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Time for a Paradigm Shift: From Economic Growth and
Price-Making Markets to Social Ecological Economics

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From Economic Growth and Price-Making Markets to Social Ecological Economics¹

by

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Abstract

Ecological economics has ontological foundations that inform it as a paradigm both biophysically and socially. It stands in strong opposition to mainstream thought on the operations of the economy and society. The core arguments deconstruct and oppose both growth and price-making market paradigms. However, in contradiction of these theoretical foundations, ecological economists can be found who call upon neoclassical economic theory as insightful, price-making and capitalist markets as socially justified means of allocation and economic growth as achieving progress and development. The more radical steady-state and post-growth/degrowth movements are shown to include confused and conflicted stances in relation to the mainstream hegemonic paradigms. Ecological economics personally challenges those trained in mainstream theory to move beyond their orthodox education and leave behind the flawed theories and concepts that contribute to supporting systems that create social, ecological and economic crises. This paper makes explicit the paradigmatic struggle of the past thirty years and the need to wipe away mainstream apologetics, pragmatic conformity and ill-conceived postmodern pluralism. It details the core paradigmatic conflict and specifies the alternative social ecological economic paradigm along with a new research agenda.

Keywords

Paradigm shift; Economic growth; Markets, Price, Value theory, Social ecological economics, Steady-state economics, Degrowth, Post-Growth, Capitalism, Neoclassical economics, Socialism

JEL: A11, A12, A13, A14, B29, B50, D40, D46, D62, O44, P1, P2, P16, P28, Q56, Q57

¹ A version of this discussion paper will appear in the journal *Ecological Economics*.

1. Introduction

Can ecological economics be described as having a core set of ideas around which the knowledge base is constructed? What are the key *problématiques* that are being addressed? How should ecological economists go about addressing them? What are the objects of study for ecological economists? Answers to these types of questions define a paradigmatic field of knowledge (see Appendix A). Despite different initial visions and the emergence of distinct camps, considerable progress has been made in providing answers and identifying a paradigmatic core for ecological economics. Incompatibility with mainstream economics is fundamental, not least on ontological grounds, which include the implications of biophysical reality for energy and material flows and the operation of economic and social systems.

The foundational critiques of economic growth, based on physics as advanced by Georgescu-Roegen (1971), stand in opposition to the macroeconomic growth paradigm and its belief in human progress through competition, innovation, technology and capital accumulation. The incorporation of ecological concepts and understanding of ecosystems add to this physically based critique of economics and emphasise that quality, not just scale, of throughput must be addressed (Spash and Smith 2019). How Nature and society are interrelated raises issues of non-monetary valuation, plural values, incommensurability and alternative meta-ethical systems (O'Neill, Holland, and Light 2007); all of which challenge neoclassical price theory (Kapp 1978 [1963]). Ethics and value theory are central to economic understanding, not a problematic normative add-on to a naïvely objective, positivistic science. On the social science side there are a variety of contributions standing in opposition to the mainstream, including psychological theories of motivation, feminist insights into exploitation, critical institutionalist approaches to markets, and Marxist theories of social relations of production.

The unifying call is for a new economic paradigm (Spash 2011; Gowdy and Erickson 2005), with a variety of suggested formulations including steady-state (Daly 1992), degrowth

(Kallis, Kerschner, and Martinez-Alier 2012; Martinez-Alier et al. 2010), post-growth (Jackson 2009a; Paech 2017), eco-socialism (Burkett 2006; Douai 2017) and ecofeminism (Salleh 2017; Perkins 1997; Perkins and Kuiper 2005). Society President, Joshua Farley, makes explicit that steady-state economics refutes the key assumptions upon which neoclassical economics (NCE) is built (Farley and Washington 2018: 447) and the need to “move away from NCE” (ibid: 446). However, the move beyond neoclassical economics has been hesitant and incomplete. Those trained in neoclassical theory continue to teach and use it as the central reference point for understanding the economy, while non-economists do likewise for pragmatic reasons, simply because of its paradigmatic dominance. What could help here is to clarify the paradigmatic revolutionary struggle in which ecological economists are engaged.

A core radical aspect of ecological economics is the rejection of the growth paradigm (a term attributed to Daly 1972). The work of Georgescu-Roegen (1971, 1995 [1979], 2009 [1975]) forms a key reference point, but as part of a larger growth critical economics literature of the 1970s (e.g., Meadows et al. 1972; Hirsch 1977; Schumacher 1973; Scitovsky 1976; Daly 1973). This literature signalled the end of the post-War unquestioning commitment to growth, but not its dominance as an economic goal (Schmelzer 2015: 268). By the 1980s, amongst economists, Herman Daly was holding the anti-growth fort almost single-handed, until the rise of modern ecological economics. The 2008 crash brought growth and capitalism under more widespread economic critique again. However, today, capital accumulating growth rhetoric remains strong. For example, in 2019 over 3000, mainly American, economists, including twenty-seven Sveriges Riksbank (‘Nobel’) Prize winners, endorsed a ‘carbon tax’ because “[s]ubstituting a price signal for cumbersome regulations will promote economic growth”.² The October 2015 UN Resolution A/RES/70/1, ‘Transforming our world: The 2030 Agenda for Sustainable Development’, set down international ‘sustainable

² Economists statement on carbon dividends. <https://www.econstatement.org/> Accessed 7th May 2019.

development goals' (SDGs) including Goal 8 to sustain per capita economic growth at a rate of 'at least 7 per cent gross domestic product per annum in the least developed countries'; a proposition in direct conflict with the Paris Agreement made by the same countries two months later (Spash 2016). Indeed, claims of 'climate emergency' are being employed to promote a new climate economy based on Green growth, backed by high profile "Better Growth, Better Climate" reports from Lord Stern and the Davos elite (see Spash 2014). That *apologia* for growth also appear in this journal should be seen as a fundamental contradiction of the foundations of ecological economics.

Daly explicitly recognised something was going wrong when he resigned from the Swedish Beijer Institute. This Institute had rebranded itself in 1990 as Ecological Economics, while applying mainstream economic theory and approaches under Board chair Partha Dasgupta. As Daly has stated, with respect to this experience: "I felt it was a kind of take-over—here is something called Ecological Economics, it is beginning to get a little following, it might get in the way some day, let's just take it over" (quoted by Røpke 2005: 272). Since then the potential for a general 'takeover' has been an ever present issue (Spash 2013a). Yet, the reluctance to complete the divorce from the mainstream remains, even amongst critical voices (e.g., Daly, Farley, Norgaard, Kallis, Jackson) and alternatives such as steady-state and degrowth/post-growth (as discussed in Sections 2 and 4).

Instead, the extent to which the critical theoretical insights of ecological economics create a divorce from the dominant paradigms of 'normal' economic science has been repeatedly downplayed (Spash 2013b; Anderson and M'Gonigle 2012). Mainstream economic theories, concepts, methods and methodology appear as if unproblematic in an eclectic pluralism. The result is contradiction, with opposing positions being simultaneously promoted: the application of monistic monetary valuation and value pluralism; developing measures of adjusted Gross Domestic Product (GDP) while opposing growth as a means to well-being; criticising commodification and the functioning of the price mechanism while

supporting an institutional theory of self-regulating markets; recognising society as emergent and complex while adopting methodological individualism; and advancing multiple criteria and needs while regarding optimal (Pareto) allocative efficiency as the outcome of markets. In hindsight, strategic and pragmatic concerns can be seen as having opened the door to the absorption of the fledgling ecological economics movement into the very paradigm it had set out to reform.

In this struggle, neoclassical economics forms an identifiable paradigm, and does so despite on-going disputes over who is in/out of the neoclassical camp and what is core/peripheral to the school of thought. Indeed, those very disputes are indicative of a failing 'normal science', facing paradigm collapse, due to discord over how to address an ever growing list of anomalies. Ideologically driven paradigm defence is evident in the increasingly narrow mathematically formalist education of economists, which escalates professional ignorance and dogmatism. Alternative economic theories are then marginalised for strategic, not scientific, reasons, and radicals isolated (Lee 2009).

Understanding where ecological economics stands relative to this paradigm provides the key for going forward (Spash 2011), and defining the future research agenda. Already distinctive groupings of researchers have been recognised and theorised (Spash 2012b, a, 2013b) and empirically investigated (Spash and Ryan 2012). This reveals ecological economics as divided amongst three main camps: New Resource Economists, broadly following mainstream (neoclassical) economics; New Environmental Pragmatists, adopting tools and methods deemed useful regardless of theoretical concerns or scientific rigour and validity; and Social Ecological Economists, seeking a theoretically coherent and epistemically sound approach that rejects flawed economic concepts and theories on scientific grounds (Spash 2013b). This last position recognises that ecological economics does have a distinct core, and that it can be based on a critical and realist philosophy of science.

Social Ecological Economics recognises the need for paradigmatic synthesis, greater unity and integration of knowledge, especially bringing in better understanding of the social (e.g., agency-structure debates, the meaning and role of power, social movements, social provisioning, social justice) and the importance of having a social theory, especially relating to structural change. However, Social Ecological Economics also recognises that a range of shared, socially relevant, ontological commitments already exist. Reality is recognised as consisting of an hierarchical structure with the economy emergent from and embedded in social relations, while social and economic systems are also subject to biophysical structures and their law like conditions. Complex systems and their interactions create emergent properties, unpredictable consequences and continual change,³ and are not explicable or realistically describable as having self-regulating equilibria. Humans as social animals rely upon instituted processes for coordination (e.g. varieties of markets), where institutions are understood as conventions, norms, rules and regulations (Vatn 2005). Humans hold plural and incommensurable values that conflict. Social stability requires means of conflict resolution that address power relations. These then are some of the core social realities.

