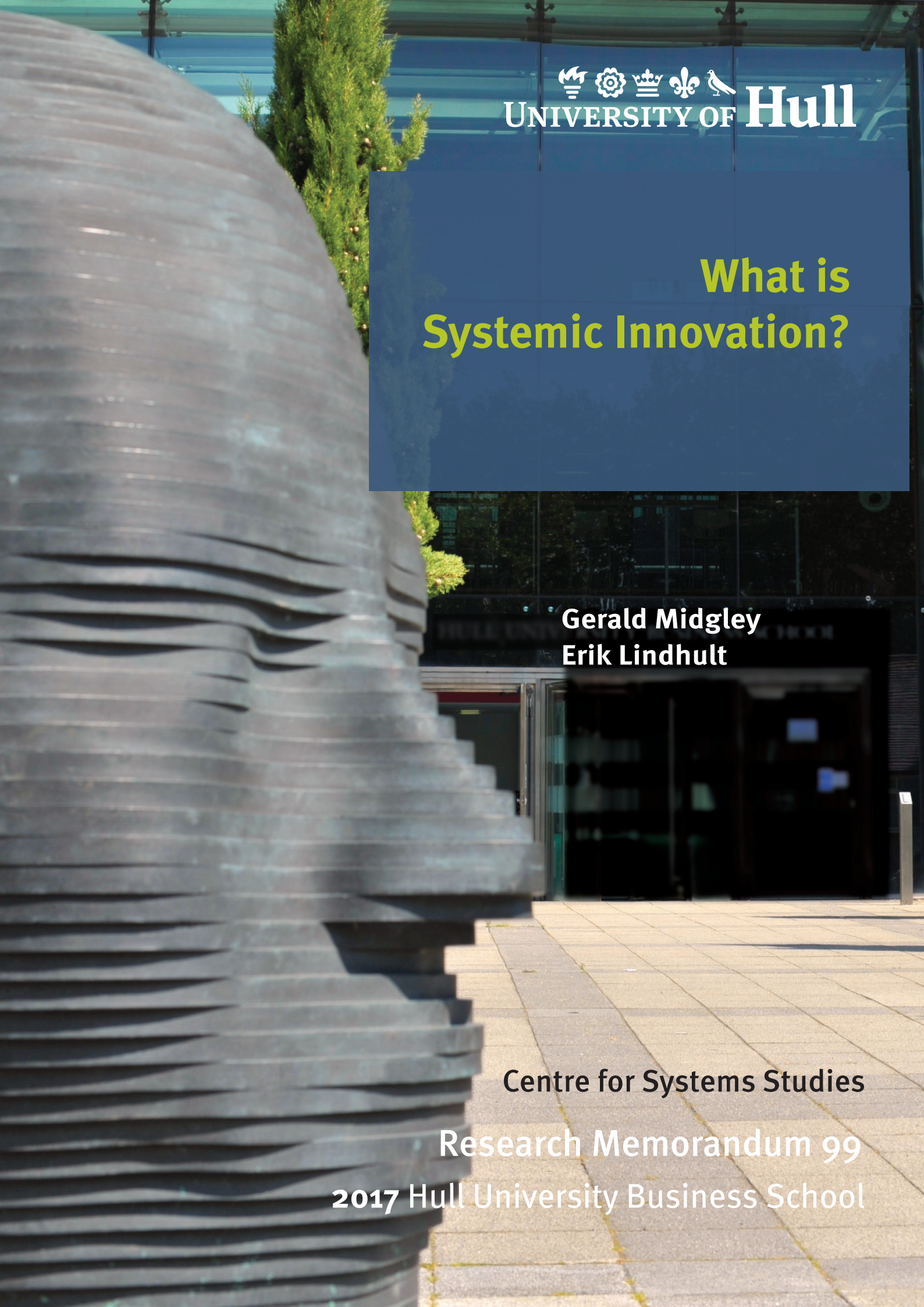

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Abstract

The term 'systemic innovation' is increasing in use. However, there is no consensus on its meaning: four different ways of using the term can be identified in the literature. Most people simply define it as a type of innovation where value can only be derived when the innovation is synergistically integrated with other complementary innovations, going beyond the boundaries of a single organization. Therefore, the term 'systemic' refers to the existence of a co-ordinated *innovation system*. A second, less frequent use of the term makes reference to the development of policies and governance at a local, regional or national scale to create an enabling environment for the above kind of synergistic, multi-organizational innovations. Here, 'systemic' means recognition that innovation systems can be enabled and/or constrained by a meta-level policy system. The third use of the term, which is growing in popularity, says that an innovation is 'systemic' when its purpose is to change the fundamental nature of society; for instance, to deliver on major transitions concerning ecological sustainability. What makes this systemic is acknowledgement of the existence of a systems hierarchy (systems nested within each other): innovation systems are parts of economic systems, which are parts of societal systems, and all societies exist on a single planetary ecological system. Collaboration is required across organizational and national boundaries to change the societal laws and norms that govern economic systems, which will place new enablers and constraints on innovations systems in the interests of sustainability. The fourth use of the term 'systemic innovation' concerns how the people acting to bring about an innovation *engage in a process to support systemic thinking*, and it is primarily this process and the thinking it gives rise to that is seen as systemic rather than the innovation system that they exist within or are trying to create. It is this fourth understanding of 'systemic' that accords with most of the literature on systems thinking published between the late 1970s and the present day. The paper offers an overview of what systems thinkers mean by 'systemic', and this not only enables us to provide a redefinition of 'systemic innovation', but it also helps to show how all three previous forms of innovation that have been described as systemic can be enhanced by the practice of systems thinking.

Keywords: Ethics of Innovation; Innovation Policy; Innovation Systems; Sustainability; Systemic Innovation; Systems Thinking.

1. Introduction

The term 'systemic innovation' has been increasing in use in recent years. While most of the papers on this draw upon the innovation literature in a relatively sophisticated manner, with only a handful of exceptions they do not reference much (if any) of the literature on systems thinking or systems science. The latter are two closely related transdisciplinary fields with a hundred-year history and many specialist journals (see Midgley, 2003a, for a set of representative readings). It is our contention that, by drawing upon the literature on systems thinking in particular, we can enhance both the theory and practice of systemic innovation.

Below, we first of all review how the term 'systemic innovation' has been used to date, mostly in the management and policy fields. Then we shift attention to systems thinking to see what we might usefully learn about how the word 'systemic' has been understood in that literature. We will see that the key difference between the meaning of 'systemic' in the innovation and systems literatures is that almost all innovation writers assume that it is the 'innovation system' that is systemic in various different ways, while systems thinkers have moved their focus to concentrate on *the design of methodological processes to support the systemic thinking of innovators*. We argue that the adoption of this reframing allows both innovation and innovation systems to be enhanced by the use of systems thinking concepts, methodologies and methods.

2. Meanings of Systemic Innovation

Takey and Carvalho (2016) present a systematic literature review of the field of systemic innovation and, while they acknowledge that there are different meanings of this term in the literature, they choose to screen out the lesser used ones and focus on the most popular definition: "Systemic innovation (SI) corresponds to the type of innovation that only generates value if accompanied by complementary innovations. It opposes autonomous innovation, which can be developed independently of other innovations" (p.97). They trace the need for a concept of systemic innovation back to the works of Teece (1986) and Chesbrough and Teece (2002), who explain how more and more business innovations require collaborations across organizational boundaries to yield the necessary synergies. Indeed, companies can no longer take for granted that all the knowledge they need to produce the next generation of technologies, products or services will be found in-house (Normann, 2001), and nor can they assume that any single innovation can be successfully pursued outside the context of a whole *innovation system* (Chesbrough and Teece, 2002).

While Takey and Carvalho (2016) are correct to point out that this is the most widely used understanding of systemic innovation to date, we believe it is a mistake to screen out less common uses. This is not only because they contain important ideas that can be incorporated into an enhanced theory of systemic innovation (as we will shortly show), but also because it is arguably the most recently introduced and so far *least used* meaning of systemic innovation that has the most potential for grounding our enhanced theory. Below, we explain the four uses of 'systemic innovation' that we have uncovered:

2.1. Systemic innovation means 'produced by an innovation system'

The most common use of the term 'systemic innovation' (as described above) is applied to a situation where an innovation system goes beyond the boundaries of a single organization, and multiple innovations need to be co-ordinated (e.g. Teece, 1986; Chesbrough and Teece, 2002; Kano, 2000; Gopalakrishnan and Bierly, 2001; Taylor and Levitt, 2004; Maula et al, 2006; Andersen and Drejer, 2008; van den Ende et al, 2008; Alin et al, 2013; Mlecnik, 2013; Takey and Carvalho, 2016).

