King's Research Portal

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Lewis, P. A. (Accepted/In press). The Ostroms and Hayek as Theorists of Complex Adaptive Systems: Commonality and Complementarity. *Advances in Austrian Economics*, 22, 49-80.

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

The Ostroms and Hayek as Theorists of Complex Adaptive Systems: Commonality and Complementarity

Paul Lewis

Department of Political Economy

King's College London

paul.lewis@kcl.ac.uk

Forthcoming in *Advances in Austrian Economics* (2017)

Abstract

This paper uses the theory of complex systems as a conceptual lens through which to compare the work of Friedrich Hayek and Vincent and Elinor Ostrom. It is well known that, from the 1950s onwards, Hayek conceptualised the market as a complex adaptive system. It is argued in this paper that, while the Ostroms began explicitly to describe polycentric systems as a class of complex adaptive system from the mid-to-late 1990s onwards, they had in fact developed an account of polycentricity as displaying most if not all of the hallmarks of organised complexity long before that time. The Ostromian and Hayekian approaches can thus be seen to share a good deal in common, with both portraying important aspects of society—the market economy in the case of Hayek, and public economies, legal and political systems, and environment resources, in the case of the Ostroms—as complex rather than simple systems. Aside from helping to bring out this aspect of the Ostroms' work, using the theory of complex systems as a framework for comparing the Hayekian and Ostromian approaches will be shown to serve two other purposes. First, it can be used to show how one widely-criticised aspect of Hayek's theory of society as a complex system, namely his account of cultural evolution via group selection, can be strengthened by an appeal to the work of Elinor Ostrom. Second, it also helps to show how to resolve a tension—ultimately acknowledged by the Ostroms themselves—between some of their explicit methodological pronouncements and the actual, substantive approach they adopted in their analysis of polycentric systems.

The Ostroms and Hayek as Theorists of Complex Adaptive Systems: Commonality and Complementarity

Paul Lewis

Department of Political Economy

King's College London

paul.lewis@kcl.ac.uk

1. INTRODUCTION¹

The past quarter century has seen a considerable growth in interest in thinking about the economy, and society more generally, as complex systems. Economists both from less orthodox mainstream backgrounds, and also from various heterodox schools, have contributed to this development. Indeed, such has been the interest in, and commitment to, the complexity approach that sage and well-informed observers have heralded of the rise of a new ‘complexity era’ in economics (Holt *et al.*, 2010).²

However, while perspectives on the economy informed by complexity theory are probably more significant now than ever before, it is also worth acknowledging—as many of those involved in recent developments do—that the burgeoning modern literature has precursors in the work of earlier generations of scholars (Rosser 2004, 2010). And it is upon some of those earlier advocates of the view that society can fruitfully be understood as a complex system that this paper will focus. It is well known that from the 1950s onwards Friedrich Hayek began to develop a view of the economy as a complex adaptive system. It is perhaps less commonly remarked upon that, beginning in the 1960s, Elinor and Vincent Ostrom also began to develop an approach to social theory in which public economies, common property resources and other kinds of polycentric system are portrayed as displaying all the hallmarks of complex systems. In

¹ I am very grateful to Emily Castle, Director of Library and Information Services at the Ostrom Workshop at Indiana University, Bloomington, for very kindly sending me copies of some of Vincent Ostrom’s unpublished papers. I am also deeply indebted to Hartmut Kliemt and Jerry Gaus, whose detailed comments on earlier drafts greatly improved this essay. Useful comments were also received from Paul Aligica and Virgil Storr, for which I am also grateful. Needless to say, none of the aforementioned are responsible for any remaining errors and infelicities.

² See, for examples drawn from a much wider literature, Anderson *et al.* (1988), Axtell and Epstein (1996), Arthur *et al.* (1997), Ormerod (1998), Rosser (1999, 2009), Sawyer (2005), Arthur (2014), Beinhocker (2006), Gintis (2006), Miller and Page (2007), Colander and Kupers (2014), and Kirman (2016).

what follows, then, the theory of complex adaptive systems will be used as a conceptual lens through which to view, and to compare and contrast, the work of Hayek and of Vincent and Elinor Ostrom, as key representatives of the Austrian and Bloomington schools respectively. As I hope to show, using the theory of complex systems as a framework for comparing the two approaches will serve three purposes. First, it will help to highlight an aspect of the Ostroms' work, namely the fact that they develop a theory of the social world as a complex system, that has perhaps not yet received the attention it deserves. Second, the juxtaposition of Hayek's and Ostrom's work can be used to show how one widely-criticised aspect of Hayek's theory of society as a complex system, namely his account of cultural evolution via group selection, can be bolstered or repaired by an appeal to the work of Elinor Ostrom. Third such a comparison can also be used to explain how to resolve a tension—ultimately acknowledged by the Ostroms themselves—between two aspects of their own work, namely: some of their explicit methodological statements, in particular their reductionist pronouncements about individuals being the basic unit of analysis in their work; and the anti-reductionist nature of their substantive contributions, in which it is the nature of the social relations obtaining between impersonally-defined social positions rather than individual people *per se* that is the central focus of their analytical attention.

The structure of the paper is as follows. After a brief overview of the nature of complex systems (Section 2), Hayek's account of the economy as a complex system will be outlined (section 3). It will then be argued that, long before explicit references to the theory of complex adaptive systems began to appear in their work, the Ostroms in practice portrayed polycentric modes of organisation as possessing the key attributes of such systems (Section 4). The Ostromian and Hayekian approaches can thus be seen to have a good deal in common, with both arguing that important aspects of society—the market economy in the case of Hayek, and public economies, legal and political systems, and environment resources, in the case of the Ostroms—should be viewed as complex rather than simple systems. The two approaches are not identical, however, and it will be argued in Section 5 that—taken in conjunction with recent developments in evolutionary biology—Elinor Ostrom's work can be used to help defend Hayek's theory of cultural evolution against some of its critics. Then, in Section 6, it will be shown that coming to a fuller appreciation of one of the key features of complex systems, namely the fact that they display emergent properties that are irreducible to the attributes of their individual component parts, helped Elinor Ostrom in particular to resolve a tension in her and her husbands' work between some of their explicit methodological pronouncements and the actual approach they adopted. Section 7 summarises the argument and concludes the paper.

2. THE NATURE OF COMPLEX SYSTEMS

There are many different definitions of complexity, none of which command universal ascent (Lloyd 2001; Rosser 2015). While acknowledging that the following account might not express perfectly everyone's account of the nature of complex systems, it does capture many of their key features. Each property will be labelled (as CS1, CS2, etc.) to facilitate ease of reference within the different sections of the essay.

First, a complex *system* is composed of a set of elements or parts that are related to each other in particular ways. [CS1] Second, the interactions between the parts or elements of the system, and therefore the latter's structure, can be described in terms of sets of rules. Those rules, which can be very simple, require that the parts or elements in question interact with each other in particular ways. [CS2] Third, when individual elements are arranged into structures, their behaviour is different compared to what it is when they are isolated from one another. This is significant because it implies that, taken as a whole, systems can display properties that are qualitatively different from those of their individual component parts. These system-level or *emergent properties*, as they are known, are structural or relational in the sense that their existence depends not only on the presence of their ('lower-level') constituent parts but also on those parts being organised or arranged into a particular structure that involves them standing in specific relations to one another (Holland 1995: 3-7, 10-12; Page 2011: 245-26; Colander and Kupers 2014: 118, 129-30, 136-37). [CS3]

Fourth, such emergent properties are often, although not always, the outcome of a process of *self-organisation*. That is to say, they arise as a consequence of the rule-guided responses of the individual parts of the relevant system to their immediate surroundings rather than as the result of orders issued by a central controller possessing an over-arching, synoptic view of the entire system. In other words, they constitute a spontaneous rather than a designed order (see Harper and Lewis 2012; Colander and Kupers 2014: 48-53, 116-18). [CS4]

Fifth, complex systems are hierarchical, in the sense that the parts of one kind of system may themselves be complex systems, formed of components that stand in certain relations to one another and so possessing their own distinctive structure and emergent properties. For example, social systems are formed of individual people, who are themselves complex structures of chemical and biological parts. On this view, the world consists of a nested hierarchy of complex systems, with the lower-level systems existing within the context of higher-level systems in a hierarchy of levels of complexity (Page 2011: 26; Colander and Kupers 2014: 50, 137). [CS5]

Sixth, because the existence of emergent properties depends not only on the presence of particular parts but also on their standing in certain relations to one another, such properties are ontologically and causally irreducible to the properties of the parts of which they are composed. Therefore, attempts to

explain the properties and behaviour of complex systems by reducing them to the properties of their isolated constituent parts are flawed. A satisfactory analysis requires knowledge not only of the isolated parts but also of the relations in which those parts stand to each other. The ontological and causal irreducibility of an emergent property implies moreover that it cannot be reduced to, or replaced without loss of cognitive content by descriptions of (the properties of) isolated individuals and thereby eliminated from causal explanations of phenomena of interest. That is to say, an eliminative reduction of the emergent entity—whereby references to it are entirely replaced by, or reduced to, statements about the properties of its isolated component parts—is not possible. Any causal explanation that rests upon the exercise of the emergent, system-level powers of some emergent entity depends not only upon the properties of that system's parts but also upon the way in which they are related to each other; the emergent properties arise, and have the causal effects they do, only because of how their individual parts are organised. Causal explanations that invoke such powers therefore depend critically upon more than the properties of the isolated individual elements, namely the relations in which those elements must stand to one another in order for the emergent causal power in question to obtain. And it is because of the need to refer to the requisite organizing structures and relations that the possibility of reduction is foreclosed (Miller and Page 2007: 41-45, 50-51; Lawson 2012: 350-53; Jepperson and Meyer 2011: 68-69). **[CS6]**

