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Exploring sustainability metrics for redesigned consumer products

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ABSTRACT

The evaluation of activities driving sustainability in the consumer product sphere, such as material recycling and product re-use, often appears to be over-optimistic. Replacement of primary resource production with secondary production, which is the source of most environmental improvements, is rarely evaluated rigorously and is often overstated. Significant progress on measuring replacement has been made in the clothing and related sectors. This study investigates the issue of whether further improvements are possible by introducing factors typically absent, such as the level of environmental burden associated with consumer purchases, and the consumer demand. Via consumer survey and consequent numerical analysis, the work establishes viable metrics to supplement those currently used for replacement. In particular, it is shown that it is not sufficient to simply examine how metrics are constructed; it is also essential to test metrics' response and sensitivity to input data, from survey and numerical analysis. The metrics developed are shown to be robust and appropriately responsive to changes in key parameters. Operations and decision-making in the sector may be significantly improved by this line of analysis.

1. Introduction

Sustainability operations such as energy recovery, material recycling and product reuse are central planks of core environmental policy concepts such as the waste hierarchy (European Union, 2008) and the drive towards more circular economies (European Union, 2015). Robust evaluation of such operations in the environmental perspective is essential for proper understanding and informed decision-making. A central feature of sustainability evaluation is the notion of avoided production and associated environmental burdens. Whenever "sustainability activity" (meaning certain actions within the traditional waste hierarchy such as avoidance/minimisation, reuse, recycling or energy recovery) takes place, environmental burdens are saved or avoided. Specifically, the sustainability activity gives rise to so-called secondary production of resources (those that are reused, recycled or recovered) which is taken to obviate the need for regular, primary production of those resources. The reduction in environmental damage arises from the implicit notion that secondary production is less environmentally burdensome than primary production.

This idea is prevalent, although rarely stated explicitly, in policy contexts. For example, the European Union (2015) action plan for the circular economy refers to saving resources, reducing waste generation, recovering valuable materials and components, avoiding landfill, and so on. The precise environmental effects of these outcomes – in terms of primary and secondary production – are often only fully exposed when performing technical environmental evaluation using life-cycle assessment (LCA). In this context, it has long been assumed that secondary production is assumed to replace primary production, often on a one-to-one basis. This has been identified as problematic (Ekvall, 2000; Weidema, 2000; Ekvall and Weidema, 2004). The essential issue is simple – secondary material may displace primary production, but it may also displace secondary material from other sources, different materials, or not displace anything at all (Zink and Geyer, 2017).

The issue is often framed in terms of material recycling but is also generally relevant for any sustainability activity (reuse, recycling, recovery). It becomes evident that secondary-primary substitution and replacement effects are potentially difficult even for resource minimisation activities, where the saving of environmental burdens is seemingly obvious at first glance. A widely-known example is the myriad of rebound effects in energy

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efficiency and consumption (Greening et al., 2000). Rebound effects have similarly been identified for material recycling and reuse (Zink and Geyer, 2017). Many of these recent arguments look highly convincing, almost self-evident. Nonetheless, for all their intellectual appeal, the arguments are mostly theoretical and appear to be weakly supported by specific evidence. For example, consumer electronics is a popular target sector for such analyses (see Zink et al., 2014) and the conceptual and practical difficulties with replacement are neatly exposed. Nonetheless, the analysis depends crucially on expert opinion and estimation. The key is in determining the degree to which one-to-one primary-secondary replacement is disrupted.

The clothing, textiles and related industries are recognised as being at the forefront of sustainability evaluation (see Castellani et al., 2015), especially in how replacement is measured and also in how the findings are implemented using life-cycle assessment (LCA). Measurement of replacement is obviously difficult. It requires the establishment of performance metrics and then collection of appropriate data for the measurements. Previous studies, for example those of Gracey and Moon (2012) are based, directly or indirectly, on the notion of replacement. Farrant et al. (2010) establish a replacement rate metric for the clothing sector, and offer a strategy for how replacement rate may be measured. Clothing and textiles features alongside electronics and furniture in a large-scale UK consumer survey of replacement conducted by Stevenson and Gmitrowicz (2013).

