Coming Full Circle

Why Social and Institutional Dimensions Matter for the Circular Economy

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Summary

In light of the environmental consequences of linear production and consumption processes, the circular economy (CE) is gaining momentum as a concept and practice, promoting closed material cycles by focusing on multiple strategies from material recycling to product reuse, as well as rethinking production and consumption chains toward increased resource efficiency. Yet, by considering mainly cost-effective opportunities within the realm of economic competitiveness, it stops short of grappling with the institutional and social predispositions necessary for societal transitions to a CE. The distinction of noncompetitive and not-for-profit activities remains to be addressed, along with other societal questions relating to labor conditions, wealth distribution, and governance systems. In this article, we recall some underlying biophysical aspects to explain the limits to current CE approaches. We examine the CE from a biophysical and social perspective to show that the concept lacks the social and institutional dimensions to address the current material and energy throughput in the economy. We show that reconsidering labor is essential to tackling the large share of dissipated material and energy flows that cannot be recovered economically. Institutional conditions have an essential role to play in setting the rules that differentiate profitable from nonprofitable activities. In this context, the social and solidarity economy, with its focus on equity with respect to labor and governance, provides an instructive and practical example that defies the constraints related to current institutional conditions and economic efficiency. We show how insights from the principles of the social and solidarity economy can contribute to the development of a CE by further defining who bears the costs of economic activities.

Introduction

The concept of the circular economy (CE) has received increasing attention over the last decade as shown by recent reviews (e.g., Ghisellini et al. 2016; Sauvé et al. 2016). Instead of linear flows of materials and products through the economy, the CE promotes circular flows as a means to reduce environmental impacts and maximize resource efficiency. In the policy arena, the CE has gained momentum with the Chinese law for the promotion of the CE entering into force in 2009. The

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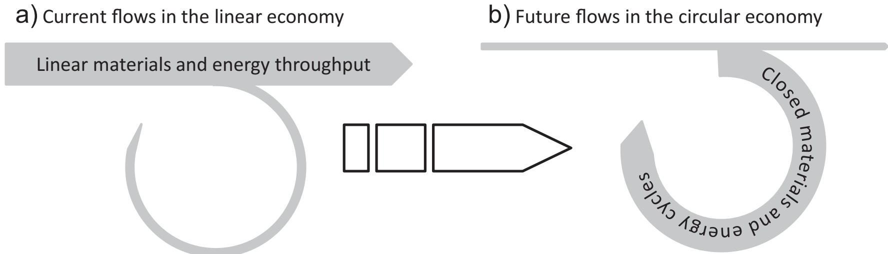

Figure 1 Moving from a linear to a circular economy.

European Union (EU) Circular Economy package, which extended earlier versions of the waste directive, was passed in December 2015 (EU 2015; Hill 2016). A large body of communications has also emerged from public and private organizations engaged in the CE, ranging from the Ellen Macarthur Foundation (EMF) in the UK, to the *Institut de l'économie circulaire* in France, *A Circular Economy in the Netherlands by 2050*, or the African Circular Economy Network, among others.

Several definitions of the CE exist and revolve around two long-standing ideas: closing material cycles and increasing resource efficiency (Ayres et al. 1996; Von Weizsäcker et al. 1998). A widely cited definition is that of the EMF:

> A circular economy is restorative and regenerative by design, and aims to keep products, components, and materials at their highest utility and value at all times. The concept [...] is a continuous positive development cycle that preserves and enhances natural capital, optimises resource yields, and minimises system risks by managing finite stocks and renewable flows. It works effectively at every scale. (EMF 2015)

This definition has been adopted by governments and academia (e.g., EU 2015; Lehmann et al. 2014), with the EU commission emphasizing the potential contribution of the CE toward new and sustainable competitive advantages, as well as additional employment for Europe (EU 2015). In France, the common definition from the Environment and Energy Management Agency states that the CE is: "an exchange and production based economic system that, at all stages of the product or service life cycle, aims to increase the efficiency of resource use and reduce the impact on the environment while developing the well-being of individuals" (Geldron 2013, 4). The Dutch Ministry for Infrastructure and the Environment has also launched a full government program on CE (NL 2016).

