Reviewing environmental rebound effects from peer-to-peer boat sharing in Finland

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Abstract: The world crucially needs to reduce the level of emissions being released in the environment in order to combat climate change. With the global population increasing and economies continuing to grow, the circular economy has been heralded by many as the potential solution to economic prosperity whilst also reducing primary resource use and emissions. However, the existence of environmental rebound effect has the potential to severely limit the emission reductions of the circular economy by increasing consumption elsewhere. This paper focuses on the definition of economic rebound effect and on its impact on a peer-to-peer boat sharing platform in Finland. A survey completed by users of the platform allowed for the quantitative analysis of environmental rebound effect experienced by the users and also provide insight into the consumption behaviour that created the most negative consequences. Rebound was experienced by almost all users with almost a third of users experiencing a backfire in which their overall emissions increased as a result of consumption made possible by the economic benefits of shared access. Primary production and the substitution of air travel for the leasing of a boat created large reductions in emissions, however, this was counteracted by increases in personal use and increased air travel by others. This real-life study of environmental rebound effect shows both its existence and impact on the peer-to-peer sharing of boats in Finland.

Keywords: Sustainable Development, Circular Economy, Sharing Economy, Peer-to-Peer Shared Access, Environmental Rebound Effect.

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Summary:

The world is increasing its consumption of primary materials and driving climate change through the release of greenhouse gasses. With the global population increasing, predicted economic growth and a developing middle class in emerging markets, many have questioned the current linear economic models ability to protect the climate whilst delivering economic prosperity.

One potential solution is the adoption of the circular economy, an industrial economy in which energy efficiency and the eradication of waste is built in by design. However, the economic benefits of the circular economy can lead to increases in consumption in other areas that limit its effectiveness by essentially ‘taking back’ some of the savings in emissions. This phenomenon is known as rebound effect and is currently under-researched in the context of circular economy.

This paper reviews the environmental rebound effects of peer-to-peer boat sharing in Finland. The study found that environmental rebound effect was experienced by every leassee surveyed and in one-third of lessors. 60% of leasees experienced a rebound of over 20%, losing one-fifth of the potential reductions in emissions through subsequent consumption behaviour enabled by the economic savings created by the sharing economy.

International air travel and increases in personal use of the boat were the biggest contributing factors towards environmental rebound effect. Users that increased consumption in these ways experienced a backfire effect in which their annual emissions actually increased. This backfire was experienced by 29% of leasees with the worst scenario increasing emissions by a factor of over eight.

The results show that environmental rebound effect is significantly reducing the potential of the sharing economy. Greater awareness is needed to help prevent the impact of an environmental rebound effect.

Keywords: Sustainable Development, Circular Economy, Sharing Economy, Peer-to-Peer Shared Access, Environmental Rebound Effect.

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1. Introduction

With the consumption of materials increasing (WBCSD 2010; European Commission 2011), atmospheric levels of carbon dioxide driving climate change (UNFCC 2015) and the world's population set to increase to 9 million by 2050 (UNEP 2017), all compounded by rapid economic growth in emerging markets (HSBC 2012), there is a need to review how economic systems can best find the necessary balance to protect the environment and economic prosperity (WBCSD 2010; European Commission 2011; Brears 2018; EMF 2013; UNEP 2017). Prieto-Sandoval et al. (2018) state that “one globally accepted solution is the circular economy (CE), a paradigm that aims to generate economic prosperity, protect the environment and prevent pollution”.

The Ellen MacArthur Foundation (2013, p.22) describes the circular economy as “an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design”. The concept depends on creating closed resource loops in which materials and energy are recycled back into the start of the supply chain in order to maximise the potential of resource and minimise environmental impact (EMF 2013).

Circular economy initiatives may be crucial to realising the Sustainable Development Goals outlined by the United Nations in 2015 (United Nations 2015). Specifically, “the strongest relationships exist between CE practices and targets of SDG 6 (Clean Water and Sanitation), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG15 (Life on Land)” (Schroeder et al. 2019, p.92).

However, one potential critical limitation of the circular economy is the ‘rebound effect’, defined by Zink and Greyer (2017) as a “phenomenon where increased efficiency makes consumption of some good (e.g., energy or transportation) relatively cheaper and, as a result, people consume more of it”. Essentially, the negatives accrued by the increase in accessibility to products have the potential to outweigh the benefits of reducing primary production.

Despite the huge potential consequences of the rebound effect “only few studies have specifically examined CE-related rebound” (Makov & Vivanco 2018a, p.2). Furthermore, “there is no specific guidance for assessing CE implementation level at the micro-scale” (Prieto-Sandoval et al. 2018, p.2) meaning that many companies are attempting to implement circular economy strategies without acknowledgement or knowledge of how to prevent rebounds that could limit or negate the positive environmental impact.

The most efficient strategy of the circular economy is to keep added value material resources (i.e. consumer goods) circulating in the use phase through reuse (Laurenti et al. 2016). Within the circular economy, sharing economy initiatives are founded on the principle of maximising the utility of a good through renting, lending and swapping goods (WEF 2014, p.24). There is, however, limited empirical evidence on the environmental benefits and potential rebound effects from reuse, specifically regarding derived changes in consumption behaviours from peer-to-peer sharing (Laurenti et al. 2019). Further research is needed into how participation in peer-to-peer initiatives is altering existing consumption in order to maximise the current potential in radically orienting consumption behaviours towards more sustainable practices.

The aim of this thesis, therefore, is to explore the rebound effect caused by changes in the consumption behaviour of users of a peer-to-peer sharing platform. With the involvement of a web-based platform facilitating the peer-to-peer leasing of boats in Finland the study has the ability to explore the rebound of products used for leisure and transport.
The thesis will explore the concept of circular economy rebound effect and provide insight into the utilisation of the rebound effect to answer the following research questions:

- Does participation in the peer-to-peer shared access of boats lead to a rebound effect?
- Does the improved access to boats result in greater consumption levels and emissions?
- What consumption behaviour is substituted as a result of participation in peer-to-peer shared access?
- Does peer-to-peer leasing lead to a reduction in primary production?
2. Theoretical Background

2.1 Current Consumption

During the course of the twentieth century, the world increased consumption of carbon-releasing fossil fuel by a factor of 12 and the extraction of material resources by a factor of 34 (European Commission 2011). Within the European Union (EU) the average current consumption of materials by each individual stands at 16 tonnes, creating a combined total of 8 billion tonnes of material consumption by the population of the EU every year (European Commission 2011). Of the 16 tonnes of personally consumed material, 6 tonnes are lost through inefficient disposal techniques such as landfill (European Commission 2011).

The United Nations Environment Programme (UNEP) (2017) estimates that annual global material extraction will reach 183 billion tonnes by 2050 which is over double the extraction rates seen in 2015. Increase in extraction is resulting in a continuing drop in quality of the ores extracted. Over the past century, ore grades in Australia declined by a factor of 2-5 and iron ore quality in the United States fell from 60% to 20% (Brears 2018). Furthermore, stocks of an increasing number of raw materials are becoming dangerously depleted with the European Commission (2015a) placing 14 out of 41 materials investigated onto a critical shortage list. The risk of shortage is furthered by raw material extraction occurring in just a handful of nations, leaving their governments the ability to dictate how much resource is exported and how much is kept to focus on domestic production (UNEP 2017).

With the heavy industries of raw material extraction and primary production being currently powered primarily by fossil fuels, increases in consumption lead to the release of harmful greenhouse gasses into the atmosphere (WBCSD 2010). Economists such as Kate Raworth promote the concept of safe operating boundaries for global economies to sustainably exist, however, the safe boundary for atmospheric carbon dioxide of 350 parts per million (ppm) has already been exceeded with current concentrations of 400 ppm and rising (Raworth 2017). Currently, 45% of carbon emissions are emitted by just 10% of the world’s population with just 13% emitted by 50% (Raworth 2017) thus as incomes rise among emerging markets this could further increase carbon release.