Seventh, the systems obtaining at each level are adaptive in the sense that they adjust to the broader context in which they are situated, either via the deliberate choice of rules by the agents that inhabit them or via an evolutionary process involving variation, selection, and (differential rates of) reproduction (Hayek [1967] 2014: 282-87, 1979: 153-65; also see Page 2011: 25; Colander and Kupers 2014: 136-37, 143, 181-91). On this view, the theory of evolution and the theory of complex systems are complementary, with evolutionary pressures operating on complex systems, in particular on the emergent properties they generate, winnowing those that are adaptive to their environment from those that are not. Hence, complex systems are often referred to as complex *adaptive* systems (Holland 1995: 4, 8-10, 38-39; Wilson 2016: 32). **[CS7]**

Eighth, and moving on to epistemic issues, emergent properties are often novel in the sense that they could not have been predicted *ex ante*, given people's knowledge of the properties of the component parts (Anderson 1972). Therefore, their occurrence may well be a genuine surprise in that it lies outside the confines of what people had hitherto imagined might happen, so that people face radical uncertainty in the sense of Keynes or Knight. This has an important implication for the possibility of representing rational decision-making as if it involves people maximising their expected utility. The reason is that the existence of such novelty violates one of the key presuppositions of the neoclassical theory of rational choice under uncertainty, namely the assumption that people possess from the outset a comprehensive list of all the various possible states of the world that are relevant to their decisions. That 'small-world' or 'grand state

space' assumption, as it is known, excludes the possibility of hitherto unimagined events, thereby ensuring that the homunculi who inhabit economic models face a well-defined decision-problem in which all the possible outcomes can be specified and then ranked by reference to the agent's preferences. However, emergence, and the genuine novelty it introduces into the economic process, makes it impossible to specify in advance all the possible states of the world in which people might find themselves. Since in view of such incompleteness people are unable to rank all the possible outcomes to which their actions might lead, their choices cannot be represented as if they involve the maximisation of expected utility, in way supposed by standard rational choice theory (Gilboa and Schmeidler 1995: 606; Harper and Lewis 2012: 329-32; Colander and Kupers 2014: 130). [CS8]

Having outlined the key features of complex systems, we are now in a position to explain how they manifest themselves in the writings of Hayek and of the Ostroms.

3. COMPLEX SYSTEMS IN THE WORK OF F. A. HAYEK

The aforementioned attributes of a complex system can be illustrated by giving a brief account of Hayek's mature account of how the market economy generates social order. Hayek established in 1937 that the key question for understanding the generation of social order concerns how people learn enough about each other's intentions to form mutually compatible plans when much of the knowledge on which those plans is based is dispersed throughout the economy and is therefore directly accessible to nobody in its totality (Hayek [1937] 2014). However, as Hayek ultimately came to realise, the dissemination of knowledge required for plan coordination is facilitated not only by price signals, as outlined in his path-breaking 1945 paper on the epistemic role of freely-formed market prices (Hayek [1945] 2014), but also by the knowledge furnished by shared social rules (including both the formal legal rules of property, tort and contract law and also informal norms of honesty and promise-keeping).³ Perhaps most notably, by facilitating enforceable contracts, the rules in question enable people to devise and act upon plans confident that the contributions from other people required to bring those plans to fruition will be forthcoming.⁴

Especially from the 1950s and especially the 1960s onwards, Hayek's efforts to express and develop these insights were increasingly couched in the terms of the language and concepts drawn from

³ For more on the development of Hayek's thought on these issues, see Fleetwood (1995), Vaughn (1999a) and Lewis (2014).

⁴ "What makes men members of the same civilization and enables them to live and work together in peace is that in the pursuit of their individual ends the particular monetary impulses which impel their efforts towards concrete results are guided and restrained by the same abstract rules. If emotion or impulse tells them what they want, the conventional rules tell them how they will be able and be allowed to achieve it" (Hayek 1976: 12).

complexity theory (Caldwell 2004: 297-306).⁵ An important landmark in this respect is a 1967 essay, entitled ‘Notes on the Evolution of Systems of Rules of Conduct’ (Hayek [1967] 2014). In it, Hayek deploys some of the key concepts described above—in particular, the notion of a ‘system’, the concept of emergent properties, the distinction between different ‘levels’ of reality, and the ideas that systems are adaptive in the sense that the set of rules on which they are based evolves so as to fit with the broader context in which the system is situated—in order to portray the economy as an example of organised complexity.

For Hayek, a market economy arises when the relations between people are governed by a set of rules that includes both the formal legal rules of contract, property and tort law, and also informal moral rules of honesty and promise-keeping. Those rules define various positions (e.g. buyers and sellers, creditors and debtors, employers and employees) and set out the rights their occupants enjoy as well as the obligations they bear. In doing so, the rules specify in broad terms how the occupants of those positions must relate to one another in a working market economy (e.g. debt contracts specify the rights and responsibilities of borrowers and lenders, detailing for example the interest rate and repayment schedule for the loan in question). The market economy is a system in the sense defined above, therefore, because it is indeed composed of a set of elements or parts that are related to each other in particular ways (Hayek 1976: 107-32; also see Lewis 2014, 2015a).⁶ [CS1, CS2]

The system thereby formed exhibits properties that differ from those of its constituent parts. Prominent amongst these emergent properties is the capacity to coordinate people’s plans, even when they are formed independently by individuals in the light of their own particular (‘local’) knowledge. What Hayek shows is that, once people’s interactions are structured by an appropriate set of rules, a configuration of relative prices is generated that—when coupled with the background information provided by social rules—enables people to adjust their plans so that they dovetail with each other and therefore have a decent chance of coming to fruition (that is, for social order to obtain). The coordinative power in question, which Hayek ([1967] 2014: 280) refers to as “the overall order of actions”, is an emergent property because it is possessed only by a particular whole—namely the economic system that is formed when people’s interactions are structured by a set of rules that includes the formal rules of contract, tort and property law, along with informal norms of trust and promise-keeping—and not by those individuals taken in isolation. It is “more than the totality of regularities observable in the actions of the individuals and cannot be reduced to them ... It is more than the mere sum of its parts but presupposes also that those elements are related to each other in a particular manner” (Hayek [1967] 2014: 282; also

⁵ For more on the Hayek’s account of complexity, see Chaunont-Chancelier (1999), Vaughn (1999b), Gaus (2006), Fiori (2009), Rosser (2010, 2015), Lewis (2015a, 2015b, 2016a, 2016b, 2016c), and Axtell (2016).

⁶ As Hayek put it elsewhere, a system is, “a coherent structure of causally connected ... parts” (Hayek n.d.: 4). Hayek acquires the notion of a ‘system’ from the work of Ludwig von Bertalanffy. For more on Bertalanffy’s influence on Hayek, see Lewis (2016a, 2016b).

see Hayek [1964] 2014: 262; Hayek: 1952: 147).⁷ [CS3, CS4] To put this slightly differently, in a way that brings out Hayek’s commitment to a hierarchical view of social reality, it is a higher-level regularity that is displayed only by the system as a whole and is quite distinct from the ‘lower-level’ properties of the individual people who populate the market system (Hayek [1961] 2014: 381-82, [1964] 2014: 264, [1967] 2014: 288-89; also see Lewis 2012, 2015a).⁸ [CS5]

Following Michael Polanyi (1951), Hayek describes systems that display this emergent order of action as “polycentric”, contrasting them with the “monocentric” orders that central planners seek to construct (Hayek [1967] 2014: 284-86; also see Hayek 1976: 178 n. 11). For Hayek, a key aim of social theory is to investigate how, if people’s interactions are characterised by a particular set of social relations, they will unintentionally produce such spontaneous social phenomena. In Hayek’s words:

It is the so-called wholes, the groups of elements which are structurally connected, which we have learned to single out from the totality of observed phenomena ... [and which] are the condition for the achievement of many of the things at which we as individuals aim, the environment which makes it possible even to conceive of our individual desires and which gives us the power to achieve them.” (Hayek [1942] 2010: 102-03, [1944] 144.)

On this view, one key aspect of providing a satisfactory explanation of social phenomena of interest lies in identifying the sets of social relations—and the systems of social rules that give rise to them—that underpin economic phenomena of interest, as Hayek himself does in his efforts to explain the possibility of social order. This task, of explaining how a *given* set of social rules underpins and gives rise to certain kinds of outcome, is central to what one might describe as a static or synchronic account of the outcomes in question (Lewis 2015, 2016c).

Hayek elaborates on his claim that the coordinative power of the market economy is an emergent property of the market system by arguing that it is the result of the causal *interaction* of several different rules, not simply the *sum* of their *separate* effects taken in isolation. We can see this most clearly in Hayek’s remark that, “[S]ystems of rules of conduct will develop as wholes” ([1967] 2014: 283):

The evolutionary selection of different rules of individual conduct operates through the viability of the order it will produce, and any given rules of individual conduct may prove

⁷ More specifically, such systems display what Hayek refers to as ‘organised complexity’ in the sense that “the character of the structures ... depends not only on the properties of the individual elements of which they are composed ... but also on the manner in which the individual elements are connected with one another” (Hayek [1975] 2014: 365).

⁸ Hayek expresses his commitment to a hierarchical view elsewhere in the same essay, in writing that “[s]ocieties differ from simpler complex structures by the fact that their elements are themselves complex structures” ([1967] 2014: 288; also see Hayek 1952). For more on Hayek’s view of people as the complex elements of complex social systems, see Lewis (2015b: 133-38, 2017: 7-11, 13-15, 19-21).

beneficial as part of one set of such rules, or in one set of external circumstances, and harmful as part of another set of rules or in another set of external circumstances. (Hayek [1967] 2014: 280)

As was noted above, the elements of a complex system behave differently when they are part of that system as compared to when they are in isolation, thereby giving rise to emergent, system-level properties. Here, Hayek analogously contends that the rules in terms of which social systems are defined have a different impact on social outcomes depending on the other rules with which they are combined and so interact. In other words, according to Hayek's complex systems perspective, there is an intricate rule *structure*, with certain rules complementing each other in the sense that, taken together, they give rise to emergent capacities that are not possessed by any of them taken alone (Hayek 1960: 36, 158; also see Hayek 1973: 105, 122-23).