Innovation, in this understanding, is 'systemic' because there is an innovation system giving rise to it. We will leave full discussion of the nature of systems until later; for now, it is sufficient to note that a system was classically defined in the early days of systems science as an organized set of parts, differentiated from their environment, giving rise to emergent phenomena that cannot be attributed to any one part, or sub-set of those parts, in isolation (e.g., Angyal, 1941; Bertalanffy, 1956, 1968; Hall and Fagen, 1956; Marchal, 1975; Bunge, 1977; Flood and Carson, 1993). The emergent phenomena are therefore properties of the *whole system*. A multi-organizational innovation system is very clearly systemic using this definition, as the different contributory innovations and organizations (parts) are organized together into a whole system, where the overall success of the emergent innovation enterprise cannot reasonably be attributed to just one sub-innovation or participating company – although, as Bröring (2008) argues, it is often the case that one organization needs to act as a central co-ordinator.

2.2. Systemic innovation refers to 'regional policy systems to support innovation'

An understanding of systemic innovation that is less often used, but still appears regularly in the literature, is one that focuses on policies (e.g., Woiceshyn and Eriksson, 2014), frameworks (e.g., Wieczorek and Hekkert, 2012) and methods (e.g., Schoen et al, 2011) at the national or regional scale to bring the kinds of innovation systems discussed in the previous sub-section into being, or enhance their performance if they already exist. Generally speaking, it is government that intervenes to support industries, the public sector, voluntary organizations and often cross-sector networks in their co-ordination of innovations (Rullani et al, 2016). Mostly this kind of systemic innovation initiative has a geographically defined scope, as the emphasis is on regional competitiveness (Cooke et al, 1998; Li and Zhong, 2011), with different continents (e.g., Manjón and Romero Merino, 2012), countries (e.g., Laranja, 2012) or sub-national regions (e.g., Cook et al, 1997; Doloreux, 2004) seeking to improve their own innovation capacity and ultimately the employment, wealth prospects and quality of life of their citizens. Some of the literature points to the weaknesses in national or regional innovation systems due to the absence of government support (Turner et al, 2016), private sector engagement (de Laurentis, 2006) or the inadequacies of incentives to innovate (Wilts et al, 2011).

Government agencies are conceptualized as being at a meta-level to the innovation system in most of the above referenced works, creating enablers and constraints for innovation. However, in some papers on policy systems (e.g., Carlsson and Stankiewicz, 1991; Jenssen and Koch, 2007; Guo, 2010), government is described as just one player *alongside* multiple other private and public sector actors, in which case the definition of 'systemic innovation' is a hybrid of the one discussed in this sub-section of the paper and the last.

It is the emphasis on the role of government as a co-ordinator, facilitator or funder that differentiates this understanding of systemic innovation from one that focuses almost exclusively on synergistic innovations across the boundaries of industrial organizations (Section 2.1). Johannesson (2013) draws upon Miller's (1978) living systems theory (which discusses social as well as biological systems) to distinguish between *economic innovations* (value creation through the development of products and services) and *institutional innovations* (changes in the governance meta-system that enables and constrains economic activity). Importantly, Johannesson (2013) argues that institutional innovations can have a far greater impact on our lives than might at first appear to be the case because they can *change the rules for future economic innovations*. For him, the design of institutional changes *is* systemic innovation. We would surmise that this would also be the case for Devine (2005): he does not use the term 'systemic innovation', but shows how problems in national innovation systems can be diagnosed using Beer's (1985) Viable System Model – a theory of organization that has been

widely deployed for improving the viability of private sector companies (e.g., Hoverstadt, 2008), public services (e.g., Espejo and Reyes, 2011), multi-agency collaborations (e.g., Midgley et al, 1998) and even whole communities (Espinosa and Walker, 2013). Devine (2005) uses it for the design of national innovation systems. He makes the point that national innovation systems can be viewed as meta-systems supporting and enhancing the viability of innovation activities across many private, public and third sector actors in a defined geographical area.

2.3. Systemic Innovation as 'a game-changer for sustainability'

The third understanding of systemic innovation that we find in the literature is usually discussed in the context of a transition to a more sustainable society (e.g., Karabeg, 2013; Pinkse et al, 2014). Often multiple innovations are involved, and together they move society towards a tipping point, beyond which a more desirable pattern of production and consumption is achieved (Bergman et al, 2008; Whitmarsh and Nyqvist, 2008). When it comes to sustainability, the innovation is often "game-changing" (Szekely and Strebel, 2013, p.472) in the sense that it transforms the rules and/or infrastructure used by organizations for future innovations (similar to the previous definition of systemic innovation, except the origins of these rule changes do not have to come from a purpose built governance system). A good example is the transition to renewable, low carbon energy (Tsoutsos and Stamboulis, 2004): if and when this is fully achieved, it will mean the end of the current situation where any new innovations that involve increased energy consumption inevitably play their part in adding to the cumulative effects of carbon emissions.

Like the two previous understandings of what it means to be systemic, an emphasis here is on innovation systems. However, unlike those previous understandings, the *context* in which those systems are embedded is viewed much more broadly and is seen as highly influential in the creation of both risks and benefits from innovation (Hellström, 2003). Society is viewed as a system that contains the economy, including its innovative sub-systems, and all three levels (society, economy and innovation systems) are a target for transformation. Beyond society, there is also the planetary ecological system: see, for example, the work of the Parliamentary Commissioner for the Environment (2002) in New Zealand, which conceptualises all economic and social activity as existing in an ecological context. Thus, the idea of a *systems hierarchy* (or set of nested systems) is important to this ecologically orientated understanding of innovation and, like the definition of a real-world system mentioned earlier, the idea of system hierarchies has been around since the first flourishing of systems science (e.g., Bertalanffy, 1956, 1968; Giampietro, 1994; Wilby, 1994). Unlike the perspectives on the national and regional governance of innovation (discussed in the previous section), which recognise just two system levels (economic innovation systems and their governance meta-systems), sustainability-orientated perspectives on systemic innovation think in terms of multiple levels, ultimately extending to the planetary boundary. It is the largest container system (the planet) that sets constraints that all its sub-systems must live within (Meadows et al, 2004; Jackson, 2009), and it is because humankind is transgressing these constraints that there is a need to change the rules for innovation before too many negative consequences of environmental change are realized.

2.4. Systemic innovation as 'a process to support people thinking in terms of systems'

The final meaning of systemic innovation that we can find in the literature is the most recently introduced and so far least used, but we argue it is this one that has the most potential to take our theory and practice to the next level: innovation is viewed as a process, which can be augmented by the use of systems modelling embedded within stakeholder dialogue methods to support social learning, enabling those stakeholders to get a 'bigger picture' understanding of the possibilities for,

and potential consequences of, innovations (Colvin et al, 2014; Gannon and Monat, 2015; Ison, 2016; Laszlo, 2017). In other words, the innovation process is constructed in such a way that the participants within it are supported in using methodologies, methods and techniques *to make their thinking more systemic*.

Like us, Ison (2016) identifies the need for a deeper understanding of what 'systemic' means. A critical point he makes is that a 'system' does not have to be viewed as a real world 'thing', but can be seen instead as a useful way of making sense of situations we face and how we might address them – *thinking in terms of systems is useful in the context of action to create change*; i.e., when innovating. Also see Checkland (1981), whose work on systems thinking has informed Ison's reframing of systemic innovation. Importantly, Ison (2016) claims that

> "a system in this tradition is a product of a distinction, formulation, or invention by someone, or a group, concerned with improving situations using systems thinking. In this tradition practitioners realise that when a system is generated it is not a thing but *a system-environment (or context) relationship mediated by a boundary judgment made for a purpose*" (p.39, emphasis added).

It is the last sentence above that hints at the utility of systems thinking, and it is worth expanding upon to begin to explain why this reframing of systemic innovation offers such potential. Keep in mind the earlier, classical definition of a real-world 'system' that we provided: an organized set of parts, differentiated from their environment, giving rise to emergent properties that cannot be attributed to any one part, or sub-set of those parts, in isolation. We can now add to this an essential extra element of theory: if a system is defined using a boundary judgement for some purpose (such as pursuing a particular focus for innovation), it *is observer* (or participant or stakeholder) *dependent* (Churchman, 1970; Ulrich, 1983; Midgley, 2000; Ison, 2016), and the *values* that are brought to bear in defining the system really matter (Ulrich, 1983, 1987; Midgley et al, 1998; Midgley, 2000; Alrøe, 2000). So, if a system is seen as a conceptual tool (a way of viewing something in the context of action), and not the thing in itself, it provides us with a range of thinking opportunities. These can be phrased as questions, such as:

- Are there stakeholders (those actually or potentially involved in or affected by an innovation) who might have different purposes to us and therefore could see the system differently? What would happen if we took account of their views?
- Are there different values that might matter in understanding the operation and outcomes of the system? What are the implications for the innovation and action in pursuit of it?
- Can we rethink the boundaries of the system to include new elements or exclude current ones? If we do this, how might it change the dynamics and outcomes?
- How would making changes in the context impact on the way that it enables or constrains the activities of the system? What are the implications for action?
- Can we change the relationships between the parts of the system (e.g., through synergistic dialogue or the reform of processes)? If we do, how would this impact its emergent properties?
- Are there other emergent properties that we might not have considered? Are these desirable or undesirable, and what consequences does the answer have for our pursuit of the innovation?