Across the world, governments have begun to acknowledge and make promises to take action on unsustainable GHG emissions that result in climate change. In 2015, the United Nations Framework Convention on Climate Change (UNFCC) adopted the ‘Paris Agreement’ with signatory nations vowing to help prevent global temperature increase of more than 2°C compared to the pre-industrial era levels whilst acknowledging that a more desirable limit of a 1.5 °C would significantly reduce the impacts associated with climate change.

2.2 Changing Demographics

As the world's leaders struggle to deliver on their promise of action, population rise and economic growth in emerging markets are set to exponentially worsen the existing strains on carbon emissions and resource depletion. The economies of Mexico and Indonesia are expected to surpass the size of the UK and France by 2030 and Turkey to surpass Italy within the same time period (PWC 2015). World economic growth, determined by GDP, is predicted to double in size by 2037 and triple by 2050 (PWC 2015).

The Philippines has a population twice the size of either Germany or the United Kingdom and can expect to see the average annual income of its citizens increase nine-fold (HSBC 2012) by 2050. The world's two largest populations, China and India, can expect to see real wages increase by factors of seven and six respectively (HSBC 2012).
The consumption trends of these emerging markets are hugely important in tracking global resource use. According to HSBC (2012), an increase in wages leads to a massive rise in discretionary spending as individuals have the disposable income to pay for “the finer things in life” (HSBC 2012, p.5). Currently, China, India, Indonesia, the Philippines, Egypt, Colombia, Peru and Russia are all in the stage of greatest change to spending patterns due to increased income, affecting more than 3 billion people (HSBC 2012).

Increases in income result in exponential increases in spending on leisure pursuits with both the restaurant and hotel sector and the recreation and culture sector expected to grow by at least 7% per annum for the next four decades in countries like China, India and the Philippines (HSBC 2012). Tourism and travel are also predicted to boom with the sharpest change in trends occurring when incomes reach circa USD$ 20,000 (HSBC 2012). Currently, only 4.3% of the Chinese population travel overseas per annum with this expected to match or surpass figures in the West, such as 34% in France and 20% in the United States, by 2050 (HSBC 2012).

An important consideration of the consumption behaviours within emerging markets is the demographics of the population. Today, the median age in both India and the Philippines is just 25 and is predicted to remain as low as 32 by the year 2050 (HSBC 2012). In addition to the boom in the leisure and tourism industry, the market share for electronic gadgets held by emerging markets is set to grow from 24% in 2010 to 55% in 2050 (HSBC 2012) resulting in a tech-savvy young population seeking to explore the world.

2.3 Linear Economy vs Circular Economy

With population increase and economic booms predicted to further existing strains on ecological and resource limits, many have questioned whether the current linear economic model can meet the world’s needs (Korhonen et al. 2018; EMF 2013; Brears 2018; Raworth 2017; Mao et al. 2018). The World Business Council for Sustainable Development (2010, p.4) argues that “shrinking resources and potentially changing climates will limit the ability of all 9 billion of us to attain or maintain the consumptive lifestyle that is commensurate with wealth in today’s affluent markets”.

The Ellen MacArthur Foundation (EMF) describes the linear model of resource consumption as one that follows a pattern of “take-make-dispose” (EMF 2013, p.14). In linear models, companies extract materials, apply energy and labour in the production process, sell the product to an end consumer and then the consumer disposes of the product once it has completed its function, usually into landfill where the material is unproductive (EMF 2013). This model assumes that resources are abundant, available and cheap to dispose of (Brears 2018) in a fashion that the depletion statistics above argues not to be the case. Over the past century, materials have been undervalued with the exhaustibility of natural resources not reflected in market prices (Brears 2018).

The concept of ‘circular economy’ is growing in response to the limitations of the linear economic model. The circular economy follows a framework of “borrow-use-replenish” (Brears 2018, p.13) which aims to keep resources in use for as long as possible, maximising the potential of the material whilst it is in use and then regenerate the material at the end of its service life into another usable product (EMF 2013). A key aim of the circular economy is to decouple economic growth from resource use and from negative environmental impact (Brears 2018).

Research suggests that a circular economy approach could drastically increase resource efficiency leading to reductions in material inputs of 17-24% within the EU by 2030 (European Commission 2015b). Enhanced resource use could lead to potential savings of €630 billion per year for European industry and boost GDP by 3.9% through creating new markets and products (European Commission 2015b). As a result of this potential, the EU has created an action plan to implement circular economy...
within its member states and “boost the EU’s competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming” (European Commission 2015a, p.2).

Additionally, the circular economy is seen as a potential tool for reducing greenhouse gas (GHG) emissions by minimising the demand for materials and energy (EEA 2017). The European Environment Agency (EEA) state that “The EU’s target of reducing greenhouse gas emissions by 80-95 % by 2050 will require fundamental changes not only in energy, food and mobility systems, but also in the way raw materials and manufactured products are produced, traded, used, maintained and fed back into the economy at the end of their life” (EEA 2017, p.7).

The greatest efficiency within the circular economy can be gained by maintaining products in their current form, maximising both utilisation of the product and its lifespan (Laurenti et al. 2016). Improving the utilisation of products can be achieved by encouraging the extensive use of materials via second-hand sales or transfers, selling services rather than products and consumers granting temporary access to their private goods to others (Tukker 2015).

2.4 Sharing Economy

The ‘sharing economy’, also known as ‘shared access’ or ‘access-based’ does not have a single fixed definition within academic literature but is described by the Ellen MacArthur Foundation as when “durable products are leased, rented or shared wherever possible” (EMF 2013, p.7).

The concept is “founded on the principle of maximizing the utility of assets via “renting, lending, swapping, bartering and giving—facilitated by technology” (WEF 2014, p.24) and is growing in favour especially amongst younger generations of consumers, which can be observed in the boom of car sharing schemes and accommodation platforms such as Airbnb (EMF 2013). Within the sharing economy, peer-to-peer shared access is an area experiencing a particular boom, fueled in part by distrust in corporations among youth as a result of the 2008 economic downturn (WEF 2014).

With peer-to-peer access being embraced by younger generations, it could hold the potential to improving resource efficiency, reducing carbon emission and material extraction. The current success of web-based platforms such as Airbnb and Uber (EMF 2013) prove public acceptance of peer-to-peer initiatives within the leisure sector which may be key to altering the consumption behaviours in the young, technologically capable population set to become economically richer in the next 30 years.

A literature review carried out by Cherry and Pidgeon (2018) identifies four divides in the debate over the definition of the sharing economy; peer-to-peer vs. business-to-consumer, profit vs. non-profit, access-based rather than exchange-based and as online (platform-based) vs. offline sharing.

Business-to-consumer sharing, such as the long term leasing of products and service provisions, has been accepted into the sharing economy definition under the umbrella term of Product-Service Systems (PSS) (Tukker 2004). The emergence of PSS has, in turn, opened up acceptance in for-profit motives in the sharing economy whether that be through business-to-consumer transactions or peer-to-peer initiatives such as Airbnb (Cherry & Pidgeon 2018). Some literature (Harvey et al. 2017; EMF 2013) argues that the internet has been such a core component in growing the sharing economy that this should be included in its definition, however, this is disputed by others (Ertz et al. 2016) who state that the internet is merely a facilitation tool rather than a fundamental element of the concept. Regardless, the internet and sharing initiatives, by both peers and private enterprise, have led to a rapid boom in the sharing economy concept that has pushed it up the political agenda and, on occasion, being vulnerable to controversy due to a delay in legislation and regulation implementation (Cherry & Pidgeon 2018).

Cherry and Pidgeon found that exchange-based sharing was a point of contention within the current
literature. For example, “Belk (2014) and Frenken (2017) contend that non-transference of ownership should remain a key feature of the sharing economy (thus excluding 2nd hand market exchange), whilst Ertz et al. (2016) argue that as long as it occurs on a peer-to-peer basis (whether mediated or not), trading and swapping of products (with inherent transfer of ownership) should also be included within the definition” (Cherry & Pidgeon 2018, p.940).

This study focuses on a peer-to-peer initiative, offering temporary access and facilitated by an online platform which is thus firmly within the accepted definition of the sharing economy proposed by current literature.

