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Circular Economy: The Concept and its Limitations

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ABSTRACT

Circular economy (CE) is currently a popular concept promoted by the EU, by several national governments and by many businesses around the world. However, the scientific and research content of the CE concept is superficial and unorganized. CE seems to be a collection of vague and separate ideas from several fields and semi-scientific concepts. The objective of this article is to contribute to the scientific research on CE. First, we will define the concept of CE from the perspective of WCED sustainable development and sustainability science. Second, we will conduct a critical analysis of the concept from the perspective of environmental sustainability. The analysis identifies six challenges, for example those of thermodynamics and system boundaries, that need to be resolved for CE to be able to contribute to global net sustainability. These six challenges also serve as research themes and objectives for scholars interested in making progress in sustainable development through the usage of circular economy. CE is important for its power to attract both the business community and policy-making community to sustainability work, but it needs scientific research to secure that the actual environmental impacts of CE work toward sustainability.

1. Introduction

Circular economy (CE) is a concept currently promoted by the EU, by several national governments including China, Japan, UK, France, Canada, The Netherlands, Sweden and Finland as well as by several businesses around the world. The European Commission recently estimated that circular economy-type economic transitions can create 600 billion euros annual economic gains for the EU manufacturing sector alone (COM, 2014; EMAF, 2013; see also CIRAIG, 2015 and COM, 2015). Finland's Independence Celebration Fund (FICF, SITRA) and Mckinsey (2014) jointly estimate 2.5 billion euros annual gains for the national economy of Finland through circular economy. The global economy would benefit 1000 billion US dollars annually (FICF and Mckinsey, 2014; see e.g. EMAF, 2013). China, as the first country in the world, adopted a law for the circular economy in 2008 (CIRAIG, 2015). Circular economy is recommended as an approach to economic growth that is in line with sustainable environmental and economic development (see EMAF et al., 2015; EMAF, 2013; EMAF, 2012; CIRAIG, 2015; COM, 2015; COM, 2014).

The current and traditional linear extract-produce-use-dump material and energy flow model of the modern economic system is unsustainable (Frosch and Gallopoulos, 1989). Circular economy provides the economic system with an alternative flow model, one that is cyclical (see EMAF et al., 2015; EMAF, 2013; EMAF, 2012; CIRAIG, 2015). The idea of materials cycles has been around since the dawn of industrialization. The idea has also been practiced accompanied by the argument that it reduces negative environmental impacts and stimulates new business opportunities already during the birth of the industrialization (Desrochers, 2004; Desrochers, 2002). But the linear throughput flow model has dominated the overall development causing serious environmental harm. Unlike traditional recycling the practical policy and business orientated circular economy (hereafter CE) approach emphasizes product, component and material reuse, remanufacturing, refurbishment, repair, cascading and upgrading as well as solar, wind, biomass and waste-derived energy utilization throughout the product value chain and cradle-to-cradle life cycle (EMAF, 2013; Rashid et al., 2013; Mihelcic et al., 2003; Braungart et al., 2007).

However, the concept of CE and its practice have almost exclusively been developed and led by practitioners, i.e., policy-makers, businesses, business consultants, business associations, business foundations etc. (see e.g. EMAF, 2013; COM, 2014; CIRAIG, 2015). The scientific research content of CE remains largely unexplored. Ecological economics may be the most fruitful source from which the new practical, policy and business orientated concept of CE could find scientific and theoretical support and guidance. Ecological economics has a long tradition in recycling and other CE-type concepts on the macroeconomic level although not presented under the CE term. Also on the microeconomic level, CE-type papers have been published in ecological economics, e.g.

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addressing eco-efficiency (Huppes and Ishikawa, 2009) or industrial ecology (Kenneth Korhonen and Snäkin, 2005). Nicholas Georgescu-Roegen (1971), Boulding (1966), Herman Daly (1996) and Robert Ayres (1999; see also Moriguchi, 2007) among others have debated the macroeconomic potential in cyclical material flows or the so called "fourth law" coined by Georgescu-Roegen (hereafter GR).

This paper has two research objectives. They are motivated by the fact that the scientific research content of the currently popularized business community originated circular economy concept remains superficial and lacks critical analysis. First, we will construct the concept of CE from the perspective of WCED sustainable development and sustainability science including the three dimensions of economic, environmental and social sustainability. Second, we will analyze the CE concept from the perspective of environmental sustainability. In the analysis, we will identify six challenges that need to be resolved for CE to be able to contribute to global net sustainability. These six challenges also serve as research themes and objectives for scholars interested in making progress in sustainable development through circular economy. Although the definition we will present for CE includes the economic, environmental and social dimensions of sustainability, we will leave the further analysis of economic and social dimensions for future work. In other words, it is beyond the scope of this paper to more thoroughly analyze economic and social sustainability in light of CE. The basic idea of the paper is to provide the reader with an initial attempt for conducting critical research analysis of CE.

The next section will consider the existing CE concept definition. After this, we attempt to produce a more scientific definition for CE from the perspective of sustainability science. The fourth section identifies six limitations of CE when analyzed against environmental sustainability that we perceive as fruitful research objectives for CE scholars. Conclusions are made in the fifth section.