The notion of a 'system' that displays emergent or 'higher-level' properties is also important for Hayek's attempt to deal with the next major explanatory task he sets himself, namely that of explaining how rules of the kind required to generate the overall order of actions comes to prevail ([1967] 2014: 279). Here, Hayek is moving beyond the static or synchronic kinds of explanation described above, in which a given set of rules acts as the *explanans*, to a more dynamic or diachronic kind of explanation that involves an account of how the set of rules in question arises in the first place (Lewis 2012: 370, 375, 2015a: 1174-79). Hayek's explanation takes the form of a theory of cultural evolution, which portrays those rules as the product of a process of competition between different groups of people. The groups in question are defined by reference to the system of rules to which their members subscribe, and the trait that forms the basis for the competition between those groups is the emergent property or overall order of actions to which each system gives rise. As Hayek puts it, "[W]hat may be called the natural *selection* of rules will operate on the basis of the greater or lesser efficiency of the resulting *order of the group*" ([1967a] 2014: 279):

It is the resulting overall order of actions but not the regularity of the actions of the separate individuals as such which is important for the preservation of the group ... [and] the selection process of evolution will operate on the order as a whole. (Hayek [1967a] 2014: 280, 283.)

The different systems of rules structure the actions of the members of the various groups and, in virtue of respective capacities to generate the emergent capacity to coordinate people's plans, determine the success of those groups in the process of competition through which selection occurs. Those groups

whose activities are structured by a rule system that gives rise to the overall order of actions are able to generate the wealth required to sustain higher populations, while groups that do not adhere to such rules decline in size and ultimately are eliminated.⁹ In the end, therefore, groups exhibiting the emergent property in question come to predominate. For Hayek, then, it is in virtue of their capacity to generate the emergent causal power to coordinate people's actions without centralised direction that groups—and, more specifically, the systems of rules that characterise them—are selected in the process of social evolution: “The reason why such rules will tend to develop,” Hayek (1973: 99) argues, “is that the groups which happen to have adopted rules conducive to a more effective order of actions will tend to prevail over other groups with a less effective order.” The precise details of the rules systems that prevail will, of course, depend on the exact nature of the external circumstances people face (Hayek [1967] 2014: 279-80, 282-83). There is, therefore, an element of what might termed ‘context-dependence’ to the rules systems that obtain, which is of course why those systems are described as ‘adaptive’ (Gaus 2006; Lewis 2015a).

While Hayek places a good deal of emphasis on the *indirect*, group-level selection of rules operating on the emergent properties generated by rule systems and practices, along the lines just described, he also discusses the possibility of the *direct* selection of rules (Lewis 2015a: 1178-1186). Hayek's accounts of innovation and imitation in rule-following both involve individual people making a conscious decision to adopt a new rule or practice in the light of their subjective assessment of the personal gains to be had from so doing. In contrast to group-level processes, therefore, where rules are selected on the basis of their capacity to contribute to a wider set of rules that generates an overall order of actions, lower-level selection involves rules being chosen on the basis of their appeal to individual people. The first source of selective pressure comes from ‘above’, as it were, as the ‘systems of cooperation’ to which those rules contribute fare more or less well in the higher-level process of group competition. But there is also pressure from ‘below’, as individual rules are selected in virtue of their appeal to, and ability to command the allegiance of, individual people. The overall picture that emerges from Hayek's writings on cultural selection, then, is one of a multi-level evolutionary process in which rules are subject to pressure from at least two directions, as a result of which the social world displays the evolutionary tendencies characteristic of a complex adaptive system (Gaus 2006). [CS7]

Hayek's goal in developing his theory of cultural evolution is to explain how modern market economies arose in the absence of conscious direction (Hayek [1967] 2014: 279). As we have seen, his explanation centres on variations in the capacity of different kinds of group or society to generate the

⁹ The growth of groups that are successful in the process of evolutionary competition may not only reflect their superior ability to sustain their own ‘internal’ populations, but may also involve them assimilating less successful groups, as the latter's members either imitate the rules of their more successful rivals or emigrate to them (Gaus 2006: 242-43).

emergent causal power to coordinate people's actions in the absence of centralised direction. But the causal power in question is irreducible both to the properties of the individual rules taken in isolation and also to the attributes and actions of the people who populate the group in question. It follows that the emergent social wholes—the groups and, more specifically, the systems of rules by reference to which those groups are defined—cannot be eliminated from Hayek's explanation, to be replaced by explanations couched solely in terms of individuals, because it is only when people are organised so as to form the group in question that the emergent causal power upon which Hayek's explanation rests actually exists. In this way, the ontological and causal irreducibility of the overall order of actions underwrites the explanatory irreducibility of the system of rules that underpins that emergent property. His work can thus be seen to endorse the sixth aspect of the theory of complex systems identified above, namely a commitment to an anti-reductionist methodology (Lewis 2016c). [CS6]

Finally, Hayek argues that the complexity of economic systems has important epistemic implications. In particular, the outcomes that result from the operation of complex systems do not lend always themselves to precise quantitative predictions, of the kind required for expected utility maximizing behaviour. People are nevertheless able to act in a purposeful, goal-driven fashion because—as noted above—they are able to exert some control over the consequences of their actions by relying on social rules, most notable the rules of the legal system. The long-term contracts facilitated by legal rules enable people to secure a degree of control over their future income and expenditure (in the case of households) and revenues and costs (in the case of firms). Such contracts do not tie down the future completely; unforeseen events may arise, which are not covered by the contract, and one or more parties may unexpectedly renege on their contractual commitments. But they do circumscribe the range of possible outcomes sufficiently for people to be able to orient themselves towards the future in a way that enables them to act in a purposeful, goal-driven fashion. In this way, the system of legal rules makes the world a more orderly place in which “we can at least say in general terms how [events] hang together ... Though not in a position to specify precisely what to expect, or even to list all possibilities ... it limits the possibilities of what else may occur ... [thereby] help[ing] us to make our action more effective” (Hayek [1955] 2014: 209-10; also see 1976: 130). [CS8]

In what follows, we shall use the discussion of complex systems provided above to shed light on the relationship between the work of the Ostroms and complexity theory.

4. COMPLEX SYSTEMS IN THE WORK OF THE OSTROMS

The term ‘complex’ occurs quite frequently in the work of Vincent and Elinor Ostrom, but is rarely clearly and explicitly defined, especially in their work prior to the mid-to-late 1990s. It appears most often

to be used as a device for differentiating the Ostroms' preferred approach to social analysis from earlier approaches to the study of social phenomena in general and public administration in particular. In her Nobel Prize lecture, for example, Elinor Ostrom contrasts her preferred approach to the study of the social world with what she describes as the "earlier world view of simple systems". The latter, mid-twentieth century approach sought to "fit the world into simple models and to criticise institutional arrangements that did not fit" (E. Ostrom [2009] 2014: 168; also see E. Ostrom 1990: 14). The simplicity of these models manifested itself in a number of ways: in their proclivity for analysing features of the social world in terms of two all-encompassing, mutually-exclusive categories (in particular those of 'state' and 'market', in the case of institutions, and those of 'pure public goods' and 'pure private goods', in the case of commodities); and also in terms of their reliance on the assumption that people can be portrayed (only) as rational, expected utility-maximisers of the kind utilised in mainstream economics and game theory (E. Ostrom [2009] 2014: 167-70). Ostrom maintains, however, that a satisfactory understanding of the diversity of phenomena in contemporary society requires a richer set of categories than is utilised by those earlier approach to social analysis. More specifically, the task of understanding how in practice people provide public services and manage common property resources requires a "more complex" (E. Ostrom [2009] 2014: 167) set of categories that can do justice to empirical findings testifying to the diversity of the institutional arrangements that people use to deliver public services and manage shared resources, to the fact that there are more than two broad kinds of good in the world, and to the way in which people appear to be motivated by a variety of considerations to which the model of man as *homo economicus* cannot do justice (E. Ostrom [2009] 2014: 167-85). "To explain the world of interactions and outcomes," Elinor Ostrom ([2009] 2014: 197; also see E. Ostrom 2005: 256) writes at the end of her Nobel lecture, "we also have to be willing to deal with complexity instead of rejecting it."

If this were all there were to the role that notions of 'complexity' played in the Ostroms' work, than one might reasonably conclude that they used the term in a more-or-less colloquial, everyday fashion to highlight the need for social scientists to use a set of concepts that is tailored to 'fit' key features of the social world. But there is arguably more to the Ostroms' use of the term 'complex' than a simple injunction not to use models that are too unrealistic. For a careful reading of their work reveals that they have also long been committed to a view of 'complexity' very much along the same lines as that set out in Hayek's work on complex systems. In what follows, an attempt is made to justify that reading of the Ostroms as viewing society as a complex adaptive system by drawing on the account provided in section 2 above to show that the attributes of complex systems described there are also attributable to the 'polycentric systems' studied by the Ostroms.

From the mid-to-late 1990s, the Ostroms do in places endorse such a reading of their work. In an article published in 1999, for example, Elinor Ostrom writes that the self-organised groups she considers

in her work on common property resources are best viewed as complex adaptive systems, where the latter are defined as follows:

Complex adaptive systems are composed of a large number of active elements whose rich patterns of interaction produce emergent properties that are not easy to predict by analysing the separate parts of the system ... Polycentric systems are themselves complex adaptive systems. (E. Ostrom 1999: 520-21.)