2.5 Rebound Effect

The concept of rebound effect was first proposed in academic literature by Jevons in 1865 when investigating the increases in energy consumption from coal burning (Jevons 1865). This led to the concept being labelled ‘Jevons paradox’. Further academic research did not become mainstream until the late 1980s when energy economists embraced Jevons ideas following global oil shortages and increasing concerns of climate change (Vivanco et al. 2016). The concept has also been termed the ‘Khazzoom/ Brookes postulate’ and more recently ‘backfire’ (Broberg et al. 2015).

Font Vivanco et al. (2016, p.60) provide the following definition of rebound: “the rebound effect is generally defined as the difference between the expected and the actual environmental savings from efficiency improvements once a number of economic mechanisms have been considered, that is, the savings that are ‘taken back’”.

Thiesen et al. (2008) provide a further explanation stating “the rebound effect deals with the fact that improvements in efficiency often lead to cost reductions that provide the possibility to buy more of the improved product or other products or services” (Thiesen et al. 2008, p.104). A commonly used example of rebound effect is the case of a “driver who replaces a car with a fuel-efficient model, only to take advantage of its cheaper running costs to drive further and more often” (Druckman et al. 2011, p.3572).

Despite an increasing level of research into the concept of rebound effect, there has been no specific consensus around a specific definition (Broberg et al. 2015). A comprehensive review of rebound effect literature by Walnum et al. (2014) identified seven perspectives that each offer unique understandings and assumptions about rebound effect; energy economics, ecological economics, socio-psychological, socio-technological, urban, planning and evolutionary and industrial ecology/sustainability. Within industrial ecology and sustainability studies, the perspective of rebound effect has been termed ‘environmental rebound effect’ (ERE), a concept that looks beyond the indicators of energy use to incorporate a wide range of environmental issues such as emissions (Vivanco et al. 2015).

Font Vivanco et al. (2016) argue that by broadening the concept to include economic and behavioural feedbacks into the analysis of rebound effect and utilising applications such as life cycle assessment (LCA) raises questions about where the boundaries to the concept should be defined and without this definition coherent analysis of the term could be jeopardised. The authors call for a greater distinction between the ‘classic rebound effect’ and ERE.

ERE has a number of advantages as an approach over the classic rebound effect calculation. Firstly, traditional rebound studies are biased towards purely technological innovations and focus on fuel efficiency. This has led to organizational innovations, such as sharing economy initiatives being overlooked by research. Furthermore, the narrow presentation of rebound studies, with results offered as a percentage of environmental savings taken back, results in a lack of data into to overall impact of rebound at the macro level. A more holistic approach is crucial in identifying innovations that deserve policy attention (Vivanco et al. 2015).
Rebound effect can be defined into two categories ‘direct’ and ‘indirect’ which combined result in the ‘economy-wide rebound effect’ (Broberg et al. 2015). ‘Direct’ rebound is the term accredited to effects calculated by narrow frameworks focussed on energy services. ‘Indirect’ rebound effects consist of the knock-on effects that follow on from efficiency gains and can be categorised as “(i) income, output and substitution effects; (ii) general equilibrium effects in terms of long-run structural change following changes in relative prices and (iii) radical changes in the social structure relating to technological development, preferences and institutions” (Broberg et al. 2015, p.27). ‘Backfire’ is a term used to describe situations where the rebound effect is so great that it actually increases energy demand (Druckman et al. 2011).

Despite a reasonable number of studies estimating direct rebound effects, there have only been a handful of studies that estimate indirect rebound effects (Druckman et al. 2011). Furthermore, as rebound effects are difficult to quantify, the existing literature is fragmented and focuses only on a subset of effects which are measured over a limited timeframe.

Even fewer studies have examined circular economy rebound effects. Makov and Vivanco (2018a) carried out the first study to quantify the rebound effects of reuse in the circular economy when they explored ERE as a result of second-hand smartphone sales. In their study, it was estimated that, under certain conditions, 100% of emissions savings could potentially be lost due to re-spending and imperfect substitution of the price saving of purchasing a second-hand phone compared to a new device. This result was in line with literature by Zink and Geyer (2017, p.600) who concluded that “circular economy activities can lead to rebound by either failing to compete effectively with primary production or by lowering prices and therefore increasing and shifting consumption”.

Within the sharing economy, a study by Briceno et al. (2005) conducted research on car sharing schemes to evaluate the changes in behaviour and consumption patterns of the users. The study took existing data from household expenditure to simulate likely scenarios caused by changes in behaviour and surmised that one likely scenario following participation in car sharing is that users will utilise the cost saving on international travel. Briceno et al concluded that users justified additional air travel with a sense that not owning a car was sufficiently doing their part in combating climate change, however, this scenario ultimately led to a rebound effect more detrimental than car ownership (Briceno et al. 2005).

As the Briceno et al. (2005) study was carried out without hypothetical scenarios rather than being based on data directly collected by users of car sharing schemes, there is a need for further investigation to corroborate the results. Furthermore, the study focussed on a PSS approach to sharing economy in which the car was leased out by a private company. In a peer-to-peer sharing scenario rebound effect can be realised by both the lessee and the lessor, the consumption behaviours of both being crucial to a positive rebound result.
3. Methodology

3.1 Literature Review

A literature review is important to “determine the questions that are most significant for a topic and to gain some precision in formulating these questions” (Yin 2009, p.9). It was, therefore, necessary to conduct a literature review prior to formulating the survey questionnaire to gain an understanding in what information is most relevant for calculating rebound, what has been successful in previous studies and what gaps are missing from the topic literature.

The main topics of the literature reviewed focussed on the history of the concept of rebound effect and current literature regarding its use in circular economy. Most literature was obtained via online databases such as; Uppsala University’s internal library (Uppsala universitetsbibliotek), Researchgate and Google Scholar. Search terms within these databases included combinations of; ‘Rebound effect’, ‘Jevons paradox’, ‘Shared access’, ‘Sharing economy’, ‘peer-to-peer’ and ‘circular economy’.

The literature review revealed that the calculation of rebound effect specific to shared access initiatives is under-researched and those papers that have conducted studies are all published within the past few years. As a result ensuring that using the most up to date literature was not an issue, however, care was still taken to ensure the highest quality of literature that has been peer reviewed prior to publication in academic journals.

3.2 Data Collection

A survey was used to collect data on the consumption behaviour of users of a peer-to-peer sharing platform. The survey received 157 responses.

The survey sample was an important consideration for this study. As stated by Punch (2003) the relationship between variables is an important consideration in determining whether the sample should be random or deliberately chosen. As peer-to-peer sharing has yet to become a mainstream activity, random surveying would provide little to no insight into the rebound effect caused by participation. In order to achieve the aims of this study, the survey needed to reach the target audience of individuals currently participating in peer-to-peer sharing initiatives.

A peer-to-peer boat sharing platform based in Finland but also operating elsewhere was identified as a case study for this study. A case study was an important element of the study as “a case study allows an investigation to retain the holistic and meaningful characteristics of real-life events” (Yin 2009, p.3). Furthermore, focus on the platform enabled access to an ever-increasing number of users with experience of peer-to-peer sharing who could provide specific details on the changes in consumer behaviour as a result of their participation in the circular economy. An additional further consideration is that access to both leasess and lessors was an important addition to this study calculating rebound effect that has been absent in previous literature.

Two surveys were produced for the study to take place; one for leasess and one for lessors. The need for two separate but similar surveys is to collect slightly varying data sets for both groups. For the leassee the main focus is on the substitution in spending with some indicator as to whether this is financially more or less than usual. For the lessor survey, the emphasis is much more on what the additional revenue generated from sharing the boat is spent on with questions regarding if the revenue was reinvested into extending the life cycle of the boat through regular maintenance.

Both surveys were quantitative in nature. Punch (2003, p.19) describes quantitative research as to when
“reality is conceptualised as variables, and the ultimate objective is to find out how different variables are related to each other”. This style of research is necessary to be able to quantifiably calculate the environmental impact of the consumption substitutions and rebound effects.