In practice, the CE focuses on improving product value chains through reduce, reuse, and recycle strategies, which have been extensively studied among parent research fields such as ecological economics and industrial ecology (IE). Circularity strategies range from extending and/or intensifying the use of product (goods and services), to recycling materials, and even landfill mining. In this article, we focus on the limitations of closing material cycles as dissipative uses absorb a large share of the economy's throughput, in particular carbon or nitrogen.

Recycling strategies in the CE lack two important aspects in order to close material cycles and implement new business models: a comprehensive view of biophysical dimensions and an inclusion of institutional and social aspects. We argue that social and institutional changes are necessary to achieve a significant level of recycling, in particular for dissipative uses of materials. Without political reform, the degree of recycling in the economy, as measured in physical terms, will remain low both at regional and global levels (see Haas et al. 2015). Globally, structural shifts from industrial to service-based economies have contributed little to the decoupling of economic activities from raw material use (Tukker 2015). Moreover, among the associated economic concepts of performance or functional economy, one proposal that has yet to be implemented on a large scale is for producers to retain ownership of materials or products along the value chain (Stahel 2010). Current reviews have pointed to a number of weaknesses in the concept of the CE as it stands. In particular, the lack of thorough analysis of the necessary social and institutional conditions is considered an important barrier to the development of the CE (CIRAIG 2015; Ghisellini et al. 2016). Conflicting social and physical scales of CE in fostering innovation to retain industrial employment while respecting labor conditions for recycling activities abroad have also been the subject of recent work in the EU (Gregson et al. 2015). The CE stays well within the current economic constraints of competitiveness and unequal distribution of wealth, albeit with renewed political inspiration compared to the concepts of sustainable development or green economy. Figure 1 illustrates very schematically the potential impact that a circular economy (figure 1b) would like to have on the currently linear flows of resources through the economy (figure 1a).[1]

The CE must be placed into perspective, which is the main goal of this article. We draw on both theoretical and practical concepts that acted as precursors to the CE and highlight their contributions to potentially advance it. Specifically, we attempt to show how nontechnical, institutional, and social dimensions matter to further develop the CE. Although the readers may be familiar with the perspective of IE, we specifically analyze material stocks and energy flows in relation to the CE. Further, we introduce notions from institutional economics and illustrate these with the case of the social and solidarity economy as one possible way to overcome some of the constraints of recycling in the CE, particularly in relation to externalities and the need for political reform. We argue that the principles and values put forward in the social and solidarity economy may enable the necessary social and institutional conditions to allow for higher material recovery, toward the desired transition illustrated in figure 1. Placing the CE into perspective means grappling with environmental, labor, and social issues in earnest. Our objectives are threefold: First, we revisit the resource efficiency and recycling agenda of the CE and show that they are necessary, but not sufficient, to decouple economic activities from primary resources and environmental impacts. Second, we aim to demonstrate the role of institutions in enhancing, or impeding, the CE concept, and third we show how the CE could be facilitated through more practical approaches proposed by recent developments in the social and solidarity economy. We emphasize the structural aspects of production and consumption more than questions related to scale, such as demographic changes.

In the following section, we introduce the CE as it emerged historically and identify the aspects relevant for strengthening CE. We then take the perspective of IE, specifically developing the analysis of material stocks and energy flows in relation to CE. In the fourth section, we emphasize the role of institutions in implementing the CE, then provide a critique based on principles and practices of the social and solidarity economy in the fifth section. We conclude this article with a discussion around the need for diversifying the CE conceptually and in practice and some indications on how this might be done.

Historical Background

The concept of the CE emerged out of a long and rich history in both economics and physical sciences. A short recount of specific contributions is necessary to understand the arguments developed in this article. Among the first economists to study the relationship between economic activities and the natural environment in a rigorous way was Georgescu-Roegen. His argument was primarily a biophysical one, in particular the second law of thermodynamics, the entropy law, which imposes constraints on economic activities (Georgescu-Roegen 1967). It describes irreversibility in isolated systems as entropy increases inevitably with the dissipation of low-entropy (high-quality) energy and materials into high-entropy (low-quality) wastes inherent to most biological and economic processes.