Such common ontological commitments define disciplinary understanding informing a structured methodological pluralism. They designate what constitutes scientifically meaningful conceptualisations of what form the objects of study for ecological economists. Foundations provide the basis for unity, coherence and integration (Spash 2012a). This is not to deny fallibilism, or the need to remain critically open to ideas to avoid dogmatism, nor to advocate ideological purity, fundamentalism, naïve objectivism or foundationalism. It is to advocate the need for a basic common understanding and one that entails a revolutionary emergent paradigm to replace mainstream economics, i.e., a paradigm shift.

Kuhn (1970 [1962]) developed the concept of a scientific paradigm to capture how scientific knowledge is created by a community of researchers (see Appendix A). His concept

³ Knowledge is possible because not everything changes all the time and there exist essential aspects of continuity.

of a paradigm describes group consensus during a period when science is normalised. He often applied the term very loosely to different collectives of researchers (Norton 1995: 124). He contrasted periods of ‘normal science’ with periods of revolutionary scientific change, when paradigms are in flux, as old ones collapse and new ones appear. The usefulness of the concept of a paradigm in what follows is less in terms of the specifics of Kuhn’s theory and more in terms of the general understanding it offers.⁴ Identifying core ‘normal’ economic paradigms allows analysis of how they are being maintained against the evidence of their failure. This relates to the creation of dominant ideas in society about the economy, which must additionally work through relations of power between groups (e.g., Buch-Hansen 2018). The aim of this paper is to make explicit how ecological economics can be understood as a scientific power struggle, and to clarify the paradigmatic basis of that struggle.

Next, some lessons from the first thirty years of ecological economics are explored in terms of identifying the presence of competing paradigms and boundary disputes with specific focus on this journal (Section 2.2) and the main textbooks in ecological economics (Section 2.3). Two economic paradigms, relating to growth and price-making markets, are then introduced and distinguished (Section 3). Opposition to economic growth, informing the development of steady-state and degrowth/post-growth ideas, is well established. Less recognised as paradigmatically problematic is the ideology of price-making markets as the best institution for organising human social relations,⁵ which is then critically explained in more detail. Why a third paradigm, Social Ecological Economics, has remained emergent, even within ecological economics itself, is argued to derive from pragmatism and passive revolutions (Section 4). Examples are given of how leading steady-state (Section 4.1) and degrowth/post-growth (Section 4.2) researchers acquiesce to the mainstream paradigms,

⁴ A similar point is made by Schmelzer (2015) in his work on the history of the growth paradigm.

⁵ Price-making markets, is a term I use throughout this paper, based on Polanyi (1957). This form of market has prices resulting from ‘negotiations’ between actors (e.g., firms-consumers; employer-employee) in contrast to being set by an administrative, or other, authority. All markets are recognised to be social constructions, institutionally defined and subject to power relations. In neoclassical and neo-Austrian theory the price-making market is typically regarded to be ‘self-regulating’.

despite resulting contradictions. The penultimate discussion (Section 5), before some concluding remarks (Section 6), outlines core aspects of the emerging alternative paradigm and sketches a vision of the related future research agenda.

2. Lessons from the First Thirty Years

Since the first meeting of the International Society for Ecological Economics (ISEE) at the World Bank, Washington D.C., in 1990 there have been a lot of changes and clarifications as to both meaning and direction of what was then a new professional organisation. The ISEE was initially heavily oriented towards North America, and this was evident both at the inaugural conference and in the initial Board of the journal (23 of 40 Board posts plus the editor-in-chief and one of the three associate editors were North Americans). However, membership quickly spread through regional associations. The establishment of the European Society for Ecological Economics (ESEE) in 1996 led to negotiations in Santiago, Chile, in 1998, which concluded with a new constitution that recognised the importance of the regional societies. Shortly after a United States society (USSEE) was established. This meant ISEE became a diverse multinational, regional, membership organisation. Diversity also meant difference, not least concerning disciplinary inclusiveness and pluralism.

2.1 Pluralism, Interdisciplinarity and Transdisciplinarity

The role of pluralism in a coherent scientific body of knowledge is an area where ecological economics has struggled to develop better understanding. The openness of ecological economists to any ‘methods’ available, regardless of disciplinary context, was advocated early on as a form of transdisciplinarity (Costanza 1991), and combined with an indiscriminate pluralism in which inclusion of mainstream economic theory was seen as strategically important (Norgaard 1989). Eclecticism led to entertaining diametrically opposed epistemologies from positivism and naïve objectivism to relativism and strong social

constructivism. Ecological economics has then been labelled both as a subfield of mainstream neoclassical economics (Hoepner et al. 2012), in a modern positivist tradition, and a post-normal science (Silva and Teixeira 2011), in a postmodern constructivist tradition. Confusion has reigned in these muddied epistemological waters.

Plurality of methods is not necessarily a problem, but methods used for scientific purposes should be appropriate for addressing the research question and object of study. Structured methodological pluralism has been recommended to avoid eclecticism (Spash 2012a; Dow 2007), and can guide use of methods, avoiding those incompatible with the core ontology. Unfortunately, methods may be adopted that are inappropriate purely because they suit a strategic purpose, or conform to a paradigm. One result is the epistemic fallacy, i.e. the belief that understanding and describing reality is consistent with the method of seeking knowledge (Collier 1994). An example would be imposing tools of monetary valuation and then claiming, if something cannot be measured in this way, it has no value and so does not constitute an object of study for economists, i.e., does not exist economically. The epistemic fallacy entered ecological economics due to the strong initial drive for cooperation with neoclassical environmental and resource economists, who employ deductive mathematical models and universally apply cost-benefit analysis (CBA). That is, their methodology and methods define their conceptualisation of reality.

As ecologists' brought their own models and methods to the table, a practical way forward was to adopt the methodology of a linkage approach, where unreconstituted models from ecology and neoclassical economics were essentially bolted together. This was perhaps a more natural approach for those working from a complex systems perspective, which was then dominant in ecology. However, a multidisciplinary 'ecology and economics' approach could not fulfil the promise of ecological economics, or what had been recognised as the necessity for 'new ways of thinking' (Costanza, 1989: 1). The approach also contrasted with the interdisciplinarity of the social economists joining the field, and became an evident

epistemological and methodological division between North American and European ecological economists (Spash 1999).

Interdisciplinarity means critically engaging in different fields of knowledge, as providing alternative perspectives on an object of study, with the aim of reaching integration and new interpretations. The challenge of going even further into a transdisciplinary approach was interpreted weakly as borrowing whatever methods/tools were deemed necessary for ‘problem solving’ (Costanza 1991). In contrast, strong transdisciplinarity requires both interdisciplinary critical thought and extending to a wider peer community, including stakeholders and members of the lay public (Luks and Siebenhuner 2007). Such strong transdisciplinarity was most popularly propounded in ecological economics by post-normal science, being described as “the democratization of knowledge by an extension of the peer-community for quality assurance” (Funtowicz and Ravetz 1994: 198). More common, in practice, was the rhetoric of weak transdisciplinarity and the application of mono, or at best multi, disciplinarity, and this is clear from looking at the ISEE’s journal.

2.2 The Flagship ISEE Journal: Pragmatism and Sociology of Science

Established in 1989, the journal *Ecological Economics* is regarded as influential because it has a high citations ranking (Web of Science top 6% in economics, 2017). Initially there were four and then six (1991), then nine (1994) and finally twelve (1995) issues per year. From publishing nineteen research papers in the first year (1989), and seventy-six when moving to twelve issues, the journal published 387 articles in 2018.⁶ If growth in scale is success, then the journal has been successful. If the concern is quality and progress in a field of knowledge, then some serious concerns arise about the direction taken in what (ironically) appears as commercialised exponential growth. Initially, for example, articles were peer reviewed by an

⁶ During the first decade each ordinary issue typically had four research papers per issue. Today each issue varies wildly in terms of number of research papers; for example in 2019 the January issue had nine articles and the March issue thirty eight.

ecologist and an economist, but this attempt at stimulating interdisciplinary integration soon disappeared. Expansion has been sustained by publishing diverse material tied loosely together on the basis of addressing environmental issues. Justification as a form of pluralism is evident in the metaphor of a 'big tent', put forward by Rich Howarth (2008) as editor-in-chief. The well intentioned ideal appears to be one of integration via engagement of diverse positions, but in the absence of any mechanisms to achieve this the result has been an acceptance of diversity for its own sake and a loss of focus.

Perhaps most worryingly, the journal has attracted and published increasing quantities of neoclassical economics the more it has expanded in size. As Anderson and M'Gonigle (2012: 40) complain:

“Rather than challenging mainstream economics, or laying the foundation for new economic paradigms, the field's seed journal widely employs and reinforces the concepts, assumptions, models and solutions that are used in the journals of environmental economics.”

This has not resulted in any progressive pluralism, debate or exchange of ideas, but merely the increasing encroachment of unreconstituted neoclassical economics that pays no attention to even the periphery, let alone the core, of ecological economic ideas. As Farley and Washington (2018: 448) note:

“we, like many other ecological economists, including Herman Daly, are disappointed that the field of Ecological Economics appears to be drifting away from its core principles. In particular, the Journal Ecological Economics is increasingly filled with articles applying the theory and methods of NCE [neoclassical economics], or what Spash (2012a, 2013b) refers to as the 'new resource economics'.