The survey was conducted through a self-administered questionnaire which, due to its simplicity to complete, ensured the maximum number of respondents possible in a limited timeframe. Each question came with predefined answers, with the exception of costs which was limited to numerical input, to allow for direct comparisons between the dataset. The survey was sent out to all platform users located in Finland and thus the survey was conducted in Finnish for ease of use for the respondents. Closed responses assisted in allowing for responses to be easily translated into English for analysis and a copy of the survey in both English (Appendix 1+2) and Finnish (Appendix 3+4) can be found in the appendices. The surveying tool chosen for this survey was ‘Google Forms’ due to its easy to use user interface, unlimited response collection and continuity having been used by the platform to conduct customer surveys in the past.

3.3 Data Analysis

This study will scrutinize the rebound effect of peer-to-peer sharing practices from the perspective of industrial ecology. The most common approach to calculating rebound within industrial ecology literature is the environmental rebound effect (ERE), a wider interpretation of the traditional notion of rebound effect which allows for a more holistic insight into environmental impact (Vivanco et al. 2016). ERE is an appropriate concept for interpreting the rebound of peer-to-peer practices as it goes beyond focussing purely on energy and can instead allow for factors such as emissions and lifecycle of the product. Peer-to-peer exchanges often result in dynamics with more complexity than the simple approach of measuring a change in the ratio of inputs and outputs from manufacturing.

The study will calculate the rebound effect by comparing the maximum potential changes in CO₂ emissions based on the user responses against those that were actually realised after additional changes in spending. A similar approach was taken by Makov and Vivanco (2018a) in their study of the rebound effect from the reuse of smartphones and is thus an approach that is supported by the literature. In that study, life cycle assessment (LCA) was a core component in calculating the changes in greenhouse gas (GHG) emissions as a result of extending the smartphones life. Similarly, this study will also present the calculation of rebound in terms of GHG emissions.

Rebound effect is the combined result of two distinct forms of rebound; re-spending and imperfect substitution (Makov & Vivanco 2018a). Re-spending rebound is the idea that certain price savings as a result of circular economy initiatives effectively increase an individual's effective income and leads to additional purchasing power. Consumers typically react to this by purchasing additional goods (Zink & Geyer 2017). In a peer-to-peer sharing dynamic, additional purchasing power can be realised by both parties as the leasee can benefit from the lower costs associated with renting and the lessor receives a financial transaction in return for the temporary access of property. It is, therefore, crucial to investigate the consumption patterns of both parties.

Imperfect substitution is the idea that circular economy strategies do not lead to the reduction of new product units on a 1:1 basis (Makov & Vivanco 2018b). In the context of this study, the lease of a boat via a sharing economy platform does not necessarily equate to one less boat being manufactured. In addition, previous studies such as Makov and Vivanco have studied products that are relatively passive in terms of GHG emissions outside of their primary production, however, in the context of extended use of boats, far greater levels of GHG emissions result in additional use and operation of the boat. Furthermore, the life of the product far exceeds the 36 months (Makov & Vivanco 2018a) average lifespan of a smartphone and can be extended further as a result of good maintenance practice (LIFE 2012).
The environmental rebound effect as a result of lessors and leasees partaking in peer-to-peer sharing of boats will be calculated via:

\[ % ERE = 100 - \left( \frac{pr + ic}{pr} \right) \]

Where \( pr \) is the maximum potential reduction from substituted previous consumption and increase in lifecycle and \( ic \) is the increased consumption in other areas resulting from additional spendable income. Both \( pr \) and \( ic \) are calculations of emissions expressed in kg CO\(_2\).

A more comprehensive breakdown of the formula can be seen below:

Equation 1:

\[ \% \text{ ERE (lessors)} = (\text{Substituted Travel (kg CO}_2\text{) + Extension of Life (kg CO}_2\text{)}) - (\text{Additional Use (kg CO}_2\text{) + Additional Spend (kg CO}_2\text{)}) / (\text{Substituted Travel (kg CO}_2\text{) + Extension of Life (kg CO}_2\text{)}) \]

Equation 2:

\[ \% \text{ ERE (leasees)} = (\text{Replaced Travel (kg CO}_2\text{) + Replaced Spend (kg CO}_2\text{) + Reduction in Primary Production (kg CO}_2\text{)}) - (\text{Use of Boat (kg CO}_2\text{) + Additional Travel (kg CO}_2\text{) + Additional Spend (kg CO}_2\text{)}) / (\text{Replaced Travel (kg CO}_2\text{) + Replaced Spend (kg CO}_2\text{) + Reduction in Primary Production (kg CO}_2\text{)}) \]

In addition to calculating rebound, the calculation of the overall change in emissions will also be presented using the following formulas:

Equation 3:

\[ \text{Lessor Change in Emissions (kg CO}_2\text{)} = \text{Additional Use + Additional Spend - Substituted Travel - Extension of Life} \]

Equation 4:

\[ \text{Lessor Change in Emissions (kg CO}_2\text{)} = \text{Use of Boat + Additional Travel + Additional Spend - Replaced Travel - Replaced Spend - Reduction in Primary Productions} \]

As the results depend on the calculation of kg CO\(_2\) emissions resulting from consumption indicated in the survey, it is important to further discuss the sources of this emissions data and further explain how the values for each category will be calculated based on the responders' survey inputs.

The use of the boat is hugely dependent on the type of boat being used. The type of boats being offered by the sharing platform studied can be placed into three different categories; sailboat, motorboat and Rigid-hulled Inflatable Boat (RIB) (or similar). An LCA was carried out by LIFE (2012) Europe project ‘BoatCycle’ and determined that the average kg CO\(_2\) emission per hour of use was; 3.04 for sailboats, 25.47 for motorboats and 13.44 for RIB (LIFE 2012).

Respondents of the survey were asked to state the number of days they used different forms of boat as this was deemed to provide a more accurate response than requesting the number of hours which some respondents may not have known. For each day of use it is assumed that the boat is under power for 8 hours which equates to a per day kg CO\(_2\) emission of; 24.32 for sailboats, 203.76 for motorboats and 107.52 for RIB.

The BoatCycle project also calculated the kg CO\(_2\) emissions as a result from the manufacturing stage of the boat’s lifecycle and found that on average the following were emitted; 46,000 for sailboats, 158,000 for motorboats and 31,000 for RIB (LIFE 2012). In order to provide a calculation of rebound, it is important to consider the lifespan of the boat which was stated as 25 years for both sailboats and motorboats and 15 years for RIB.
Calculating the potential savings as a result of a reduction in primary production, leasees were asked to state whether they would purchase a boat if leasing was not an option for them. In cases where the respondent stated that they would purchase a boat if leasing was not an option then a portion of the average production emissions is subtracted in the rebound calculation. As we will assume that the potential owner will offer average maintenance of the boat over its lifespan the total production emission is divided by the average lifespan to provide the annual saving of; 1840 kg CO\textsubscript{2} for sailboats, 6320 kg CO\textsubscript{2} for motorboats and 2067 kg CO\textsubscript{2} for RIB.

For lessors, the calculation of emission saving through the reduction in primary production was calculated in a similar manner. As the boat has already been produced, total minimisation in primary production can obviously not be achieved, however, thorough maintenance of boats can significantly increase their lifespan and thus reduce the need for further primary production (LIFE 2012). Lessors were asked to state whether they used the income from leasing their private boat towards maintenance. Those that respond that the income is not used for this purpose will not gain an extension to the life of the boat as a result of leasing, however, those that do utilise income in that manner are divided into a further two categories. A follow-up question as to whether the income covers the entire costs of maintenance determines the extent of the extension of life. For those that respond that the full cost of maintenance is met, it can be assumed lifespan can be extended by 50% raising the lifespan of sailboats and motorboats to 37.5 years and RIBs to 22.5. Calculating annual emission saving from the reduction in primary production over the new longer time period gives values of; 613 kg CO\textsubscript{2} per annum for sailboats, 2107 kg CO\textsubscript{2} for motorboats and 689 kg CO\textsubscript{2} for RIB. For those that stated they used the generated income on maintenance but the full costs were not covered, the lifespan increase is calculated at 25% giving annual emission savings of 362 kg CO\textsubscript{2} for sailboats, 1264 kg CO\textsubscript{2} for motorboats and 413 kg CO\textsubscript{2} for RIB.

