Polanyi, Hayek, and Adaptive Systems Theory

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Abstract: The characterization of science as a "spontaneous order" was forcefully put forward by Michael Polanyi in his principled opposition to schemes for government management of science pressed in the 1930s and 40s. Polanyi insisted that scientific communities were self-governing arrangements based on tacitly held liberal traditions which would be destroyed by the application of central control. At the same time, in response to the trends toward government economic planning, F.A. Hayek was also exploring the idea of spontaneous order, but applied to the economy rather than to science. Hayek argued that the prices emergent from the interactions within the market order could not be duplicated by central planning.

While Both Polanyi and Hayek employed the concept of spontaneous order to expose the unintended consequences of government control, neither put forward a fully consistent theory of spontaneous order. Polanyi not only favored prescriptive rules for science but also, in arguing that government funding would be helpful in enabling scientific research to proceed unhampered, seemed oblivious to the unintended effects that could arise from such funding. Hayek, influenced by both Polanyi and the "general systems" ideas of Bertalanffy, later tried to generalize the spontaneous order concept from markets to other social orders, but his use of the idea in the defense of classical liberalism introduced normative elements that betrayed the basic scientific thrust of his approach.

Notwithstanding their brilliant and enduring insights, we argue that Polanyi's and Hayek's treatments of spontaneous order are certainly incomplete and are marred by normative and interventionist elements. We claim, however, that, building on their work, the theory of adaptive systems can go a long way toward providing an approach that avoids unnecessary normative excursions, is grounded in generalizations of the observed characteristics of actual systems, and advances the understanding of spontaneous order in general.

Keywords: Polanyi, Hayek, complex adaptive systems, emergent orders, science

1. INTRODUCTION

The idea of "spontaneous order" was in the air in the 1920s. The term itself was not yet in use—that came later in the work of first Wilhelm Röpke, then Michael Polanyi, and, finally and decisively, Friedrich Hayek[1]—but the concept was there.[2] The setting was not in the context of economics, despite obvious earlier foreshadowing in the writings of Mandeville, Ferguson, Hume, and Smith in the 1700s and Menger in the 1800s,[3] but in biology and psychology, where theorists of both were seeking to establish their fields as positive sciences distinct from physics and chemistry.

In the 1920s the biologists Joseph Woodger at the University of London and Paul Weiss and Ludwig von Bertalanffy in Vienna argued against the vitalist account of the biological world for its apparent introduction of a nonmaterial animating force and against materialism for its reductionist neglect of the importance of the relations between the constituent parts of a biological system.[4] Their crucial innovation was the emphasis on "system thinking"—the taking account of the interrelations and interactions between the ordered components of biological systems which resulted in the emergence of phenomena at the system level which could not be described except in terms of the system context, thereby justifying a distinctive subject matter for biology.

A similar argument was taking place at the same time among psychologists, and doubtless the ideas of biologists and psychologists cross-fertilized each other. In opposition

to the associationist's reduction of mental phenomena to elementary sensations and to the behaviorist's mechanistic concentration on elementary stimulus and response and denial of higher-level mental phenomena, and also in opposition to any suggestion of a "thinking substance" separate from physical matter, Max Wertheimer, Kurt Koffka, and Wolfgang Köhler, working at the Psychological Institute in Frankfurt-am-Main and building on earlier work of Wilhelm Wundt, developed the theory of the "Gestalt". The basic thrust of Gestalt psychology is the insistence that perceptions are not the sum of elementary sensations but result from the capacity of the nervous system to organize and mold those sensations into a perceived whole.[5] Again, we see the idea of the emergence of system-level phenomena from the ordered interactions of the constituents of the system. In both biology and psychology, "system thinking" was on the rise.