Indeed, the criteria for epistemological advance seem lacking and rather than facilitating the promise of a paradigm shift the approach has been undermining its potential by empowering those opposed to such a change.

Indeed, the Board of the journal has become constituted of paradigmatically divided positions.⁷ Board members include those arguing that ecological economics is close to neoclassical resource economics (Turner, Perrings, and Folke 1997), those calling for it to be retitled as “Sustainability Economics” in order to repair the “unfortunate divide between ecological economics and environmental and resource economics in the study of sustainability” (Baumgärtner and Quaas 2010: 449); those seeing no real gap between it and mainstream economics (van den Bergh 2010: 2051); and those who are often highly critical of but still wish to include neoclassical economics (Söderbaum 1990; Norgaard 1989). These are merely indicative references to Board members who include in their work *apologia* for the necessity of maintaining the presence of mainstream economics. Other Board members support a radically different position that raises issues of social injustice, political economy and human-Nature relationships in a way that denies the relevance of mainstream economics. This is as highlighted by: ecofeminist calls for “a new theoretical vision of an economy which is socially and ecologically sustainable” (Perkins 1997:); linking academic theory to political practice (Perkins and Kuiper 2005; Healy et al. 2013); advocating a radically alternative degrowth economy as a new paradigm (Martinez-Alier et al. 2010); arguing for a total reorientation of economics towards needs (Cruz, Stahel, and Max-Neef 2009), and identifying the basic ecological insights that inform a new paradigm (Norton 1995).

How these apparent tensions play out can be indicated by some empirical research. Plumecocq (2014) conducted discourse analysis of 6308 abstracts published between 1989 and 2013 to compare *Ecological Economics* with neoclassical environmental economics. His results show the increasing encroachment of environmental economics with the use of such concepts as ecosystem services and the practice of monetary valuation. He argues that: “this trend is parallel to Costanza's career-path, which suggests the rise of a tacit recognition of the

⁷ Board Membership taken from the inside cover as of April 2019. Board members included in the references cited are: Baumgärtner, Folke, Martinez-Alier, Max-Kneef, Norgaard, Norton, Perkins, Perrings, Söderbaum, Turner, and van den Bergh. The strong gender bias reflects that of the Board itself, which has consistently been overwhelmingly male dominated.

New Environmental Pragmatic scientific approach” (Plumecocq 2014: 457). This is further supported by Söderbaum (2007: 622-623) who notes that during a workshop, on ‘Ecology in a Cost–Benefit Society’ held in 2004, “Costanza argued in favour of a pragmatic position where CBA is not excluded: If CBA can be used to convince people about the importance of environmental issues, then we should not hesitate to use this approach”. Plumecocq’s conclusion is important for two reasons: (i) the role pragmatism has played in ecological economics and how this creates alliances with both the mainstream in economics and neo-liberal ideology in society; (ii) the role it attributes to a sociology of science and the potential influence of key interests and actors on a field of knowledge.

New Environmental Pragmatism is distinct from the philosophical school of American Pragmatism, which has roots in the realism of Charles Saunders Peirce (Spash 2013b). It should be recognised as a more general phenomenon of recent decades, spread across environmental non-governmental organisations, ecology and conservation (Spash 2009). The position holds that society is now money obsessed, growth oriented, based on price-making markets and there are no alternatives. Therefore the agenda is to use methods of monetary valuation, make growth Green, get the prices right and ignore alternatives. Indeed, the idea of alternatives to the price-making markets of capitalism is itself removed from the research agenda with talk of ‘the economy’, as if there were only one possible institutional form for social provisioning and allocation. Theoretical rigour is undermined by New Environmental Pragmatism, and even those confessing sympathy with the approach are “deeply concerned that an emphasis on monetary values and market-based instruments could backfire” (Farley and Washington 2018: 448). If taken seriously, claims of usefulness would require assessing what such an approach has achieved, failed to do and prevented from happening! Advocates would also need to be aware of how pragmatism is used by power elites to achieve their own ends (see Section 4).

In terms of the sociology of ecological economics, the second point drawn from Plumecocq's analysis, the most extensive review is that of Røpke (2004, 2005), who employs the sociological theory of a 'reputational organisation' to evaluate the field's development. Amongst other things, she notes the tension between 'mainstream' economists and their sympathisers, and 'socio-economic' researchers. Her conclusions make two key points concerning the future of ecological economics:

"One risk is that the field becomes uninteresting as a field, if identity is lost by the acceptance of anything as being justified because of transdisciplinarity. [...] Another risk (others would call it a chance) is that the field loses its bite and becomes a sub-field of neoclassical environmental and resource economics modelling links between ecosystems and the economy." (Røpke 2005: 287)

The first concern relates to a shallow transdisciplinarity, and the advocacy of an eclectic pluralism that is the antithesis of creating knowledge (Spash 2012a; Dow 2007). The second raises the issue of conflicting paradigms and the threat of mainstream economic imperialism. Røpke (2005) finds several substantive weaknesses in ecological economics as a 'reputational organisation', including: poor and unsystematic organisation of the knowledge structure and weak identity as a field of knowledge. This highlights the damage resulting from failing to recognise the paradigmatic conflict which is also evident elsewhere, even as the knowledge structure and identity of ecological economics has improved.

2.3 Textbooks in Ecological Economics

Since the articles by Røpke in the early 2000s, an important development has been the appearance of two large textbooks: Common and Stagl (2005) and Daly and Farley (2004, 2011). As noted in Appendix A, textbooks are taken by Kuhn as key identifiers in the creation of paradigmatic scientific identity. They provide a reference point for students and instructors, and indicate the paradigmatic boundaries. An interesting aspect is then the extent to which

both textbooks make use of, and indeed rely upon, mainstream economics as their central reference point and include *apologia* for the role of neoclassical theory.

Common and Stagl (2005: 15) are at pains to reassure their readers that their text, while critical, is totally consistent with going on to study neoclassical economics, and that: “Much of what you will learn from this book carries over into neoclassical economics”. Further reassurance is that: “There is much that the majority of neoclassical and the majority of ecological economists agree about” (ibid: 6). At the same time the paradigmatically conflicting core aspects of ecological economics concerning limits to growth are expounded (ibid: 236-246). Ecological economists are also noted to be sympathetic to arguments for ‘seeking to change’ and ‘educating’ tastes; seemingly justified as necessary for improving individual and social health (ibid: 10). Thus, a core liberal aspect of neoclassical choice theory (i.e. the inviolability of individual preferences) appears to be overridden, although the grounds for doing so remain unclear and contradictory positions arise. For example, what ‘social health’ means is never explained and, while highlighted in the introduction as central to distinguishing the ethical position of ecological economics from neoclassical economics, it never appears again in the textbook. Instead the text conforms to methodological individualism and later sections refer to ‘social capital’, i.e., making the social an investment with a rate of return. The text also conforms to neoclassical price and value theory.

In the second textbook, Daly and Farley (2011: 407) warn that extending the market to all domains may destroy society, and they clearly advocate policies that would require strong top-down government. They recognise the limits to markets and many flaws in the neoclassical approach to economics; highlight the role of speculation in causing upward sloping demand curves; recognise producer control of consumer preferences via advertising and the ‘treadmill’ of consumerism; and question maximizing monetary value and the operation of allocation in actual markets. Like Common and Stagl, theirs is clearly not a standard neoclassical economic approach, but also remains embedded within the context of

that school. As a result critical elements can appear as mere side constraints, qualifying failures or Kuhnian anomalies relating to neoclassical economics.

The conflict is that the anomalies overthrow the theory, so that attempting to explain actual economies relative to mainstream thought becomes highly problematic. Indeed, in a recent paper authored by Farley and Washington (2018)—but stated to be inclusive of Daly—a defence is made against criticism by Pirgmaier (2017) that Daly’s steady-state theory is neoclassical economics in disguise. In doing so the authors explain their agreement with the flaws of neoclassical economics, deconstruct its validity and, as quoted earlier, criticise its increasingly frequent occurrence in this journal. However, despite all this, Daly and Farley (2011) state, in their textbook’s introduction, that:

“the sections presenting basic micro and macroeconomics, as well as other parts discussing distribution and trade, are based on standard economics” (xvii), “[w]e accept more of traditional economics than we reject” (xviii), and that between neoclassical and ecological economics there is “basic agreement on the fundamental nature of the [economic] system” (xxiv).

The underlying thesis is that price-making markets provide an efficient mechanism for resource allocation, and problems can be met by constraints. Macroeconomics is explained using neoclassical ISLM analysis and microeconomics using neoclassical marginal analysis. The two core improvements recommended are optimal scale to achieve sustainability followed by redistribution on the grounds of fairness. Optimal scale is defined, in neoclassical terms, as the point where the marginal benefits of additional growth are just equal to the marginal costs of the reduction in ecosystem function that this growth imposes. So, some sort of highly aggregated CBA is required, that would convert all values into money on the presumption of universal commensurability. Again, Daly and Farley may well recognise problematic aspects with such an approach, but the approach remains.