Of course these questions are all high level and abstract – lacking the content that would be brought in by stakeholders in a situation where real innovations are being pursued. It is actually the synergies that can be obtained from bringing these kinds of questions (derived from the notion of 'a system' as a way of thinking about things) together with the problems, threats and opportunities being faced in

business and policy practice that make all the difference to innovation. This is because they encourage us to *think about the way we are thinking* in a real innovation context, and can therefore facilitate reframing. Cabrera et al (2008, 2015) and Cabrera and Cabrera (2015) call this "meta-cognition", and it's fundamentally about exposing what we are taking for granted in order to free ourselves from limiting assumptions – not in a random way, but in a way that is strongly informed by systems theory, which places a special emphasis on whose purposes and values matter, how boundaries are set to enable and constrain the innovation process, how the wider context contributes to or inhibits innovation, how the elements being organized within those boundaries are catalysed to facilitate the emergence of value, and (to return to the question of whose purposes and values matter) how that 'value' is perceived from different perspectives. Value creation from one perspective, using a narrow boundary judgement, might be value destruction from another perspective, using a wider boundary for analysis (Churchman, 1970). An example is when a stretch of rainforest is logged, which may be profitable for the logging company (and value can be added when the wood is made into furniture), but the reduction of irreplaceable biodiversity and the contribution to climate change are systemic side-effects that can be viewed as value destruction (Midgley, 2000).

Quist and Tukker (2013) talk about requirements for systemic innovation, focusing primarily on how multiple innovations can be coordinated and integrated across organizational boundaries in the context of transitions to greater sustainability at the global and societal scales. Following Argyris and Schön (1974), Quist and Tukker say that one of the key requirements is "double loop learning" (p.170). Single loop learning is when people find ways to improve an existing system without fundamentally changing the assumptions they are working with. In contrast, double loop learning is when the whole system needs to be changed and the learning is much more extensive because it is about rethinking fundamental assumptions. Quist and Tukker (2013) make the point that, if whole new innovation systems are to be conceptualized across organizational boundaries, and new values concerning sustainability are to prevail, then double loop learning is critically important.

Actually, systems thinking can help with *both* single loop and double loop learning. for single loop learning, there are systems approaches to improving the efficiency of service delivery and/or manufacturing processes (e.g., Ohno, 1978; Gregory, 2007; Seddon and Caulklin, 2007; Seddon, 2008; Ufua et al, 2017): essentially, these are aimed at innovating the relationships between the component parts of existing systems to remove waste, enhance performance and increase the emergent value, as defined by stakeholders. However, the utility of systems thinking really becomes apparent when applied to facilitate double loop learning (Flood and Romm, 1996a): it can revolutionise how value is defined if we rethink the boundaries of what matters using new value sets, and involve previously invisible stakeholders, and this can transform what is seen as a meaningful innovation.

A proviso, however, is that we need to appreciate the full implications of widening the boundaries we work with: as Lleras (1995) and Colvin et al (2014) show, it is all too easy to enable transformative systemic thinking in a local context, only to find that it is then out of step with the thinking in the wider organizational, policy or economic system, and innovations therefore meet resistance. There are systems thinking modelling tools that are useful for getting a better understanding of the wider systemic barriers to innovation, and these can help in the identification of leverage points for change: Bergman et al (2008) and Turner et al (2016) provide analyses of barriers in systemic innovation contexts using these kinds of tools. Generally speaking, however, widening the boundaries of people's thinking *has to involve widening the boundaries of who is considered a stakeholder and needs to be engaged* (Churchman, 1970; Ulrich, 1983; Midgley, 2000) if the innovations are to be implementable. If this is not possible in the short term, an evolutionary approach can be taken, where people look for

niches in which new systemic innovations can be embedded and flourish, and these can be scaled at a later date when tensions come to a head in the wider system, making the latter more receptive (Geels, 2005; Tukker et al, 2008; Karabeg, 2013).

So, having started to explain this fourth way of thinking about systemic innovation, and having begun to make the case for the utility of systems thinking, we will now dive more deeply into the latter to explain how its theory and practice has evolved since the 1950s. We will draw out the implications for our understanding of systemic innovation along the way. Afterwards, however, we will return to the other three definitions of systemic innovation and examine how a systems thinking approach could help their advocates tackle their main concerns. This is important because it is potentially disruptive to advocate for a minority understanding of systemic innovation (concerned with thinking systemically) just when the majority in our research community are beginning to settle on the idea that an innovation is systemic because it is generated by a real-world innovation system. If our new way of thinking is to be received positively, rather than being seen as an irritating irrelevance, we must be able to argue that it can add value for the majority of researchers in our community.

3. Systems Thinking

The first thing we need to clarify, before our deep dive into history of systems thinking, is that the field is very diverse and somewhat fragmented. This is partly because there has been an emphasis, since the 1950s, on the development of systems methodologies (and associated methods) to support management and policy intervention, and many of these methodologies make different philosophical assumptions about the world and our knowledge of it (Jackson, 1991a, 2000; Midgley, 1992a, 2000, 2001; Pretel Wilson, 2017). Nevertheless, despite this diversity, there has actually been an overall evolution in thought in the systems thinking research community, with two well established paradigm shifts taking place between the 1950s and the 2000s, even though some systems thinkers still cling onto older ideas (as Kuhn, 1962, made clear when he introduced the concept of 'paradigm' into the philosophy of science, the fact that some people stick with older ideas is to be expected). It will be useful to give an overview of this history, not least because the first paradigm shift that took place in systems thinking (moving from a focus on real world systems to *thinking in terms of systems*) is precisely the one that we believe is needed to rethink systemic innovation. Then the second paradigm shift will be reviewed because the first one proved to be inadequate on its own: both the older and newer ideas were relatively naive concerning power relationships and were limited methodologically. Systemic innovation researchers and facilitators can learn from the second paradigm shift too, so they don't fall into the same traps as systems thinkers did – we can launch a new view of systemic innovation that already starts where systems thinkers are now. While this will be a very brief exposition of the history of systems thinking, more detailed accounts can be found in Hammond (2003), who focuses on the early days; Jackson (1991a, 2000), who covers the rest of the 20th Century; Midgley (2000, 2003b), who brings us close to the present day; and Ramage and Shipp (2009), who offer a review of some key authors.

3.1. The early systems sciences

Systems thinking is a child of the systems sciences, and it has also been strongly influenced by cybernetics and complexity theory. It is noteworthy that these three scientific communities were in close communication back in the 1940s (Hammond, 2003; Midgley and Richardson, 2007). Systems scientists were trying to establish the foundations for a general theory of all open systems (e.g., cells, organs, organisms, families, organizations, communities, societies, planets, solar systems and galaxies) in order to transcend the specialised languages of the disciplines and reunite science, which

was perceived to be overly fragmented by arbitrary disciplinary boundaries (e.g., Boulding, 1956; Bertalanffy, 1956, 1968).

While it is self-evident that this grand reformation project did not reunite science in the mid-20th Century, the work of systems scientists has nevertheless fundamentally informed how we began to think of organizations, in subsequent years, as open, adaptive systems that thrive by generating value to meet community/customer needs and desires (Beishon and Peters, 1981), and of course we know that value can be added through synergistic partnerships in processes of innovation (Chesbrough, 2006) and co-production (Normann, 2001).

Alongside their colleagues in systems science, cyberneticians (e.g., Weiner, 1948; Ashby, 1956; Bateson, 1970) focused on how systems use feedback processes to self-regulate and adapt to their environments, and their work not only informed some important 20th Century understandings of organization (e.g., Beer, 1985), but also gave rise to information theory (Shannon, 1948; Shannon and Weaver, 1949), radical new theories of the mind (Bateson, 1972) and ultimately computing and artificial intelligence (Gefter, 2015). In a complementary strand of work, complexity theorists were particularly preoccupied by differentiating between simplicity (predictable causality), organized complexity (the domain of systems) and disorganized complexity (where patterns are difficult to find) (Weaver, 1948); and by articulating the generic properties of complex adaptive systems, including human organizations (Simon, 1962). This work would later inform a scientific revolution in our understanding of complex causality and the inherent unpredictability of complex adaptive systems that attracted several Nobel Prizes (for Simon, 1962; Prigogine, 1987; and Gell-Mann, 1994). It should be clear from these descriptions that the agendas of the three research communities were very closely related, and they were all talking about the development of theories of real-world systems.

It was in the 1950s that people first began to ask what the implications are of systems theory for management and policy intervention. A number of different systems methodologies for applied research and intervention were developed at this time, prior to any use of the term 'systems thinking'. Perhaps the four best known are *System Dynamics* (e.g., Forrester, 1961), a method for quantitatively modelling complex feedback processes and considering the impacts of changes to system relationships; *Systems Engineering* (e.g., Hall, 1962; Jenkins, 1969), an approach which focuses on the design of whole organisational systems, using quantitative methods, to meet given purposes in an optimal manner; *Systems Analysis* (e.g., Quade and Boucher, 1968; Optner, 1973; Quade *et al*, 1978; Miser and Quade, 1985, 1988), which helps in assessing costs, effectiveness and risk given multiple scenarios; and *Viable System Modelling* (e.g., Beer, 1959, 1966, 1981, 1985), which facilitates the diagnosis of organisational problems through comparisons between a real organisation and an ideal model derived from cybernetic and systems theories. Note that a key assumption of all of these approaches, which were widely applied between the 1950s and 1970s, is that it is possible to objectively model real-world complex systems (often using computers) and thereby predict the effects of different proposals for business strategy or government policy. There were clear implications for innovation, even though this word was hardly ever used by systems methodologists: potential strategies or policies could be creatively generated and then tested for their likely systemic effects, and these tests would go beyond the good intentions of those proposing them to include consideration of wider impacts on society and the environment (Forrester, 1961, 1969; Meadows et al, 1972).