Emissions associated with other forms of leisure travel were calculated by a set list of options which included the following; travel within the Nordic region, travel within the Baltic region, travel within Europe and long-haul travel. In the calculation of travel to and from these destinations, it is assumed that the travelling group is equal to the average size Finnish family of 2.8 persons (Official Statistics of Finland 2015) rounded up to 3 individuals for convenience.

The destinations used for the calculation of travel are determined by the popularity of destinations among Finnish travellers as stated by the Official Statistics of Finland (2018). Estonia is the most popular destination for leisure travel both within the Baltic and in general. For the Nordic region, Europe and long-haul, the most popular destinations are Sweden, Spain and Thailand respectively (Official Statistics of Finland 2018). The GHG emissions created by different transport methods are taken from DEFRA’s GHG Conversion Factors (DEFRA 2018) and multiplied by the point to point distance, between Helsinki and the capital city of the destination country, as calculated by online tool ‘Distancefromto.net’ (DistanceFromTo 2019).

The calculations provide the following CO\textsubscript{2} emission levels for the leisure transport options provided for a family of three. Travel within the Baltic is a 164 km return journey taken by ferry emitting 0.12774 kg CO\textsubscript{2} per km totalling 62.85 kg CO\textsubscript{2}. Travel within the Nordic region is a 790 km return journey taken by ferry emitting 0.12774 kg CO\textsubscript{2} per km totalling 302 kg CO\textsubscript{2}. Travel within Europe is a 5896 km return journey taken by short-haul aeroplane emitting 0.16155 kg CO\textsubscript{2} per km totalling 2857 kg CO\textsubscript{2}. Travel long-haul is calculated as a 15,774 km return journey taken by aeroplane emitting 0.2115 kg CO\textsubscript{2} per km, totalling 10,009 kg CO\textsubscript{2}.

Not all users of the platform have made a direct substitution between leisure activities and have instead found either a gain or reduction in income spent on regular living costs compared to previous years. This is an important factor in calculating the rebound from engaging in peer-to-peer access as every unit of currency spent in modern economies leads to carbon emissions of some form. According to World Bank figures, each US dollar worth of spending in Finland resulted in 0.209 kg CO\textsubscript{2} emission in 2014 (The World Bank 2014). Adjusted into Euros (IRS 2019) using the average conversion rate of that same year (IRS 2019) gives emissions of 0.268 kg CO\textsubscript{2} per Euro spent. Respondents stated whether
their ability to lease a boat came from changes in their regular spending rather than substitution in travel and this figure will be used to calculate the GHG emissions impact of the consumption behaviour change.

In the event that a leasee respondent has stated ‘regular living costs’ as the biggest utilisation of the financial savings but has also indicated an increase in travel, the double calculation will be avoided by including two-thirds of the spending impact and one-third of the travel impact. Likewise, the same ratio will be made in the lessor calculation between maintenance and increased travel or living costs.

### 3.4 Ethics

Four major ethical considerations that should be made prior to research consist of: do no harm, obtain informed consent, protect privacy and avoid conflicts of interest (Ruane 2016). All four of these considerations were made prior to the survey being conducted and a statement of intent, informing respondents of how their data will be used and published, was sent out with the survey link. All responses were offered on a voluntary basis with responders able to opt out at any stage of the short questionnaire without further prompt to continue. Survey respondents were not asked for their names in order to protect their privacy and all questions were set to ‘optional’ so respondents could further avoid providing answers to any questions they were not fully comfortable sharing.

The author declares no conflict of interest in conducting this study.

### 3.5 Limitations

Due to the time constraints of the study, a purely quantitative research method has been adopted. Although this is a perfectly fitting approach with many advantages, a mixed method approach, “research in which a researcher or a team of researchers combines elements of qualitative and quantitative research approach” (Johnson et al. 2007, p.11), may have generated some extra insight. Qualitative interviews were considered in order to provide further detail to the different variables offered in the quantitative survey, however, the literature review has provided a satisfactory base to build upon.

A further limitation of the study was the level of detail provided by the survey responders. The decision was made to focus on simplicity in order to capture the largest number of responses whilst also maintaining accuracy in the response itself. A more complex survey requiring greater specific detail of expenditure may have provided marginally more insight, however, the accuracy of the response may have dipped. This is especially the case as users were providing responses on their expenditure and consumption in the summer prior to the studying taking place, a period of up to one year. A different time of year may have been better suited to conduct the study if timeframe had allowed for this or preferably a multi-year study in which users knew to take more detailed notes of their expenditure.
4. Results

The results of the survey, using the data analysis described above, will reveal if ERE does occur during the peer leasing of boats and will outline the extent at which it inhibits the full potential of the circular economy. Survey responses from users of the peer leasing platform will shed light on real-world changes in consumption and determine these consumption changes result in a drop in primary production.

There were 29 responses to the lessor survey and 128 responses to the leasee survey. Of the 128 leasee responses, 9 were not sufficiently complete to include in the calculation dropping the used number of responses to 119. Therefore, 148 users of the peer-to-peer sharing platform have been included in this study.

4.1 Rebound

Using the calculations outlined in the chapter above, the response of each user (both leasee and lessor) enabled the calculation of rebound shown as a percentage of potential gains in emissions reductions that have been lost due to substituted consumption.

4.1.1 Lessors

As Figure 1 shows, among lessors, 55% of users did not experience ERE and thus maximised the potential emissions savings from leasing their boat. However, due to the consumption of the remaining 45% of users, the overall average ERE grows to 46.5%. Furthermore, 17% of users experienced backfire, increasing their overall emissions with one user increasing emissions by a factor of 4.8.

In order to achieve 100% of the potential gains, the entirety of the generated income must be reinvested into the upkeep of the boat. Users that did not achieve this full potential either increased their personal use of the boat or utilised the revenue on additional travel.
4.1.2 Leassee

**Fig. 2 - Rebound Effect: Leassee**

All leassee experienced ERE in some form with the extent varying greatly. The lowest recorded ERE was just 0.82%, however, the highest was 883%.

Figure 2 indicates that there is a large variation in realising the potential emissions savings from participation in the peer-to-peer sharing of boats as a leassee.

27% of respondents experienced a rebound of 10% or lower with 40% experiencing less than 20% rebound. Amongst users that had a net reduction in emissions, the average ERE stands at 24.84%.

29% of users experienced backfire, increasing their emissions as a result of leasing a shared boat. Of this group, 53% increased their travel as a result of cost savings. Of the top 10 greatest increases in emissions, 8 of the users had substituted travel within the Baltic or Nordic Regions with the leasing of a boat. Within those that reduced their emissions just 18% increased their travel consumption.

### 4.2 Insight into Changes in Consumption and Emissions

As ERE is a calculation against the maximum potential reduction in emissions, a high ERE can still lead to a significant net reduction in emissions. For example, one user experienced a rebound of 68% due to taking a flight within Europe limiting the reduction of emissions from less primary production, however, this still resulted in an overall emission reduction over 2 tonnes CO$_2$. It is therefore important to also consider what changes in consumption realised the largest overall changes to CO$_2$ emission.

**Fig. 3 - Reduction in Emissions: All Users**
Figure 3 shows that there is a large variation in the generated reductions in emissions as a result of changes in consumption due to participating in the peer-to-peer sharing of boats. The highest calculated reduction in emissions was 10,212.8 kg CO$_2$ and the highest calculated increase in emissions was 11,751.7 CO$_2$, thus giving a difference in the result of over 20 tonnes of CO$_2$. 63% of responses resulted in a net reduction in CO$_2$ emissions whereas the remaining 37% resulted in an increase in carbon emissions (shown on the graph as a negative value). The average change in emissions across all 148 users was a 1,473.9 kg CO$_2$ reduction in emissions.

Breaking down the results into the two categories of leassee and lessor gives further insight into how the consumptive behaviour of both parties can lead to changes in emissions footprint.

**Fig. 4 - Reduction in Emissions: Lessors**

**Fig. 5 - Reduction in Emissions: Leassee**
As Figures 4 & 5 show, both groups experienced both reductions in emissions and backfire based on their consumptive behaviour. Leasseees had the largest difference in results with the overall highest reductions and overall highest increase both coming from this category. The average effect on emissions based on all lessee responses was a 1,623.9 kg reduction CO$_2$ output and 57% of users experienced an overall reduction.