As neoclassical theory provides the basic reference point, to which problematic issues must refer, there then appears to be only one type of economy, the capitalist market economy. This limits how economics is to be understood. In particular, the paradigmatic boundaries to economics are stated very strongly in the “Note to Instructors”:

“We have little patience with anti-economists who want to abolish money, who consider all scarcity to be an artificial social construct, or who think that all of nature’s services should be free.” (ibid: xviii)

This is interesting, both for the mainstream prescriptive approach to defining what constitutes economics (i.e. money, scarcity, pricing Nature as service provider) and because of the apparent intolerance for, and even ridiculing of, the grounds for an alternative paradigm. Instructors are being told what is deemed unacceptable for the paradigmatic field. The important proviso ‘all’, in this sentence, could allow for consideration of alternative thinking, but seemingly as an addition, or more marginal concern, and with strong emphasis placed upon the danger of becoming an ‘anti-economist’.⁸

This form of exposition limits the paradigm shifting potential that is clearly present in the critical work of Daly and Farley and their textbook. Indeed, they have declared: “We support Spash's (2012, 2013) call for socio-ecological economics, which we view as a return to the core principles of ecological economics” (Farley and Washington 2018: 448).⁹ The problems highlighted here are then indicative of the more general problem of conflicting commitments that arise when operating under the conditions of a paradigm shift. Such a shift requires leaving ones old paradigmatic training behind, but until a new paradigm is established the old lingers on, and in a Catch-22 prevents the paradigm shift. The process of paradigm change is far from quick or easy.

⁸ This position also seems to run foul of something the authors themselves have rather strongly rejected: being “obsessed with ideological purity”, a practice of those ecological economists who “attack any perceived deviation from their rigid views”, unjustified “purists” who claim to know “precisely how the current system works, and how to transition to an economy based on ecological sustainability and social justice” (Farley and Washington 2018: 448).

⁹ Note, ‘we’ in their paper is explicitly stated to include Daly.

3. The Competition Amongst Paradigms

Social Ecological Economics is an emergent paradigm, but has deep roots both in the work of Otto Neurath, William Kapp, Karl Polanyi and Nicholas Georgescu-Roegen (as will be explored below), as well as energetics of the 1800s (Martinez-Alier 1990). Franco (2018) has recently presented evidence for social energetics being an historical scientific metaparadigm (i.e., falling short of a Kuhnian paradigm but providing a common set of organising principles and ideas). The broad historical consensus he finds is the same ontological position that informs modern ecological economics, namely that: “economic processes are subject to natural laws—mainly thermodynamic laws—and, thus, a proper understanding of the social provisioning processes can only be achieved by a biophysical approach to economic science” (ibid: 200). That is, social provisioning is core to the economic problem and addressing it requires inclusion of the structural constraints imposed by biophysical reality as law like conditions and tendencies.

In contrast, the neoclassical position on social provisioning is based upon the price-making market paradigm. In the ‘normal’ science of economics this paradigm combines with the economic growth paradigm. However, their supporting collectives may also operate separately, and outside of neoclassical economics. Clarifying the two paradigms as distinct, and potentially separate, is important for understanding how they appear as influences affecting ecological economics.

In today’s society, the links between economic growth and price-making markets might seem very strong both in practice and theory. In practice, capitalism is integrally linked to the use of such markets. Yet, the political and ideological commitment to a growth economy is also divorced from the need to commit to price-making markets as the main allocative institution, and capitalism is just one form of capital accumulating economy. Thus, growth has been a popular element of productivism in various forms of Marxist, political left and

state planned economic systems, where price-making markets are rejected in favour of fixed, administratively set prices or direct in-kind provisioning. In addition, although capitalism depends upon price-making markets the reverse is not true.

In theory, mainstream economics seems to unite the two paradigms. However, there is nothing in neoclassical microeconomic (market) theory of the firm, or consumer demand theory, that necessitates growth. The idealised perfectly competitive firm of neoclassical economics has zero (not growing) profits in its long run equilibrium. There is also no necessary link of macroeconomic growth to microeconomic market theory. The idea that there is such a link has been encouraged by invasion of macroeconomics by ISLM analysis creating a school of neoclassical-Keynesianism that employs equilibrating market mechanisms modelled under mathematical formalist rules. Yet, not even prices are essential for macroeconomic models, a point noted by Georgescu-Roegen (2009 [1975]: 348) with respect to Solow's growth model. Indeed he highlighted Solow's hypocrisy in criticising Meadows et al. (1972) for not having prices in their limits to growth simulation model runs when they were absent from his own models! So, both in theory and practice the two distinct paradigms can be separated, i.e. economic growth without price-making markets and price-making markets without economic growth.

The rabid popular support for economic growth is clearly hegemonic.¹⁰ This is recognised by the term 'growthmania' used by Daly (1992).¹¹ The economic growth paradigm came to prominence as part of American foreign policy after World War II (Sachs 2015 [1999]), and the development of macroeconomics by Keynes (1930, 1978 [1936]). Schmelzer (2015) provides a critical review of the rise of the growth paradigm in the international community and its conventional definition of economic growth as desirable, imperative, and

¹⁰ Hegemony is a political concept from Gramsci that means an ideological position that comes to dominate "to prevail, to gain the upper hand, to propagate itself throughout society—bringing about not only a unison of economic and political aims, but also intellectual and moral unity, [...] thus creating the hegemony of a fundamental social group over a series of subordinate groups." (Gramsci, Hoare, and Smith 1971: 181-182)

¹¹ A term current in the degrowth literature and often attributed to Georgescu-Roegen, although he himself cites its origin as Ezra Mishan (Georgescu-Roegen 2009 [1975]: 349)

essentially limitless, given the political will to implement the ‘right policies’. He notes that this position (erroneously) assumes that: GDP adequately measures economic activity, growth is a panacea for a multitude of social and economic problems and growth is synonymous with progress, well-being and national power (ibid: 264). In the 1970s economic growth came in for considerable criticism on social, ecological and economic grounds (Hirsch 1977; Meadows et al. 1972; Easterlin 1974; Mishan 1969; Barkley and Seckler 1972; Lecomber 1978; Schumacher 1973; Daly 1973; Scitovsky 1976). Daly has been a persistent critique of what he terms “neoclassical-Keynesian growthists” (Daly 2016), while requiring limits on scale. In more recent times, both the work of Georgescu-Roegen and Daly’s steady-state economy have appeared as part of the degrowth movement, supported by arguments from ecological economists (Kerschner 2010; Martinez-Alier et al. 2010; D’Alisa, Demaria, and Kallis 2014).

The price-making market paradigm has received far less direct critical attention from ecological economists as an identifiable hegemonic ideology. It is promoted in slightly different forms by two schools: (i) Austrian economics and its modern neo-liberal ideological project, (ii) neoclassical economics. The latter is open to government intervention to correct market failures, on the basis that a perfect market can be actualised to achieve optimally efficient resource allocation. Austrian economists simply regard capitalist price-making markets as the only option for resource allocation in large scale human societies, and believe, rather contradictorily, both that entrepreneurs are key decision-makers and that consumers are sovereign (Fellner and Spash 2015). As neo-liberalism became a political reality, over the last thirty years or so (Mirowski and Plehwe 2009), neo-Austrian and neoclassical positions merged considerably—government intervention has been increasingly derided, despite general recognition of its necessity, while the ‘efficiency’ of the ‘free’ market price mechanism has been rhetorically promoted. Critical theoretical insights into the flaws of

price-making markets comes from the work of Polanyi (1944, 1957) and Kapp (1978 [1963]) and also the socialist calculation debate almost a century ago.

Polanyi (1944) highlights problems of commodification and negative social repercussions of price-making market exchange due to the rise of capitalism. The restriction of economics to social provisioning through price-making market institutions is credited with creating an economics profession unable to understand the variety of social economic systems that have existed throughout human history (Polanyi 1977). However, Polanyi (1971) created a false dichotomy between formal economics (basically neoclassical price theory), and substantive economics (Spash 2019). He applied the latter to pre-capitalist economies where price-making markets were believed totally, or largely, absent. Polanyi (1971) based this division on a definition by Carl Menger, and he accepted the validity of marginalist (neoclassical) price theory as the explanation of a capitalist economy (Gemici 2015). He still argued that such an economic system was highly problematic in terms of its commodification of land, labour and money, and the repercussions it had both socially and environmentally. He therefore advocated a transformation from capitalism to a form of market Guild socialism, with resource and production prices fixed by administration (ibid).

Reforming capitalism to prevent its collapse is what Polanyi (1944) calls the ‘double movement’, where exploitation and excess on the part of a minority (movement in one direction) become so extreme that some payback, to prevent political revolutionary change, has to be undertaken (counter movement). He does not advocate this movement, but rather sees it as a recurrent theme explaining why capitalism has not collapsed. The idea is developed extensively by the French Regulation School building from the 1976 book *Régulation et crises du capitalism* (Aglietta 2015 [1979]). A Polanyian double movement is evident in the rise of health and safety measures from the late 1800s, Fordism that allows workers to buy versions of the products they produce, the 1930s ‘New Deal’, and more generally post-war welfare economies that provide unemployment safety nets, pensions and

health care for ‘workers’ or sections of the underclass. Preserving capitalism in a welfare economy tradition avoids the capitalists’ other main option, which is authoritarianism and fascism under a securitised and militarised state, that cooperates with owners of capital or is constituted by factions of them. Whether the system is saved for a while by a New Deal or an authoritarian regime will not address the fundamental problems created by hegemonic price-making markets under capitalism, and their conversion of everything into commodities, domination of private property rights over the commons, promotion of competition over cooperation and reduction of all values to money. The aim of capitalist markets is profitable returns, not protection of Nature, social justice or a good life for all.