3.2. The 1st paradigm shift: from real-world systems to ways of thinking in systems terms

However, this work came under sustained attack in the 1970s and 1980s: for some of the original critiques, plus later reviews of the debates, see Hoos (1972), Lee (1973), Lilienfeld (1978), Ackoff

(1979), Checkland (1981), Jackson (1991a), Midgley (2000) and Midgley and Richardson (2007). In a relatively short paper like this, it is impossible to cover every issue that has been discussed in the literature, so here we will focus on one particular critique that is very relevant to systemic innovation: the assumption of objectivity in modelling. There was often a failure to realise that 'the system' was being seen from a particular point of view, and in most systems analyses this was the point of view of the expert modeller and/or the paying client (Checkland, 1981; Jackson, 1991a). Unsurprisingly, gaps often appeared between the expectations of clients, modellers and other stakeholders. These approaches did not work well in situations characterised by multiple stakeholder perspectives because there has to be agreement on the nature and parameters of the issue to be addressed if modelling is going to be effective (Jackson and Keys, 1984). In the absence of this agreement, modelling can actually cause or exacerbate stakeholder conflict, as from some perspectives the model might be addressing the wrong problem or not accounting for the variables that matter (Midgley, 2000).

This is highly relevant to systemic innovation. As Ison (2016) argues, the assumption of objectivity brings with it certain dangers: if we see innovation systems as objective 'things', there is a tendency to take their boundaries, parts and/or interconnections for granted. This may "lead us down the wrong pathway from the start" (p.39) when it comes to innovation. Or, as Ulrich (1983) says, analysing how systems *ought to be* (or could be) in the eyes of stakeholders is as important as understanding what currently exists, and taking as immutable what currently exists can limit our innovation potential. There is a delicate balance to be struck here because stakeholders have to move to a future, more desirable state from where they are at present (Checkland, 1981), so the current situation should not be totally disregarded. However, understanding that 'systems' are always seen from a point of view, so the systems idea can be reconceptualised as a tool for thinking, is helpful for striking this balance because it reminds us to test our assumptions about what needs to be taken as given and what can and should be changed (Checkland and Scholes, 1990). While the term 'systems thinking' had already been coined a couple of decades previously, it was Checkland (1981) who used it explicitly in this new way and did a lot to popularise the term. The bottom line for systemic innovation is that, even if a researcher prefers to stick with one of the earlier definitions (concerning networks of innovations, governance of those networks, and innovation for sustainability), practice still inevitably involves multi-stakeholder co-ordination. It is not only the technical and organizational challenges that go with this that matter, but also stakeholder perspectives on the overall innovation initiative (and its contributory parts); whether it is responsive to their values; and whether the initiative might be seen as having positive or negative social or environmental effects. Using the systems idea as a thinking (or learning) tool helps here, as we can question what perspectives, boundaries, elements (e.g., participants and resources), relationships and anticipated emergent properties are most relevant in a systemic innovation initiative.

As a response to the attack on systems methodologies from the 1950s and 1960s, a new set of systems methodologies for intervention emerged in the 1970s and 1980s. Examples are *Soft Systems Methodology* (Checkland, 1981), which helps stakeholders compare systemic analyses of proposed transformations with people's perceptions of what those transformations aim to change; *Interactive Planning* (Ackoff, 1981), which asks stakeholders to innovate using an almost clean slate, encouraging consensus on far-reaching visions of change; *Interactive Management* (Warfield, 1994), which supports stakeholders in forming a consensual view of how their different understandings and desires for action can all contribute to an emergent change agenda; and *Strategic Assumption Surfacing and Testing* (Mason and Mitroff, 1981), which supports stakeholders in subjecting two or more alternative policies or business strategies to dialectical (oppositional) debate, from which an innovative new understanding may emerge. All these approaches are strongly participative

(implemented in multi-stakeholder workshops), compared with earlier ones which were more expert-driven, which makes them appropriate to use in 'living labs' (Eriksson et al, 2006; Niitamo et al, 2006) or 'change labs' (Vänninen et al, 2015).

Following this paradigm shift, some of the earlier methodologies from the 1950s and 1960s were thoroughly reconceptualised in the 1980s and 1990s to take account of multiple perspectives instead of assuming objectivity (e.g., Espejo and Harnden, 1989; Sterman, 1994; Vennix, 1999), and these authors displayed greater humility with respect to prediction: in response to some high profile failures to predict social dynamics and inform policy using computer models (Lee, 1973), the new generation of systems thinkers acknowledged that social systems are usually much too complex for detailed prediction, so the emphasis instead should be on *systemic learning* by stakeholders about the *possible* effects of different courses of action (e.g., de Geus, 1994; Sterman, 1994). One idea informing all these approaches is that it matters for stakeholders to participate as equals in the learning process, as nobody has a complete understanding on their own, and invariably solutions will require accommodations between stakeholders to facilitate co-ordinated actions across boundaries.

Most importantly, all the methodologies in this new generation embodied the idea that systems thinking is about *thinking in terms of systems*. However, this is not merely a move from objectivism to subjectivism. Checkland (1985) stresses *inter-subjectivity*, which is about the collective construction of meaning across stakeholder and organizational boundaries. This does not require consensus or a shared worldview – merely a willingness to find sufficient accommodations to enable co-ordination (Checkland and Scholes, 1990; Checkland and Poulter, 2006). The importance of inter-subjectivity (as opposed to subjectivity) cannot be over-stressed. All the methodologists associated with this new wave of systems thinking understood that emergent inter-subjective understandings, giving rise to possibilities for systemic innovation, do not arise in a vacuum: dialogue processes are needed to support people in getting to them; and to promote better systemic insight, these processes can usefully be informed by the systems idea (building systemic, mostly qualitative models, but understood as *explorations of possibilities for change*). Thus, both *the process and the thinking it enables* is viewed as systemic, rather than the real-world innovation system that participants might have been drawn from, and (in one way or another) all the methodologies discussed above help people in exploring different perspectives, evolving new purposes, rethinking boundaries and the value judgements giving rise to them, and delving into how actions need to be linked up systemically to deliver innovative emergent properties that add value.

'Value' here is understood in terms of transformations that are subject to two assessment criteria (Checkland and Scholes, 1990). The first is *systemic desirability*: the innovation must account for all interactions and effects that are important to the participants, so transformations that cause more problems than they solve, or have unacceptable side-effects, are avoided. The second is *cultural feasibility*: it must actually be possible to implement the innovation within the cultural and other constraints identified in the systemic analysis. While Mingers (1980, 1984) and Jackson (1982, 1991a) say that this second criterion is inherently conservative, acting to prevent radical, counter-cultural innovations, it should be noted that Checkland (1981) and Checkland and Scholes (1990) are clear that what counts as a cultural or environmental constraint is open to contestation by stakeholders, and indeed there are tools in their methodology for enabling this. Also, Checkland (1988) makes clear that, in practice, the facilitator plays an important role because he or she can ask questions that support people to think carefully about how to make counter-cultural innovations more feasible.

The central lesson for systemic innovation from this second generation of systems thinking approaches has already been discussed: the meta-cognitive use of the systems idea as a device to enhance critical thinking about what should be accounted for in defining value from an innovation process can help stakeholders reframe when they are 'stuck', and it can also help them anticipate possible negative consequences of proposed innovations as well as ones that constitute positive value. What hasn't yet been mentioned, however, is the opportunity to import the methodologies and methods discussed above (as well as others) into the practice of systemic innovation in industry and government. The literature on systems thinking includes literally thousands of examples of the successful use of systems approaches for innovation (mostly in the form of case studies of practice, with some methodological learning coming out of them that others can utilise), including many where the purpose was explicitly to co-ordinate across the boundaries of multiple organizations (e.g., Midgley et al, 1997, 1998; Gregory and Midgley, 2000; Taket and White, 2000; White, 2001; Kärkkäinen and Hallikas, 2006; Collins and Ison, 2010; Hale and White, 2014; Brocklesby, 2015). Interestingly though, the word 'innovation' itself is not used very much in the systems literature, with words like 'transformation', 'change' and 'improvement' being more common instead. It is one of the intentions of this paper to stimulate a productive dialogue across the innovation and systems thinking research communities.