However, it was not until the mid-to-late 1990s that, drawing for example on the work of Holland (1995) and Miller and Page (2007), the Ostroms provided an explicit and sustained account of polycentric systems as a class of complex adaptive systems (Ostrom 1999: 520-25; Gibson *et al.* 2000: 217-24, 230-34). But it will be shown below that the Ostroms had developed an account of polycentric systems as displaying most if not all of the hallmarks of organised complexity long before they began to refer explicitly to the notion of a complex adaptive system and to the literature on that topic penned by authors such as Holland and Page.

The Ostroms began to use the notion of polycentricity in the 1960s, in the course of their work on the reform of public administration in metropolitan areas in America.¹⁰ In an important early essay, Vincent Ostrom defines the concept as follows:

‘Polycentric’ connotes many centres of decision-making, which are formally independent of each other. Whether they actually function independently, or instead constitute an interdependent system of relations, is an empirical question in particular cases. To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a manner with consistent and predictable patterns of interacting behaviour. To the extent that this is so, they may be said to function as a ‘system’. (Ostrom *et al.*, 1961: 831; also see V. Ostrom [1991] 2014: 45.)

On this view, as Vincent Ostrom explains elsewhere, a ‘system’ is “a set of ordered relationships that persists through time” (V. Ostrom [1972a] 1999: 52). This is, of course, the same as the definition of a

¹⁰ They did so prior to their acquaintance with the work of Polanyi (V. Ostrom [1991] 2014: 46).

system as set of elements or parts that are related to each other in particular ways as is used in complexity theory (see point **CS1** above).

Furthermore, as the Ostroms later make clear, polycentric systems of governance are formed when people's interactions are governed by sets of rules: "A polycentric organization," Vincent Ostrom states, is "a pattern of organization where many independent elements are capable of mutual adjustment for ordering their relationships with one another within a general system of rules" (Ostrom [1972a] 1999: 73; also see p. 58). The elements of such systems are positions: those of buyers and sellers (in market systems); those of citizens, private producers and officials located in many different units of government, some of the latter serving as production units and some as collective consumption units acting on behalf of various communities of people (in the case of polycentric systems of metropolitan governance); and those occupied by the various users, non-users, and monitors, of common property resources (in the case of socio-ecological systems). By specifying the duties and rights—the "capabilities and constraints"—associated with each position, the rules in question define them and specify how their occupants should relate to one another (V. Ostrom [1972b] 1999: 124; E. Ostrom ([1986] 2014: 99; V. Ostrom and E. Ostrom [1977] 1999: 82-89; also see E. Ostrom [2009] 2014: 179-81). More specifically, the Ostroms distinguish between three types or levels of rules. Operational or working rules are those governing people's everyday activities. Prominent amongst such rules are the legal rules governing contracts, whether between participants in a market or between various local and federal authorities within a polycentric system of metropolitan governance, and the rules-in-use regulating entitlements to access and duties to maintain various kinds of common property resource (V. Ostrom [1972a] 1999: 60-62, V. Ostrom ([1991] 2014: 46-50, 54; also see E. Ostrom [2009] 2014: 173-77). At a slightly higher level of abstraction than operational rules are the collective choice rules governing how people decide upon and craft the operational rules they will follow. At a still higher level are the constitutional rules that shape the processes through which collective choice rules are decided upon (V. Ostrom [1972a] 1999: 59-60, 70; Kieser and Ostrom [1982] 2000: 76-79). What these examples all go to show is that, as Vincent Ostrom put it, "rule-ordered relationships ... are constitutive of human organization" (V. Ostrom [1973] 2008: 2). All in all, therefore, it seems fair to conclude that as conceptualised by the Ostroms polycentric systems display the second of the attributes of complexity described above, namely that of being rule-governed.

[CS2]

Hayek argued that it was necessary to employ theory in order to see underneath the apparent chaos of rivalrous market competition there was an orderly outcome in which people's plans tended to dovetail. In a similar vein, the Ostroms maintained that in the case of polycentric systems of metropolitan governance the existence of overlapping jurisdictions and fragmentation of authority did not necessarily signify chaos and waste, as suggested by the traditional, Wilsonian view of public administration. Rather,

when viewed through the lens provided by contemporary political economy,¹¹ multiple jurisdictions could be seen to generate outcomes that were orderly, in the sense that the plans made by the relevant decision-makers about what kinds of public goods to demand and provide were brought into closer harmony with one another: “The appearance of disorder that prevails at the surface ... may upon further inquiry reveal coherent patterns of order ... where many elements are capable of making mutual adjustments to one another” (V. Ostrom [1991] 2014: 46; also see V. Ostrom and E. Ostrom [1977] 1999: 89, and E. Ostrom [2009] 2014: 177-71). According to the Ostroms, therefore, the mutual adjustment of decision-making, the plan coordination, characteristic of a polycentric market order can also be displayed by polycentric systems of metropolitan governance (V. Ostrom [1972a] 1999: 52-53, 73, V. Ostrom [1991] 2014: 73).¹² Such patterns of order are spontaneous or self-organising in the sense that they arise when the “many autonomous elements or units seek to order their relationships with one another rather than by reference to some external authority” (V. Ostrom [1991] 2014: 47). More specifically, where collective choice and constitutional rules afford people the opportunity to devise the operational rules governing their day-to-day conduct in the light of their particular local circumstances, then they may be able to craft those rules in such a way as to generate the knowledge and incentives required to enable them to coordinate their plans: “individuals will have incentives to create or institute appropriate patterns of ordered relationships”, Vincent Ostrom ([1972] 1999: 59) argues; and they will be guided in their efforts to respond to those incentives both by the knowledge of each other’s behaviour provided by the relevant system of rules and also by the error-correcting negative feedback afforded them by the gain or loss of contracts and the movement of people within jurisdictions as they ‘vote with their feet’ (E. Ostrom [1972] 1999: 147-48, V. Ostrom [1972a] 1999: 57-60, 69-73; V. Ostrom [1972b] 1999: 127; V. Ostrom and E. Ostrom [1977] 1999: 92, 94-99; Kieser and Ostrom [1982] 2000: 75, 79-82; also see E. Ostrom and V. Ostrom [2004] 2014: 70 and E. Ostrom 2011: 372). As conceptualised by the Ostroms, therefore, polycentric systems display the fourth of complex systems, namely the capacity to self-organise. **[CS4]**

The capacity to self-organise can also be viewed as an emergent property of polycentric systems. Thanks to their “self-organizing capabilities,” Vincent Ostrom has written, polycentric systems are “capable of yielding emergent patterns of order” (V. Ostrom [1991] 2014: 47, 45; also see E. Ostrom [2009] 2014: 179). Vincent Ostrom does not explicitly define the term ‘emergent’, as it is used in the passage just quoted. However, given that on his account the capacity to self-organise arises only when people’s interactions are governed by an appropriate set of rules, it seems fair to portray the ordering power in question as a structural or emergent property that is possessed, not by any of the individual

¹¹ By ‘contemporary political economy’, Ostrom means works such as Simon (1959), Buchanan and Tullock (1962), Stigler (1962), Olson (1965) and Tullock (1965).

¹² Vincent Ostrom also provides an account of the market order in terms that closely resemble those used by Hayek in Ostrom ([1991] 2014: 48-50).

people take in isolation—as would be true of a monocentric system—but rather by the rule-governed, polycentric system as a whole. Hence his description of polycentricity as “the *structural* basis”, and as embodying the “structural conditions”, of self-governing systems (V. Ostrom [1991] 2014: 46, [1972a] 1999: 53; also see E. Ostrom [2009] 2014: 168). Therefore, the Ostroms did indeed conceptualise the self-organising capacity of polycentric systems as structural or emergent properties of complex systems, albeit without always using that term.¹³ [CS3]

This conclusion is reinforced by another parallel between Hayek’s work and that of the Ostroms, namely that in both cases the emergent coordinative powers of the complex or polycentric system are portrayed as the result of the causal *interaction* of several different rules, not simply as the *sum* of the separate effect of each rule taken on its own. We have already seen this in the case of Hayek who, as noted above, argues that sets of complementary rules form an intricate rule *structure* or system that generates emergent capabilities that are quite distinct from those possessed by any of the rules on its own. The Ostroms make the same point, referring to it as “the configurational character of rules” (E. Ostrom [1986] 2014: 99). Just as Hayek maintains that outcomes are the result of the causal *interaction* of different rules, rather than the aggregate of the separate effect of each rule taken in isolation, so the Ostroms argue that rules are configurational in the sense that the effect of a change in one rule may depend upon the other rules-in-use. More specifically, according to the Ostroms, “rules combine in a configurational or interactive manner”, in that “the way one rule operates is affected by other rules”, so that “[t]he results predicted in one situation, using one rule, are dependent upon the other rules simultaneously in use” (E. Ostrom [1986] 2014: 108, 110, 104; also see E. Ostrom and V. Ostrom [2004] 2014: 77).¹⁴ The implication for the social sciences is the redundancy of methods that attempt to analyse social phenomena by studying each rule in isolation, out of context, and then aggregating the results thereby obtained. Such approaches, by erroneously treating rules as separable or atomistic phenomena, ignore the causal interaction between them and so lead to misleading analyses of their consequences: “theorists needs to specify a set of rules, rather than a single rule, when attempting to ask what consequences are produced by changes in a particular rule” (E. Ostrom [1986] 2014: 115; also see E. Ostrom [1986] 2014: 101-110, and E. Ostrom ([1998] 2014: 146-47, 150).¹⁵

¹³ This interpretation is supported by a later paper, written by Elinor Ostrom and some of her associates, where she discusses ‘emergence’, defined as a phenomenon whereby the “larger units” formed through the structured combination of smaller parts have characteristics “that are not simple combinations of attributes of smaller units, but can show new, collective behaviours” (Gibson *et al.* 2000: 221). In the case of the method of studying public economies utilised by the Ostroms, the approach used “is similar to that of ecologists who study the patterns of interaction among a large number of organised units within a spatial terrain and discover emergent properties resulting from the way that individual units work together” (Gibson *et al.* 2000: 234).