This, then, was the intellectual environment in which Polanyi and Hayek, early in their careers, moved. Although Polanyi established himself as a distinguished physical chemist at the world class Kaiser Wilhelm Institute in Berlin in the 1920s and then from 1933 at the University of Manchester, he became immersed in social theory and the sociology of science as a result of his alarm at the growing pressure for State planning of science. From 1935 on he dedicated much of his academic activity to this field. Hayek emigrated from Austria to England in 1931, joining the faculty of the London School of Economics. Already well versed in philosophy, law, and psychology, and familiar with the work of Menger, Hayek began to question the equilibrium focus of economics and increasingly incorporated into his work the sort of system thinking described above.[6] The concept of spontaneous order had been discovered many times before, but after Polanyi and Hayek it didn't need discovering again.[7]

But regardless of their insightful and ground-breaking theorizing on spontaneous order, their work does not constitute a fully consistent positive theory of spontaneous order. As we shall explain in detail, their treatments were both incomplete and marred by normative elements. We argue that their positive treatment is not wrong, but it does not go far enough. Their introduction of normative and interventionist elements are premature and diversionary; we argue that a positive analysis of spontaneous order (incorporating modern versions of "system thinking" in terms of complex adaptive systems—dynamic, self-organizing networks of structured interactions) should be pushed as far as possible before introducing or deriving normative propositions, and we outline a possible direction that this could take. While social theory inevitably bumps into important normative issues, we hold that the premature introduction of normative propositions unnecessarily muddies the waters and diverts attention away from a more complete understanding of the phenomena in question.

2. MICHAEL POLANYI AND THE SPONTANEOUS ORDER OF SCIENCE

2.1. The threat of central control

When Polanyi arrived in England in 1933 the Social Relations of Science Movement, which denied the legitimacy of pure science and claimed that scientists should not independently serve their own aims but the practical needs of society, had gained the endorsements of many leading British scientists. Respected scientists, such as J.R. Crowther, L. Hogben, and J.D. Bernal, called for central planning and direction of science by government.[8] Polanyi saw their proposals as a clear and present danger to science that needed to be actively countered.[9]

As Polanyi mentioned in "Rights and Duties of Science" (1939, p. 3), on his 1935 visit (one of several) to the USSR he heard Bukharin explain that pure science was an illusion created by capitalist society because, as Polanyi recounted, "the distinction between pure and applied science was inapplicable" in communist society. This claim had become a rallying cry of the Marxist theory of science espoused by the aforementioned "social relations of science" movement among British scientists in the 1930s. The idea was that only in communist society would scientists, in shedding their capitalist baggage that "deprived scientists of their consciousness of their social functions", inevitably pursue scientific research compatible with the social goals of the central planning of science. As Polanyi wryly noted, "Accordingly, comprehensive planning of all research was to be regarded merely as a conscious confirmation of the pre-existing harmony of scientific and social aims" (1939, pp. 3-4).

In 1936, Polanyi was invited to give a lecture at the Ministry of Heavy Industry in the U.S.S.R. and it was there that he engaged Bukharin, who explained to him that "owing to the complete internal harmony of Socialist society [scientists] would inevitably be led to lines of research that would benefit the current Five Years' Plan" (1939, p. 3). The claims advanced by the social relations of science movement and of Marxists-Leninists like Bukharin ran profoundly counter to Polanyi's liberal sensibilities. Perhaps equally, his experiences as a researcher within the highest echelons of the scientific community anchored his conviction that science could not in fact be "planned" and that the freedom of scientists to

autonomously pursue research was crucial for the continued growth of knowledge. For Polanyi, the pursuit of fundamental or pure science to "find truth for its own sake" (1939, p. 2) cannot be planned or directed.[10]

2.2. Polanyi's reaction

By the late 1930s, Polanyi's interests had shifted from his research in physical chemistry to the defense of unencumbered science and to the defeat of attempts to centrally plan and direct science.[11] In the course of explicating why central planning would be a disaster for science, Polanyi provided a conception of science as a spontaneous social order. In a series of important works, he presented an account of science as an emergent adaptive order but one necessarily wedded to tacitly-held liberal values and constraints and supported, at least in part, by public funding. Also relevant to note is that Polanyi believed his argument against central planning in science (as well as the economy in general) required a philosophy of science rooted in "tacit knowledge", a position which led him away from social theory toward an increased concern with epistemology.