Invariably, these measurements are indirect, based on consumer survey data. However, it has been noted (Mont and Plepys, 2008) that focusing solely on circular-economic activity such as material substitution and end-of-life product management may have a limited overall effect. Sustainability depends crucially, even principally, on the end-consumer and measuring their behaviour is crucial. Laitala (2014) provides a comprehensive analysis of what is done to assess consumer behaviour in the clothing sector (mostly surveys) and also what could be done but typically is not (including interviews, observations and field experiments).

The goal of the study was to further the drive towards sustainability in the textile-related industries by deriving new sustainability metrics accounting for the above issues. In particular, levels of consumption and consumer demand needed to be considered in ways not captured by existing replacement rate metrics. The work was part of a broader study in which replacement rates had been measured using a fairly standard consumer survey approach. The alternative metrics were to be derived using the same consumer survey data that had been gathered for replacement rate measurements.

The study is based on the operations of Fretex AS, which as part of the Salvation Army (Frelseesarmeen) is one of the largest operations in Norway for the retail of reused consumer products. The focus is on clothing and textiles. An important element of Fretex operations is “redesign” which signifies the remanufacturing of products from donated materials that are in themselves unsuitable for retail, e.g. due to wear and damage. Redesign is value-adding activity that enhances the reuse of materials that would otherwise have been discarded or in some cases downgraded and used in the production of other products, such as insulation materials. Redesign activities also support Fretex as a social enterprise. Fretex collaborates with the Norwegian Work and Welfare Agency (NAV) in employing people who have difficulty accessing the conventional labour market. The main aims of the redesign operation are social in nature – however, improved understanding of the environmental benefits is also a key objective.

The redesign products in focus are mostly in the broad category of personal accessories (including handbags, purses and wallets). Most of the raw materials (principally leather and wool) are recycled, with additional elements such as zips, studs or buttons typically being added new. The remanufacturing process itself involves cutting of the raw materials to shape and then relatively simple operations such as shaping, sewing or sticking.

The paper first shows how replacement was directly measured within the sector of redesign and remanufacturing for clothing-related products. It thereafter explores how alternative, demand-based metrics, derived from the same underlying data, may offer further improvements. The implications for sustainability measurement are discussed more broadly. The insights both on the measurement and on the evaluation of sustainability should be generally applicable to a wide range of industries, well beyond clothing and textiles, wherever sustainability operations such as recycling are taking place.

2. Materials and methods

The study analysed the sustainability of redesign operations using the following metrics. Firstly:

- Replacement rates associated with consumer purchases, broadly as in previous studies

Then, based on some observed shortcomings in replacement rates, the following metrics were derived:

- Consumption/environmental burden associated with purchases
- Consumer demand and demand fulfilment

The process was as follows:

- Survey questions were derived, and survey data were gathered (all the metrics used the same underlying data)
- A mapping of survey data onto the metric was developed, according to specific logic
- The metric was then calculated for actual survey responses and for numerically-generated hypothetical survey responses

The final stage of the process arose from the observation that replacement rate was far from uniquely related to survey response; very different responses could give the same replacement rate. Thus, actual survey data were supplemented with numerically-derived populations of respondents giving the same replacement rate, allowing the other metrics to be measured and tested for sensitivity. The approach was to take many random survey response sets and then to solve numerically for the replacement rate each time. A wide range of valid solutions was obtained.

2.1. Survey questions and responses

The replacement rates of reuse product (second-hand clothes) and redesign products were each investigated as part of a larger survey of Fretex's customers. The survey questions were informed by literature studies in sustainable consumer behaviour research. Questions for the replacement of second-hand clothes followed an earlier study across several European countries (Farrant et al., 2010). The study reached a total of 474 respondents across four weeks in May/June 2016 through various channels, including via the websites and social media pages of Fretex, emails sent to previous Fretex customers, as well as emails sent out via the research group network. Most data were collected and recorded online using the SurveyXact tool, with some gathered in-store via a paper-based version. Further details regarding the data collection and analysis can be found in the main study report (Gram-Hanssen et al., 2016).

Redesign was the specific focus here. Around a quarter of all