Georgescu-Roegen experienced how institutions and economic activities have modified the relationships between people and the environment. He witnessed firsthand the evolution of economic processes brought by oil extraction in Romania, his country of origin (Martinez-Alier 1987; Mayumi 2001). The rapid depletion of reserves after the oil peak in the mid-1970s supported his view that the evolution of economic systems cannot be isolated from that of the environment (Georgescu-Roegen 1967). In addition to the economic exercise of characterizing flows (monetary and nonmonetary) across boundaries between economic systems and/or the environment, Georgescu-Roegen introduces the notion of funds and stocks. Human work, for example, as a result of what he called endosomatic energy, is a renewable flow provided by a fund of people. Land is an equally renewable fund, continuously supplying energy and materials through primary production of biomass. Renewable funds should be distinguished from stocks also supplying flows of nonrenewable materials and energy on which most of industrial societies' exosomatic energy demand depends (Giampietro and Mayumi 1997). Georgescu-Roegen therefore makes this crucial distinction for the CE between energy and materials in renewable funds and that in nonrenewable stocks, which are exhausted or depleted. This flow fund model was the first attempt to grasp the biophysical dimension of the economic process. He even suggested that a "desirable" population size would rely entirely on flows from renewable funds (Georgescu-Roegen 1977). Outside of his seminal contribution to the field of ecological economics and with the exception of critical institutional economics (Kapp 1976; Veblen 1898), interactions between economic activities and the environment were very much understood as mechanistic.

In parallel to the biophysical perspective, physicist Robert Ayres and economist Allen Kneese (Ayres and Kneese 1969) provided an economic argument for the analysis of interactions between economic processes and the environment. The fact that economic activities rely on seemingly free resources, such as clean air and water, leads to suboptimal allocation of resources and generates externalities. Ayres and Kneese viewed externalities essentially as a material balance problem, in the sense that the law of conservation of mass also applies to economic systems. Their contribution became a cornerstone of material and energy flow analysis and laid out an ambitious research plan for IE (Fischer-Kowalski 1998). In accounting practices such as life cycle costing, externalities and foreseeable future costs should be internalized (Moreau and Weidema 2015). Institutional economist William Kapp viewed externalities primarily as an institutional issue. He made a similar argument, noting that: (1) the monetary counterpart of externalities is an improper reduction of their heterogeneous nature; (2) legislation sets a formal boundary between costs borne by private agents and those that can be shifted onto society; and (3) competitiveness forces cost shifting onto others. The ensuing asymmetries of power are reflected in the institutional conditions that result from powerful agents' institutional strategies (Kapp 1950).

IE and the CE appeared almost simultaneously in the literature, based on the biological and physical concepts of metabolism and material balance. In his chapter entitled "Industrial Metabolism," Ayres (1989) suggests that a characteristic of industrial processes is precisely resource efficiency and recycling. At the same time, Frosch and Gallopoulos (1989) explain how IE should underlie all manufacturing strategies. The notion of the CE itself, whereby wastes are essentially transformed into useful (secondary) resources, first appeared in an environmental economics textbook by Pearce and Turner (1990). Both draw upon the so-called biological analogy and show how industrial processes can learn from biological systems to produce complex products from basic ingredients and recycle even the lowest-grade substances in just a few steps. Hence, the concept of IE, where industrial activities attempt to mimic symbiotic relationships found in ecosystems, which was later shown to have deep roots in system ecology (Erkman 1997; Odum 1970).

This analogy with natural systems allows practitioners and researchers in IE to disengage, for the most part, with questions related to people and power relations (Sahakian 2016). Earlier developments in IE took these issues more seriously, as put forward in the work of Edward Cohen-Rosenthal. Coming from a labor perspective (see Cohen-Rosenthal 1979), he placed an emphasis on social processes in relation to material and energy flows—including a concern for health and the global commons—and, more generally, the question of public welfare (Cohen-Rosenthal 2004). Whereas Georgescu-Roegen (1988) was also concerned with the relationship between biophysical and institutional aspects, Cohen and Howard (2006) revealed that the objectives and institutionalization of IE can be conflicting. Examining the institutional dimensions of a fortiori similar theories or practices such as the CE is therefore needed. Salmi and Toppinen (2007) validated the claim that general lessons can be drawn from the institutional embeddedness of IE despite the site specificities of social and political conditions. The social dimension of IE has been further developed more recently by researchers such as Boons and Howard-Grenville (2009). We attempt to show that integrating the institutional and social dimensions are essential for the development of the CE on a large scale.

