

Human-in-the-circular-loop (HITCL): A human-centric approach in circular economy ecosystems research

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Abstract— This paper introduces the Human-in-the-circular-loop (HITCL) framework, which aims to systematise the role of humans within circular economy ecosystems. The framework integrates established theories from a range of disciplines, such as psychology and human resource management, to provide an understanding of the human factors influencing the adoption of circular practices. Acknowledging the important part that humans play as both consumers and employees in shifting to a Circular Economy, the HITCL framework provides the lens under which we can study how individuals embrace the circular economy concept and how this influences their behaviours and decision-making when it comes to circular practices.

Keywords— *attribution theory, core self-evaluation, wishcycling, psychology, human resource management, marketing*

I. INTRODUCTION AND MOTIVATION

It is widely acknowledged that a Circular Economy (CE) provides the prospect of cultivating a more sustainable society, including enhancements in both social well-being, through environmental preservation, and economic prosperity [1]. It has been posited as a remedy to the complex socio-environmental-economic crises of the twenty-first century by scholars [1], [2], policymakers [3] and private organisations [4].

The CE paradigm has been developed as an umbrella concept [5] and is attracting global interest to address key sustainability considerations and, more specifically, to explore environmental and economic concerns [6]. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) recommends this approach as a means to achieve sustainable consumption and production, thereby enhancing the sustainability of economic and financial systems [7]. Circular economy-related initiatives and policies have been adopted in national settings, for example in the European Union [3], UK [8] and China [9]. Moreover, these strategies manifest at the organizational level, facilitating the advancement of the circular economy through the formulation of innovative business models [10]. The integration of CE into the business domain has been realised

through diverse approaches and concepts, including industrial symbiosis, closed-loop supply chains, and designing-out waste products [11]. These methodologies follow fundamental principles, notably the expansion of finite resource efficiency, extension of product life cycles, and the closure of material and nutrient loops [5]. The appeal of these policies originates from their potential to attain sustainability by enabling and decoupling economic growth from environmental degradation [12].

Despite widespread acceptance and development of the concept focusing on environmental and economic dimensions, most CE frameworks lack treatment equitably addressing all three pillars of sustainability (social, environmental, economic) [6]. Therefore, many scholars advocate for an intensified focus on the social dimension of the CE, emphasizing the necessity of establishing a comprehensive and holistic sustainable approach [5], [11], [13], [14], [15]. In a systematic review, De Pascal et al. [16], measured 61 CE indicators across micro, meso and macro levels, and noted the absence of works exclusively addressing the social aspects.

Recent attempts to incorporate the societal dimension in the CE paradigm have mainly focused on the notion that actions within the business domain would positively affect societal well-being and the environment [11], in terms of job creation [17], safety in the work environment [18], improved recyclability [19], product life cycle assessment [20] and energy saving potentials [21]. Similarly, diverse propositions have emerged for indicator frameworks designed to quantify circularity, yet the social sustainability aspect has been largely overlooked [22], [23].

Although it has been documented that the circular economy can provide a valuable “toolbox” for achieving a number of the UN Sustainable Development Goals (SDGs) [24], further research and attention to the social dimension is imperative for the CE to substantively contribute to sustainable development. This involves fostering social equity and presenting an alternative, holistically sustainable economic system [13].

In this paper, we argue that we need to put humans in the centre of the circular loop. All processes, procedures and policies need to be developed, implemented and accepted by humans; the notion that circularity involves biological and technical loops alone is outdated. We argue that scientists, policymakers and industry have managed to implement the development and, in most parts, the implementation of circularity but so far a tool to measure and influence the acceptance of circularity in the human sphere has not yet been developed.

II. HUMAN IN THE CIRCULAR LOOP (HITCL)

A. Human In The Loop concept

The concept of “Human In The Loop” has evolved, reflecting the increasing recognition of the pivotal role that humans play in various systems and processes [25]. Initially emerging in fields such as human-computer interaction and control systems, the concept highlighted the importance of human decision-making and intervention alongside automated technologies [26]. As advancements in artificial intelligence and automation have progressed, the concept has expanded to encompass broader domains, including robotics, machine learning, and complex socio-technical and cyber-physical systems [27].

The evolution of the concept reflects a growing understanding of the limitations of purely automated systems and the need to integrate human expertise, judgment, and ethical considerations with these [28]. It emphasises the value of human input in decision-making, adaptability to context, learning from feedback, flexibility, creativity and problem-solving ability [29].