Kapp (1978 [1963]) makes clear another problem, that of social costs related to the environment and operations of any economy where competitive business enterprises exist, whether Western capitalist (e.g. USA) or Eastern centralised state productivist (e.g. former USSR). Kapp (*ibid*) rejects the idea of pollution as an ‘externality’ because this inaccurately describes what are deliberate acts of ‘cost shifting’ in the search for profit; a critique that corresponds to that of institutional economist Clark’s theories concerning the operation of the firm (Berger 2017: 99-114). The extent of such social costs and their non-monetary and incommensurable aspects means price-making markets can neither allocate resources as in the neoclassical textbooks, nor as under the formal economics of Polanyi, nor as claimed by neo-liberals of the Austrian school. For a brief time environmental economists, in the neoclassical tradition (e.g., Kneese, Ayres, and d’Arge 1970), also recognised the all pervasive nature of pollution—under a growth economy—making Adam Smith’s invisible hand into a cost-shifting foot, giving a boot up the backside (Hunt and d’Arge 1973). However, this foundational critique was soon dropped completely as environmental economists reverted to treating pollution as a minor anomaly between two contracting parties that could be easily corrected via price adjustments. Paradigmatic conformity prevailed.

Pervasive social costs and Kapp's critique destroy the claims of price-making markets to be efficient allocative mechanisms, but such markets also fail for other reasons. They allocate resources to those that need them least. Two examples are Sen's (1986) work on famines, showing food being exported from famine struck regions, and Aventis developing a drug (eflornithine) that cures sleeping sickness, but selling it for removing unwanted facial hair in women rather than supplying sick, but financially poor, Africans (Daly and Farley 2011: 151). Competitive markets are also notoriously wasteful of resources, e.g., food waste, built-in obsolescence, fashion, conspicuous consumption. Such problems contributed to their opposition during the 1920s and 1930s and the promotion of socialism.

At that time, paradigmatic change was under discussion in the socialist calculation debate over the feasibility of a planned economy (see O'Neill 2011). In brief, one side was led by the Austrian and neo-liberal economists, Ludwig von Mises and Frederick Hayek, while opposing were socialists from neoclassical economics, such as Oskar Lange and Fred Taylor. In addition, the philosopher and economist Otto Neurath made his own distinct contributions supporting the socialist side. Lange's pro-socialist contributions are typically regarded as key (see Lange 1936, 1937; Lange and Taylor 1938). Today readers may be surprised that they involved an elaborate model of neoclassical pricing, but with government intervention establishing prices by trial and error. Kapp also contributed to the debate with his 1936 thesis in German (partially translated by Berger 2016 Chapter 2), which raised the problem of social costs as a criticism of von Mises (his supervisor). Neurath's contribution argued for a non-market economy in-kind, and his work has been noted as highly relevant for modern ecological economists (O'Neill and Uebel 2015). Neurath was what would today qualify as an academic activist who, besides being a founder of the Vienna Circle, engaged in social housing projects and workers education in economics and wrote extensively on the economy (Uebel 2004). However, as an advocate of the abolition of money he would qualify as one of Daly and Farley's 'anti-economists', which highlights the problematic character of their

mainstream prescriptive position (noted in Section 2.3) in denying alternatives to price-making markets.

Future oriented—post-growth/degrowth/steady-state—economics cannot afford to limit the search for new forms of exchange, minimising entropic effects, developing local economies and promoting social-ecological well-being. Questioning the role of money, scarcity and pricing while seeking alternatives is substantively present in growth critical research (Weiss and Cattaneo 2017; Nelson and Timmerman 2011). In addition, non-monetary economies have existed throughout human history, and are an important aspect of economic and social anthropology, which also have traditions of questioning the conceptualisation of scarcity in mainstream economics (e.g., see Polanyi, Arensberg, and Pearson 1957). The mainstream approach also ignores female unpaid labour and the reproductive activities of women in making the economic system work in the first place, as highlighted by feminist economists and ecofeminists (Waring 1989; Salleh 2011). These are all areas that need to be given serious attention in the move to a new Social Ecological Economics paradigm.

4. Paradigm Shift, Pragmatism and Passive Revolutions

In debates over the paradigm shifting potential of ecological economics, several ISEE Presidents have denied a new unifying theory is possible and fallen back on ‘methodological pluralism’ inclusive of the economic mainstream (Costanza 1996; Costanza, Cumberland, et al. 1998; Norgaard 1989; Turner, Perrings, and Folke 1997). Despite recognising the foundational opposition between irreconcilable new and old paradigms they have been regarded as complimentary rather than exclusive (Klaasen and Opschoor 1991). The result is promotion of “a pragmatic approach that merges a rhetorical allegiance to the field’s substantive pre-analytic vision with the use of mainstream methodologies that might have public policy purchase” (Anderson and M’Gonigle 2012: 40).

This is evident in advocacy of market mechanisms, monetary valuation, ‘natural capital’ and ecosystem services and their combination (e.g., Jansson et al. 1994; Costanza, d’Arge, et al. 1998; Farber, Costanza, and Wilson 2002). While the original intentions of those using such conceptualisations might have diverged from the mainstream (e.g., non-substitutable, non-monetary value, strong sustainability), the result has been to undermine ecological discourse and reinforce the price-making market paradigm (Spash and Aslaksen 2015). The rhetoric of efficiency, optimality, internalising externalities and ‘getting the prices right’ is adopted, so that ecological economics becomes indistinguishable from the mainstream. Thus, Turner, Perrings and Folke (1997) build their argument against ecological economics being a new paradigm on its use of the same methods, and prescribing the same policy measures, as environmental and resource economics. They regard its concern for biophysical systems as merely making it closer to resource economics.¹² Yet, the biophysical foundation of ecological economics is core to its ontology and why it is not mainstream!

In confronting the hegemonic mainstream paradigms, critique faces rejection or ‘adjustment’ for conformity. Hence, environmentalism itself has been ‘mainstreamed’, producing policy proposals that support ‘business-as-usual’—sustainable development, ecological modernisation, Green growth, bioeconomy, circular economy, low carbon economy, new climate economy, and so on... The outcome is to preserve a capital accumulating, high-technology, growth economy, embedded in price-making markets that serve the interests of capital to maximise exchange value, not those of society to meet social needs. The history of capitalism reveals social movements that threaten those in power being neutralised by co-opting their leaders and creating internal division by separating-off the ‘pragmatists’ from the radicals. Threatened elites create captured movements, adopting the language of the rebels and claiming to address their concerns. Those joining them can claim to be more ‘pragmatic’ and system saving than others due to their new connection to the

¹² Charles Perrings was the fourth ISEE President.

powerful. Resulting change appears to empower the aggrieved, while not actually changing anything substantive in the social-economic structure of capitalism. Environmentalism to date appears to have been just such a passive revolution.¹³

This is also reflected in ecological economics circling around the paradigms it rejects. Neoclassical economics often appears as a default set of theoretical ideas, simply because it has been paradigmatically dominant. A few examples follow to briefly highlight how this results in contradiction and paradigmatic restriction. Selected are two key areas regarded as having radical potential to support a paradigm shift: the steady-state economy and degrowth/post-growth.

4.1 Capitalist Markets and the Steady-State Economy

As has been made clear, Daly strongly opposes the economic growth paradigm and promotes a steady-state economy. However, in a recent exchange Daly (2016) makes explicit his support for ‘markets’, caricatures socialism as a relic of the Cold War and refers to Marxism as basically dead. While he approvingly references the neoclassical market socialist work of Lange and Taylor (1938), as matching what he means by markets, their work actually rejects price-making markets and promotes centrally planned prices. In contrast, Daly (2010) has confirmed his “preference for the market over centralised planning”. Elsewhere, Daly (2007) refers positively to “free markets” (p.18), “the decentralized system of pricing” (p.29) and, subject to two constraints, claims that “the market can always, determine allocatively efficient prices” (p.98), and is “able to effect exchange, [and] determine prices” (p.99). This appears to be straight forward advocacy of the price-making market paradigm in a neoclassical economic setting.

¹³ Passive revolution is a term associated with the writings of Gramsci (1971: 106-114) and is used here in terms of relating to the passive integration of subordinate segments of society while keeping them powerless. Potential revolutionary or oppositional intellectuals and leaders are absorbed into the system. See also Candeias (2011).

Daly consistently qualifies markets as “ecologically and socially constrained” (i.e., neoclassical market allocation subject to side constraints). He sometimes refers to these constraints collectively as ‘social values’. The ecological constraint relates to the scale of the economy—addressing the growth paradigm—not markets *per se*, but with implications for their form and operation. The social constraint is to control distribution of income as a central means of achieving fairer outcomes, i.e., more equitable votes in the market place. Arguments for redistribution have a long tradition in economics, and other traditional restrictions on price-making markets are also recognised by Daly.

“Reliance on markets for allocation (now within prior ecological and distributional limits) is further constrained, even within traditional microeconomics, by opposition to monopoly, and restriction of market allocation to rival and excludable goods. Non-rival and non-excludable goods have long been recognized to require non-market allocation.”

(Daly 2016: 27)

So price-making markets can operate subject to a precondition (income distribution), a competitive requirement (no monopoly power) and for limited types of goods (rival, excludable). None of this is inconsistent with neoclassical economic theory, and allocative efficiency is then expected without further problems. As Daly (2007: 98) states: “Once these social values are reflected in constraints on the market, the allocative prices calculated by the market will reflect, and in a sense ‘internalize’ these external constraints”. Thus, Daly (1974) has long been an advocate of tradable permits markets, or cap-and-trade, even for the allocation of rights to give birth. Daly (2007: 109) has used the term “social market environmentalism” with respect to cap-and-trade, because he believes that “setting the cap at a sustainable level is a social-ecological decision”.