If Ayres (1989) emphasized the large share of dissipative uses of materials that cannot be recycled economically, Pearce and Turner (1990) pointed to another important constraint for recycling in the CE: Anthropogenic stocks, accumulated from nonrenewable geogenic stocks, would need to grow substantially before materials can be recycled. As described below, stocks of the main metals in the economy have grown sufficiently for secondary sources to supply a significant share of demand. In light of Goergescu-Roegen's thermodynamic analysis, a decrease in the entropy within an economic system can only occur at the expense of an entropy increase in the broader system, beyond the boundaries of isolated economic processes. Although this brings new economic opportunities and possibly higher standards of living, the limits to accumulation are clearly set by the materially closed system Earth. Thus, measures of material circularity are sensitive to system boundaries as materials and energy shift within and across product life cycles.

The Biophysical Dimensions

The CE clearly shares some of IE's underlying principles. Although the comparison between CE and IE holds up to a certain point, the former emphasizes low-entropy material flows rather than high-entropy stocks or even funds. The CE also promotes the economic opportunities from recycling and remanufacturing without systematically accounting for material flows that are economically nonrecoverable. Indeed, 44% of the material throughput of the global economy in 2005 consisted of minerals and fuels for energetic uses, which are dissipated and cannot be recycled (Haas et al. 2015). Twenty-seven percent of the throughput consisted of net additions to anthropogenic stocks as construction materials, whereas recycling amounted to only 6% (the remaining 23% consisted of short-lived agricultural products and waste rock). Thus, the current degree of circularity in the global economy is low, even if we account for the biomass recycled through biogeochemical processes outside the economy. The CE should therefore focus on the 44% (nonrenewable) energy and material stocks in order to make a significant contribution to decouple economic activities from primary resources, rather than on the 6% of recycled products that account for a small share of the total throughput. Ayres (1999) shows that Georgescu-Roegen's flow-fund model could be expanded to include anthropogenic stocks as a source of renewable flows subject to the availability of renewable energy. He concludes that, in practice, the anthropogenic stocks of low-grade materials would have to be significant. The following section briefly looks at how the CE can build on the analysis of material stocks and energy flows as developed within IE.

Material Stocks

The role of anthropogenic stocks has often been overlooked, partly attributed to the methodological and empirical challenges of evaluating and quantifying historical accumulation. A recent study estimated anthropogenic stocks by using time series of material flow data, or the annual additions to stocks over a period of 75 years for the United States and Japan (Fishman et al. 2014). Other contributions exist, particularly for materials that have a high recycling rate, namely metals. Stocks of the main metals and alloys, aluminum and steel, are relatively well documented (e.g., Allwood and Cullen 2012). For instance, anthropogenic and geogenic stocks of iron in the United States were shown to be equivalent, such that recycling can potentially supply all of domestic consumption (Müller et al. 2006). Great disparities exist between countries in the levels of steel stocks per capita, with the global average approximately one quarter of the 12 tonnes of steel per capita, beyond which secondary steel proves more economic than primary sources (Allwood and Cullen 2012; Müller et al. 2006). Both Chinese and Indian stocks per capita are below the global average. Yet, the estimated anthropogenic stocks of steel in the Chinese economy shows that advanced recycling technologies could supply up to 80% of consumption (Pauliuk et al. 2012; Wang et al. 2015). Transforming in-use stocks, such as retrofitting houses and vehicles, can further reduce the extraction of raw materials and the emissions of greenhouse gases (Pauliuk and Müller 2014).

Although decoupling economic activities from raw material extraction has occurred for given spatial and temporal scales, globally there is little evidence of decoupling, particularly in light of the share of materials being added to anthropogenic stocks (Wiedmann et al. 2015). A wealth of literature on rebound effects also shows how efficiency directly and indirectly increases consumption in relative and absolute terms (e.g., Sorrell 2007; York and McGee 2016). For example, the material requirements, so-called raw material equivalents, of infrastructures supporting the provision of seemingly dematerialized services are shown to be significant compared to overall material consumption in the EU (Schoer et al. 2012). Indeed, as described above, decoupling between material consumption and economic growth in absolute terms only becomes possible for economic processes at the expense of entropic increase in the economy elsewhere. In order to validate the claim that the CE works on every scale, as stated in the EMF's definition, the full value chain should be accounted for given that industrial sectors trade material-, energy-, and labor-intensive activities across boundaries.