B. Human In the Circular Loop (HITCL) definition

Here, we introduce the Human in the Circular Loop (HITCL) theoretical framework that studies and emphasises the role of human acceptance, perception and decision-making within a circular economy ecosystem. It builds upon the concept of Human-in-the-Loop (HITL) in computer science, which explores human intervention and control in machine learning systems [30]. In the context of HITCL, the focus is on understanding how humans (as consumers and employees) accept the concept of CE and how it affects their behaviour and decision-making towards the transition to a circular sustainable future.

This concept encompasses the various human aspects that can potentially influence circular economy loops. Factors such as self-esteem [31], consumer/employee attribution [32], circular economy knowledge [33], status consumption [34] and organisational sustainable performance [35] can influence choices between circular and linear practices.

By introducing established theories and concepts on motivations, attributions and decision-making to circular economy from domains such as psychology and human resource management, amongst others, we can develop effective strategies and interventions to encourage circular sustainable behaviours and address challenges more efficiently and inclusively.

The objective of HITCL is to identify and study the human factors that enable or hinder the transition towards circular practices. In this perspective, an informed consumer/employee is seen as being central to the control of the circular loops actively participating in the circular economy.

C. Transferable properties between concepts

According to the HITL literature, the concept needs to promote a number of properties to be successful [36], including fairness [37], accountability [38], transparency [38], trust [39], explainability and interpretability [36]. Those properties are summarised in Table 1, alongside their translation in the respective HITCL concepts in the CE domain.

TABLE I. HIGH-LEVEL MAPPING OF PROPERTIES BETWEEN THE HUMAN IN THE LOOP AND HUMAN IN THE CIRCULAR LOOP CONCEPTS

<i>Human in the Loop (HITL)</i>	<i>Human in the Circular Loop (HITCL)</i>
Fairness [32]	Fairness is one of the main premises of CE, ensuring equitable and just outcomes for individuals within social systems.
Accountability [38]	Individuals should have access to information on how decisions are made, the criteria used, and the potential impacts.
Transparency [38]	Includes providing clear information about the goals, strategies, and impacts of circular economy initiatives and agendas
Trust [39]	People need to trust policymakers and academics that the changes they suggest would be beneficial for their well-being, the environment and the economy
Explainability [36]	This allows individuals and communities to evaluate the potential benefits and risks associated with the adoption of circular practices.
Interpretability [36]	Ability to explain the cause-effect relationships between circular economy activities and outcomes.

From the HITL properties outlined above, fairness seems to carry a considerable amount of weight as it is directly aligned with the underpinning philosophy of the circular economy[40]. Fairness in the context of the circular economy requires that the benefits and opportunities generated by circular practices are distributed equitably among individuals and communities. This includes considering issues such as fair wages, worker rights, and access to resources and services derived from circular economy activities [41]. Efforts should be made to prevent the concentration of benefits in the hands of a few, ensuring that the transition to a circular economy promotes social equity [42]. Moreover, fairness entails ensuring that the shift towards a circular economy does not disproportionately impact vulnerable or disadvantaged groups. This includes providing support, resources, and opportunities for those affected by the changes, such as workers in industries undergoing transitions [42].

Moreover, leveraging HITL concepts on CE enforces the view of the need for a *data-driven* CE approach, where information would flow within the system and be accessible for the individuals and communities to help them make informed decisions.

III. HITCL INTERDISCIPLINARY APPROACH

The focus of this study is to provide an approach for the identification of social factors and interactions that influence adoption of CE practice. Here, we categorise humans into two distinct roles: consumers and employees. These two classifications represent the principal stakeholders involved in the implementation processes of CE practices [43].