3.3. The 2nd paradigm shift: understanding power relations and mixing methods

Just as the first generation of systems thinkers was criticised by the second generation, so the second generation was critiqued by a third in the 1980s and 1990s, and extending into the early 2000s. There were actually two different strands of work that evolved in parallel in these decades. The first was started in response to a bitterly entrenched paradigm war between the first and second generations (Dando and Bennett, 1981; Jackson and Keys, 1984), which threatened to split the systems research community: a large flurry of proposals were made for *methodological pluralism* (i.e., drawing creatively from both traditions, and reinterpreting their methods through new frameworks or guidelines for choice) to give us a more flexible and responsive intervention practice than either of the previous two paradigms (e.g., Jackson and Keys, 1984; Jackson, 1987a,b, 1990, 1991a,b, 2000, 2003; Oliga, 1988; Flood, 1989, 1990; Midgley, 1990, 1992a, 1996, 2001; Flood and Jackson, 1991a,b; Keys, 1988, 1991; Gregory, 1992, 1996a,b; Flood and Romm, 1996b; Mingers and Gill, 1997). The second strand of work focused on *power relationships* in systems practice: i.e., the consequences of a mistaken belief in the first generation that the systems modeller and/or the paying client know best, so solutions could either be imposed coercively or fail due to the absence of stakeholder buy-in (e.g., Churchman, 1970; Ackoff, 1979, 1981; Checkland, 1981; Ulrich, 1981; Eden et al, 1983; Rosenhead, 1989; Jackson, 1991a); and, in contrast, the consequences of a belief in the second generation that stakeholder participation in dialogue will allow the better argument to prevail, which ignores (or overly minimises) problems of coercion, groupthink, deceit, ideological framing and disempowerment (Thomas and Lockett, 1979; Mingers, 1980, 1984; Jackson, 1982, 1991a; Midgley, 1997a; Munro, 1999).

These two parallel strands of work were then integrated into a new Systemic Intervention approach by Midgley (2000, 2004, 2006, 2015), who recognised that the work on systemic power relationships could support deep diagnoses of the contexts in which we want to innovate, and these diagnoses could then inform the construction of interventions drawing creatively upon methods from both previous generations of systems thinking *and* from other traditions (e.g., the social and natural sciences). Below we will concentrate primarily on this later, integrated work and its implications for systemic

innovation, as this goes beyond the separate work in the two previous parallel strands. It is also still influential 17 years after its first introduction, and continues to be developed.

The Systemic Intervention approach makes three fundamental assumptions about the nature of the world and our place in it: first, everything in the world is either directly or indirectly connected with everything else; second, the complexity of this is so far beyond human understanding that we always have a partial view. It is partial in two senses: there are always boundaries defining what we consider relevant in any situation, and the setting of boundaries is strongly driven by value judgements, which are associated with our purposes, or what matters to us (Churchman, 1970; Ulrich, 1983, 1987, 1993; Midgley, 1992b, 2000; Cilliers, 1998). The third assumption is that intervention is unavoidable: everything we do (even when we refrain from doing something) has an impact on the world and/or our understanding of it (Midgley, 2000). Thus, all knowledge creation takes place in relation to a context of action to enable change. This is quite obvious in the case of much applied research for innovation, where the change context might be in industry, government or across more than one sector of society, but it is also the case for so-called 'pure' research, where the action arena is academia, and we want to intervene to change the debates that take place within it (Midgley and Ochoa-Arias, 2001). Let us now bring these three observations (interconnectedness, partiality and the inevitability of intervention) together to draw a critically important conclusion: because we act in relation to values-informed, bounded knowledge, and we can't avoid our action having impacts, it puts *ethical responsibility* (defined as explorations of, and choices between, values and their associated boundaries) at the heart of systems practice.

Earlier, when we were discussing the 4th definition of systemic innovation, we explained how the classic definition of a system (an organized set of parts, differentiated from their environment, giving rise to emergent properties that cannot be attributed to any one part, or sub-set of those parts, in isolation) is enhanced by recognition that system boundaries are meaningful in terms of human purposes and values. The Systemic Intervention approach recognises that the boundary idea (which is always associated with values) is actually the *most fundamental* of the systems concepts (Midgley, 2000), for two reasons. First, the vast majority of our experience as human beings is 'given' to us by our perceptions; we make thousands of distinctions at any moment in time without consciously having to think about them, giving rise to the experience of a concrete, real world around us (Maturana and Varela, 1992; Mingers, 1995). The framings we use to make sense of this world (or what Senge, 1990, calls 'mental models') are a part of this unconscious distinction-making, which is what makes reframing so hard for people if they have no tools to support them. The boundary concept, perhaps more than any other element of the systems idea, is a useful tool for conscious reframing because it can allow us to systematically ask what interactions we are leaving out of our understanding; who might see things differently; what values might impel the use of a different boundary; and what the consequences would be of changing this boundary. The second reason why the boundary concept is arguably more fundamental than the other systems concepts is that the perspectives, parts, wholes, interactions and emergent properties that we are aware of are always dependent on a prior conscious or unconscious boundary judgement (Midgley, 2000). As Ulrich (1983, 1988) and Midgley and Ochoa-Arias (2004) make clear, no view of the world is comprehensive (all perspectives are bounded), but we can paradoxically achieve *greater* comprehensiveness by exploring different possibilities for making boundary judgements than we can by taking any one boundary for granted.

The value of the boundary concept to systemic innovation practice has already been recognised by Gibbert and Välikangas (2004) and Välikangas and Gibbert (2005), who talk about how boundaries simultaneously enable and constrain human activity (also see Cilliers, 1998; Juarrero, 1999; and Midgley, 2000). This is a vitally important observation: one reason why reframing is so difficult when

organizations hit problems is that boundary judgements get taken for granted and entrenched precisely because they have been historically enabling, and nobody has had to seriously question their utility before. In the 'fuzzy front end' of the innovation process (Takey and Carvalho, 2016), if innovators are 'stuck' in their attempts to identify a potential innovation, the boundary concept can help by raising questions about who to involve and what issues to consider, and then the other systems concepts (concerned with identifying parts of the system and their necessary interactions) can be brought on stream to support the implementation of a new vision of innovation.

A consequence of realising that boundaries are enabling is that we need to challenge the familiar metaphor of 'transcending' boundaries, as if, once we have broken a constraint, we are absolutely free (for examples of the use of this metaphor, see Mitroff and Linstone, 1993, and Wilber, 2001). When we reframe, *we do so by adopting another boundary that is informed by different values and enables a new (innovative) pathway for action*. This is so important, not just because it tells us that explicitly redrawing boundaries is useful for innovation (Välikangas and Gibbert, 2005), but also because of the inescapable connection between boundaries and values. The metaphor of transcendence encourages a suspension of critical thinking once we have broken a constraint, and this is potentially dangerous: we reframe using a new set of values, and our understanding remains partial, even when transformed. Thus, it is important to make the new values explicit to avoid the complacency that can come with the success of reframing, as the new values may themselves carry problems we are not yet aware of. While comprehensive analysis of the limitations of boundaries and values is impossible (Ulrich, 1983), being explicit about them, and the actions they enable, is the first step to openness to new questions and further possibilities for innovation. This is all about *ethical responsibility*: because all boundary judgements come with associated value judgements, a key question is 'what matters, and why, over what timeframe, and from whose perspective?' Also see Helfgott (2017).

We can provide an example of questioning boundaries from our own practice. The first author was involved in a consultancy with the senior management team of a national public water company that was about to be privatised and split into 9 regional companies. We were asked to help explore if there could be a role for a public sector body to serve the new companies after privatization. The managers' values were all concerned with the business model in the new reality and their own survival in the public sector. Realizing that water is an ecological resource, we argued for an independent ecologist to join the discussions with the senior management. This was a widening of the boundaries of participation and would potentially introduce new values, but we did not know what might emerge as a result. After a fruitless first day of exploration, when the senior managers continued to operate with their business framing, the consultants consciously broke that constraint by introducing the ecological boundary and associated values. The ecologist explained how all the rivers in the country are linked by underground aquifers (which the senior management were unaware of). There was a sudden realization: if one company were to allow water quality to fall to unacceptable levels, it would affect the operations of all the other companies. The need for an independent body to oversee the monitoring of water quality became clear, and one way to ensure independence from the companies' operations was to make it a public sector organization.

The relationship between value and boundary judgements, first proposed by Churchman (1970) and then elaborated by Ulrich (1983) and Midgley (1992b), is captured in Figure 1 (the peak represents the values and the oval represents the boundary of what is seen as relevant): it is a two way relationship because values direct the drawing of boundaries concerning what is viewed as relevant and who is considered a legitimate stakeholder, but previously given boundaries that have become taken for granted can constrain the set of values that it is legitimate to express. This is why it's so

important to explore *both* boundaries and values, as tacit restrictions on thought in relation to either one of them can be challenged with a focus on the other.