Energy Flows

Dissipative emissions are challenging to recycle by definition, given that the associated costs are inversely proportional to concentration, similar to any extractive activity. Hence, the relatively high recycling rates for metals whose properties are preserved, whereas other essential elements are not concentrated enough to be recycled economically (Graedel et al. 2011). The nitrogen cycle, for example, has largely been altered by modern agriculture, to a greater extent than the carbon cycle (Ayres et al. 1994; Gruber and Galloway 2008). Global anthropogenic carbon dioxide (CO_2) emissions reached approximately 36 gigatonnes (Gt) in 2014, essentially from the combustion of fossil fuels (FFs) and industrial activities, in particular the production of cement (Le Quéré et al. 2015). The cumulated stock of anthropogenic CO_2 in the atmosphere now exceeds 800 Gt and becomes technically recoverable (Meylan et al. 2015). The proposal to build an anthropogenic carbon cycle using the atmosphere instead of the lithosphere as a reservoir could close the loop on the bulk of the emissions from point and diffuse sources (Erkman 2000). Although the potential to substitute FFs with synthetic equivalents made from atmospheric CO_2 grows, the concentration level of 0.04% or 400 parts per million already leads to considerable impacts from climate change (IPCC 2013). Thus, the cumulated anthropogenic stock of dissipated emissions that would have to be recycled already exceeds biogeochemical thresholds or planetary boundaries. Georgescu-Roegen's bioeconomics stressed that the magnitude of the material throughput of the economy needed to be lowered before considering the opportunities of closed material cycles (Ayres 1989; Odum and Odum 2001; Bonaiuti 2011).

Relevance for Social and Institutional Dimensions

In his flow-fund model, Georgescu-Roegen emphasized the biophysical dimension of labor as a flow of work from a renewable fund of people, as opposed to burning FFs extracted from nonrenewable stocks. Similarly, Stahel and Reday-Mulvey (1981) argued in favor of remanufacturing strategies to substitute labor for FFs. In a simulation experiment, the material and energy inputs were significantly reduced in industrial sectors active in the same markets as remanufacturing activities (Ferrer and Ayres 2000). Moreover, such reduction compounded along the entire value chain irrespective of where remanufacturing took place. Ferrer and Ayres (2000) also showed that the demand for labor from remanufacturing activities was proportional to the price discount of remanufactured products compared to original ones. A more recent study by the Club of Rome also estimated the additional employment expected from a transition to the CE to vary between 300,000 and more than 1 million in five European countries combined according to different scenarios (Wijkman and Skanberg 2015). Stahel (2010) suggests shifting the tax burden from labor to energy and materials as a leverage with which institutions can encourage remanufacturing. Therefore, substituting labor-intensive activities for energy intensive activities is a direct way to increase the degree of circularity of the economy. The quality of labor activities could be brought into question, however, as we further expose through discussions around institutional perspectives, and the example of the social and solidarity economy, in the following two sections.

An Institutional Perspective

Keeping products and materials at the highest possible utility and value at all times, as in the EMF's definition of the CE, largely depends on how costs and benefits are distributed along production and consumption chains. The evolution of property rights and institutional conditions (ICs) largely determines the boundaries between private and social costs, which, in turn, affect how profits are made. Yet ICs result from stakeholder participation and power distribution in the political and legislative processes. Institutional economics provides a reading of the CE along three main lines: the social embeddedness of the economy; normative aspect of who bears what costs; and political process. ICs generally set the rules of the game, shaping people's preferences, behavior, and values, all of which influence individual and collective decision making (Vatn 2012).