It is also important to highlight that he was first and foremost a scientist whose principal formative activities and experiences occurred in the premier scientific institutes and research centers in Germany and Britain. Unlike some commentators on science and the philosophy if science, Polanyi was immersed in the on-going practice of actual front-line research within top echelon research communities. These experiences as to what scientific research is really like render his views on how science works more than merely armchair reconstructions.

2.3. Science as a coordinating dynamic order

The principal features of Polanyi's understanding of science refer to the social communities in which scientists participate. While the relevant operative unit within such communities is the individual scientist, science is for Polanyi fundamentally a cooperative and coordinative undertaking among scientists having the capacity to generate knowledge. It is through overlapping spheres of personal expertise that scientists are enabled to advance knowledge according to the standards and procedures developed within their respective communities. Polanyi (1962, p. 54) argued that in the absence of ongoing interactions among scientists, whether in the daily encounters of fellow laboratory or institute colleagues or indirectly via the exchange of scientific papers, scientists would soon exhaust "developing problems … of any value" and as a result "scientific progress would come to a standstill".

Polanyi conceived of science as a process of mutual adjustment among scientists. If a scientist has free reign over his research, including the selection of problems to pursue, "his task is to discover the opportunities in the given state of science for the most successful applications of his own talents and to devote himself to the exploitation of these openings" (1945, p. 142). These choices, Polanyi told us, are essentially driven by educated guesses about useful ways to proceed based on scientists "constantly collecting, developing, and revising a set of half-conscious surmises" and "an assortment of private clues" (ibid). Yet, scientists are "in fact cooperating as members of a closely knit organization" by virtue of "the adjustment of the efforts of each to the hitherto achieved results of the others" (1967, p. 54). This "mutual adjustment of independent initiatives" represents a dynamic coordinating principle among scientists whereby the growth of knowledge is seen as a byproduct of the separate actions of individual scientists that "leads to a joint result which is unpremeditated by any of those who bring it about" (1967, p. 55). This adjustment and the cooperation among scientists that it reflects can only proceed, Polanyi explained, in a stepwise fashion as advances are made on the basis of previous results in the "discovery of a hidden system of things" (ibid). Whatever advances are forthcoming are derived from the considered judgments made by scientists as to which problems to pursue. Thus, the discovery of knowledge will take on contours that are determined by the process itself and is unknowable in advance. The growth of knowledge, according to Polanyi, is a byproduct of the mutual adjustments that scientists make that could not have been predicted or been made to follow a blueprint.[12] That is, scientific knowledge is advanced by the process itself of scientists adjusting their research efforts to previous results and the discovery of such knowledge cannot be divorced from that process.[13]

For Polanyi (1945, p. 143), scientific research must occur within a social context; each scientist, he argued, "cannot practice his calling in isolation" but "must occupy a definite position within the framework of institutions" in which he "belongs to a particular group of specialized scientists". He saw this social context and its attendant institutions as fundamental to the advancement of science:

> The opinion of this community exercises a profound influence on the course of every individual investigation. Broadly speaking, while the choice of subjects and the actual conduct of research is entirely the re-

> sponsibility of the individual scientists, the recognition of claims to discoveries is under the jurisdiction of scientific opinion expressed by scientists as a body. Scientific exercises its power largely informally but partly also by the use of an organized machinery (ibid).

Polanyi argued that the standards within which scientists operate are indigenous to the scientific community and embody a development over many years that largely emerged from within the scientific community itself. These standards and the institutions that instantiate them, he held, are suitably geared toward maintaining the critical stance of modern science and its methods in its "search for truth set by the examples of Galileo and his contemporaries" (1945, p. 144). Polanyi highlighted the role of specialized journals and the gatekeeper functions of editors and referees in determining the cogency of manuscripts and their usefulness for other researchers. Together with the advisory role played by senior or eminent specialists, certain promising research questions are encouraged while others are discouraged. This also applies, Polanyi observed, to the dispensing of funding and subsidies for laboratories and other facilities, awards of distinction, the creation of endowed chairs, and prizes.