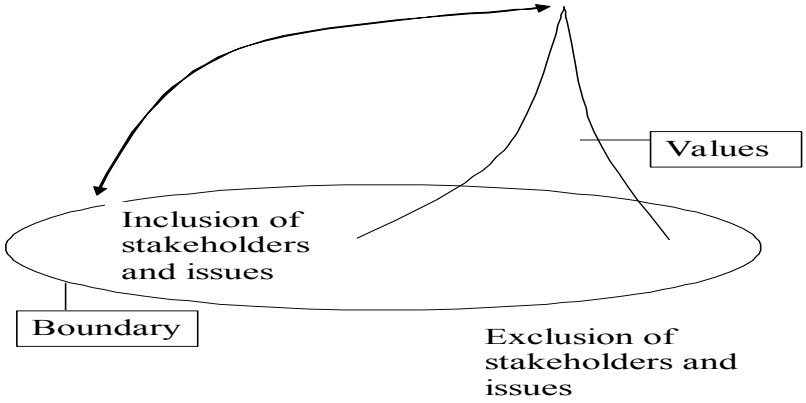

Figure 1: Basic relationship between values and boundaries.

The diagramming convention in Figure 1 can then be extended to help us understand both conflict and marginalization processes. Starting with conflict, we see that it can be conceptualized as stakeholder groups operating with divergent values but overlapping boundaries, so a phenomenon of interest to both is framed differently by the two sides (Figure 2) (Midgley, 2000; Yolles, 2001). When conflict becomes entrenched, the stakeholders end up stereotyping or demonising each other (Figure 3). Issues of identity come to the fore (also see Midgley et al, 2007). Figure 3 is helpful because it tells us that there are three potential approaches that can be used to address conflict and turn a destructive or unproductive situation into one in which synergistic innovations can emerge: interveners can work to transcend narrowly conceived values; draw causal connections between elements in the two sets of boundaries so that everybody ends up working with a wider system boundary; and/or challenge stereotypes (Midgley, 2016).

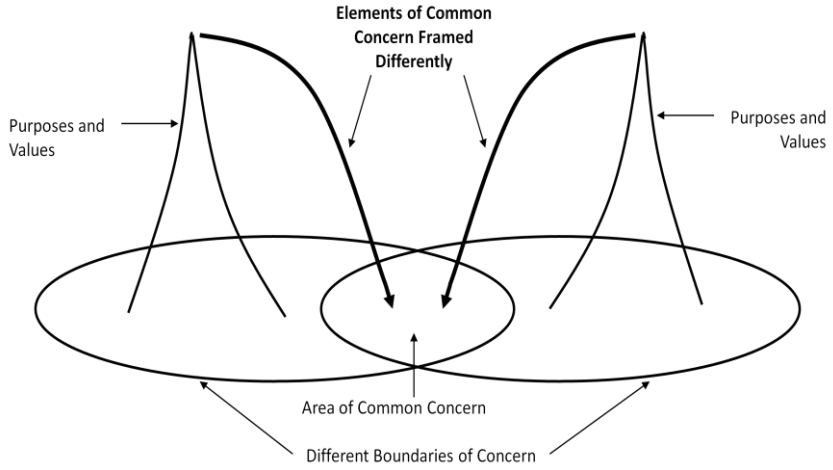

Figure 2: Conflict, with the elements of common concern framed differently (from Midgley, 2016)

While it is often claimed that stakeholder conflict is a resource for innovation (Yolles, 1999; Stacey et al, 2000; Sword, 2007; Andrade et al, 2008), we observe that this is only the case if the conflict can be handled productively. Thus, knowing how to turn an unproductive conflict into a productive one (in the sense that the participants can identify new innovations that address or transcend their competing concerns) is vitally important. Systems thinking can help with this, and for some examples from our own innovation practice, see Foote et al (2007) and Midgley (2016).

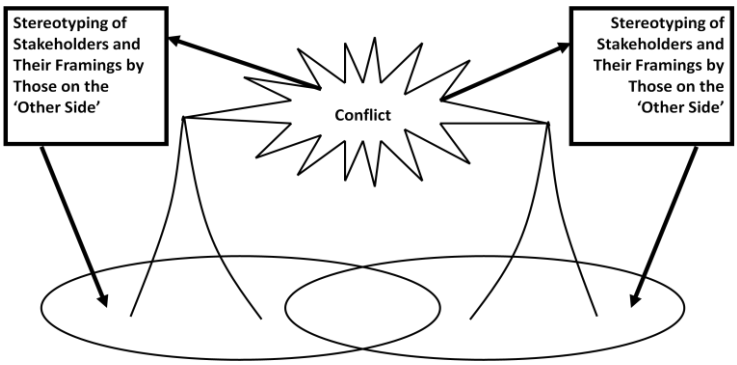

Figure 3: The addition of stereotyping to the model of conflict (from Midgley, 2016)

The diagramming convention in Figures 1, 2 and 3 can also be used to conceptualize *marginalization*. Figure 4 shows how one stakeholder group can draw a narrow boundary while another group can draw a wider boundary. This brings the values being pursued by the two groups into conflict. The people or issues in the margins (between the two boundary judgements) then become the focus of conflicting interpretations: those wanting to draw a narrow boundary will interpret whatever or whoever is in the margins as *profane* (marginal elements need to be derogated so they can justifiably be ignored in the work of organizations); and in consequence, those drawing a wider boundary will view whatever is in the margins as *sacred*, as they want to point out the importance of the marginal people or issues. The words 'sacred' and 'profane' are not used in a religious sense, but to indicate the strength of feeling that goes with these attributions. What is more, one or other of these attributions often becomes solidified through the use of organizational rituals, making it dominant over the other. An example that has been discussed in the literature (e.g., Midgley, 1992b, 2000) is unemployment: the unemployed are in the margins between a narrow boundary defining employees and a wider one defining citizens capable of working, and they are subjected to exercises that are widely experienced as ritual humiliation (being forced to 'sign on', attend job application workshops, do workfare, etc.). Another example is environmental issues that are routinely marginalized because if industrial organizations were suddenly required to account for all their side-effects and externalised costs, their profitability could be seriously undermined, and indeed our whole economic system could go into crisis (Midgley, 1994).

This is important for systemic innovation in three ways. First, marginalization processes can reinforce innovation-limiting boundaries and values, making them very difficult to challenge. If a potential innovation is associated with an issue that an organization (or network of organizations) is unconsciously colluding in marginalizing, it may be resisted, even if it could bring significant financial, social and/or environmental benefits. The identification of marginalization, and conscious action to address it, especially in 'fuzzy front end' innovation initiatives, is therefore necessary.

Indeed, the importance of 'deviant' ideas is well recognised in the innovation literature (Collm and Schedler, 2014).

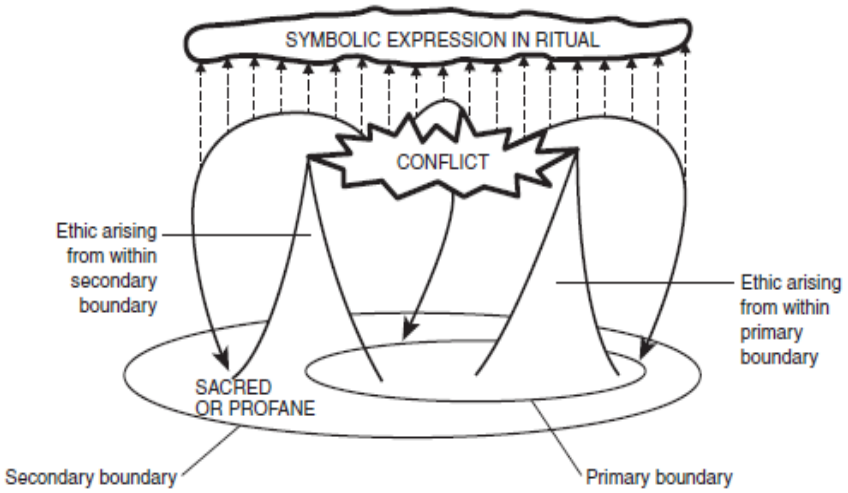

Figure 4: Marginalization (from Midgley and Pinzón, 2011) (note: the word 'ethic' has been used in this diagram instead of 'value' because the authors defined ethics as values in action, and the purpose of this theory of marginalization was originally to inform systemic action research).

The second sense in which marginalization is important is in relationships between partners in innovation systems. If there is a dominant player (and Bröring, 2008, argues that there usually needs to be if a systemic innovation system is going to be successful, because co-ordination is essential), there can be a tendency for them to prioritise narrow self-interest and start to marginalize other participants. One of us witnessed this in a supply chain innovation project where the dominant industrial partner initially supported its suppliers in co-ordinating innovations to meet their collective needs. As the product line became successful, the suppliers were then given incentives to drop other customers and solely supply the central company. After the network of suppliers had been made dependent, the company then aggressively cut what they were willing to pay them, reducing the profit margins of the suppliers by an average of 75% and commensurably increasing their own profits. However, they did not anticipate an economic downturn, and the now-fragile supply chain collapsed, dragging the dominant company down with it. Tensions between narrow self-interest and wider, 'enlightened' self-interest in systemic innovation initiatives may spawn marginalization dilemmas, and these are useful to identify and explicitly address in advance of these sorts of problems manifesting themselves.