¹⁴ Elinor Ostrom also refers to these sets or systems of rules as ‘institutions’, defining the latter as “the set of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained ... what procedures must be followed ... and what payoffs will be assigned to individuals dependent on their actions” (1990: 51). Also see Kieser and Ostrom ([1982] 2000): 56, 64-67).

¹⁵ Both Hayek and Elinor Ostrom argued that statistical methods are less well-suited for the investigation of complex social systems than their widespread use might suggest. The reason, they argued, was that the application of statistical methods presupposes that variables combine in an

The Ostroms also acknowledge the epistemic consequences of complexity, in particular the radical uncertainty that characterises such systems. The uncertainty arises for two main reasons. First, while prevailing social rules inform and guide people's actions, thereby enabling people to navigate such systems with sufficient confidence that they can act in a purposeful, goal-driven fashion, they do not uniquely determine what people will do. People enjoy a measure of discretion in deciding how rules are to be interpreted and applied in a particular situation, and so whilst following rules may still act in ways that defy prediction (V. Ostrom 1980, 1982: 34; also see E. Ostrom 1968, Kiser and Ostrom [1982] 2000: 73-74 and E. Ostrom 2010: 5). Hence, as Hayek also observed, while rules may circumscribe the range of possible outcomes sufficiently for people to act in a purposeful, goal-driven fashion, they may not do so sufficiently to enable each person to have probabilistic knowledge of the consequences of his or her actions. Second, people may decide to change one of the rules in question. In that case, the configurational character of social rules implies that the new rule may interact with existing rules in such a way as to give rise to novel and so unpredictable emergent properties (E. Ostrom 1990: 207-10). If that is so, then people will again lack the knowledge of all the possible outcomes of their actions, so that their decisions cannot be represented according to the Savage axioms as if they involve expected utility maximization (V. Ostrom and E. Ostrom [1971] 2000: 38; V. Ostrom [1973] 2008: 44-46, 189-90).¹⁶ In such cases, where people confront radical uncertainty rather than simply numerical risk, "the use of extreme rationality assumptions ... runs the risk of stripping away and ignoring essential epistemic ... considerations" (V. Ostrom [1997] 2014: 250; also see p. 252):

To assume that individuals perform calculation processes requiring high levels of information when they are acting in uncertain environments may lead to the formulation of beautiful analytical models that are empirically irrelevant. A major question to be pursued is how institutional arrangements structure decision situations in complex arenas so that individuals are able to achieve productive outcomes even when we cannot derive analytic solutions. (Kieser and Ostrom [1982] 2000: 83; also see E. Ostrom 1968: 88 and E. Ostrom 1990: 25-26)

On this view, one should substitute the assumption of bounded rationality—the idea that people are intendedly rational but only limitedly so—for the assumptions of perfect information and utility maximisation used in axiomatic choice theory. Rather than behaving as if they maximise their expected

additively rather than in the emergent fashion implied by the presence of organised complexity (Hayek [1975] 2014: 363-65; E. Ostrom [1982] 2014: 217).

¹⁶ Vincent Ostrom explicitly acknowledges Hayek's contribution in emphasising how the human capacity creatively to generate new knowledge leads to uncertainty in V. Ostrom (1986: 242 n.1)

utility in a ‘small world’ of interactive decision-making, therefore, people inhabiting complex systems will fall back on the use of heuristics or rules of thumb to guide their actions (V. Ostrom [1997] 2014: 244; E. Ostrom [1998] 2014: 136-37).¹⁷ In short, like other students of complex systems, the Ostroms acknowledge the epistemic implications of complexity, arguing that it makes it implausible to model people if they are inhabit a ‘small world’, thereby undermining the relevance of models which assume that people act as if they maximise their expected utility.¹⁸ [CS8]

The question then arises of how people are able to learn rules of thumb or heuristics that are well-enough adapted to their particular context to enable them to coordinate their actions with each other (Kieser and Ostrom [1982] 2000: 83). The Ostroms argue that people do so by experimenting with different configurations of rules until they find one that works in their particular setting. It is here that the notion of polycentricity becomes especially significant. Under a polycentric system of governance, people—citizens and the official leading various production units, in the case of a public economy, or the users of the resource, in the case of common property—have the authority to experiment with different configurations of operational rules governing how they act. This autonomy enables them to try out different rule combinations, in the light of their local knowledge of the particular circumstances they face, in an attempt to discover systems of rules that work well for them (in the sense of satisfying their preferences for public goods at reasonable cost, for example, or of facilitating the successful management of the natural resource in question respectively). In such cases, as Vincent Ostrom put it, human society is “constituted by the simultaneous operation of diverse experiments variously linked to one another” ([1991] 2012: 265; also see V. Ostrom [1997] 2014: 256).¹⁹ If people then receive feedback on their efforts—as providers lose or gain contracts and people leave or move into local areas, in the case of public economies, or as the users of a natural resource discover how it performs under their control, both in absolute terms and also perhaps relative to similar controlled by other groups who have adopted different approaches—then they may be able to learn how to refine and improve their choice of rules, correcting errors and imitating superior practices used elsewhere. In this way, according to the Ostroms, polycentric systems can facilitate a process of social learning whereby the parallel efforts of different groups of people to devise configurations of rules may in the end make it possible to discover better combinations than if the systems of rules in question were designed using a top-down, or monocentric or constructivist approach (E. Ostrom 1968, E. Ostrom 1990: 182-216, V. Ostrom [1972a] 1999: 55, 59-60,

¹⁷ Compare Hayek ([1964] 2014: 260-61 n. 9) with E. Ostrom (1999: 519) on the epistemic problems that arise in systems in which created by the multiple combinatorial possibilities that arise in complex systems of interacting elements.

¹⁸ Of course, the degree of complexity of a system is ultimately an empirical matter: systems might be only loosely coupled, displaying moderate complexity, if the functioning and consequences of only some rules are dependent on others; but they will be tightly coupled, displaying maximal complexity, where every rule is interconnected with every other rules, so that a change in one rule moves the system to a new state that is entirely uncorrelated with its original state (Gaus 2016: section 2.4).

¹⁹ Both Ostroms emphasise that the public entrepreneurs who craft new combinations of rules draw on their local knowledge in doing so (E. Ostrom 1990: 34, V. Ostrom [1991] 2012: 288, and Ostrom and Ostrom [2004] 2014: 65).

V. Ostrom 1982: 31-32, V. Ostrom [1991] 2012: 275-84, V. Ostrom [1993] 2012: 298-300; also see E. Ostrom 1999: 497, 508-21, 525-30; cf. Hayek [1967] 2014: 284-86). Where the experimentation facilitated by such polycentric systems is successful, then—as noted above—the system is said to be ‘self-organising’, and to constitute a ‘complex adaptive system’, with a suitable system of rules arising through the adaptation of the sets of rules used by different groups to their immediate circumstances rather than by central direction. In the words of Vincent Ostrom, “In a society that works under such contingencies, it is more appropriate to say that policies *emerge* from the interaction of multiple centres of authority than to presume that they are *made* by some single centre of ultimate authority” (1991: 17; also see V. Ostrom [1972a] 1999: 58-60 and E. Ostrom 2011).

This process of adaptive self-organisation is of course an example of an evolutionary process in which systems of rules adjust to the broader context in which they are situated via an evolutionary process involving variation, selection, and (differential rates of) reproduction, as well as through the conscious choice of rules by people. More specifically, on the Ostromian account, the mechanism through which systems of rules evolve appears to take the form of a process of multi-level selection in which variation is introduced through the process of experimentation described above and where selection takes place not only through people’s decisions about whether or not to continue to follow a particular rule but also through the success or failure of the institution or system of rules as a whole in facilitating the sustainable use of the resource in question. If an institutional arrangement or configuration of rules is not adaptive in the sense being able to respond to ever-changing environment, then it is unlikely to prosper and faces the prospect of withering away (V. Ostrom [1972a] 1999: 47-48, V. Ostrom [1991] 2012: 269, 279, V. Ostrom [1993] 2012: 298; also see E. Ostrom 1999: 523-25, E. Ostrom and V. Ostrom ([2004] 2014: 73-74, E. Ostrom and Basurto 2011: 318, 325-26, 333-35, and Wilson *et al.* 2013). The Ostroms therefore view the development of systems of rules as taking place through a process of multi-level selection not dissimilar in its essentials to that adopted by Hayek and other complexity theorists, indeed even referencing Hayek’s account in places (Gardner and Ostrom 1991: 124; Becker and Ostrom 1995: 123).²⁰

[CS7]

There is, then, a good deal of common ground between Hayek’s account of complex systems and that to which the Ostroms subscribe. For example, in both cases, society is thought to consist at least in part of rule-governed systems that govern people’s interactions; the systems in question possess their own distinctive, structural or emergent properties; the latter include the power to coordinate people’s actions, so that the systems in question are self-organising; and those systems also evolve over time so as to adapt to the environment in which they are situated. In the remainder of the paper, however, I seek to move

²⁰ Ultimately, it is an empirical matter whether these efforts succeed, and the Ostroms readily acknowledge that such evolutionary approaches may well not lead to solutions that can be described as optimal in any meaningful sense of that term (E. Ostrom (1990: 182-83, 187-88)).

beyond highlighting similarities between the work of Hayek and the Ostroms to make two points. First, I shall argue that the Ostroms' work on human agency and, in particular, the variety of sources of human motivation, can help to deal with a problem in Hayek's analysis of society as a complex system, centring on Hayek's theory of cultural evolution. Second, I shall consider two of the properties of complex systems highlighted above, namely their hierarchical and anti-reductionist natures (**CS5** and **CS6**), in order to highlight a tension, which is ultimately resolved, between the substance of the Ostroms' work and the ways in which, in a more reflective mode, they at times describe their approach to social science.

