Take back process unknown, supply quality and quantity
Drivers	- Impacts on profitability - Future price and cost uncertainty for materials - Policy	- User demand attitudes - Industry pressure points: Material scarcity - Future price and cost uncertainty for energy	- Industry pressure points: disruption of material flows - Reduce waste disposal costs
Benefits	- Prolonged commercial relationship with the consumer - Opportunities for collaborative partnership - Reduced material costs	- Reduced environmental impacts - Potential profits - Potential for new business models - Less price volatility for materials - Reduced risk for supply disruption - Greener company image	- Benefits for society

6.1 Barriers

Cost restraint was ranked as a high level barrier, and this barrier was closely related to the consumer, as it was perceived that "these models [could] represent additional costs without clear benefits for the consumer". With reference to the 'upgrade and leasing model' there was a consensus between participants that "price points need to be set such that switching from ownership is [considered as] worthwhile".

Similar comments were found when *consumer perception and behaviour* was rated. These were also ranked as high level barriers and it could be said that consumer perception and behaviour were strongly related to cost restraints, as a strong relationship between 'cost vs. convenience' was found. From the findings, it was seen that consumers might not be willing to trade off convenience (in terms of quality, safety and hygiene, amongst others) if they do not see a clear benefit for them. In order to make the two models work, clear benefits of these approaches should be communicated to consumers, resolving the costs vs. benefits dilemma of switching from ownership to a service provision system.

Cost restraint was linked to two other further barriers related to the manufacturer – *lack of investment capital to develop and build new facilities* and *lack of operational capital* (see table 1). Despite these two barriers being ranked as low, participants believed that in general a cost restraint "having multiple regional centralised facilities [would] be very expensive." From a manufacturing perspective, a strong relationship was found between this barrier and a closed loop supply chain (which was rated as medium), as "current supply chains are not

[prepared] to handle reverse product flows costs effectively." For example, one of the major costs considered in the 'upgrade and leasing model' was transport, due to the amount of product flows that centralised facilities might need to handle. These findings support Preston's research that the transaction costs needed for change are considered as barriers to shifting to a circular model [2]. In addition international supply chains are complex as operations take place across many different countries [2].

Another barrier ranked as high, *was producers and consumers locked into the current economic market system*. For producers this was due to the costs that these models represent. Participants perceived that at the moment there is no "incentives for business" that can make them shift to a service provision model. This was related to other barriers ranked as low, such as time constraints due to increased time in processing and tracking repairs/maintenance, and the time and the cost needed to test these new business models. In addition the lack of knowledge due to the expertise needed and complex information flows in the supply chain related to logistics in transportation and information processes were also other reasons that might hinder producers.

In terms of consumers being locked into the current economic market system, it was found that this was related to the medium level barrier of *cultural expectations*. Participants agreed that these models would only be feasible if consumers accept them and they are competitive with current models. Acceptability would depend on specific circumstances such as age, life stage, economic background, culture, and environmental context, amongst others. In the 'community laundry model', participants stressed that this model has been successful in some cultures (e.g. Sweden) and with some specific users (e.g. students) however; this might not work in the UK. Their concerns were related to a similar study conducted by Fletcher and Goggin in which the findings revealed that a community model was not considered hygienic and its use had connotations of low economic and social status [32].

6.2 Drivers

Impacts on profitability were ranked as a high level driver, as it was thought that these models could be successful if they had clear impacts on profitability. Participants agreed that these models could be profitable if brand value is enhanced, if they offered a clear commercial benefit, and if material costs rise and reprocessing becomes a cheaper option.

With reference to the last point, participants considered *future price and cost uncertainty for materials* as another high level driver as "scarcity equals increased costs [on materials] and lack of supply [of materials]." This was considered "as a result of industry pressure points." In contrast, *future price and cost uncertainty for energy* were considered as a medium level driver, because volatility of price on materials was not directly related to *disruption of energy supply*, but was to material scarcity and disruption of material flows.

Despite this, at the moment *material scarcity*, *disruption of material flows and of energy* are not considered as high level pressure points for industry but are predicted to be so in the future.

Policy was seen as a high level driver, which be used to provide incentives to influence consumers and producers to adopt these types of business models. In terms of influencing producers, participants agreed that policy should encourage extending producer responsibility, developing materials specifications, and tighten waste and materials regulations (and in which end of life should be considered). It was mentioned that most large appliances manufacturers and retailers already comply with the WEEE directive, which incentivises them to follow careful waste disposal procedures to get more value from scrap. Thus, *reduced waste disposal costs* were considered as a low level driver.

In terms of influencing consumers, it was suggested that policy could help to increase awareness of and education in end of life value through encouraging things to be kept for longer. It could support community models that encourage re-use and repair, and look to make changes in current policy. Cooper suggests scrapping VAT on repair or upgrading work, which would have obvious implications for the Treasury [35]. However the development of policy frameworks could ultimately help create the demand for these types of new business models, as consumers would be able to see added benefits. If demand increases it could trigger manufacturers to deliver changes in their business models.

6.3 Benefits

Prolonged commercial relationship with the consumer and *opportunities for collaborative partnerships* were ranked as high level benefits. Participants considered that service provision models could build relationships with the consumer and across the supply chain, including service networks. Participants thought that these models could help to build long term relationships that are trustworthy and

that this would bring mutual benefits. Building trust with consumers could help to 'unlock' them from current economic market systems, which had been identified as a barrier.

Reduced material costs were also discussed as a high level benefit, as participants agreed that any business model that encourages reduction in the use of material represents lower costs for the manufacturer and the consumer. It was also acknowledged, but as a medium level benefit that these models could help to stabilise *material price* and reduce the risk of *disruptions in the supply chain*. This could particularly advantage manufacturers if the costs over the supply chain were reduced this would become a benefit rather than a barrier.

Potential profits and *potential for new business models* were just considered as a medium level benefit. However as Preston argues, more research and examples of success are needed to demonstrate that a service model could have high profit margins and while developing competitive markets [2]. Thus it could be argued that the models would have to be taken up first to actually generate these new markets and make a real impact on profits. In addition, the findings revealed that these models could boost job creation in the UK, which could benefit the economy, supporting research findings from the Ellen Macarthur Foundation [6].

Greener company image was considered as a medium level benefit as it was related to the benefit of *reducing environmental impacts* (also rated as a medium level benefit). Participants agreed that adopting a green image could be a market differentiation as consumers are more aware of environmental impacts due to their impacts to *society* in general.

By studying the barriers, drivers and benefits of these depicted models for LHA the findings show that the overarching framework could be an enabler to develop new models to deliver change. However, consumers and their behaviours, habits and actions have to be strongly considered as most of the participants acknowledged that consumer demand for these alternative models would be a key influencer for shifting towards a service economy. The Great Recovery Project report acknowledged that to move towards circularity a better collaboration across the supply chain including consumers is needed [5]. Through these preliminary findings it could be said that to move *beyond* the circular economy, companies need to focus more on consumer's attitudes and behaviours to propose new business models that could redefine the actual economic system without undermining prosperity.

7. CONCLUSIONS

The framework was successful in engaging debate around the changes that are needed to move beyond a circular economy. Despite the fact that several barriers to change were seen, the framework helped to draw some enablers and opportunities that could be used to move the debate forward. Next steps for this research would explore how the framework could roll out to wider sectors, and would look for similarities and differences across them. In addition, further exploration on the role of consumers would be made by using consumers to co-design similar models to explore barriers, drivers and benefits from their perspective.

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