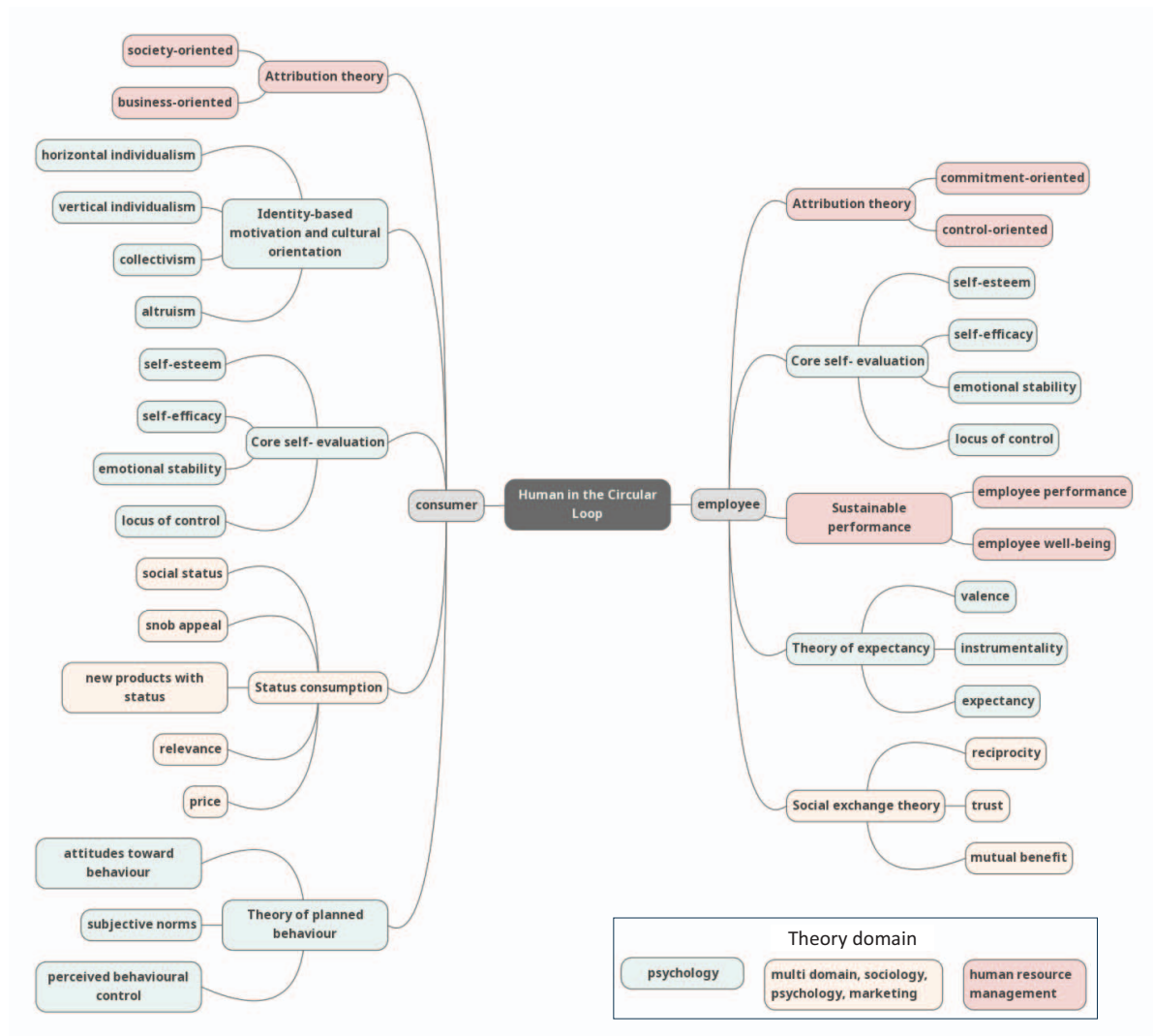


Fig. 1. The Human in the Circular Loop (HITCL) framework (created by the authors using mindmap.com)

Consumers play a pivotal role in the development of CE as they purchase goods, maintain them, repair, resell, reshare, refurbish, repurpose and recycle or dispose of them [44]. Not enough attention has been given to date on the role of consumers in CE adoption and how they will affect or be accepted by circular economy ecosystems[13]. Consumers are frequently characterized as “passive agents” within the current discussion [45]. Disregarding consumers may lead to the formulation of incomplete business models, impeding the realisation of the full potential inherent in a Circular Economy [13], [46], [47].

In the organizational context, employees constitute an integral stakeholder group within the organizational framework [48]. They engage in the utilisation of resources, actively contributing to the establishment of habits, behavioural patterns, and organizational practices [43]. In this context, employees play a crucial role in organisational settings and operations which is a crucial aspect that demands attention for comprehensive understanding [48].

Understanding employees’ perceptions regarding the incorporation of CE practices within their organizations will offer valuable insights into the capacity of organisational systems to implement circularity [43], and this domain remains inadequately explored within the existing body of research [49].

The Human in the Circular Loop (HITCL) framework incorporates established theories from diverse disciplines, contributing to a comprehensive understanding of human aspects within the circular economy. The integration of these theories enriches the analysis of factors influencing human acceptance, perception, and decision-making in the context of circular practices. The HITCL diagram is presented in Figure 1.

The theories presented in Figure 1 are indicative of the selection of interdisciplinary theories and metrics that can be used in the research of CE attribution and acceptance. It is noted that although in the context of this paper, humans are

regarded as consumers or employees, there are a number of theories that apply in both settings.