For Polanyi, a critical function of the scientific community is to cultivate the "art of making certain kinds of discoveries … by transmitting and developing the tradition of its practice" (1945, p. 145). He saw modern science functioning as a spontaneous order and as a social structure that has endogenously generated the conventions, routines, and rules consistent with its ability to generate scientific knowledge.[14] Yet, he averred, science requires support from the general public if it is to sustain itself. "This response is indispensable to science," he said, "and needs to be exercised in the form of funding for research expenses and to educate and train new scientists" (ibid). Polanyi, like many other leading scientists of his time, was a recipient of financial support from large industrial firms; yet, he took for granted that the modern scale of scientific research could only be maintained by public provision of financial resources in science over and above those provided by the private sector.[15]

2.4. The recognition of other dynamic orders

Several commentators on Polanyi have seen his analysis of science as yet another application of the economic theory extolling the virtues of unhampered markets.[16] It is true that his exposure to economics and his interest in the economic issues of his day was ongoing from his early years and continued into his later life. It also bears mentioning that he actively propagated the message of Keynes's *General Theory* by making short films and publishing articles and monographs on economics. And in his articles on science Polanyi often invoked economic terminology and alluded to similarities between the market order and science, as is clearly seen, for example, in his "Republic of Science" (1962). However, there is no doubt that he neither confused nor conflated the market order with the scientific order. In "The Growth of Thought in Society" (1941) he distinguished three separate "dynamic orders"—the market order, the common law, and science. Each of these treat different aspects of the social realm, deal with different problems, and exhibit different structural manifestations and functional mechanisms. Yet, they all are similar in that they are social phenomena that display the attributes of complex adaptive systems or spontaneous orders.

Noting the structural similarities of these different dynamic orders does not preclude recognizing important differences between them. Polanyi was at pains to identify such differences for science in terms of the necessary and broader framework that underpins science. This was an important insight—it enjoins social scientists to refrain from migrating analytical propositions from one context where they have validity to another context where they do not. In particular, thinking of science in the same sense as we think about markets presents serious pitfalls because the institutions germane to each of these systems are very different.[17]

2.5. Liberty, private and public

The freedom of scientists to freely choose and pursue questions and problems is central to Polanyi's vision of science. It is precisely this freedom that gives teeth to science as a dynamic order and which makes possible the growth of knowledge by means, as he put it, of the "mutual adjustment of initiatives" within the community of scientists. Polanyi claimed that without this freedom the advancement of science would come to a standstill because the predetermination of lines of inquiry by directives from a central planning board is incompatible with scientific research that seeks to discover knowledge. For Polanyi, science is a process of discovery and scientists adapt their research efforts to the ongoing discovery of new knowledge and the attendant questions and directions that discovery puts into motion.

Polanyi, however, noted that the freedom of scientists to pursue research in the absence of constraints is not strictly absolute. Consider the governing role played by scientific communities in establishing standards and conferring legitimacy on what individual scientists do. Within any com-

munity, we would expect internally generated constraints to emerge if the order is to be sustained and remain viable. Such provisions are not arbitrary or optional but ordinarily have been accepted through trial and error, or as marginal adjustments to the order, and have demonstrated a compatibility with the system's success while satisfying the aims of its participants. As such, the evolved internal constraints of the order which contribute to its success are not, per se, problematic. If they become so, Polanyi argues the community's participants would have the option to follow a different path and attract others to join in.[18]