Lessors experienced a larger percentage of users gaining a reduction in emissions with 87% of respondents. However, the combined average change in emissions is an 858.5 kg reduction CO$_2$ output which is lower than the combined average of the leasee responses. The difference in the maximum and minimum values for lessors was much smaller than that of the leasseees with a range just 8,790. The range and average were skewed by an anomaly in the responses with one user reporting an increase of 4,849.0 kg CO$_2$ emissions, 3,000 kg greater than the next largest increase. However, as the large increase is explained by a seemingly realistic change in consumptive behaviour, namely a 30-day increase in personal boat use due to additional revenue, it was decided to include the value in the dataset to highlight just how much overall effect can be achieved.

4.2.1 Lessors

The lessors had the closest range of change caused by their consumption alterations and this group also had a higher percentage of users experience a drop in emissions. One of the biggest factors in that reduction in emissions came from maintenance extending the lifespan of the boat. 96.6% of those surveyed stated that at least some of the income they generate from peer-to-peer sharing goes towards maintenance of the boat.

Fig. 6 - Lessors: How do you spend the generated revenue?
However, when asked the follow-up question of whether the income generated covers the full cost of maintenance, 55.2% responded that it did not. This limits the increase in lifespan within the calculation to a 25% extension rather than the 50% increase in lifespan from the full cost of maintenance being covered.

**Fig. 7** - Lessors: If you utilise the revenue on boat maintenance then does this cover the entire costs of annual maintenance (incl. dry dock etc)?

Among those that responded that the full cost of maintenance had not been covered by the income generated, the average received income was €2,468 with an average of 11.3 days of sharing. Among those that responded that the income had covered the full extent of maintenance costs (with the removal of an anomaly response seven times greater than the next closest response), the average received income was €3,554 with an average of 15.8 days of sharing.

Of the users that responded that maintenance costs were not fully covered, the average change in emissions was a 768 kg CO$_2$ reduction. Among the users that responded that maintenance was fully covered the average change in emissions was 970 kg CO$_2$, however, this group also included 80% of the users that experienced a backfire rebound resulting in an increase in emissions, due to increasing spending elsewhere.

Of the five users that experienced an increase in emissions, three increased their personal use of the
boat by more than 10 days, one experienced the highest recorded increase in regular spending and one utilised the increase in income by taking a trip to Europe.

Other users indicated that they had taken an additional trip to Europe as a utilisation of the additional income and gained an overall reduction in emissions, however, those users all operate motorboats which, as a result of a more carbon-intensive production process, gain greater reduction in emissions from extending the life of the boat through thorough maintenance compared to the sailboat of the user described above. Despite this insight, the type of boat shared was not the primary factor in determining the rebound effect as 22% of sailboat users and a comparative 15% of motorboat users experienced a backfire rebound.

Overall, lessors indicated an overwhelmingly positive experience of peer-to-peer sharing with 79.3% of users responding in the top three categories of most likely to recommend the platform to others.

4.2.2 Leasees

Leases had a far more diverse spectrum of potential changes in consumer activity as participating in peer-to-peer sharing has the potential of both increasing and decreasing spending. Changes in expenditure from leasing a boat were utilised in the following ways:

Fig. 8 - Lessors: Likelihood to Recommend Peer-to-Peer Sharing Platform to Others

Fig. 9 - Leasees: Changes in expenditure compared to previous years
23.5% of users surveyed stated that leasing a boat through peer-to-peer sharing had been an additional expenditure compared to consumption in previous years. In order to afford this increase in expenditure towards a leisure activity, 8.4% substituted other forms of travel and 15.1% reduced their expenditure on regular living costs.

26.9% of users stated that their expenditure on leisure had remained consistent with previous years with a simple substitution of other forms of travel allowing for the lease of a boat.

Almost half of those surveyed, at 49.6%, stated that they had saved money as a result of leasing a peer-to-peer shared boat. This led to an increase in spending in other areas with 31.1% stating that they had more revenue to go towards regular living costs and 18.5% stating that had taken additional travel compared to previous years.

Among users that had substituted other forms of travel, 81% experienced a reduction in emissions compared to previous years. Across the entire spectrum of those that substituted travel, the average change in emissions was a 3,902 kg CO₂. Unsurprisingly, those that gained the biggest reduction in emissions were those that substituted long haul flights with an average saving of 10,199 kg CO₂ amongst this group.

The type of boat leased does not appear to have affected the ability to gain a reduction in emissions with users of each of the three categories of boat experiencing both increases and decreases in emissions when substituting other forms of travel. Nor does the amount of time that a boat was leased with the second highest reduction in emissions for this category coming from a user that leased a sailboat for 20 days.

Among users that increased their travel as a result of cost savings from peer-to-peer sharing, 91% experienced an increase in their emissions compared to previous years. Increase in emissions was experienced by users of all three boat types and by increase travel to each of the four destination categories.

However, an increase in travel does not automatically equate to an increase in emissions with one user leasing a motorboat for one week, taking an additional flight to Europe and still reducing emissions by over 2 tonnes CO₂ as a result of leasing rather than purchasing a boat causing an overall increase in emissions from the primary production.

Changes in expenditure on living costs do not massively impact the emissions of users. For those that
responded that the biggest change in expenditure was an increase in living costs, 38% experienced an increase in emissions whilst 62% experienced a reduction. For those that primarily reduced their expenditure on living costs, 39% experienced an increase in emissions whilst 61% experienced a reduction.

The greatest factor for those that have predominantly altered their regular living spending is whether or not they are likely to purchase a boat for themselves if leasing was not an option. 43% or leassee respondents stated that they would be in the market for purchasing their own private boat if leasing were not an option to them. These 51 users alone are saving 232 tonnes of CO\textsubscript{2} per year just by leasing rather than creating further primary production. Of those that experienced a reduction in emissions 85% users indicated that they would be in the market for purchasing their own boat. Of those that experienced an increase in emissions, 100% of users indicated that they would not be in the market for purchasing a boat.

Indeed the impact of reducing emissions through reducing primary production can be seen clearly when isolating just those users who would be in the market for purchasing their own boat if leasing was not an option.

**Fig. 10** - Leassee: Reduction in emissions for users who would be in the market for purchasing a boat if leasing wasn’t an option

Of all users who indicated that they would be in the market for purchasing a private boat if leasing was not an option, 90% experienced a reduction in emissions resulting from reducing primary production. Within the top 20% of reductions 9 of the 10 users also substituted flight travel with the lease a boat. The 10% of users that did not experience a reduction in emissions all increased their travel as a result of cost savings.

For users that would not be in the market for purchasing a boat if leasing was not an option, the change in emissions was a lot more varied.

**Fig. 11** - Leassee: Reduction in emissions for users without interest in owning a boat
Overall, 65% experienced an increase in emissions as a result of leasing a peer-to-peer shared boat with 35% experiencing a reduction in CO$_2$ emissions. Among this demographic cost savings had a massive impact on whether emissions increased with 97% of those that saved money by leasing a boat experiencing an increase in emissions. Every user that indicated that had travelled more as a result of the cost savings increased their overall emissions. In contrast, 70% of those that replaced travel with the leasing of a boat experienced reductions in emissions.

Similarly to the lessors surveyed, the leasee users of the peer-to-peer sharing platform indicated an overwhelmingly positive experience with 82% of responses within the highest three categories of likelihood to recommend the platform.

**Fig. 12 - Leassees: Likelihood to recommend peer-to-peer sharing to others**

The results of the study show that ERE does exist in the context of peer-to-peer leasing of boats, affecting lessors and leasees in different ways. There is a much lower rebound effect acting on lessors with the majority of users indicating that they are maximising the potential reductions in emissions. Leasees, on the other hand, have much more varied results with consumption changes drastically increasing the rebound effect to the extent that 29% of leasees experienced backfire and increased their overall emissions output. The largest contributor to the rebound effect was increasing other forms of
travel especially when an aeroplane was the mode of transport.