5. HAYEK'S ACCOUNT OF GROUP SELECTION: A TENSION AND AN OSTROMIAN CONTRIBUITION

As explained above, Hayek argues that systems of rules develop via a process of group selection that operates on the emergent property to which they give rise. The difficulty with this argument is that it depends on the members of the group in question following the relevant set of rules, not because doing so necessarily benefits the individuals themselves, but because it is advantageous for the group as a whole. The problem with such self-sacrificing behaviour, the critics argue, is that such groups will be undermined by the growing presence amongst their membership of free-riders who benefit from being part of the group without incurring the costs of conforming to the rules in question. While such groups might enjoy a 'between group' advantage in the process of competition with other collections of people, the critics contend that they will ultimately be undermined from within because the selfish free-riders will enjoy the benefits of group membership without incurring any of the costs of sustaining it. As a result, they will enjoy a 'within group' advantage over the more altruistic group members who adhere to the relevant rules, being able to out-compete the latter and eventually coming to dominate the group (Vanberg 1986: 85-89).

However, when taken in conjunction with recent work in evolutionary biology, the work carried out by Elinor Ostrom can help to show that such criticisms need not be fatal for group-selection arguments of the kind advanced by Hayek. Recent developments in the theory of multi-level selection have shown that within-group selection of the kind emphasised by Hayek's critics need not always prevail over between-group selection of the sort invoked by Hayek. Groups such as those described by Hayek, whose members follow a set of rules even though there may be occasions when it is not in their narrowly-defined individual self-interest to do so, need not be undermined by free-riders, and so can indeed survive

the process of evolutionary competition, so long as the force of ‘between-group’ selective pressure exceeds that of ‘within-group’ selection (Sober and Wilson 1998; Wilson 2004, 2016: 33-35, 40-42).²¹

The relative strength of the two levels of selection depends upon a variety of factors, and so is ultimately an empirical matter. But it can be shown that the so-called ‘core design principles’ set out by Elinor Ostrom, which specify the attributes of groups—and, more specifically, of the systems of rules to which those groups subscribe—that are conducive to the successful management of common property resources, also describe the kind of situation in which the impact of between-group selection is likely to outweigh that of within-group selection. The design principles stipulate, for example, that there should be proportional equivalence between the benefits that users of a resource enjoy and the costs they incur, thereby helping to avoid the creation of differences between members that might constitute the basis for within-group selection; that monitoring, sanctioning and conflict resolution arrangements should be established to deter behaviour that benefits some members at the expense of others, thereby discouraging within-group selection; and that the collective choice rules governing the group in question should entitle most of its members to participate in the process of choosing and modifying the operational rules governing their day-to-day activities, which militates against within-group selection by preventing some members of the group choosing operational rules that benefit them at the expense of other (disenfranchised) members.²² As Ostrom and some of her co-authors have put it, “[W]hen a group possesses the core design principles, the opportunities for some members to benefit at the expense of others becomes extremely limited” (Wilson *et al.*, 2013: S26). Where groups conform to the design principles, therefore, successful group-level adaptation of the kind discussed by Hayek can indeed take place. In this way, the Ostroms’ work on common property resources can be seen to contribute towards the defence and development of group-selection arguments of the kind advanced by Hayek (Wilson *et al.* 2013: S23-S27; Wilson 2015: 11-13, 65-68, 100-01, 124-25).

6. ELINOR OSTROM ON EMERGENCE, BASIC UNITS OF ANALYSIS AND METHODOLOGICAL INDIVIDUALISM

It was noted earlier that one of the key features of complex systems is that they possess emergent

²¹ Put slightly differently, according to this point of view, human groups can function successfully as adaptive units because certain pro-social individual traits—such as the capacity to internalise social norms that benefit the group, other-regarding preferences, and a disposition to punish those who violate accepted social rules—have been selected for indirectly, at the level of the group. In this way, “mechanisms evolve that suppress forms of selection within groups that are detrimental to the group” (Wilson and Gowdy 2015: 41; also see pp. 42-43, 48 and Wilson 2016: 124-45). As Gaus (2006: 241-42) has noted, this kind of argument is quite consistent with Hayek’s view that individual people’s powers of reason are shaped by culture, which itself developed through a process of evolution via group selection.

²² For more on the design principles, see E. Ostrom 1990: 89-102.

properties that are ontologically, causally and explanatorily irreducible to the properties of their constituent parts. That underwrites the explanatory irreducibility of the emergent wholes—in the case of social sciences, the system of rules—that underpins those emergent properties. This is quite at odds with reductionist approaches that seek to replace references to emergent wholes by statements about the properties of its isolated component parts.

Where do the Ostroms stand on this issue? At first glance, there would appear to be a tension between their substantive theorising—which, as we have seen, involves them postulating the existence of complex systems with irreducible emergent properties—and their explicit methodological pronouncements, in which they espouse an individualism seems to be at odds with the structural/relational properties postulated in their substantive theories about the coordinative powers of polycentric *systems*. “In a theory of polycentric orders,” Vincent Ostrom (1972a] 1999: 57) writes, “individuals are the basic unit of analysis.” Similarly, Elinor Ostrom argues that her work rests on a “methodological individualist perspective” according to which “[a]ttributes of the individual decision-maker constitute the core of the analysis” (Kieser and Ostrom [1982] 2000: 58). Such explicit methodological pronouncements, in which the individual seems to be accorded analytical priority—as “the core” or “the basic” unit of analysis—sit somewhat uneasily with the Ostroms’ substantive claim that it is the structure of relations between impersonally-defined positions that is critical for determining the possibility of social order arising in market and public economies. For if such orders have a “*structural* basis”, being generated by the emergent coordinative powers of a social system that is ontologically, causally and explanatorily irreducible to its individual members, then claims to the effect that the individual is the basic unit of analysis are unwarranted.²³

Elinor Ostrom in particular ultimately recognised this tension and distanced herself from methodological individualism. Writing in 2004 about the ten books that had most influenced her, she explained how reading the sections of the American evolutionary biologist Ernst Mayr’s book, *The Growth of Biological Thought* (Mayr 1982) on emergence—a key feature of complex systems, as we have seen—had led her to realise the shortcomings of the methodological individualism she had hitherto explicitly espoused:

Mayr’s book ... laid the foundation for my understanding of the importance of the embedded nature of systems. I was raised on methodological individualism and the mantra ‘the individual is *the* basic unit of analysis’ was solidly pounded into my head. Therefore, coming

²³ Another indication of this tension in the Ostroms’ work is the conflicting readings it has inspired, with authors such as Boettke and Coyne (2005) emphasising the way in which, at least, at times the Ostroms describe themselves as methodological individualists whilst others, such as their long-term associate Michael McGinnis, argue that their most recent work is no longer accurately described using that term (McGinnis 2005: 170).

from that scholarly tradition, reading Mayr's discussion of emergence was also a major shock. Mayr was of course reacting to the presumption made by physical scientists that you could reduce all biology to chemistry and physics since underlying any living system were chemical and physical elements. (E. Ostrom 2004: 44.)

What reading Mayr enabled Ostrom to realise, therefore, was that the presumption that the individual is *the* basic unit of analysis, to be accorded special methodological status, is unwarranted: the individual is of course important, not least because of his/her emergent capacity to interpret situations and imbue them with meaning; but the emergent properties of the higher-level social systems, whereby individuals stand in certain relations to one another and thereby form higher-level wholes with their own distinctive attributes, are equally significant for understanding for the social world. As Ostrom puts it elsewhere in her 2004 essay: "For ages, social scientists have been struggling to identify the basic unit of analysis. I now realise that there is no single basic unit of analysis. All organised life is nested in higher levels of organisation and contains lower level units of organisation" (E. Ostrom 2004: 41; also see E. Ostrom 2005: 11-15, E. Ostrom 2011: 372, and V. Ostrom 1985: 20). As she came to appreciate, therefore, describing her approach as 'methodological individualism' is misleading.²⁴ Since, on her view, social outcomes of interest are in fact produced by the interplay of the emergent causal powers possessed by people and by higher-level systems, with people relying on such systems in order to act and, through their actions, contributing to the reproduction and/or transformation of those systems, and with those higher-level systems therefore having a causally and explanatorily irreducible role to play, her approach might be more accurately described as an example of a transformational model of social activity (Lawson 1997: 166-71, Lawson 2003: 35-45, 116-29, Lewis and Runde 2007: 179-83, Lewis 2015a: 1170-71).²⁵ As Elinor Ostrom has written, her approach "will allow scholars who stress structural explanations of human behaviour and those who stress individual choice to find common ground, rather than continue the futile debate over whether structural variables or individual attributes are the most important" (E. Ostrom [1998] 2014: 124; also see Kieser and Ostrom [1982] 2000: 58-60 E. Ostrom 1990: 187, 192; cf. Lewis 2015a: 1172-74, 1186-87). And what this reveals, of course, is that over time the Ostroms did come to

²⁴ Similar issues also arise in the case of Hayek and other Austrian economists (Lewis 2005: 308-11, 2008: 851-52).