Beyond such internally generated standards, Polanyi argued that the ideal of science is made possible by the framework of values provided by a conception of conservative liberalism closely aligned, for example, to Edmund Burke. Polanyi's conception of liberalism is based on a nexus of shared values among individuals who practice certain traditions. Liberty for Polanyi means adhering and submitting to these shared traditions by self-dedication and in the practice of transcendent moral ideals that are ends in and of themselves and not a means to anything else. Within this broader social context, he saw the emergence of spontaneously generated orders, such as science, made possible by generations of scientists committing themselves to transcendent ideals, such as truth-seeking,[19] that supersede the values that motivate activities for personal gain and profit. According to Polanyi, transcendent ideals are necessarily contained and transmitted in the evolved traditions of science, serving as the bedrock upon which science must function. The "origin of the spontaneous coherence amongst scientists", he said, "arises because they are informed by the same tradition" (1946, p. 38). Absent these traditions, he argued, the ongoing viability and success of a dynamic scientific order is not possible:

> It seems clear enough then that the self-governing institutions of science are effective in safeguarding the organized practice of science … [but] their functions are mainly protective and regulative and are themselves based … on the preexistence of a general harmony of views among scientists … (1946, p. 36).

And,

> Only if scientists remain loyal to scientific ideals rather than try to achieve success … can they form a community which will uphold these ideals. … The discipline required to regulate the activities of scientists cannot be maintained by mere conformity to the demands of scientific opinion, but requires the support of moral conviction … Scientists must feel under obligation, both in exercising authority and in submitting to that of their fellows, otherwise science must die. … It would then appear that when the premises of science are held in common by the scientific community each must subscribe to them as by act of devotion. … These premises … are not merely indicative, but also normative. The tradition of science, it would seem, must be upheld as an unconditional demand if it is to be upheld at all (1946, p. 40).

Polanyi called the kind of freedom required for science "public liberty" and argued that it ought to be "upheld as an aim in itself". But this kind of liberty, which he differentiated from "private liberty", is not meant to insulate individuals from arbitrary incursions or to establish a protected domain within which each may freely function.[20] Rather, Polanyi saw public liberty in a "positive" sense, as a "kind of liberty that goes far beyond personal freedom" in that it calls for a "judgment of a higher order" and on that account warrants one's freedom "to act according to his own convictions" (1941, p. 438). Importantly, however, he claimed such privileges come with considerable duties and responsibilities necessitated by the devotion to practicing the ideals of science. These transcendent ideals are principally embodied in and secured by practiced traditions—traditions that are held tacitly by all members.

3. FRIEDRICH HAYEK AND THE SPONTANEOUS ORDER OF THE MARKET

3.1. The trend of Hayek's thinking

In 1933 Hayek delivered "The Trend of Economic Thinking" at the LSE. Although he reaffirmed economics as a theoretical science and chided the German Historical School, especially the second generation led by Schmoller, the more important theme may have been his discussion of spontaneous order and unintended effects, themes he saw as arising out of the Scottish Enlightenment in the work of Hume, Smith, and others. It was in this context that Hayek used Mises' *Socialism* in referring to society as an "organism and not an organization" (Hayek 1933, p. 27). His discussion of spontaneous order, however, was perhaps aligned most closely with Carl Menger's (1883) extended remarks on the subject in *Problems of Economics and Sociology*.[21] But while "The Trend of Economic Thinking" and Hayek's ideas on

spontaneous order are sometimes linked to his rediscovery of Menger's work, there is evidence that ideas and questions relevant to spontaneous order had been lurking in the shadows since Hayek's student days and would continue to surface throughout his life. Such questions clearly emerge as an important part of his research agenda as he matured and as his interests turned increasingly toward issues in broader social theory and the various domains of social life we understand as spontaneous orders.

Although Hayek directed his efforts in the 1930s and 1940s largely to economics, his remarks in "The Trend of Economic Thinking" seem to signal a deepening interest in broader questions—an interest which would bear fruit in the appearance of his "knowledge papers" beginning with "Economics and Knowledge" (1937), then "The Use of Knowledge in Society" (1945), and also "The Meaning of Competition" (1946)—all of which address the functional attributes of a catallaxy as a spontaneous order.[22] *The Pure Theory of Capital* (1941b) may be reckoned as Hayek's final work in theoretical economics, after which he decidedly shifted his interests to broader social theory and wide-ranging investigations in methodology, the philosophy of science, and notably a return to cognitive science. During this post-WW II period his diverse interests refer to questions about the nature and functioning of spontaneously organized complex social phenomena.