In more detail, the selected theories provide mature measures for quantitative research that can contribute to investigating human understanding and acceptance of circularity are as follows:

1) *Attribution theory.*

Central to attribution theory is the assertion that individuals are consistently engaged in an ongoing attempt to analyse the events they face [50]. Although it is a well-established theory in Human Resource Management for employees [51], it has recently been applied in sustainable studies in consumer settings [32]. It studies how people explain the causes of behaviour and events [52] and is a valuable theory on how humans attribute the motivations behind circular policies and practices [53]. In a consumer context, quantification may be realised by analysing society-oriented attributions, wherein consumers perceive business actions as directed towards enhancing community well-being, or business-oriented attributions, where people believe that corporate actions are profit-driven.[54] Equally, for employees, the assessment involves commitment-oriented, referring to quality enhancement, and control-oriented, cost minimization, attributions [55].

2) *Identity-based motivation and cultural orientation*

Grounded in psychological theories, identity-based motivation explores how individuals' perceptions of themselves and their affiliations influence their commitment to sustainable behaviours, incorporating elements such as self-concept and social identity theory [53]. It is frequently used to study consumer behaviour and its association with culture and identity saliency, attempting to explain the circumstances and mechanisms under which consumers' identity and cultural values act as motivators for engagement in specific actions, such as recycling or purchasing environmentally friendly products [56]. The metrics utilised to quantify and investigate this phenomenon are the need for social status, which is measured by horizontal and vertical individualism and collectivism and altruism assessed in terms of pure and competitive dimensions [56].

3) *Core self- evaluation*

Originating from industrial and organisational psychology, core self-evaluation (CSE) is a construct described as "an advanced concept demonstrating people's central evaluations about self and their functioning in the environment" [57]. Research into CSE challenges the comprehension of personality trait structure and provides novel insights into the interconnections between traits and behaviour. It is a construct that can be used for both consumers and employees [58]. The measurements for CSE are self-esteem, self-efficacy, emotion stability and locus of control [59].

4) *Status consumption*

Status consumption is an established theoretical framework in domains such as sociology [60], psychology [61], consumer behaviour and marketing [62]. Status consumption is defined as a motivational process where individuals try to enhance their social standing by visibly consuming products that present and symbolise status, both for the individual and their social environment [63]. The items measuring status consumption are the need for social status,

snob appeal, new products with status, relevance and more expensive [63].

5) *Theory of planned behaviour*

The theory of planned behaviour is a widely recognised psychological framework utilised to explain and predict human behaviour and decision-making across various domains [64]. It has been noted that it is the main theory in social psychology that effectively aids in conceptualising and identifying factors or variables considered by customers in their planned, intended, or goal-oriented buying behaviour [65]. The theory consists of three key constructs: attitudes toward the behaviour, subjective norms, and perceived behavioural control [64].

6) *Sustainable performance*

Although the sustainable performance of organisations and industry has been widely researched, the concept of employee-sustainable performance is still in the early stages [66]. Employees demonstrating high levels of sustainable performance actively contribute to the cultivation of a sustainable future for both themselves and their respective organisations [66]. Sustainable performance consists of two main determinants; employee performance and employee well-being [66].

7) *Theory of expectancy*

Expectancy theory, originated from psychology, focuses on the belief that employees will be motivated to exert effort if they believe their efforts will lead to good performance, and good performance will be rewarded [67]. It considers the relationship between valence, instrumentality, and expectancy in shaping employee behaviour [68].

8) *Social exchange theory*

Rooted in the social sciences, social exchange theory holds broad implications across diverse research domains [69]. Social exchange theory emphasizes the mutual exchange of resources and benefits between employees and their organizations [70]. It suggests that employees engage in behaviours that they perceive will result in fair and equitable exchanges, influencing their commitment and performance. The measurement of social exchange theory involves reciprocity, trust, and mutual benefit as key indicators [71].

IV. HITCL ILLUSTRATED

To illustrate the potential of HITCL, we present an example case of circular packaging for food and beverage products and its placement on the Remanufacture, Refurbish, reuse and Recycle loops, in regards to wishcycling [72]. Taking into consideration that these concepts are examined under the lens of consumers, we employ attribution theory and core self-evaluation, derived from the HITCL framework, to reveal the underlying mechanisms and psychological factors shaping the wishcycling phenomenon. Although these two theories have been researched extensively in other disciplines, to our knowledge, they have not yet been applied adequately to sustainability studies.