The third and final way in which marginalization is important to systemic innovation is within organizations, when the latter are attempting to balance the continued delivery of current products or services (maintaining the revenue flow) against the need for new innovations to initiate the next product or service lifecycle. When there are competitions for resources between day-to-day delivery and innovation, this can generate marginalization. The authors recently worked with a large multinational engineering company where this was a significant problem. Their current products were generating diminishing returns, and the senior management was aware of the importance of innovation, but there was a dynamic within the company that pitted those with a 'technology' focus

against those with a 'service' orientation. The view of the Innovation Unit within the company was that the next cycle of innovations would come from using a 'service dominant logic' (Vargo and Lusch, 2004, 2008), while those trying to maintain the profitability of production in an increasingly competitive market thought the answer was maintaining their traditional focus on new technology embodied in products. Given that the large majority of employees were technology orientated, this put the Innovation Unit in a marginal position. The situation was further complicated by a strategic plan that mandated the top down selection of innovations for investment, while the Innovation Unit were pointing out that nearly all past profitable innovations had come from 'skunk works' (the curiosity-driven activities of scientists and engineers, undertaken outside the boundaries of organizationally sanctioned projects). Thus, the Innovation Unit was doubly marginalized; for their view of where innovations would come from *and* for their disagreement with the strategic plan. The production managers and the innovation managers were clearly caught up in a sacred/profane dynamic, with the Innovation Unit continually repeating a self-defining narrative that can only be described as a 'tragedy of enlightenment' story – one where they thought that only they could see what was needed to rescue the future of the company, and others were unwilling to listen. In the three years that we worked with the Innovation Unit, it was restructured twice, with roles changed and key individuals transferred elsewhere, which seriously compromised its delivery of new innovations, thus fulfilling the prophesy of failure made by those wanting to preserve the status quo. It is vital to identify the potential for these kinds of destructive dynamics and improve mutual understanding across functions within organizations, so everybody understands how necessary differences in values and boundaries link to important differences in roles.

Exploring multiple possibilities for making value and boundary judgements, transforming entrenched conflicts into generative discussions and diagnosing and rectifying issues of marginalization can all liberate the potential for innovation, remove 'innovation taboos' and ensure constructive participation across inter- and intra-organizational boundaries, as we have seen. However, the Systemic Intervention approach also advocates *methodological pluralism*: mixing methods drawn from a variety of methodological sources (whether originally associated with systems thinking, in its various guises, or not) to create a highly flexible intervention/innovation practice (Midgley, 2000, Midgley et al, 2017).

It is beyond the scope of this paper to review multiple systems methods and their utility for different aspects of the innovation process (that would require a whole book). Also, there is a limit to the production of rules for choosing methods because each innovation context is different, which is why Midgley (1990, 1997b,c, 2000) emphasises the "creative design of methods" (Midgley, 2000, p.217) in response to an analysis of the specific context, and especially the relationships between stakeholders. However, we would like to reflect on one generic issue concerning methodological pluralism of particular relevance to systemic innovation:

Let us take the traditional conceptualisation of innovation as a process which progresses from an initial exploration of ideas through to resourcing, testing and then implementation (Chesbrough, 2006), with a later phase of organizational development to support scaling and expansion (Brown, 2017). However, in working with this idea, we reject the common assumption that the 'initial exploration' has to be done by technologists within a single organization: multiple stakeholders and/or organizations can potentially be involved, as in the practice of 'living labs' (Eriksson et al, 2006; Niitamo et al, 2006) or 'change labs' (Vänninen et al, 2015). Also, along with Godin and Lane (2013), we challenge the idea that most innovations are generated by scientists (science can be influential, but so can non-scientific disciplines and perspectives, either instead of, or alongside, science). Finally, following Chesbrough (2006), we reject the 'funnel' metaphor, where thinking can initially be wide

(in terms of both ideas and stakeholders) but, as we progress to implementation, the innovation is conceived much more narrowly and is implemented by a single organization. Rather, innovations can involve networks of stakeholders throughout the whole process, including the eventual delivery of innovations in the form of products, policies and services (Normann, 2001; Chesbrough, 2006). Keeping these three caveats in mind, there is nevertheless a substantial difference between the kinds of methods that might be required for the 'fuzzy front end' phase of systemic innovation; the 'firming up' phase, when organizations have to explore how best to distribute investments, responsibilities, risks and benefits; the 'delivery' phase, when capabilities are being utilized in a co-ordinated manner to deliver value (variously defined by the different stakeholders); and the scaling and expansion stage. At the 'fuzzy front end', explorations of boundaries, purposes and values (already discussed) are essential, and various systems methods for this can be brought on stream (e.g., Ulrich, 1983; Cohen and Midgley, 1994; Midgley et al, 1998; Boyd et al, 2004). Once it comes to bringing together the intellectual property, investments, resources and activities of innovation partners to assess the viability of delivering upon an innovation, methods from other approaches that are much more focused on the systemic co-ordination of activities (acknowledging different perspectives) will be useful (e.g., Wilson, 1990; Checkland and Poulter, 2006; Wilson and van Haperen, 2015), in addition to disciplinary knowledge (e.g., from Law, Finance, Management and Engineering). Then, when it comes to refining the collaboration during the implementation or delivery of an innovation, methods concerned with improving the efficiency and effectiveness of workflow processes (e.g., Ohno, 1978; Gregory, 2007; Seddon and Caulklin, 2007; Seddon, 2008; Ufua et al, 2017) may come to the fore. Finally, when the structure and communications of an organization need to be reviewed to support scaling and expansion, the Viable System Model (Beer, 1985), discussed earlier, can help with this. Here, the analysis of conflict and marginalization processes may also be useful because often tough choices face organizations when they start to scale innovations, as they may not have the resources to simultaneously maintain the delivery of older products and services while also investing in the growth needed for expanding upon the delivery of the new innovation (Brown, 2017).

In addition, if this systemic innovation process is taking place in the context of a national or regional innovation plan, then methods for exploring purposes, values and boundaries are useful for actually creating the plan; and the Viable System Model can be useful for co-ordinating the organizational delivery (Devine, 2005). It is then within this that specific product, service or policy innovation processes can be embedded.

The logic of the methodological progression expressed in the last two paragraphs is very important (Boyd et al, 2007): if we want to keep the idea of ethical responsibility at the heart of systemic innovation, which the systems theory discussed earlier calls for (Ulrich, 1983; Midgley, 2000), then we need to move from highly creative and inclusive explorations of values and boundaries through to the detail of implementation, dealing with issues of power, conflict and marginalization along the way, always with the possibility of iterating back to values and boundaries again if something that had previously been taken for granted becomes problematic (Córdoba and Midgley, 2006, 2008).

4. Redefining Systemic Innovation

As discussed earlier, this understanding of systems thinking is current, and (in our view) it provides a good basis to inform systemic innovation theory and practice. There are two reasons. First, it offers a systems theory of how multiple perspectives, power, conflict, identity and marginalization play out in stakeholder relationships (e.g., Midgley and Pinzón, 2011), which is important because these things have been identified as significant barriers to systemic innovation (e.g., Brown and Duguid, 2001; Moodley and Morris, 2004; Andersen and Drejer, 2008; Chiesa and Frattini, 2011; Lehtinen, 2011; Li

and Zhong, 2011; Turner et al, 2016). However, the systems thinking literature offers more than just a way to understand them: it also offers a wide range of methods for intervention to address them and "liberate" (Flood, 1990) the potential for innovation. If we embrace methodological pluralism, we can include the best methods from all forms of systems thinking within our systemic innovation tool kit, alongside more commonly deployed methods for innovation and management, providing a flexible and responsive resource to innovation facilitators.

We can now move to formulate a new definition of systemic innovation, based on the foregoing discussion. At its most basic, *a systemic Innovation is one that emerges from a process that supports innovators and their stakeholders in using systems concepts to change their thinking, relationships, interactions and actions to deliver new value*. The definition of stakeholders needs to happen within that same process.

It should be noted that this definition breaks from the idea that systemic innovation is solely "the type of innovation that only generates value if accompanied by complementary innovations" (Takey and Carvalho, 2016, p.97), which is the most commonly used previous definition stemming from the works of Teece (1986) and Chesbrough and Teece (2002). These authors use the word 'systemic' to indicate the presence of an innovation system, and we have argued, in contrast, that there is value in concentrating on *the design of methodological processes to support the systemic thinking of innovators.* This is not to say that systems thinking lacks utility for understanding and developing innovation systems (far from it – see the next section); rather, we want to emphasise the use of the 'systems idea' as a tool for critical thinking so innovation facilitators do not fall into the trap of taking for granted the boundaries, parts and/or interconnections in innovation systems, making them appear immutable and limiting the potential for innovation.