Ironically, Hayek's clearest treatment of organized complexity and emergent phenomena was not in the social arena but in *The Sensory Order* (TSO) published (1952a) as a far more up-to-date, detailed, and developed analysis of psychological concepts of a (1920) student paper. Here, cognitive activity occurs within a decentralized adaptive structure whose principal emergent output is a classification of qualities that the cognitive order constructs about the external world. This classification represents knowledge and conjectures upon which the individual acts and adjusts to perceived and anticipated circumstances.[23] This important monograph was generally neglected, and despite some spillovers in *The Counter-Revolution of Science* (1952b), only years later would Hayek state the broader significance of TSO (beyond that of a monograph in cognitive science) for his understanding of social theory.[24]

3.2. Hayek's defense of the liberal order

During the 1930s and 1940s, it was Polanyi and not Hayek who relentlessly promoted the general concept of spontaneous order, specifically with respect to science. It was not until *The Constitution of Liberty* (TCL) in 1960 that Hayek explicitly couched his restatement of the principles of the liberal order in terms of spontaneous order and evolution. At this time, Hayek was resigned to the fact of liberalism as an "abandoned road"[25] but still believed that, by systematically restating the "ideal of freedom" and expounding fundamental insights of liberal thought, the existing institutional framework could undergo reform to produce an environment conducive to the reemergence of liberal society (1960, p. 1). By 1973, when volume 1 of *Law, Legislation and Liberty* (LLL) was published, Hayek believed that the "traditional doctrine of liberal constitutionalism" (1973, p. 2) had not secured liberty and that liberal democratic institutions were the cause for the erosion of freedom. TCL approaches its task by working within a set of rules, as Buchanan might have said, whereas LLL is concerned about changing the rules or, in Hayek's words, a "problem of constitutional design" (1973, p. 4).

Despite these rather different agendas, Hayek, in both TCL and LLL, prominently featured the constraints imposed by "the knowledge problem" within an evolutionary context. In LLL, the evolutionary argument was couched in terms of the implications of contending philosophical positions—evolutionary rationalism and constructivist rationalism—for understanding the emergence, nature, and evolution of social orders. Hayek claimed that constructivist rationalism is demonstrably erroneous on scientific grounds because it is based on the untenable assumption that a planning board has the capacity to "assemble as a surveyable whole all the data which enter into the social order". He emphasized in both TCL and LLL that the "fact of irremediable ignorance of most of the particular facts which determine the processes of society is, however, the reason why most social institutions have taken the form they actually have" (1973, p. 13). Spontaneous orders, such as the catallaxy or grown law, he argued, are superior because they confer epistemic advantages to individuals in adjusting to new and unforeseen circumstances. Such advantages are closed to central planners because they must direct the actions of individuals toward specific ends solely on the knowledge available to a single voice. In a spontaneous order, on the other hand, individuals are free use "knowledge which nobody possesses as a whole" (1973, p. 49).[26]

Hayek argued that achieving the benefits of spontaneous orders required rules of conduct regarding social interactions (e.g., rules of property and contract) and rules governing the relationship between individuals and government. Rules of conduct for Hayek are themselves often undesigned and, like traditions and conventions, are byproducts of an

evolutionary process. Yet, "it is this submission to undesigned rules and conventions whose significance and importance we largely do not understand, this reverence for the traditional, that … is indispensable for the working of the free society" (1960, p. 63). The transmission of rules of conduct, including the nexus of traditions and habits, is driven according to Hayek by a selection and retention process via imitation and the weeding out of rules, habits, and traditions that yield poor results in terms of the advantages they confer. The selection mechanism functions at the societal level among groups with competing systems of rules; Hayek claimed that "better rules of conduct" (ibid) will prevail by displacing inferior sets of rules and by sustaining larger populations.[27]