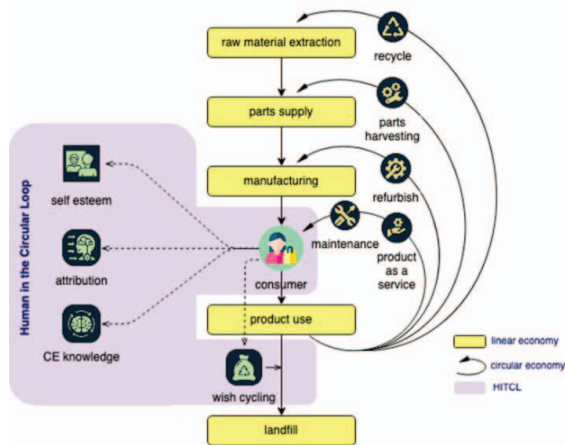


Fig. 2. The Human in the Circular Loop (HITCL) framework influencing consumer behaviour towards wishcycling (created by the authors).

Note. Icons made by Flaticon.com.

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 the circular economy. For example, consumers being influenced by factors such as self-esteem, consumer attribution, or circular economy knowledge, may choose to engage in circular or linear practices. HITCL provides a map of theory background from diverse disciplines that researchers can use to explain and influence human acceptance of and transition towards CE policies. In this instantiation of HITCL, we argue that an informed consumer will not only disengage from wishcycling activities but will be at the centre of control of the circular loops.

Some example use cases are outlined as follows. In product design, HITCL can bring in aspects of consumer behaviour and specifically show how consumer attitudes, beliefs, and behaviours can influence the design and adoption of circular products. By considering factors such as perceived value, convenience, and social norms, HITCL can help identify strategies to encourage consumers to choose circular products over traditional linear alternatives. Similarly, in the domain of organisational culture, it can explore employee attitudes, motivations, and behaviours that impact the implementation of circular economy practices within organisations. Factors such as employee values, job satisfaction, and organizational culture derived from HITCL, can help identify approaches to enhance employee engagement and promote circularity within the workplace. Another domain that HITCL can be used is the effective creation of communication and marketing strategies to promote circular economy initiatives. Moreover, HITCL can facilitate the development of impactful educational interventions that can inspire and empower individuals to embrace circular practices in their daily routines.

V. LIMITATIONS OF THE STUDY

While this study aims to offer valuable insights and contributions, it is important to acknowledge its main limitations.

Firstly, the HITCL is a conceptual framework, and its applicability and effectiveness in real-world settings are yet to be tested. Future empirical research is necessary to validate and refine the framework.

Secondly, the HITCL framework does not necessarily encompass all possible human factors and theories relevant to human acceptance, attribution and implementation of circular economy practices. Additional research into peer-reviewed literature, potentially in the form of systematic review methodologies, is essential to further enhance HITCL framework. Furthermore, research including grey literature sources, such as policy papers and market studies can unveil other relevant theoretical perspectives and dimensions that could be considered for a more comprehensive understanding of human behaviour in CE loops.

Moreover, this study does not investigate specific implementation strategies or policy recommendations associated with the HITCL framework. While it highlights the practical implications of incorporating human aspects into circular economy initiatives, detailed operationalisation and practical guidance are beyond the scope of this paper.

Lastly, the study's generalisability might be limited to specific cultural, geographical, or socio-economic contexts. Cultural differences, institutional variations, and regional disparities could influence the applicability and effectiveness of the HITCL framework in different settings. For example, Masi et al. [73] have documented that there is a positive trajectory of CE research in the Western literature, projecting a bias among those communities.

VI. CONCLUSIONS

The HITCL framework provides insights into the human aspects of the circular economy, underscoring the central role of well-informed consumers/employees in understanding, accepting, controlling, and implementing circular loops. By incorporating established theories from diverse disciplines such as psychology and human resource management, the HITCL framework provides valuable insights into human acceptance, perception, and decision-making in the context of circular practices. It emphasises the need to develop effective strategies and interventions to encourage circular sustainable behaviours and address challenges more efficiently and inclusively.

To further enhance the understanding and application of the HITCL framework, future research needs to explore additional relevant theories and dimensions that influence human behaviour in circular economy loops. Unveiling other theoretical perspectives would contribute to a more comprehensive understanding of human decision-making and behaviour in the context of circular practices.

Additionally, future research could focus on investigating specific implementation strategies and policy recommendations associated with the HITCL framework. While the paper highlights the practical implications of incorporating human aspects into circular economy practices, further exploration and guidance on operationalisation would be valuable.

Furthermore, considering the potential influence of cultural, geographical, and socio-economic contexts on the applicability and effectiveness of the HITCL framework, future research could explore the framework's generalisability across different settings. Examining cultural and institutional

variations, and regional differences would provide insights into the framework's adaptability and help tailor strategies for specific contexts.

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