2. Background: On the Current Concept of Circular Economy

2.1. The Main Challenge

In this section the new business community popularized concept of circular economy is considered from the perspective of the concept of and scientific research on sustainable development. In particular, sustainability science (Kates et al., 2001; Rockström et al., 2009; Broman et al., 2017; Broman and Robért, 2017; Robért et al., 2013) and the WCED (1987) three-dimensional concept of sustainable development are used as the main philosophy of the approach adopted in our discussion. Sustainable development (WCED, 1987) was originally defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. There exists a common consensus on this broad qualitative definition. It is beyond the scope of this paper to contest or discuss various diverging perspectives on this basic definition of sustainable development or sustainability science. The planetary boundaries of Rockström et al. (2009) are also widely accepted as the direction of environmentally sustainable global development (see, e.g. Robért et al., 2013).

In Fig. 1, the main challenge of sustainable development is depicted from the perspective of physical flows of materials and energy. The key issue in global sustainable development is the linear (one way) throughput flow of materials and energy between nature and human economy. The throughput flow is "running down" the system in which it operates, from which it sources and to which it releases its wastes and emissions. Brown (2006) shows that the global ecosystem is becoming smaller. The global natural ecosystem is shrinking in size and volume. The shrinking is clear if measured simply in quantitative terms, but very apparent also in the sense of the qualitative potential of the earth's ecosystems to provide life-sustaining functions. Measured by the land area that can support human habitation, the earth is shrinking, and at an accelerating pace. Deserts are expanding, the sea level is rising, the population is growing, per capita consumption is increasing,

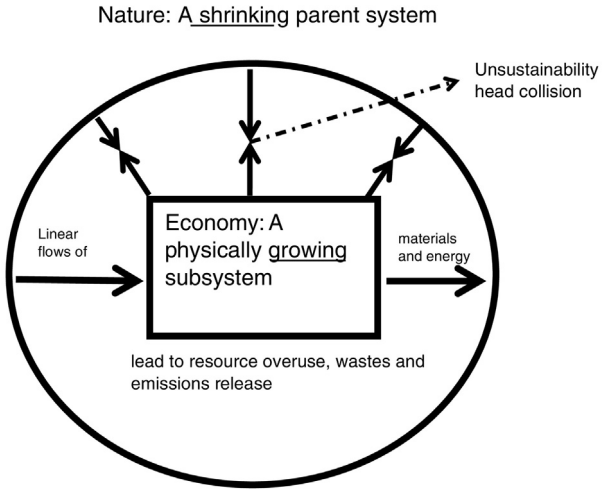

Fig. 1. Linear materials and energy flow in the shrinking world. Linear (one way) throughput flow of matter and energy resulting in the current unsustainable development of the global economy. The economic subsystem operating within the parent ecosystem uses physical flows of materials and energy in a linear fashion. Resources and energy are extracted from the parent system, produced and consumed within the human economic subsystem and wastes and emissions are dumped back to nature in harmful concentrations. The life supporting parent ecosystem that used to be fixed/constant in its size is now shrinking in terms of physical scale. Deserts are expanding and sea level is rising reducing the life-supporting physical scale of nature. As the human economic subsystem is growing, development is encountering a head-collision. Overwhelming scientific evidence shows that the linear flow is unsustainable in terms of all the three dimensions of sustainable development; economic, ecological and social.

the volume of livestock and cattle is growing and biodiversity is depleting at ever faster rates. The shrinking is best illustrated by advancing deserts and rising sea levels that work inwards in Fig. 1 toward the economic system, which in, turn is expanding outwards. This process is leading to a head-collision.

A simple and logical answer to the problem of the linear flow model is its reverse; a cyclical flow of materials and energy. Although, by definition, energy cannot be recycled, only cascaded for extended use on lower temperature and pressure levels, one can speak about materials and energy cycling for the purpose of simplification.

2.2. The Currently Proposed Circular Economy Solution

The answer to the question of unsustainable global linear flow economy would seem to come from the physical flow concept in which the flows are reverse; the concept of circular economy. In this paper, the CE concept is considered in scientific terms. The CE vision is here constructed from the viewpoint of the WCED definition of sustainable development and from the perspective of planetary boundaries on environmental sustainability (Rockström et al., 2009; Robért et al., 2013).

The current practitioner and business world formulated CE concept is given in Fig. 2. The CE message is that the inner circles of Fig. 2, product reuse, remanufacturing and refurbishment, demand less resources and energy and are more economic as well than conventional recycling of materials as low-grade raw materials. The time the value in the resources spends/lives within the inner circles should be maximized. Materials should first be recovered for reuse, refurbishment and repair, then for remanufacturing and only later for raw material utilization, which has been the main focus in traditional recycling. According to CE, combustion for energy should be the second to last option while landfill disposal is the last option. In this way, the product value chain and life cycle retain the highest possible value and quality as long as possible and is also as energy efficient as it can be.