Despite a clear indication that rebound effect does exist and limit the potential of the circular economy, reductions in emissions were experienced by 63% of the combined user base with an average reduction of 1,473.9 kg CO$_2$. The two biggest factors contributing to the reduction of emissions were substituting air travel and reducing primary production of boats.
5. Discussion

The results provide insight into the existence of ERE on the peer-to-peer shared access of boats and show that improved access does not necessarily result in an increase in emissions. However, despite decreases in primary production, substituted consumption behaviour, such as increases in flights or increased personal use of a boat, can result in significant rebound and, in almost a third of cases, backfire.

The study shows that peer-to-peer leasing of boats can lead to significant reductions in CO₂ with an average saving across all users of 1,473.9 kg CO₂. This is in line with literature claiming that the circular economy can be effective in reducing the environmental impact from the consumption of goods.

One of the biggest contributing factors to an overall reduction in emissions comes from extending the lifespan of existing products through good maintenance and from the reduction in primary production. The fact that 96.6% of lessors indicated that they utilised the additional income on maintenance was surprising and the fact that 55.2% of lessors are yet to have the full cost of maintenance covered by the income generated by leasing shows that there are potentially greater gains to be made through an increase in leasing.

Among leasess, the 43% of users that stated they would be in the market for purchasing a private boat if leasing were not an option are saving over 232 tonnes in CO₂ emissions per year as a result of the avoidance of primary production. That is a staggering saving from just 51 users of the platform and proves that shared access can successfully prevent primary production at a significant level. None of the users who indicated that they would purchase a boat privately experienced a backfire from their increases in consumption elsewhere resulting in a net loss of emissions. Zink & Geyer (2017) argue that, in order for circular economy to work, it is fundamental that consumers are drawn away from primary production and the results of this study suggest that this can and does occur in practice.

However, such a high rate in primary production reduction may not necessarily be replicated as access to boats increases through peer-to-peer sharing. One can assume that the individuals with the greatest interest in boating have been the early adopters of sharing platforms such as the one studied and future new users have less interest in owning a boat of their own. The platform studied is still within its first five years of operations and is growing at a rapid rate, therefore, further research is needed to investigate the long term trends of peer-to-peer sharing and determine if similar reductions in primary production are replicated across increasingly larger pools of users.

Despite the overall reductions in emissions resulting in participation in shared access, it is clear that ERE is very present. Among lessors, the average ERE stood at 46.5% despite 55% of the users experiencing no rebound at all. The increase in use and travel by a minority of users wiped out almost half of the overall potential savings across the board showing that the consumption of few can have a huge impact on the success of circular economies.

Among leasess every single user experienced ERE of some extent proving that the potential gains from circular economy can very quickly become eaten into by consumption in other areas. 60% of users experienced an ERE of over 20% with 29% of users experiencing backfire and completely reversing any benefit achieved by their participation in shared access. The potential for peer-to-peer boat leasing to become a net increase on environmental pressures is hugely worrying and greater awareness of this potential is needed to educate consumers that their use of sharing schemes does not inherently lead to an overall reduction in emissions.

Briceno et al (2005) warn of a scenario in which consumers justify energy-intensive consumption with the fact that they have reduced primary production through participation in shared access schemes. This scenario could well explain the increase in consumption that led to the highest rates of rebound effect. However, this study did not explore the incentive behind increased consumption in other areas and thus
fails to provide evidence to fully support the hypothesis.

The ERE average experienced by lessees of the boat sharing platform is higher than the 29% ERE average found by Makov & Vivanco (2018a) smartphone reuse. However, with the actual use of the boat during the leasing period contributing to an increase in rebound it is inevitable that the ERE is higher than a relatively passive product to use such as a smartphone. Makov & Vivanco acknowledge that their study only investigates direct replacement between smartphones and therefore does not include an increase in consumption through the use of services such as cloud storage that would result in a situation where the user upgrades from a regular phone (Makov & Vivanco 2018a).

Similar to the Makov & Vivanco study, life cycle analysis is a fundamental component of the calculation of rebound. Reduction in primary production was a hugely important factor preventing backfire with the reduction in emissions from production far outweighing increases in consumption in other areas for the vast majority of cases. Lessors similarly experienced a net reduction in emissions caused by an increase in the boats life span, however, the emissions resulting from an increase in maintenance were not considered in the ERE calculation nor the overall impact on emission.

Outside of improvements in life span and a reduction in primary production, the greatest impact on ERE was an increase in air travel. Increased travel occurred in 91% of users who experienced backfire. This supports the conclusion proposed by Briceno et al (2005, p.12) that “annual intercontinental air travel leads to worse overall environmental impacts” when funded by cost savings from participation in shared access”.

Finally, the results also demonstrate an incredibly high level of satisfaction in participation in shared access. Satisfaction from participation is fundamental to sharing platforms success and continued reduction in emissions year on year from shifting consumption.
6. Conclusion

The results of this study show the existence of ERE in the peer-to-peer sharing of boats in Finland. ERE is severely limiting the full potential of peer-to-peer sharing in reducing carbon emissions as increased consumption in other areas leads to further release of GHG emissions. In almost a third of cases, emissions actually increased due to changes in consumption enabled by the economic benefits of the sharing economy.

The largest contributing factors creating ERE were increases in personal use of the shared boat and increases in air travel. Utilising the additional income on air travel has the potential to create a backfire, increasing emissions by a factor of eight in the worst scenario experienced. Therefore, greater awareness of the consequences of re-spending is needed in the future to help combat the impact of ERE on the circular economy.

The circular economy has the potential to provide economic growth (SDG 8), responsible production and consumption (SDG 12) and take climate action (SDG 13). With predicted growth in global population and global economy, a different economic approach is necessary to fulfil the desires of a growing middle class and a sharing economy is a suitable approach. With high levels of satisfaction amongst existing users and a massive rise in popularity across the world the mainstream acceptance of sharing schemes is a real possibility. The peer-to-peer sharing of boats can provide a cheaper and more environmentally form of travel compared to continental air travel, however, without adequate recognition and mitigation against ERE its ability to deliver on these goals becomes limited.

Overall, reductions in emissions were seen by the majority of users despite the existence of ERE. Therefore, the sharing economy can remain effective in reducing carbon emissions and primary production, both of which are fundamental to governments achieving the requirements of the Paris Agreement and coping with shortages in primary materials.

ERE is limiting the full potential of the sharing economy and further research and policy are needed to combat its impact. Emphasis must remain on reducing consumption in all forms and not to become complacent in the idea that the circular economy is better for the environment in all circumstances.
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List of Abbreviations and Figures

Abbreviations

EMF  Ellen MacArthur Foundation  
ERE  Environmental Rebound Effect  
EU  European Union  
GDP  Gross Domestic Product  
GHG  Greenhouse Gas  
PPM  Parts per million  
PSS  Product Systems Services  
UNEP  The United Nations Environment Programme  
UNFCC  United Nations Framework Convention on Climate Change

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Appendices

Appendix 1 - Leassee Survey (English)

- What type of boat did/will you lease?
  - Sailboat
  - Motorboat
  - RIB (or similar)
- For how many days did/will you lease the boat?
- If leasing was not an option then I would be in the market for buying my own boat?
  - True
  - False
- We are investigating substitutions in spending regarding the leasing of boats. Which of these statements applies the most? [Tick one]
  - I have saved money by leasing a boat resulting in more funds for regular living costs
  - I have saved money by leasing a boat leading to additional travel
  - I have equalled my spending compared to other years by directly substituting other forms of holiday travel
  - I have spent additional money leasing a boat taken from regular living costs
  - I have spent additional money resulting in less travel than previous years
- How much saving or additional expense have you encountered from leasing a boat compared to previous leisure activities? (Please answer in €, a rough estimate will suffice)
- If you have replaced existing holidays with the leasing of a boat then please indicate the option that best applies:
  - Travel within the Nordic Region
  - Travel within the Baltic Region
  - Travel to Europe
  - Long Haul travel
  - Not applicable
- On these replaced trips, what type of accommodation would you have stayed in?
  - Hotel
  - Rented apartment (i.e. AirBNB)
  - Camping or caravan
  - Not applicable
- If you have taken additional trips as a result of cost saving then indicate the option that best applies:
  - Travel within the Nordic Region
  - Travel within the Baltic Region
  - Travel to Europe
  - Long Haul travel
  - Not applicable
- On these additional trips, what type of accommodation did you stay in?
  - Hotel
  - Rented apartment (i.e. AirBNB)
  - Camping or caravan
  - Not applicable
- How likely are you recommending Skipperi to your friends?
  - 1-10