On the basis of the above, Daly would clearly seem to accept neoclassical price theory. Pirgmaier (2017) has also detailed how neoclassical economics enters into aspects of Daly’s work on the steady-state economy. She argues that this makes it subject to the failings of

neoclassical theory and leads to the neglect of alternatives. Due to the resulting inconsistencies with Daly's critical and realist ecological economics work, she believes the motivation has been misguided pragmatism:

“Daly's pragmatic use of mainstream theory weakens the analytical and political contribution as well as the relevance of steady-state economics. It has neither convinced mainstream economists, nor led to the implementation of steady-state policies.”

(Pirgmaier 2017: 59)

In reply, Farley and Washington (2018) argue neoclassical economics is not part of the steady-state theory or indeed Daly's real position (e.g., citing his 'person in community' concept).¹⁴

The resulting defence is important for exposing a series of core conflicts between neoclassical and steady-state economics, with Farley and Washington (ibid) actually making their own devastating attack on the price-making market paradigm. However, this leaves them without justification for the role given to markets in the steady-state economy, which they then try to address. Unfortunately, this results in contradictions when they claim “voluntary market exchanges can generate Pareto improvements”, because their critique rules this out, especially due to “ubiquitous externalities” (corresponding to Kapp's cost-shifting critique). Two non-neoclassical arguments also appear, one neo-Austrian using references to Hayek claiming markets promote individual choice, and the other pragmatic, claiming markets “already exist, are widely accepted, and should be used until something better emerges” (ibid: 446). The obvious fallacy is that neo-Austrian economics created neo-liberalism with Hayek a core player (Mirowski and Plehwe 2009), and the resulting promotion of capitalist price-making markets has been, and is being, used to both deny and prevent the emergence of alternatives (the attempt to enforce a paradigmatic Catch-22).

¹⁴ Ziegler (2007) has noted the contradiction of promoting the person in community concept alongside a green GDP measure. Another move that seems based on pragmatism, as apparently confirmed by Daly and Cobb (2007).

Indeed, adopting market capitalism would result in adopting capital accumulation and growth, while markets do not need capitalism (e.g., Lange and Taylor 1938). Market form is not singular. The institutional context, constraints and means of price calculation are central to designing markets for social and ecological needs. Ecological constraints appeal to understanding social provisioning based on a biophysical approach to economic science (Franco 2018: 200). Daly applies this with the concern for scale. Additionally qualitative ecological issues (e.g., chemicals, radiation, genetic modification) should be added, i.e. type not just scale. The orthodox contention is that such constraints could be set and then markets (under price-making capitalist conditions) can operate. However, these adjustment totally change the operation of the market and its basis. As Franco (2018: 201) puts it:

“The allocative approach of mainstream economics does not support social energetics as a foundation and, thus, competes with the biophysical approach both philosophically and as a source of influence on policy makers.”

That is, the price-making market fails to address the ecological issues as recognised by ecological economics as foundational. The issue here is not just that the mainstream has an unrealistic model, but that markets are instituted process and placing them in a capitalist context has entropic consequences that neither it nor ecological economics can reconcile. As Anderson and M'Gonigle (2012: 42) explain:

“markets driven by *capital needs* are designed for one end, to seek *returns to capital*, that is, to maximize ‘exchange values’ that can grow the quantum of capital. These markets must grow *by their nature* because the point of any investment of capital is to return more capital to it, and they do this only through the exchange process itself. Exchange activity (and all its entropic effects) is the basis of their mode of operation, and the more such *activity*, the more that capital is generated.”

In addition, price-making markets require commensurable commodities and this conflicts with ecological constraints, as evident in biodiversity offset markets (Spash 2015).

Other critiques have also pointed out the impossibility of a steady-state market capitalism because of the necessity for accumulation (Smith 2010), and expected significant decline, if not total disappearance, of productivity gains due to the move from quantitative to qualitative growth, e.g., expanding the service sector (Trainer 2016). Additionally, Blauwhof (2012) doubts the capitalist social relations of production would allow the steady-state to achieve stability and social justice. The arguments from steady-state economics would then seem to offer a radical critique of capitalist markets, rather than supporting their constrained use.

The radical critique also appears left implicit and undeveloped in the argument that specific goods can be objectively identified by their characteristics (i.e., rival, excludable) that select them for trading in price-making markets. First, accepting this means all other goods would need to be supplied by unspecified alternative institutions. The door opens to central planning, socialism and other forms of social provisioning. Second, markets as instituted processes may be designed in different ways. Capitalists attempt to create ‘new goods’ (commodification) with the necessary market characteristic (e.g. rival, excludable) for market trading—making the formerly untradeable tradable, e.g., carbon, biodiversity. Alternative institutional designs for provisioning could be radically different with administered prices or limited in ways beyond those so far considered. Third, capitalist markets are integrated with mechanisms enforcing growth. However, in actual economies counter mechanisms can allow non-growing firms to exist (Leonhardt, Juschten, and Spash 2017). This indicates the potential for alternative market design to create the conditions for non-growing firms. Fourth, actual markets are not well explained by neoclassical theory, and determining a role for markets does not require adopting their paradigmatic positions. In summary, the paradigm shifting potential of the steady-state economy is being denied by adoption of market capitalism and neoclassical theory in support of the price-making market paradigm.

4.2 *Degrowth and Post-Growth*

The academic degrowth movement has been heavily associated with ecological economics, e.g., via former ISEE President Martinez-Alier and members of his institute in Barcelona. Daly's steady-state economy has been described as the ultimate, if aspirational, objective of degrowth (Kerschner 2010), and the Barcelona degrowth researchers invited Farley to write an entry on the steady-state economy in their definitional book (D'Alisa, Demaria, and Kallis 2014). The concise entry makes no reference to the institutions governing resource allocation or production in such an economy nor operations of markets. Degrowth allies itself with Marxist political ecology and radical critiques of capitalist market economies. There would then seem to be a totally unrecognised and unarticulated conflict with the standard reliance of steady-state economics on (constrained) capitalist markets.

Another apparent paradigmatic inconsistency is the role of growth itself. A common argument that appears is the necessity of growth for the poor. For example, Kerschner (2010: 548) argues, "that the rich North will need to de-grow in order to allow for some more economic growth in the poor South". Kerschner's paper is endorsed by Martinez-Alier et al. (2010) running counter to their claim that: "The de-growth movement vigorously supports the 'post-development' critique" (ibid: 1745). That critique rejects the use of economic growth to intervene in other countries and highlights its basis in a narrowly defined concept of poverty that ignores cultural diversity. For example, Sachs (2015 [1999]) differentiates the materially poor into what can be described as living frugally, suffering deprivation and living under systems of institutionally constructed economic scarcity. Consistent with degrowth, traditional societies have economic systems of social provisioning that are structured on frugality and sufficiency, while interventions for the purposes of economic growth (as development) create deprivation due to the destruction of sustainable livelihoods, land grabbing, resource exploitation, industrialisation of agriculture and environmental pollution. A growth critical perspective on poverty, more consistent with post-development, is expressed in a later paper

by Kallis, Kerschner and Matinez-Alier (2012), and elsewhere (Demaria et al. 2013).

However, other prominent academics, associating with degrowth, persist with claims of the necessity for growth to address poverty.

For example, Tim Jackson, is an ecological economist engaging with the degrowth community who argues for a post-growth society. He also appears in the aforementioned degrowth edited volume (D'Alisa, Demaria, and Kallis 2014), with a chapter entitled “New Economy”, that proposes such a transition based on text taken directly from his book *Prosperity Without Growth*. Yet, in that book he states a “key message” is that: “There is no case to abandon growth universally” (Jackson 2009a: 41). Again growth is validated as a means to alleviate ‘poverty’. What seems to go unrecognised is that promoting the expansion of the economic growth model to the ‘poor’ means spreading the capital accumulating system from a minority to the majority of the world’s population, decimating any anti-growth position. The problematic ‘growth=development’ ideology of progress then comes in through the backdoor. In Jackson’s case his report/book could more honestly be retitled *Prosperity After Growth*.

That the post-growth service based ‘new economy’, envisioned by Jackson, conflicts with capitalism is something he felt compelled to address when converting his report (Jackson 2009b) into a book (Jackson 2009a). He added a short section addressing capitalism (Jackson 2009a: 197-202), but this makes extremely disappointing reading and goes nowhere. Indeed, he tries to rhetorically avoid the issue that his ‘new economy’ might either endorse or destroy capitalism by using a Star Trek joke (It’s capitalism, but not as we know it), and asking rhetorically “Does it really matter?”. Anderson and M’Gonigle(2012: 43) point out that growth is treated by Jackson as an optional add-on (a position repeated by Bill McKibben in the book’s introduction), rather than inherent to capitalism, where its absence is, by definition, a crisis.

In terms of GDP, Jackson also believes that: “Whether it deserves pride of place in a new ecological macro-economics is an open question” (Jackson, 2009a: 123-124). So what is left of opposition to the growth paradigm? Pirgmaier (2017) notes, as “highly problematic”, Jackson’s reliance on the neoclassical production function approach for explaining macroeconomics. In a similar vein, Morgan (2017: 169) explains how Jackson and Peter Victor have inadvertently employed a macroeconomic modelling approach that “contributes to the reproduction of the problematic position of ecological concerns within dominant ways of conceiving economics”.