Bromley (1989) characterized institutions as defining the spectrum of possible choices for economic activities. Who bears the costs of externalities, that is, social (e.g., inequalities) and environmental impacts (e.g., air and water pollution), directly relates to institutions. In line with Kapp (1950), he argues that the institutional structure, legislation in particular, defines what costs economic activities must be held accountable for and thus influence their profitability and competitiveness. In their historical account of institutionalism, Gerber and Steppacher (2011) dwell on the evolutionary nature of institutions and how they have transformed these legal and economic conditions, under the political pressure of private agents. Perhaps more than any other economic concept, the CE exemplifies the essential role of institutions in distributing costs among economic agents instead of transferring them onto the environment. Some institutions have powerful leverage, with taxes and subsidies, fiscal policies, as well as investment programs to maintain profitable and competitive conditions for a CE without necessarily requiring new institutional regimes. Georgescu-Roegen (1988), however, warned against rules and regulations established to safeguard private interests, in the name of the common good, instead of transforming ICs to avoid cost shifting. Vested interests continue to hinder the evolution of institutions, and accounting for externalities remains a challenge in practice (Vatn 2009).

Many economic activities could change significantly through ICs, which supports CE. Waste management policies, for example, have direct impacts on the amount of resources diverted or recycled. Alternative ownership models where materials are leased instead of sold, by the countries of origin, provide one way to maximize their value (Stahel 2010). Who owns the atmospheric carbon from dissipative uses of FFs would have legal implications upon closing the anthropogenic carbon cycle and, by the same token, the degree of circularity in the global economy (Erkman 2000). Further, territorial policies and planning are crucial in the development of markets for secondary resources and for industrial symbioses (ISs) projects. Eco-industrial parks, for example, have been initiated from the bottom up and the top down through policies (e.g., Erkman 2005; Mathews and Tan 2011; Chertow and Ehrenfeld 2012). The Chinese law for the promotion of the CE provides a good example of top-down approaches to improve resource management and environmental quality (Su et al. 2013).[2] By contrast, the IE principle enacted in the constitution of the state of Geneva, Switzerland, resulted from bottom-up processes to improve resource efficiency and, in particular, land and energy uses.[3] Moreover, resource efficiency generates added value within and across multiple economic activities. There is no shortage of business models that integrate some degree of circularity for efficiency purposes (Bocken et al. 2014). Thus, closing material cycles pertains as much to the ICs as to the characteristics of the resources themselves.

Entitlements and access to, as well as valuation of, resources can redefine how the benefits and costs are shared along the value chain and contribute not only to closing material cycles or ISs, but also to reinforce current models of ownership and profitability. Similar to the idea of decoupling, profitability would gain to be defined in relative and absolute terms, as competiveness compels firms to be not only profitable, but more profitable than competitors (Van Griethuysen 2010). Relative profitability requires cost shifting, which induces negative environmental repercussions if, for example, renewable sources of energy (including labor) are to compete with FFs. This important distinction between relative and absolute profitability provides one clue on how to level the playing field for activities that have goals other than profit alone, such as fair labor conditions. Specifically, relative profitability means that even activities with low economic returns are ousted from the competitive environment, let alone nonprofitable ones. The social and solidarity economy (SSE) is an interesting counterpoint, as an economic practice that departs from the constraint of relative profitability and private ownership, and includes notions of equity in relation to the cost of labor. Whereas other economic models could be equally helpful, we have chosen the SSE as one example of how institutional conditions can contribute to the development of a CE by taking into account social institutions, societal norms, and political considerations, through (1) clearly defining who bears the costs of economic activities and (2) working toward reducing social inequalities and a more inclusive economy.

Social and Solidarity Economy Principles

The social and solidarity economy is a social movement and an existing practice, building on the history of the social economy that emerged in nineteenth century Europe. It has been revived in recent years around the world—from Asia to Europe, and from North and Latin America[4]—and conceptualized in response to a number of growing socioeconomic issues: recurring financial crises; the failure of the welfare state to address social ails; widening inequalities; and *un*sustainable forms of production and consumption. The SSE includes different types of economic initiatives, ranging from new social relations such as fair trade programs and new currencies such as community currencies. Although the SSE is practiced differently around the world (Fraisse 2003), it is generally understood as placing human beings at the center of economic and social life (ISGC 1997). For some researchers, the social and solidarity economy challenges the notion of the nonprofit sector: Rather than act as a palliative response to the failures of the welfare state, through the increased dependence on nongovernmental and community organizations, the SSE is poised as a means for transforming all economic activities, including market exchanges and wealth redistribution (Laville 2011; Kawano 2009). The main focus of the SSE is to give more importance to people and to the planet, rather than the accumulation of capital or profit. SSE can be summarized as prioritizing "service to its members or to the community ahead of profit; autonomous management; a democratic decision-making process; the primacy of people and work over capital in the distribution of revenues" (Defourny et al. 2000, 16).

