Understanding the Dynamics of the Circular Economy

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Within the Circular Economy (CE) context several persistent problems can be identified: increased waste, moderate recycling rates, lower life-spans, increased consumption. These are connected and contribute to the problematic of decoupling. The aim of the research presented is to explore this problematic, and provide a preliminary understanding from a Systems Thinking and Dynamics perspective. The investigation introduces several hypothesis, and at multiple system levels. At the macro-level, it is proposed that the current societal focus in economics is 'undermining' the efforts of transitioning to sustainability. At the micro-level, some dynamics of life-span and repair are suggested. The meso-level has been explored in more detail, and some preliminary dynamics are advanced: the simple principles of extending product life-span and reducing waste, may positively contribute to change the overall dynamics of the system; Ecodesign activity is perceived as a key leverage for change towards sustainability; a "Fast CE" future scenario may arise deriving from the current system structures originating growth and resulting intensification of CE activities – since these may have high environmental impacts, decoupling may not be achieved; a "Slow CE" scenario based in sufficiency and products with long-life-spans is regarded as the key towards a long term sustainability transition; regarding waste dynamics, technical and biological cycles of CE are proposed as having very different behaviours; finally, multiple delays have already been identified. Overall, while the research presented is still at an early stage from a System Dynamics (SD) perspective, it already introduces valuable insights and a preliminary understanding of the CE dynamics.

From problem definition and literature, several challenges are identified. At the **macro-level**, we propose the need to redefine the CE scope towards fundamental sustainability goals (Fig.1), grounded in a hierarchy of the sustainability dimensions: acknowledging the *environment* as the basis from which *societies* can flourish, and that *economy*, a social construction, should be at the service of the previous (and not the other way around, the dominant paradigm). At the **meso-level**, we propose some general principles of resource use efficiency, in that for a given material consumption, product life-span should be ideally high/extended, and waste minimized/low. Currently, we witness the opposite relationship: low life-spans and high amounts of waste. This is also generally aligned with the resource productivity perspective, and is illustrated in Fig 2.

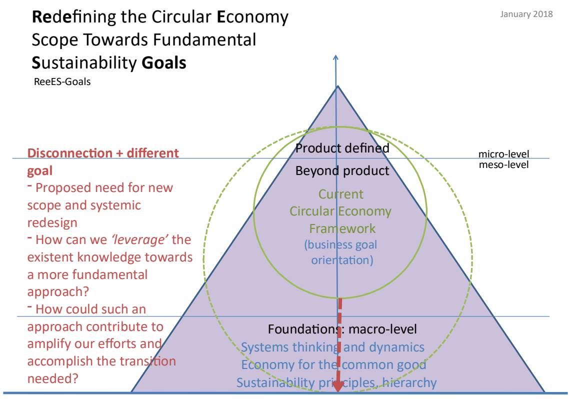

Fig.1. Proposed general Model: the need for a systemic redesign at the foundations macro-level

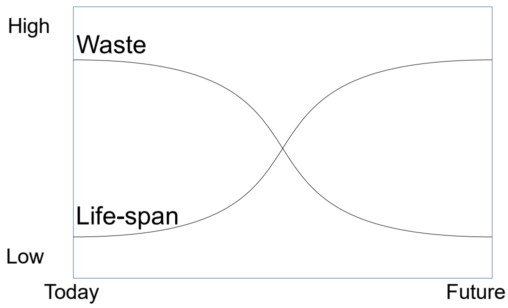

Fig.2. Proposed general CE and resource efficiency principles, and respective dynamics towards decoupling

Introducing the "Fast CE" versus "Slow CE" hypothesis

The current CE system being developed is still generally structured and incentivized by growth models which may not suffice to accomplish absolute decoupling. We designate this a 'Fast CE' scenario or hypothesis in which the profit making is 'tagged' to the activity (e.g. a repairer has profit when the product breaks, not by preventing it! - the true solution), promoting an intensification of CE activities, but which also have significant environmental impacts not yet properly calculated (e.g. repair requires spare parts and transport; there are few LCAs of CE activities, Güvendik (2014) is an example of Fairphone including repair scenarios). Alternatively, to accomplish long term solutions, we propose shift towards a 'Slow CE' path, which incentives a longer use of resources at highest value (as generally proposed in CE literature), and based in slow cycles of resource consumption, inspired in Fuad-Luke (2002/10) and Bocken (2016), but which moves forward in proposing a slower metabolism of resource use; of slow/long cycles of extraction, production, consumption, long life-spans, cascading within CE/circulation (e.g. repair), and final recycling and End of Life; making the most of the resources at each step, and progressively transitioning towards a slower metabolism.
RQ – How would such a system work, enabling to conserve resources instead of wasting them, and how would business models have to be designed to facilitate this?
From an ecological perspective we may even propose that the 'overarching goal' of a sustainable system is actually NOT to circulate resources – or to circulate only little and mostly locally, as symbiosis. We need to use resources, but these should not be the end goals of society.

Meso-level CE dynamics exploration

A preliminary Causal Loop Diagram (CLD) of high level CE dynamics is generally introduced, and this represents the main inflows and outflows of the materials system, and related dynamics as currently understood (Figs.3 and 4). This is preliminary work; further research is underway. Furthermore, general expected behaviours of waste dynamics for different CE materials or cycles are also presented (Fig.5). While for technical cycles of CE, relating to materials with high longevity or low depreciation rates (e.g. polymers can take five hundred years to decompose; metals) the waste stock should grow continuously (high inflow, low outflow), for the biological cycles of CE, depending on decomposition circumstances, the stock behaviour may possibly be inverse or in equilibrium, suggesting that these may be easier to manage and influence. This is a preliminary understanding of general dynamic behaviours relevant for CE.

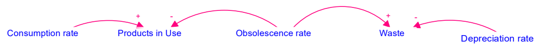

Fig.3. Construction of the Causal Loop Diagram of high level Circular Economy dynamics, main inflows and outflows

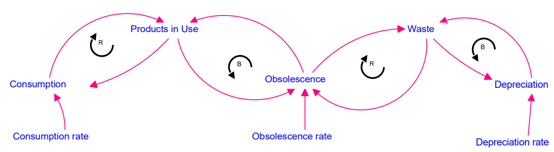

Fig.4. Causal Loop Diagram of high level Circular Economy dynamics – current understanding

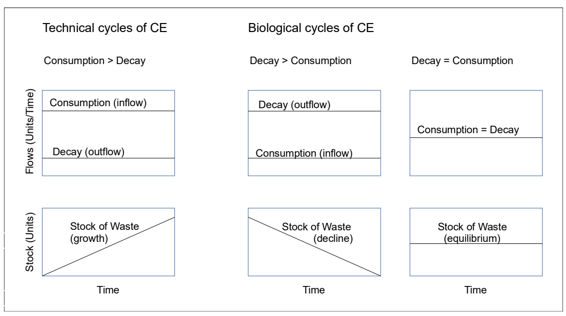

Fig.5. Graphical integration of general behaviours of waste dynamics – Technical vs Biological CE cycles

At the **Micro-level**, it seems important to understand the dynamics underlying (short) life-spans, and a need to shift towards maintenance (prevention) instead of repair (correction) is suggested.

Conclusion: there are important dynamics in the CE, yet to be discovered, and this understanding may be key to find long term solutions for CE uptake, and accomplish absolute decoupling. The work presented is a preliminary exploration.

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