In operationalising this definition, innovation facilitators can take advantage of the following:

- The network of stakeholders to be involved in a systemic innovation can be decided through stakeholder analyses (e.g., Mitchel et al, 1997; Ackermann and Eden, 2011), and the boundaries of participation can shift over time (although they will generally become firmer the closer the participants get to delivering value). New participants bring fresh knowledge and the potential for new synergies.
- Systemic innovation has ethical responsibility at its heart, understood as the conscious and participative exploration of multiple boundaries and values of potential relevance to the innovation, which can support reframing and counter resistance to change while making participants more aware of their economic, social and environmental responsibilities.
- It offers theory and methods to understand and intervene in conflicts and processes of marginalization when any of the following three conditions apply:
    - Overcoming conflict or marginalization is judged to be ethically necessary;
    - Addressing a particular conflict or marginalization is the reason for innovating; or
    - Conflict and/or marginalization are barriers to innovation.
- It offers a range of methodologies and methods to support all aspects of the innovation process, including:
    - Exploring purposes, values, boundaries, stakeholder perspectives and the construction of innovation processes at the 'fuzzy front end' (e.g., Ulrich, 1983; Midgley, 2000);
    - Reforming or designing organizations (e.g., Beer, 1985), meta-organizational co-ordinations (e.g., Midgley et al, 1997, 1998; Lowe et al, 2016) and policy governance systems (e.g., Devine, 2005);

- Visioning far-sighted innovation futures (e.g., Ackoff, 1981; Ackoff et al, 2006; Christakis and Bausch, 2006);
- Participatively developing, comparing and evaluating alternative innovation proposals (e.g., Mason and Mitroff, 1981; Checkland and Poulter, 2006);
- Refining and enhancing value in the process of its delivery (e.g., Ohno, 1978; Gregory, 2007; Seddon and Caulklin, 2007; Seddon, 2008; Ufua et al, 2017); and
- Evaluating systemic impacts (e.g., Gregory and Jackson, 1992a,b, Boyd et al, 2007; Williams and Imam, 2006; Reynolds et al, 2016).

This is a logical progression from idea exploration through to delivery and evaluation, and while not all systemic innovation initiatives will require all of these aspects, methodologies and methods for them are available if required.

5. Integrating the Systemic Intervention Field

We started this paper by explaining the four different definitions of systemic innovation that have been discussed in the literature, and have advocated for the one that is most recent and (so far) the least used. We also mentioned the need to show that our approach can add value to the work of those who are using the other three definitions of systemic innovation. We will therefore revisit these below, and through our analysis we will point to the possibility that, if widely accepted, a systems thinking approach can integrate as well as enhance our field.

5.1. Rethinking innovation systems

The first and most commonly used definition is the one referred back to in Section 4: the word 'systemic' refers to the existence of an innovation system that enables the co-ordination of multiple innovations across organizational boundaries (Teece, 1986; Chesbrough and Teece, 2002; Takey and Carvalho, 2016). While we earlier described our definition of systemic innovation as a break from a sole focus on innovation systems, it does not make innovation systems irrelevant. On the contrary, we have emphasised the utility of the systems *idea* to inform the design of innovation processes that can support participants in thinking systemically, and the purpose of this, for someone interested in facilitating the development of an innovation system, is to enable them to keep an open mind about the boundaries that could be set for both the participation of stakeholders and the issues and technologies to be engaged with. Systems thinking can also help people to remain open to different purposes and values that might be relevant; it can support managers in the design of multi-organizational structures and communications; and it can provide collaborative methods to aid *self*-organization among diverse organizational participants. We therefore argue that systems thinking can *add value* to the practice of working with innovation systems.

There is an interesting paradox here. Our definition of systemic innovation implies that the co-ordination of innovations across multiple organizations is not its defining feature, and indeed systems thinking is potentially relevant to so-called "autonomous innovations" (Takey and Carvalho, 2016, p.97) in single organizations too, given that even these have to be used in a context, so they are not *strictly* autonomous. However, if we bring systems thinking to bear to explore the context of any potential innovation, this will generally involve sweeping in stakeholders so that they become possible participants in the innovation initiative, and the ultimate outcome is therefore more likely to be the evolution of an innovation system. De-emphasising innovation systems in favour of systems thinking in our definition of systemic innovation could actually increase the emphasis on, and success of, innovation systems!

5.2. Rethinking policy and governance systems

For those who define systemic innovation in terms of the development of policies and governance structures to set enablers and constraints on the operation of (usually regional or national) innovation systems, the kind of systems thinking we have described can also add value. Earlier we mentioned the Viable System Model (VSM) (e.g., Beer, 1985; Espejo and Harnden, 1989; Hoverstadt, 2008; Espejo and Reyes, 2011; Espinosa and Walker, 2013) as a particularly useful tool for informing the development of inter-organizational co-ordination, management, foresight and governance structures. Following Devine (2005), we repeat this recommendation, but wish to add a caveat: a model like the VSM is good for enhancing the viability of organizations and multi-organizational clusters, but has nothing to say about the ethicality of the purposes that those organizations and clusters serve, other than to claim that an organization must fulfil needs or desires in its environment if it is going to survive or thrive. As Ulrich (1981) points out, some human desires could be considered unethical, or their fulfilment could have unwelcome side-effects. It is for this reason that, in our own practice (e.g., Midgley et al, 1997, 1998; Boyd et al, 2007), we only use the VSM following a stakeholder engagement exercise to support a systemic analysis of the purposes, values and boundaries that an organization or innovation cluster should be working with. Also, 'stakeholders' in this context are not just those people who are *currently* involved in or affected by the activities of an innovation initiative, but also those who might be affected in future if the activities change. Thus, the boundaries of stakeholder engagement can evolve along with the reflections of those developing the innovation initiative.

Not only can this ethical focus (alongside use of the VSM and other methods) add value to the development of meta-level governance systems to support regional or national innovation, it is also relevant in support of the kind of innovation geared towards societal change, and particularly ecological sustainability:

5.3. Rethinking 'game-changing' innovation, particularly in the context of sustainability

The third kind of systemic innovation, which aims to bring about societal shifts (including new enablers and constraints on the ethical direction of future innovations), can clearly be enhanced through the application of systems thinking discussed here, as the latter has the notion of ethical responsibility at its heart. Societal systems are exceptionally complex, and when co-ordinated attempts are made to transition to new arrangements (e.g., renewable energy replacing fossil fuels), the ramifications beyond the issue in focus can be unpredictable. It is notable that ecological sustainability at the global scale has interactions with many other 'wicked' policy problems (to borrow a phrase from Rittel and Webber, 1973), forming a 'global problematique' (Meadows et al, 1972; Slaughter and Riedy, 2009) where changes in one domain will impact on many others. In such a situation, the dangers of uncritical thinking about the consequences of innovation are acute, and with interconnected issues like climate change, wealth distribution, population growth, public health, food production, water availability, etc., the stakes are particularly high. Therefore, using the systems idea to inform processes of engagement to enhance systems thinking will be particularly useful in terms of raising awareness of the relevance of multiple values, boundaries, interconnections and both actual and potential feedback effects. Indeed, the literature on systems thinking for sustainability is large and rapidly growing (e.g., Clayton and Radcliffe, 1996; Meadows et al, 2004; Ison, 2010; Espinosa and Walker, 2011; Higgins, 2015).

The vision of systems thinking we have presented here will arguably add value in the context of systemic innovation for sustainability as much as, if not more than, others that are already being well

used in this domain (e.g., Meadows et al, 2004) because we know that there are systemic barriers to change (e.g., Kang and Hwang, 2016), with vested interests reinforcing these, so understanding power relations, conflict, marginalization and how to respond to these is highly pertinent (e.g., Ulrich, 1993; Midgley, 1994; Ison, 2010).

6. Conclusion and Final Reflection

We have argued that we should understand systemic innovation as the use of processes that draw upon the systems idea to support innovators and their stakeholders in systems thinking. While this contrasts with the other three definitions that people have been using in recent years, it does not undermine our appreciation of the characteristics of innovation systems, the governance of innovation or innovation in the context of societal transitions. On the contrary, it can enhance research and practice in all these areas by deepening our appreciation of 'systems' and by providing concepts, methodologies and methods to support critical thinking and ethical responsibility. In this sense, we suggest that our approach to systemic innovation can help to integrate the field, providing a systems language and concepts to support the cross-fertilization and further development of the mostly separate agendas being pursued in association with all three of the other definitions of systemic innovation.

Here, we have written a largely conceptual paper based on our separate and joint experiences of developing the theory and methodology of systems thinking (1st author) and innovation (2nd author) in the context of three decades of practice. We are engaged in on-going collaborative research, and the next stage of this will be to dive more deeply into practice once again. We suggest that three approaches to practice are needed in future research. First, it is possible to mine the thousands of case studies of systems thinking employed in the service of organizational, social and environmental change that have been published without the 'innovation' keyword, with a view to drawing out further lessons for systemic innovation facilitators and researchers. Second, given that this paper is the first to bring the Systemic Intervention approach (and other systems thinking methodologies and methods that can be drawn upon when applying it) to the attention of those interested in systemic innovation, there is a need for others in the latter field to independently test the utility of these ideas and publish the results. For this purpose, the evaluation of methods will be essential (White, 2006; Midgley et al, 2013). Our expectation is that evaluations will reveal both further insights to enhance systemic innovation, and issues (such as barriers to using particular systems ideas and methods) that have to be addressed through new conceptual and methodological innovations. While systems thinkers generally pride themselves on the development of generic concepts that are transportable across application domains (see Midgley, 2003a, for examples), our experience is that adaptations are usually necessary, and the types of context that systemic innovation facilitators and researchers work in are exceptionally broad, covering all sectors of society and their interactions. We therefore look forward to the further evolution of these ideas as they extend into systemic innovation theory and practice.

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