Appendix 2 - Lessor Survey (English)
• What type of boat do you lease out?
  ○ Sailboat
  ○ Motorboat
  ○ RIB (or similar)

• How much revenue do you expect to collect from leasing your boat per annum? (in €)
• For how many days per year do you expect your boat to be leased out per annum?
• How do you spend this generated revenue? (Please tick the two that apply most)
  ○ Towards maintenance of the boat
  ○ Towards additional personal use of the boat (running costs such as fuel or taking additional unpaid leave)
  ○ Towards other forms of leisure travel
  ○ Towards regular living costs

• If you utilise the revenue on boat maintenance then does this cover the entire costs of annual maintenance (incl. dry dock etc)?
  ○ Yes
  ○ No

• If you use the funds towards additional personal use of the boat (funding fuel costs etc.) then does this substitute other holiday plans?
  ○ Yes
  ○ No

• How many additional days of personal boat use did you utilise from the extra income?
• If you utilise the revenue on other forms of leisure travel then please indicate which form of travel applies most:
  ○ Travel within the Nordic Region
  ○ Travel within the Baltic Region
  ○ Travel to Europe
  ○ Long Haul travel
  ○ Not applicable

• What type of accommodation did you stay in?
  ○ Hotel
  ○ Rented apartment (i.e. AirBNB)
  ○ Camping or caravan
  ○ Not applicable

• If you have replaced existing holidays with greater use of the boat then please indicate the option that best applies:
  ○ Travel within the Nordic Region
  ○ Travel within the Baltic Region
  ○ Travel to Europe
  ○ Long Haul travel
  ○ Not applicable

• What type of accommodation did you stay in?
  ○ Hotel
  ○ Rented apartment (i.e. Airbnb)
  ○ Camping or caravan
  ○ Not applicable

• How likely are you to recommend Skipperi to your friends?
  ○ 1-10

Appendix 3 - Leassee Survey (Finnish)

• Minkä tyyppisen veneen olet vuokrannut tai aiot vuokrata?
  ○ Purjevene
  ○ Moottorivene
○ RIB (tai vastaava)
● Kuinka monelle päivälle olet vuokrannut tai aiot vuokrata veneen?
○ Pitää paikkansa
○ Ei pidä paikkaansa
● Tutkimme korvaaavaa rahankäyttöä veneen vuokraamiseen liittyen. Mikä näistä väittämistä kuvaa parhaiten tilannettasi? (valitse yksi)
   ○ Olen säästänyt rahaa vuokraamalla veneen. Tämä on jättänyt enemmän rahaa elämiseen.
   ○ Olen säästänyt rahaa vuokraamalla veneen ja käyttänyt säästynyt rahat muuhun matkusteluun.
   ○ Vuokraamalla veneen käytän saman verran rahaa kuin aiempina vuosina, vuokraaminen korvaa suoraan muuta lomamatkailua.
   ○ Olen käyttänyt enemmän rahaa koska olen vuokrannut veneen ja veneen vuokraan menevää raha on poissa muusta elämisestä.
   ○ Olen käyttänyt enemmän rahaa koska olen vuokrannut veneen ja se on poissa muusta matkustamisesta.
● Kuinka paljon rahaa olet säästänyt tai käyttänyt enemmän vuokraamalla veneen verrattuna aiempiin vapaa-ajan aktiviteetteihin? (€ säästöä/lisäkulut, karkea arvio riittää)
   ○ Jos olet korvannut muuta lomamatkustamista vuokraamalla veneen, mikä kuvaavaa muita lomia parhaiten:
      ○ Matkustus Pohjoismaissa
      ○ Matkustus Baltian alueella
      ○ Matkustus Euroopassa
      ○ Kaukomatka
      ○ Mikään vaihtoehtoista ei ole kuvaava
● Näillä korvatuilla matkoilla, minkälaisessa majoitukseessa olisit yöpynyt?
   ○ Hotelli
   ○ Vuokra-asunto (esim. AirBNB)
   ○ Leirintäalue/telttailu tai asuntoauto
   ○ Mikään vaihtoehtoista ei ole kuvaava
● Mikäli olet käyttänyt vuokraamisen avulla säästettyjä rahojaa muuhun matkustamiseen, mikä kuvaavat matkusteluun parhaiten:
   ○ Matkustus Pohjoismaissa
   ○ Matkustus Baltian alueella
   ○ Matkustus Euroopassa
   ○ Kaukomatka
   ○ Mikään vaihtoehtoista ei ole kuvaava
● Minkälaisessa majoitukseessa olet/olisit yöpynyt näillä matkoilla?
   ○ Hotelli
   ○ Vuokra-asunto (esim. AirBNB)
   ○ Leirintäalue/telttailu tai asuntoauto
   ○ Mikään vaihtoehtoista ei ole kuvaava
● Oletko aiemmin vuokrannut venettä muun palvelun kautta?
   ○ Kyllä
   ○ Ei
● Aiotko vuokrata veneen tällä kaudella?
   ○ Kyllä, ja olen vuokrannut veneen Skipperistä myös aiemmin
   ○ Kyllä, vuokraan ensimmäistä kertaa veneen Skipperin kautta
   ○ Mahdollisesti
   ○ En ole vuokraamassa venettä tällä kaudella
● Mikäli olet vuokraamassa venettä tällä kaudella, milloin olet tekemässä varauksen? (milloin teet varauksen, ei milloin lähdet veneellä lomalle)
   ○ Tein jo
   ○ Huhtikuussa
Appendix 4 - Lessor Survey (Finnish)

- Minkä tyyppisen veneen omistat?
  - Purjevene
  - Moottorivene
  - RIB (tai vastaava)
- Minkä verran vuokratuloja odotat saavasti tulevalla kaudella? (€)
- Kuinka monta päivää oletat veneesi olevan vuokralla ensi kaudella?
- Mikäli käytät vuokratuloja veneen ylläpitoon ja huoltoon, lisääntyneeseen omaan käyttöön (kattamaan esimerkiksi bensakustannuksia), korvaako tämä käyttö muita lomasuunnitelmia?
  - Kyllä
  - Ei
- Mikäli käytät vuokratuloja lisääntyneeseen omaan käyttöön, kuinka monta lisäpäivää olit/olet vesillä?
- Mikäli käytät vuokratuloja muuhun matkustamiseen, mikä vaihtoehtoista kuvaa matkustamistasi parhaiten?
  - Matkustus Pohjoismaissa
  - Matkustus Baltian alueella
  - Matkustus Euroopassa
  - Kaukomatka
  - Mikään vaihtoehtoista ei ole kuvaava
- Mikäli käytät vuokratuloja muuhun matkustamiseen, minkä tyyppisistä lomista on ollut kyse?
  - Matkustus Pohjoismaissa
  - Matkustus Baltian alueella
  - Matkustus Euroopassa
  - Kaukomatka
  - Mikään vaihtoehtoista ei ole kuvaava
- Mikäli olet korvannut muita lomia veneen lisääntyneellä omalla käytöllä, minkä tyyppisistä lomista on ollut kyse:
  - Matkustus Pohjoismaissa
  - Matkustus Baltian alueella
  - Matkustus Euroopassa
  - Kaukomatka
  - Mikään vaihtoehtoista ei ole kuvaava
- Minkä tyyppisessä majoituksessa olisit yöpynyt?
  - Hotelli
  - Vuokra-asunto (esim. AirBNB)
  - Leirintäalue/telttailu tai asuntoauto
  - Mikään vaihtoehtoista ei ole kuvaava

- Kuinka todennäköisesti suosittelet Skipperiä ystävillesi?
  - 1-10

- Kuinka todennäköisesti suosittelet Skipperiä ystävillesi?
Kuinka todennäköisesti suosittelit Skipperiä ystävillesi?
○ 1-10