4.3 Formalist Inclusion

What the above cases reveal is how problems are formalised for inclusion in an existing theoretical frame that makes them conform to rejected paradigmatic positions, so creating contradictions. That the capitalist economic system depends upon expropriating and privatizing wealth from those parts of the social and natural world that lie outside the market sphere means that countering these acts undermines the system and its political economy. As McMahon (1997: 168) explains:

“Neoclassical economic solutions to inefficiency often mirror the traditional liberal solution to inequality. Both say 'bring them in': bring women into the public sphere; bring the environment (and pollution) efficiently into the market by full market accounting. Market rationality is seen as the solution. But such solutions of bringing those for whom the system doesn't work more fully into the (market or political) system as equals cannot work because it fails to understand how the system is dependent on their being outside: the spheres of women and nature are preconstructed as unequal outside the marketplace.”

Formalist growth based approaches to quantifying poverty miss the point, because the people saved from “poverty”, become the oppressed living in the economy of material scarcity measured by money.

Ecofeminism similarly notes the divorce between the formalist approaches to equality, based on voting rights and income, and the issue of social justice and discrimination in family and work life. Thus, Bauhardt (2014) argues that, whether Green growth, Green New Deal, degrowth, or solidary economy, the gendered labour functioning of the system has been ignored. The formalist approach results in denial of dependency and interdependency, which hides the transfers from female labour (care work and reproduction of the social system). The same applies to Nature. Thus, monetising, pricing and commodifying Nature formalises and legitimises its exploitation rather than addressing the structural causes of that exploitation.

Along the lines of Gramsci’s passive revolution the content of counter hegemonic discourse becomes co-opted into the mainstream. Actors adjust their discourses and practices in the process of adapting and reproducing neo-liberal hegemony. In this way, many ecologist and conservationists have lost their own language and concepts, which have been replaced by those of the market place and financier (Spash and Aslaksen 2015). For any alternatives to offer real change requires that they are not merely passive revolutions that renew the problematic norms of existing structures. This is also why the agenda for the next thirty years must move beyond discourses about reforming a failing social and economic system that creates ecological crises, and pretending there are no real alternative types of economies.

5. The Agenda for the Next Thirty Years

In *New Foundations for Ecological Economics* some basic aspects of ontology, epistemology, methodology and ideology are advanced (Spash 2012a); here the focus is on outlining the establishment of the new paradigm in economic science. The case has already been made that the economic mainstream must be left behind and the two paradigmatic theories it advances—

economic growth and price-making markets—overthrown. Changing economics is necessary because it fails to address the reality of the economic system and neither can it address the transformation to alternative economies.

In terms of the research agenda, there are three aspects to the work ahead. First, understanding the real operation of the current system is necessary and that means descriptive and explanatory realism. The production sector today is comprised of many international private and state owned corporations, monopolies and oligopolies, varieties of small to medium enterprises, the unpaid reproductive and care work of women, and small scale subsistence. Deductive mathematical optimal models of non-existent competitive firms are irrelevant. Real institutional arrangements of conventions, norms, rules and regulations create the context and structure of reproductive operations. The psychology and sociology of consumption must similarly be realist and not some fantasy of consumer sovereignty. The need for change requires understanding how past systems have operated, and the current system is operating. This means an economic theory covering common conceptual aspects such as money, markets, pricing, work and consumption, but from a realist perspective that includes the role in the economy of the non-monetary, non-market, unpriced and unpaid.

Second, social ecological transformation of the economy means alteration of the current institutional and social relations of production. The change ahead is not a minor price adjustment, but a major transformation in both physical and social structure. Human induced climate change, and its dominant trend towards global warming, “has rendered mainstream economics so wanting that a new economic paradigm is needed” (Anderson and M’Gonigle 2012: 40), but it is just one environmental problem amongst many. The systemic problem is cost-shifting. What human induced climate change does is to highlight the need for systemic change. The impossibility of addressing Greenhouse Gas emissions without removing fossil fuels from the economy means the end of the historical form of the industrialised economy.

A positive and conscious change therefore faces all the powerful and vested interest groups that benefit from a fossil fuel economy and requires understanding of power relations—relating to the State, organised labour and corporate capitalists and related elites. This implies going beyond the growth theoretic analysis of political economy to theories of more radical social and institutional change (Buch-Hansen 2018). Social-ecological transformation requires research on alternative economies and ways of living (not paradigmatically excluding them), and developing policies that encourage and create them (not deny their potential because they have not been actualised).

Third, there is the need for alternative visions, a set of utopian views about idealised social, ecological and economic relations. Plural values, community, harmony, care, love, cultural diversity, tolerance, inclusion and a meaningful life for all. Allowance for human-Nature relations, doing good for Nature not just exploiting it as ‘services’ and ‘capital’, but also Nature-Nature relations and Nature with autonomy from humans. Utopian visions that are not those of the current hegemony and its dominant paradigms—everlasting economic growth, materialism, ever advancing technologies, always living beyond the limits with dreams of living forever. The alternative social ecological utopias should be scientifically based in terms of being realisable, not science fiction nor purely romantic. Scientific utopias in this sense act as inspirational positive visions of the future. They also need to be part of the research agenda.

The research agenda must be open to varieties of economic structure—economies not ‘the economy’—and alternative institutional arrangements. As Anderson and M’Gonigle (2012: 40) state: “It is one thing to criticize growth on the basis of the science of thermodynamics; it is another to situate the sources of that growth in the real world of political economy”. The rejection of the growth paradigm means addressing an alternative structure for economies that removes capital accumulation, competition over resources, institutions of profit seeking, and surplus creation and destruction (i.e. the consumer society).

Economics is to be understood as social provisioning in accord with biophysical reality. In addition, economics has a role in relation to the forms of resource allocation and what in mainstream economics is reduced down to individual choice. In both social provisioning and resource allocation the relations of production are central. This means power relations are also an explicit consideration. The economy is an aspect of the social. Economics is political economy.

In terms of the price-making market paradigm I have highlighted the long standing critiques. Prices are not formed as in economic textbooks. Cost-shifting is a central element operative in competitive surplus-accumulating market economies, and more generally where competition and individual gain are promoted. The structure of the actual economy and resulting prices involve competing interests. The last century has witnessed the rise and dominating roles of the corporation, the industrial-military complex and, in recent decades, the financial sector. Once the price-making market paradigm is seen as a fiction hiding the real mechanisms of resource allocation, involving political power and cost-shifting, then planning social provisioning becomes an explicit concern.

Two major positions on alternative forms of economies go back to the socialist calculation debate. One overarching form is market socialism, where prices are not made in the market power game but by administrative intervention, with the mechanisms of market allocation still employed but not dominant. The other is an economy with social provisioning in-kind, such as social housing, national health care, free education, libraries, museums, energy, water, infrastructure and so on. Variations on and alternatives to markets are broadly recognised as necessary, but which form under what circumstances remains under researched and contestable. In-kind provisioning is consistent with the role in ecological economics given to needs and satisfiers (Rauschmayer and Omann 2017) and a tradition back to Neurath (O'Neill and Uebel 2015; O'Neill 2011). Research developing needs and satisfiers as a central aspect in social provisioning could connect to allowing for cultural diversity in a post-

development context (Sachs 2015 [1999]). The post-development critique of growth and its approach to poverty should be made common knowledge amongst ecological economists to avoid equating poverty to income or Western materialist approaches.

Another key aspect of social provisioning is the material and energy flow through the economy and here the work on social metabolism is of central import (e.g., Krausmann 2017; Gerber and Scheidel 2018). This links to the historical metaparadigm of ecological economics (Franco 2018), and its modern ontological foundations (Spash 2012a). It also relates to the type of society desired and answering the questions of production of what, for whom and for what ends? Production today is highly skewed and inequitably distributed as is income, wealth and power. Biophysical reality means confronting limits and rejecting the mythical utopian promise of the growth paradigm (i.e., everyone can be a materialist at the level of the average American).

Constraints also raise the issue of sustainable populations and their treatment across time and space. Intergenerational ethics became encapsulated in the weak vs. strong sustainability debate and the formalised discussion of sustainability, in terms of resource substitution, scarcity and time preferences, with a focus on discounting. In this way the mainstream placed intergenerational ethics into the growth and price-making market paradigms. Engaging with this approach means mainstream paradigmatic conformity prevails and broader understanding of ethics and value is excluded. This is exemplified by the whole economic discourse on climate change (Spash and Gattringer 2017; Spash 2002). Rejecting the hegemonic paradigms means taking the role of ethics in economics seriously.

A similar problem relates to temporal changes in ecosystems. The mainstream position either ignores the importance of ecosystems or claims changes in ecosystems can be captured via the effect on human well-being expressed as money values. The first is a strategic adoption of ignorance, while the second is impossible and highly misleading. The spatio-temporal aspects of change, scale of impacts and their irreversibility all affect the evaluation

of and policy response to ecosystems change. Future research must remain focussed on the paradigmatic distinctions here and re-establish their formerly recognised implications for policy (e.g., Norton 1995).

In the consideration and development of alternative economies the role of money and unpaid work must be addressed both in their current forms and in terms of how different types of economies and economic relations can and do operate. This contrasts with imposing the price-making market paradigm, where the role of money must be spread to everything and everything done must be treated as paid work. Such an approach is the imposition of a singular type of economy on all else—Polanyi's (1977) economic fallacy—along with its problematic conceptualisation of work and life. As with the attempted spread of commodification and pricing Nature, this ignores value pluralism, incommensurability and alternative ethical approaches.