The conceptual foundations of the SSE are often tied to Karl Polanyi's notion of reciprocity and his fundamental argument that the economy is "embedded" in the social realm. The economy is not neutral not necessary in and of itself; it rather has a social purpose, is subordinated to social relations, and inseparable from social norms and institutions (Polanyi 1944). According to Bromley (1989), this is a basic tenet of institutional economics as well, given that institutions are the result of cultural, social, and political processes. Further, both Georgescu-Roegen and Kapp explained that the economy and society are open systems embedded in the environment. Whereas one definition of reciprocity lies in a dual exchange between giving, receiving, and an obligation to give in return, between two parties, the notion of solidarity expands that of reciprocity to include exchanges across and between different parties (Polanyi 1957). This entails complementary relations based on voluntary interdependence (Servet 2007), or being "invested with the potential of solidarity, consciously interdependent on others" (Servet 2009, 80). The SSE is therefore a form of reciprocity that includes an interest in the commons and the community, towardssocial and environmental goals, rather than reciprocity out of necessity or unequal social relations.

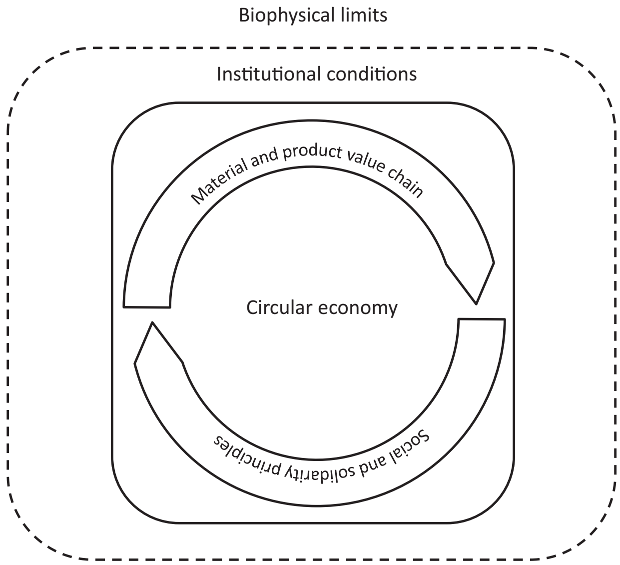

Figure 2 The interplay between institutional conditions and social and solidarity principles around the circular economy.

More practically, the SSE works at the local or regional level, bringing together cooperative efforts and promoting democratic participation in economic activities. Among the few examples of large-scale SSE activities are the Mondragón cooperative (Basque region, Spain) (Kaswan 2014) and cooperatives in Trento county (northern Italy) (Prades 2013). Whereas accounting for SSE activities differs in varying contexts, the percentage of jobs involved in the SSE has been estimated to approximately 10% both in France and the City of Geneva (INSEE 2013; Dunand 2010; Utting et al. 2014). In Geneva, all economic sectors are represented among the current 265 members in the SSE, including finance, insurance, housing, food, and education, among others. Based on a 2008 survey, SSE members in Geneva had low wage gaps between highest and lowest paid employees, higher than average starting salaries, and more employees on flexible work schedules (APRES-GE 2010).

By placing people above profit, the SSE makes its value system explicit, toward more equitable labor conditions and participative decision making, but also aims toward social well-being and the democratization of the economy overall. In the SSE, for example, societal decisions could be made in terms of what materials should be reduced or reused, or what materials should be recycled as a priority, toward a common good, regardless of economic profitability. Unemployment programs, which strive toward social reinsertion, would entail the state partially covering the cost of labor in certain remanufacturing initiatives, for example. Or, rather than herald in an era of planned obsolescence (London 1932), the SSE could create rules and regulations guaranteeing the longevity and reusability of products, including household items, but also building infrastructure. As illustrated in figure 2, social and solidarity principles fill the gap toward CE opportunities that would otherwise be cost-*in*effective.