²⁵ A long-time associate of the Ostroms, Michael McGinnis, argues that Vincent Ostrom underwent a similar epiphany, preferring in his later years to describe his approach not as methodological individualism but rather as 'methodological communalism' or 'Tocquevillian analytics' in recognition of the fact that, as argued in the main text, individuals and institutions were accorded equal causal and explanatory weight in their analysis (McGinnis 2005: 170). It is also noteworthy in this regard that in a similar vein Hayek over time tended seemed less and less inclined to describe his preferred approach to social analysis as individualistic, referring to it instead for example as evolutionary in nature (Caldwell 2004: 284-85, 295).

appreciate both the hierarchical and anti-reductionist properties of complex social systems (**CS5** and **CS6**).²⁶

7. CONCLUSION

Both Hayek and the Ostroms were committed to a view of the social world as a complex adaptive system. Both view the social world as a rule-governed, layered self-organising system that displays emergent properties and which develops over time via a multi-layered evolutionary process. Where there are differences in emphasis between the two approaches, they often tend to complement each other. That complementarity manifests itself, for example, in their different choice of subject-matter: Hayek's account of self-organising systems tends to focus on the market economy and to the common law; whereas the Ostroms' main interest is in non-market systems, whether they be local public economies or common property resources. It can also be seen in their theoretical work, where the Ostroms drew on Hayek's work on local knowledge and spontaneous market orders amongst many others in order to develop an account of social order in non-market settings, while also providing conceptual resources that can be used to develop and improve Hayek's own theory of cultural evolution. In addition, the development of an analytical framework along the lines suggested by the theory of complex systems led in both cases to a growing acknowledgement that reductionist approaches to the study of social world—that is, approaches that presupposed that the social world consists of isolated atomistic beings that can be studied in isolation and which therefore constitute a single key 'unit of analysis'—ignored key emergent features of social reality and so need to be replaced by methods that do justice to the existence of social structures that possess their own distinctive ontological, causal and explanatory significance.

²⁶ The Ostroms' commitment to a hierarchical view of the world is underlined by the way that they argue that that different systems of rules are nested within each other, with rules at one level—for example, the operational rules that govern people's everyday activities—being subject to or nested within a higher-level set of collective-choice rules governing how they can be changed or to be formed, which are in turn nested within a still higher-level set of constitutional rules governing how the collective rules can be altered (E. Ostrom 1999: 528, 2005: 6, 55-62).

REFERENCES

- Anderson, P. 'More is Different.' *Science*, 177 (August 2): 393-96.
- Anderson, P., K. Arrow and D. Pines (1988). *The Economy as an Evolving Complex System*. Redwood City, CA: Addison-Wesley.
- Arthur, B. (2014). *Complexity and the Economy*. New York and Oxford: Oxford University Press.
- Arthur, B. S. Durlauf, and D. Lane (1997). *The Economy as an Evolving Complex System II*. Reading, MA: Addison-Wesley.
- Axtell, R. (2016). 'Hayek Enriched by Complexity Enriched by Hayek.' *Advances in Austrian Economics*, 21: 63-121.
- Axtell, R. and J. Epstein (1996). *Growing Artificial Societies: Social Science from the Bottom Up*. Cambridge, MA: MIT Press.
- Becker, C. and E. Ostrom (1995). 'Human Ecology and Resource Sustainability: The Importance of Institutional Diversity.' *Annual Review of Ecology, Evolution and Systematics*, 26: 111-33.
- Beinhocker, E. (2006). *The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics*. London: Random House.
- Boettke, P. and C. Coyne (2005). 'Methodological Individualism, Spontaneous Order and the Research Program of the Workshop in Political Theory and Policy Analysis.' *Journal of Economic Behavior and Organization*, 57: 145-158.
- Buchanan, J. and G. Tullock (1962). *The Calculus of Consent: Logical Foundations of Constitutional Democracy*. Ann Arbor: University of Michigan Press.
- Caldwell, B. (2004). *Hayek's Challenge: An Intellectual Biography of F.A. Hayek*. Chicago and London: The University of Chicago Press.

Chaumont-Chancelier, F. (1999). 'Hayek's Complexity.' *Journal des Economistes et des Etudes Humaines*, 9: 543-64.

Colander, D. and R. Kupers (2014). *Complexity and the Art of Public Policy*. Princeton and Oxford: Princeton University Press.

Fiori, S. (2009). 'Hayek's Theory on Complexity and Knowledge: Dichotomies, Levels of Analysis, and Bounded Rationality.' *Journal of Economic Methodology*, 16: 265-85.

Fleetwood, S. (1995). *Hayek's Political Economy: The Socio-Economics of Order*. London New York: Routledge.

Gardner, R. and E. Ostrom (1995). 'Rules and Games.' *Public Choice*, 70: 121-49.

Gaus, J. (2006). 'Hayek on the Evolution of Society and Mind.' In E. Feser (ed.), *The Cambridge Companion to Hayek*. Cambridge: Cambridge University Press.

Gaus, J. (2016). 'Hayek, Complexity and "Classical" Liberalism.' Unpublished paper, University of Arizona.

Gibson, C., E. Ostrom and T. Ahn (2000). 'The Concept of Scale and the Human Dimensions of Global Change: A Survey.' *Ecological Economics*, 32: 217-39.

Gilboa, I. and D. Schmeidler (1995). 'Case-Based Decision Theory.' *Quarterly Journal of Economics*, 110: 605-39.

Gintis, H. (2006). 'The Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics. By Eric D. Beinhocker.' *Journal of Economic Literature*, 44: 1018-31.

Harper, D. and P. Lewis (2012). 'New Perspectives on Emergence in Economics.' *Journal of Economic Behavior and Organization*, 82: 329-37.

Hayek, F.A. ([1942] 2010). 'Scientism and the Study of Society. Part 1.' In Hayek (2010).

Hayek, F.A. ([1943] 2010). 'Scientism and the Study of Society. Part 2.' In Hayek (2010).

Hayek, F.A. (1952). *The Sensory Order: An Inquiry into the Foundations of Theoretical Psychology*. London and Henley: Routledge & Kegan Paul.

Hayek, F.A. ([1955] 2014). 'Degrees of Explanation.' In F.A. Hayek (2014).

Hayek, F.A. (1960). *The Constitution of Liberty*. London and New York: Routledge.

Hayek, F.A. ([1961] 2014). 'A New Look at Economic Theory.' In F.A. Hayek (2014).

Hayek, F.A. ([1964] 2014). 'The Theory of Complex Phenomena.' In F.A. Hayek (2014).

Hayek, F.A. ([1967] 2014). 'Notes on the Evolution of Systems of Rules of Conduct.' In F.A. Hayek (2014).

Hayek, F. A. ([1975] 2014). 'The Pretence of Knowledge.' In F. A. Hayek (2014).

Hayek, F.A. (1976). *Law, Legislation and Liberty: A New Statement of the Liberal Principles of Justice and Political Economy. Volume II: The Mirage of Social Justice*. London and New York: Routledge.

Hayek, F.A. (1979). *Law, Legislation and Liberty: A New Statement of the Liberal Principles of Justice and Political Economy. Volume III: The Political Order of a Free People*. London and New York: Routledge.

Hayek, F.A. (2010). *The Collected Works of F.A. Hayek, Volume 13: Studies on the Abuse & Decline of Reason*. Edited by B. Caldwell. Chicago: The University of Chicago Press.

Hayek, F.A. (2014). *The Collected Works of F.A. Hayek, Volume 15: The Market and other Orders*. Edited by B. Caldwell. Chicago: The University of Chicago Press.

Hayek, F.A. (n.d.). 'Within Systems and About Systems: A Statement of Some Problems of a Theory of Communication.' Typescript. Hoover Institution Archives, Hayek Papers, box 104, folder 22.

Holland, J. (1995). *Hidden Order: How Adaptation Builds Complexity*. Reading, MA.: Perseus Books.

Holt, R., J.B. Rosser, Jr., and D. Colander (2011). 'The Complexity Era in Economics.' *Review of Political Economy*, 23: 357-69.

Jepperson, R. and J. Meyer. (2011). 'Multiple Levels of Analysis and the Limitations of Methodological Individualism.' *Sociological Theory*, 29: 54-73.

Kieser and Ostrom ([1982] 2000). 'The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches.' In M. D. McGinnis (ed.) (2000), *Polycentric Games and Institutions: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Kirman, A. (2016). 'Complexity and Economic Policy: A Paradigm Shift or a Change in Perspective? A Review Essay on David Colander and Roland Kupers' *Complexity and the Art of Public Policy*.' *Journal of Economic Literature*, 54: 534-72.

Lawson, T. (1997). *Economics and Reality*. London and New York: Routledge.

Lawson, T. (2003). *Reorienting Economics*. London and New York: Routledge.

Lawson, T. (2012). 'Ontology and the Study of Social Reality: Emergence, Organisation, Community, Power, Social Relations, Corporations, Artefacts and Money.' *Cambridge Journal of Economics*, 36: 345-85.

Lewis, P. (2005). 'Agency, Structure and Causality in Austrian Economics: Tensions and Resolutions.' *Review of Political Economy*, 17: 291-316.

Lewis, P. (2008). 'Solving the 'Lachmann Problem': Orientation, Individualism and the Causal Explanation of Socio-Economic Order.' *American Journal of Economics and Sociology*, 67: 827-57.

Lewis, P. (2012). 'Emergent Properties in the Work of Friedrich Hayek.' *Journal of Economic Behavior and Organisation*, 82: 368-78.

Lewis, P. (2014). 'Hayek: From Economics as Equilibrium Analysis to Economics as Social Theory.' In R. Garrison and N. Barry (eds.), *Elgar Companion to Hayekian Economics*. Cheltenham: Edward Elgar.

Lewis, P.A. (2015a). 'Notions of Order and Process in Hayek: The Significance of Emergence.' *Cambridge Journal of Economics*, 39: 1167-90.

