

**Human-in-the-circular-loop (HITCL): Towards the systematization of human factors in circular economy ecosystems research**

Anastasia Vayona<sup>1\*</sup>, George Alexandris<sup>2,3</sup>, Heather Hartwell<sup>1</sup>, Sotirios Ioannidis<sup>2,3</sup>

<sup>1</sup>*Bournemouth University, Poole, UK*

<sup>2</sup>*Circular Economy Foundation, Brussels, Belgium*

<sup>3</sup>*Technical University of Crete, Greece*

*\*Corresponding author: avayona@bournemouth.ac.uk*

Although there is widespread consensus in current research that the societal dimension is a key pillar of the circular economy, its treatment and study remain limited compared to other dimensions (Scarpellini, 2022). This could be attributed to the fact that the early definitions and studies of circular economy ecosystems were dominated by the technical and biological dimensions – or flows – as depicted by the seminal butterfly diagram (MacArthur, 2013). It is well advocated, however, by an overwhelming proportion of the CE research community, that human-made practices of (linear) production and consumption are mainly responsible for the environmental decline and finite resource demise (Kumar et al., 2021). As such, studying the human aspects and human factors that affect the transition to circular economy is of paramount importance, should a pragmatic and actionable sustainability solution be developed.

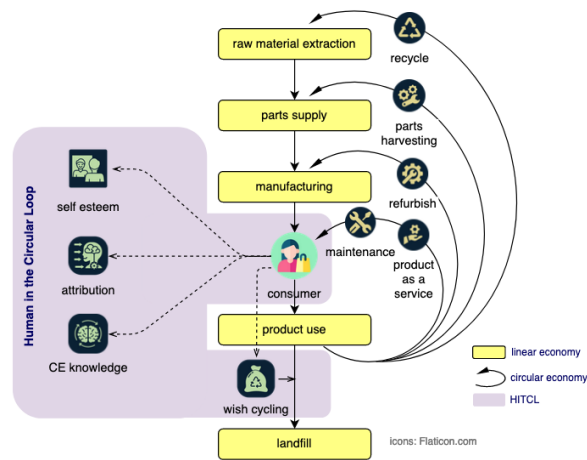
In this paper we introduce the concept of the Human-in-the-circular-loop, HITCL. Inspired by the well-known concept of Human-in-the-Loop (HITL) in computer science which studies the need and arrangements for human intervention and control in machine learning systems, this paper introduces and elaborates the term of Human-in-the-Circular-Loop (HITCL). HITCL places the emphasis on modelling and understanding the human perception and decision-making process when interacting within a CE ecosystem. More specifically, the scope of the HITCL concept covers those human aspects that can potentially influence circular economy loops. It studies human decision making in ways that can either hinder or support the transition towards a circular economy.

HITCL engages with the CE loops by introducing human activity monitors in the various circularity activities. Using the seven principles (“7Rs”) as a starting point (Popovic et al. 2022), we construct a mapping of these against specific, measurable activities that have been identified by current research to be related to the delivery of such Rs. Such activities are mainly comprised of validated measurement scales and can be conducted on a micro, meso or macro level (De Abreu, 2022).

To illustrate this, we present an example case of circular packaging for food and beverage products and its placement on the *Recycle* and *Reuse* loops, as influenced by enterprise greenwashing (Stecker, 2016) and consumer wishcycling (Robinson, 2018). Factors that have shown to affect and interfere with the reuse and recycling attitudes for packaging are the consumer’s perception on enterprise greenwashing (attribution), their personality (Judge et al. 2003) and of course their knowledge of CE. Such HITCL illustration is depicted in Figure 1.

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Against the above example, this paper elaborates on how HITCL can be used as a methodological approach for studying a diverse range of activities and behaviours relating to the transition to a CE.



**Figure 1.** HITCL instance for recycling & reuse of circular packaging

**Key words:** human aspects; consumer behaviour

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