Rather than distributing pieces of the proverbial pie, an economy based on solidarity would aim toward considering the pie as a shared resource—addressing societal needs, with both current and future generations in mind (Sahakian 2016).[5] Perhaps the most important contributions of SSE to the CE are precisely that of equity, avoiding cost shifting in time and place, and models of collaborative and democratic governance systems, which challenge the profit motive. Moreover, evolving institutional conditions to support more solidarity-based production and consumption systems could lead to more resource-efficient activities, which is one of the core principles of the CE. The SSE is therefore an example, in practice, of how institutional perspectives can lead to more robust CE strategies toward societal and environmental aims.

Conclusions

The CE focuses essentially on strategies to increase resource efficiency, including reducing, reusing products and their components, and recycling materials. Yet efficiency and profitability can be achieved without necessarily reducing energy use in absolute terms. Similarly, maintaining products and materials at the highest potential value through reuse, remanufacture of recycling means that cost-effectiveness underlies these circular economic activities, possibly at the expenses of lower energy intensity and higher labor intensity. To a large extent, the distribution of costs and benefits of material and energy use depends on institutions. Economic as well as territorial policies can also modify the conditions for profitability toward a CE as in waste management, for example. Therefore, we argue for the need for political reform not only changes from biophysical or even economic rationality, but also toward social rationality. The prevailing institutional and biophysical conditions clearly limit the degree of recycling. Georgescu-Roegen's flow-fund model brings subtle, but important, distinctions from IE's material balance approach of stocks and flows, showing that lower entropy and higher quality in one process comes at the expense of another. Therefore, the lessons for CE are both qualitative and quantitative in the challenge to reach a significant level of circularity through recycling.

Multiple strategies toward the CE are necessary and complementary in our current industrial and societal metabolism. However, given the magnitude of dissipative material and energy flows, circularizing the economy through material recycling would need to go beyond economically viable efforts alone and the externalization of costs to future generations. In fact, research in IE and ecological economics demonstrates that the CE may require a significant increase in material throughput and addition to stocks before closing material cycles, in particular within the current institutional conditions. Greater throughput, however, runs against the biophysical constraints of natural sources and sinks, and the tacit hypothesis that smaller throughput of primary resources means lower environmental and possibly social impacts. Moreover, Georgescu-Roegen and Cohen-Rosenthal's contributions, as well as Stahel's work, emphasize the need to reestablish labor at the core of the economy given its renewable nature. As such, the social and solidarity economy is an instructive and constructive example for the CE, increasing labor-intensive activities while raising the quality and diversity of human work involved in remanufacturing and recycling. Beyond shifting the bulk of taxes from labor to resource consumption, as put forth by Stahel, changing institutional conditions in support of SSE and participative governance would ensure a more suitable environment for cultivating both biophysical resources and human labor. Although the entropy law remains intransigent, institutional conditions and societal values can be challenged and transformed through political processes, in order to usher in a more equitable and circular economy.

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Notes

1. A more elaborate version was depicted with two hourglasses in exchanges between Georgescu-Roegen and Daly on the steady-state economy (see Georgescu-Roegen 1977).
2. An English translation of the law can be found at www.fdi.gov.cn/1800000121_39_597_0_7.html. The law focuses on resource reduction, recycling, and recovery. The implementation of the CE should be economically and technically feasible and simultaneously preserve the environment. The law emphasizes the role of the state in procurement policies as well and fiscal and regulatory incentives. Social dimensions are mentioned once, in article 3, where public participation appears last in the general guidelines.
3. In October 2012, article 161, entitled Industrial Ecology, was introduced in the constitution of the state of Geneva, calling for the respect of IE principles and the implementation of waste reduction policies, in particular for environmentally harmful wastes. This came after a decade of cooperation and coordination between public, private, and academic stakeholders.
4. For an overview of SSE initiatives around the world, please consult the following platform: www.ripess.org/.
5. This section summarizes and further expands upon a book chapter on the relevance of the SSE to IE (see Sahakian 2016).

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