Lewis, P.A. (2015b). 'An Analytical Core for Sociology: A Complex Hayekian Analysis.' *Review of Behavioral Economics*, 2: 123-46.

Lewis, P.A. (2016a). 'The Emergence of "Emergence" in the Work of F. A. Hayek.' *History of Political Economy*, 48: 111-50.

Lewis, P.A. (2016b). 'Systems, Levels of Organisation and Structural Properties: The Influence of Ludwig von Bertalanffy on the Development of the Work of F.A. Hayek.' *Research in the History of Economic Thought and Methodology*, 34A: 125-59.

Lewis, P.A. (2016c). "Ontology and the History of Economic Thought: The Case of Anti-Reductionism in the Work of Friedrich Hayek.' Working paper, Department of Political Economy, King's College London. Available online at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2784713.

Lewis, P.A. (2017). 'Shackle on Choice, Imagination and Creativity: Hayekian Foundations.' *Cambridge Journal of Economics*, 41: 1-24.

Lewis, P. and J. Runde (2007). 'Subjectivism, Social Structures and the Possibility of Socio-economic Order.' *Journal of Economic Behavior and Organization*, 62: 167-86.

Lloyd, S. (2001). 'Measures of Complexity: A Non-exhaustive List.' *IEEE Control Systems Magazine*, 21, no. 4: 7-8.

Mayr, E. (1982). *The Growth of Biological Thought: Diversity, Evolution, and Inheritance*. Cambridge, MA: Belknap Press.

Miller, J. and S. Page. 2007. *Complex Adaptive Systems*. Princeton and Oxford: Princeton University Press.

Olson, M. (1965). *The Logic of Collective Action*. Cambridge, MA: Harvard University Press.

Ormerod, P. (1998). *Butterfly Economics*. London: Faber and Faber.

Ostrom, E. (1968). 'Some Postulated Effects of Learning on Constitutional Behavior.' *Public Choice*, 5: 87-104.

Ostrom, E. ([1972] 1999). 'Metropolitan Reform: Propositions Derived from Two Traditions.' In M. McGinnis (ed.), *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Ostrom, E. ([1982] 2014). 'Beyond Positivism.' In Sabetti and Aligica (eds., 2014).

Ostrom, E. ([1986] 2014). 'An Agenda for the Study of Institutions.' In Sabetti and Aligica (eds., 2014).

Ostrom, E. (1999). 'Coping with Tragedies of the Commons.' *Annual Review of Political Science*, 2: 493-535.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press.

Ostrom, E. ([1998] 2014). 'A Behavioral Approach to the Rational Choice Theory of Collective Action.' In Sabetti and Aligica (eds., 2014).

Ostrom, E. (2004). 'The Ten Most Important Books.' *Tidsskriftet Politik*, 7: 36-48.

Ostrom, E. (2005). *Understanding Institutional Diversity*. Princeton and Oxford: Princeton University Press.

Ostrom, E. (2007). 'A Diagnostic Approach for Going Beyond Panaceas.' *Proceedings of the National Academy of Science*, 104: 15184-151-87.

Ostrom, E. ([2009] 2014), 'Beyond Markets and States: Polycentric Governance of Complex Economic Systems.' In Sabetti and Aligica (eds., 2014).

Ostrom, E. (2011), 'Honoring James Buchanan.' *Journal of Economic Behavior and Organization*, 80: 370-73.

Ostrom, E. and X. Basurto (2011). 'Crafting Analytical Tools to Study Institutional Change.' *Journal of Institutional Economics*, 7: 317-43.

Ostrom, E. and V. Ostrom ([2004] 2014). 'The Quest for Meaning in Public Choice.' In Sabetti and Aligica (eds., 2014).

Ostrom, V. ([1991] 2014), 'Polycentricity: The Structural Basis of Self-Governing Systems.' In Sabetti and Aligica (eds., 2014).

Ostrom, V. ([1972a] 1999). 'Polycentricity (Part 1).' In M. McGinnis (ed.), *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Ostrom, V. ([1972b] 1999). 'Polycentricity (Part 2).' In M. McGinnis (ed.), *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Ostrom, V. ([1973] 2008). *The Intellectual Crisis in American Public Administration*. 3rd edition. Tuscaloosa: The University of Alabama Press.

Ostrom, V. (1980). 'Artisanship and Artefact.' *Public Administration Review*, 40: 309-17.

Ostrom, V. (1982). 'The Human Condition.' Workshop in Political Theory and Analysis. Bloomington, IN: Indiana University.

Ostrom, V. (1985). 'Conceptualizing the Nature and Magnitude of the Task in Institutional Analysis and Development.' Unpublished paper, Indiana University.

Ostrom, V. (1986). 'A Fallibilist's Approach to Norms and Criteria of Choice.' In F. Kaufmann, G. Majone and V. Ostrom (eds.), *Guidance, Control, and Evaluation in the Public Sector*. Berlin: Walter de Gruyter.

Ostrom, V. (1991). *The Meaning of American Federalism: Constituting a Self-Governing Society*. San Francisco, CA: Institute for Contemporary Studies.

Ostrom, V. ([1991] 2012). 'Some Ontological and Epistemological Puzzles in Policy Analysis.' In V. Ostrom, *The Quest to Understand Human Affairs, Volume 2: Essays on Collective, Constitutional, and Epistemic Choice*. Edited by B. Allen. Lanham; Lexington Books.

Ostrom, V. ([1993] 2012). 'Interpreting Social Experiments: An Agenda for Critical Reflections about a Research Program in Comparative Institutional Analysis and Development.' In V. Ostrom, *The Quest to Understand Human Affairs, Volume 2: Essays on Collective, Constitutional, and Epistemic Choice*. Edited by B. Allen. Lanham; Lexington Books.

Ostrom, V. ([1997] 2014). 'Epistemic Choice and Public Choice.' In Sabetti and Aligica (eds.) (2014).

Ostrom, V. and E. Ostrom ([1971] 2000). 'Public Choice: A Different Approach to the Study of Public Administration.' In M. D. McGinnis (ed.) (2000), *Polycentric Games and Institutions: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Ostrom, V. and E. Ostrom ([1977] 1999). 'Public Goods and Public Choices.' In M. McGinnis (ed.), *Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis*. Ann Arbor: The University of Michigan Press.

Ostrom, V., C. Tiebout and R. Warren (1961). 'The Organization of Government in Metropolitan Areas: A Theoretical Inquiry.' *American Political Science Review*, 55: 831-42.

Page, S. (2011). *Diversity and Complexity*. Princeton and Oxford: Princeton University Press.

Polanyi, M. (1951). *The Logic of Liberty*. London: Routledge and Kegan Paul.

Rosser, J.B. (2004). 'Introduction.' In J.B. Rosser and K. Cramer (eds.), *Complexity in Economics: The International Library of Critical Writings in Economics 174*. Aldershot: Edward Elgar.

Rosser, J.B. (2009). 'On the Complexities of Complex Economic Dynamics.' *Journal of Economic Perspectives*, 13: 169-192.

Rosser, J.B. (2010). "How Complex are the Austrians?" *Advances in Austrian Economics*, 14: 165-179.

Rosser, J.B. (2015). 'Complexity and Austrian Economics.' In P. Boettke and C. Coyne (eds.), *The Oxford Handbook of Austrian Economics*. Oxford: Oxford University Press.

Sabetti, F. and P. Aligica (eds.) (2014). *Choice, Rules and Collective Action: The Ostroms on the Study of Institutions and Governance*. Colchester: ECPR Press.

Sawyer, R. (2005). *Social Emergence: Societies as Complex Systems*. Cambridge: Cambridge University Press.

Simon, H. (1959). 'Theories of Decision Making in Economics and Behavioral Science.' *American Economic Review*, 49: 258-83.

Sober, E. and D. Wilson (1998). *Unto others: The Evolution and Psychology of Unselfish Behavior*. Cambridge, MA: Harvard University Press.

Stigler, G. (1962). 'The Terrible Range of Functions of Local Government.' In E. Phelps (ed.), *Private Wants and Public Needs* (New York: W.W. Norton).

Tullock, G. (1965). *The Politics of Bureaucracy*. Washington, DC: Public Affairs Press.

Vanberg, V. (1986). "Spontaneous Market Order and Social Rules: A Critical Examination of F.A. Hayek's Theory of Cultural Evolution." *Economics and Philosophy*, vol. 2: 75-100.

Vaughn, K.I. (1999a). 'Hayek's Implicit Economics: Rules and the Problem of Order.' *Review of Austrian Economics*, 11: 128-44.

Vaughn, K. (1999b). 'Hayek's Theory of the Market Order as an Instance of the Theory of Complex, Adaptive Systems.' *Journal des Economistes et des Etudes Humaines*, 9: 241-56.

Wilson, D.S. (2004). 'The New Fable of the Bees: Multi-level Selection, Adaptive Societies, and the Concept of Self-Interest.' *Advances in Austrian Economics*, 7: 201-220.

Wilson, D.S. (2015). *Unto Others: Does Altruism Exist? Culture, Genes, and the Welfare of Others*. New Haven and London: Yale University Press.

Wilson, D.S. (2016). 'Two Meanings of Complex Adaptive Systems.' In D. Wilson and A. Kirman (eds.), *Complexity and Evolution: Toward a New Synthesis for Economics*. Cambridge, MA: MIT Press.

Wilson, D.S., E. Ostrom and M. Cox (2013). 'Generalizing the Core Design Principles for the Efficacy of Groups.' *Journal of Economic Behavior and Organization*, 90S: S21-S32.

Wilson, D. and J. Gowdy (2015). 'Human Ultrasociality and the Invisible Hand: Foundational Developments in Evolutionary Science alter a Foundational Concept in Economics.' *Journal of Bionomics*, 17: 35-52.