Non-monetary life and livelihoods should be researched (e.g., Nelson and Timmerman 2011), and regarded as part of Social Ecological Economic understanding. The variety of social relations must be understood as inclusive of gift and reciprocity as explored in social anthropology. Contra Polanyi, this substantive aspect of the economy is relevant for all economies and understanding of their social structure (Spash 2019). Social relations also raise the need for social theory, which is totally absent from mainstream economics due to its reliance on methodological individualism. This would also reinforce the need for addressing and researching the roles of different forms of political power (e.g., Stör 2017), and their associated institutions.

A reaction against the idea of this emergent paradigm will inevitably be that it is another top-down imposition of a restricted and dogmatic science. This could be so if the approach failed to maintain elements of critical thinking. The vision is of a paradigm in the social sciences that is interdisciplinary, integrative of knowledge and coherent (Gerber and Steppacher 2012), but neither dogmatic nor eclectic pluralism. There is also an important

aspect of being an emancipatory science in the critical realist sense of scientific understanding having a purpose (Collier 1994), and that is why Social Ecological Economics seeks transformation. There is no question of apathy about rejecting the growth and price-making market paradigms. Academic activism is also highly relevant for transformation and the new paradigm must help inform degrowth and post-growth and other similar social movements.

6. Concluding Remarks

For over fifty years the systemic and structural problems of the economic system with respect to the environment and society have been recognised—increasing inequity, social division, exclusion of ‘others’, loss of biodiversity, mass species extinction, pollution of land, air and water, and resource wars. The response has been:

“the paradigm of the necessary and sufficient role of innovation, growth, adaptation, evolution, and the centrality of new and emerging sciences and technologies such as life science and biotechnology. [...] the main solutions have long since been tagged to a paradigm of industrial growth and competitiveness. This ‘paradigm’, furthermore, is directly linked to a macro-economic outlook that is now causing havoc across European societies.” (Rommetveit et al. 2013: 76-77)

The arguments against this and its economic form in the economic growth and price-making market paradigms are core to ecological economics and its *raison d’être*. Yet, even within the supposedly more radical degrowth/post-growth movement and steady-state theory we see contradictory and conflicted support for the hegemonic paradigms. In ecological economics, the combination of New Resource Economists with New Environmental Pragmatists blocks the emergence of a new paradigm, or at least delays realisation of its full potential. There also appears to have been a strong ideological bias against considering alternative forms of social provisioning. Market socialism was the commonly accepted conclusion of the socialist calculation debate and needs serious reconsideration along with non-market alternatives.

Understanding past and present forms of economies and structuring alternatives requires openness to potentialities.

Ecological economics consists of long established ideas that form a conceptual core that can be specified, along with what is peripheral and what stands in opposition. That core combines ecological understanding, social structure and a redefined economics. Important theoretical insights then arise, such as the dependence of social and economic structures on biophysical reality, impossibility of equilibrium theories, the role of ethics and plural values, institutions as social structures and the connection of economics with politics and power. It creates a theoretical body of understanding that builds from, but is fundamentally different to, preceding theories.

A paradigm shift requires explicit articulation, identifying what is different from the past and being clear about what must be left behind, as well as social commitment on the part of the community. This is not merely a different story, or alternative perspective, in some competition for the best social construction, but rather a paradigmatically different theory and social ontology than exists in mainstream economics and one that challenges its continued existence. As Kuhn discovered, humans can choose to commit to theories for a range of strategic and social reasons (e.g., careers, power, money, prestige), that bear no relationship to understanding their objects of study. However, the scientific validity of a theory is not based on who believes it, but lies in how it matches up to reality, and that is why maintaining belief in and pragmatic support for unrealistic economic theories contributes to on-going social ecological crises and helps create new ones.

In terms of what future economies might be like there are numerous options including: planning, government ownership of the means of production, socialist economies, communitarian and local community economies, caring economies, solidarity economies, soviets and anarchistic communes, and so on. Social and economic systems require reproductive processes and involve unpaid maintenance, gift and reciprocity. However, today

all this is ignored and denied under financial, corporate and neo-liberal domination of actual economies, despite the resulting social and environmental problems they create. More than ever alternative economies and forms of social provisioning are necessary that break the hegemony of growth and price-making market paradigms. Needs can be met through in-kind provision for people not profit. The variety and form of resulting institutions, including the role of markets and their form, is part of the research agenda. However, the change required involves a scientific paradigm shift in economic thinking, and that means a struggle to overcome narrow prescriptive definitions of economics that play to hegemonic forces and outdate ideological divisions.

Social, ecological and economic crises are integrated and cannot be addressed by the old unrealistic paradigms or their pragmatic use. The next thirty years require a major social-ecological transformation of the economy based on an economics that studies and understands actual economic institutions, power relationships and social provisioning systems, but also recognises the unfulfilled potentialities of alternative social and economic systems and seeks to explore and actualise them. The conditions for change are already present as the failures of the current system become increasingly recognised. Crises evidence the failures of understanding and the practical inadequacy of knowledge. The attempts to cooperate with, apologise for and infiltrate into existing hegemonic paradigms have at best achieved passive revolutions that fail to address structural problems, and, by playing to existing power groupings, do nothing to contribute to changing the substantive operations of actual economies. They have revalidated not invalidated the irrelevant discourses of mainstream economics, and supported marginalisation of radical critique. The change outlined here requires creating the necessary conditions that can sustain new ideas, which means refocussing the journal, textbooks, teaching and conferences to exclude redundant and rejected theories and invalidated knowledge, rather than supporting and including them under the guise of pluralism and pragmatism. There is nothing to be gained and much to loose from

continuing to maintain the misguided belief that there is some fruitful discussion to be had with those supporting the very system ecological economists oppose and aim to totally transform. The time of passive revolutions is over. Now is the time to fully implement the long promised revolutionary paradigm shift!

Appendix A: What is a Paradigm?

According to Kuhn (1970 [1962]) a paradigm is more than a theory and involves: how future research in a field should proceed, which problems are to be tackled, what are the appropriate methods for ‘solving’ problems and what would constitute an ‘acceptable solution’? Kuhn recognised the importance of the scientific community in answering such questions and defining knowledge in a given field, and this stimulated the development of the sociology of science and boosted constructivism (e.g., science and technology studies). Thus, a paradigm combines scientific theory and practice along with community beliefs and institutions (conventions, norms, rules and regulations) affecting content and conduct.

In periods of normal science, a particular research tradition is institutionalised, by combining rules and standards for scientific practice with accepted examples of actual scientific practice, and established through accredited publications. Kuhn (1970 [1962]: 10) specifies books and textbooks as the publications that “define the legitimate problems and methods of a research field for succeeding generations of practitioners”, while also identifying problems left open to be resolved. Today, in many fields, peer reviewed journals would also be added as fulfilling this definitional role, with Editors acting as gate-keepers of what is designated as legitimate knowledge. In this way a scientific field and its boundaries are established.

In Kuhn’s approach a dominant paradigm arises to rule over a field of knowledge. As Chalmers (1999: 108) summarises: “A mature science is governed by a single paradigm. The paradigm sets the standards for legitimate work within the science it governs. It coordinates and directs the ‘puzzle solving’ activity of the groups of normal scientists who work within it.” The sociological aspects mean

commitment by the relevant scientific community to their shared ontology, assumptions, theoretical beliefs, values, instruments and techniques. This makes paradigms inherently conservative in Kuhn's approach, because they define what unites a scientific community and what is 'normal' in the scientific practice of a given field of knowledge. Contrary to Karl Popper, Kuhn argues that, in periods of normal science, scientists avoid novelty in facts and theories and defend the paradigm using auxiliary hypotheses. Scientific revolutions, or paradigm shifts, only occur when anomalies become overwhelming. A period of revolutionary crisis then arises, and is resolved when a new paradigm attracts enough scientists and the old one is abandoned.

There are various problems with Kuhn's approach, of which only a few can be briefly mentioned. An individual's choice to commit to a paradigm does not define the practical adequacy of knowledge. That is, the scientific grounds on which an existing paradigm is regarded as better than its rivals is distinct from sociological acceptance. Additionally, a distinction can be drawn between social construction of concepts and theories and the evaluation of those theories against reality. Strong social constructivism denies there is any valid basis for such evaluation, ironically by universalising and overgeneralising the role of socialisation. Kuhn rejected such an extreme relativism. However, he problematically claims paradigms are incommensurable, which would prevent scientists rationally comparing them; a position broadly rejected by the fact that new science tends to communicate with and build from previous knowledge. How science is meant to progress is also contentious in Kuhn's theory. A variation is that of Imre Lakatos who defines a defended 'hard core' where progress is meant to occur and a protective belt which is contested (see Chalmers 1999).

Kuhn is concerned with natural sciences and as a result the power to progress in solving quantitative problems, while qualitative explanation might diminish. The quantitative focus is highly problematic for both natural and social sciences, and the importance of qualitative information for evolutionary and economic systems was something Georgescu-Roegen (2009 [1979], 1971) was at pains to point out. The definition of science as problem solving is also narrow and, for example, downplays the role of descriptive explanation and interpretation. Social sciences engage in hermeneutics, and the search for new and deeper concepts, while natural sciences tend to work with established and more stable interpretations. This is an aspect of the object of study, the structure of say

the phenomenon of gravity is not changing, while our interpretations may do so. Social structure can and does change, but not as fast as some constructivists would like to claim, nor in most circumstances due to simply studying an object. Indeed, deliberate attempts to change social structure prove hard to achieve and may take a generation or two. Social science researchers do aim to use knowledge to change the structure of the object of study (e.g. the economy) and in doing so hope to improve the human condition. In contrast, natural sciences have traditionally worked to understand the structure of their objects of study, taken as given, working within those structural constraints to achieve outcomes for human ends.

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