In this way, Hayek identified a dynamic, evolutionary process of adaptation based on the epistemic consequences of alternative social arrangements and institutions, a viewpoint central to his broader social theory. But Hayek, like Polanyi, also sought to go beyond this scientific approach and defend the liberal order as a normative ideal. And these two perspectives are joined in his broader social theory in the claim that adherence to liberal principles tends to generate better outcomes.[28] Hayek, to his credit, attempted to defend his normative claims on scientific grounds centering on the superior epistemic properties of spontaneous orders. The liberal goal of freedom and the corresponding limitations placed on government, the rule of law, and a domain of individual autonomy protected from arbitrary incursions, were seen by Hayek as essential for the emergence of spontaneous orders and, hence, the generation of the epistemic advantages necessary for progress. Hayek grounded this argument on his work in economics with regard to the constraints implied by the division of knowledge and in so doing thereby elevated it to a generalizable social principle. But compared to the analytics of catallactic theory, Hayek's broader social theory is less definitive in establishing exactly how arrangements promoting spontaneous orders are fully consistent with the liberal order.

3.3. Hayek on science as a spontaneous order

Hayek strongly sided with Polanyi in opposing the central planning of science, but his position seems to be derivative from his general rejection of central planning.[29] His discussions of science were embedded in works with that overriding theme—particularly the essay on "Planning, Science and Freedom" (1941a), *The Road to Serfdom* (1944, principally pp. 161-164 and pp. 189-193), and TCL (1960, ch. 24, Sections 7-10, pp. 388-394).[30] In those writings on science, the principal arguments he advanced were the futility of trying to centrally plan scientific research (arguments which Polanyi had made in the early 1930s) and the dangers associated with government interference and political control over science.

Like Polanyi, Hayek understood science as a non-market social order, an order that extends the "boundaries of knowledge" upon which "the general intellectual life of a country chiefly depends" (Hayek 1960, pp. 388, 389). He highlighted the role of European universities in the 19th century in providing an environment centered principally on research. Noting that the growth of knowledge in science occurs "on the outskirts of knowledge" where there are "often no fixed objects or fields" in which the "decisive advances will frequently be due to the disregard of the conventional division of disciplines", he argued (in agreement with Polanyi) that therefore the advance of knowledge requires that scientists have the academic freedom to pursue their science autonomously within the evolved conventions of science and unencumbered by "political interference", especially given that "universities were generally state institutions". Although specifically arguing against government interference, he was also suspicious of "unitary planning and direction of all research" under a committee of eminent university scientists. On that basis, Hayek explained that scientific freedom does not mean *carte blanche* for scientists but the freedom to pursue knowledge in "as many independent centers of work as possible". While he argued that a "multiplicity of such institutions" might each be "subject to different outside pressures", a decentralized and autonomous system of research institutions would be preferable to centralized planning (1960, p. 390).

But Hayek believed that a greater danger was "the increased control which the growing financial needs of research give to those who hold the purse strings" (1960, p. 392). Importantly, he argued that "the prospects of [scientific] advance would be most favorable if … there were a multiplicity of independent sources" engaged in supporting scientific research, adding that "the multiplicity of private endowments interested in limited fields is one of the most promising features of the American situation" (1960, p. 393). He did not directly speak of government funding of science, suggesting that "As elsewhere, the preservation of freedom in the spheres of the mind and of the spirit will depend, in the long run, on the dispersal of the control of the material means and on the continued existence of individuals who are in a position to devote large funds to purposes which seem important to them" (1960, pp. 393-394).

4. PRESCRIPTIVISM AND INTERVENTIONISM IN POLANYI AND HAYEK

4.1. Their respective contributions

Our discussion of Polanyi and Hayek has highlighted their path-breaking contributions to the theory of spontaneous orders. Polanyi was instrumental during the 1930s and afterward in stating the theoretical case against central planning of science and also in documenting the effects of central planning on science as practiced in the Soviet Union. He published "Rights and Duties" in 1939, and in a series of writings discussed in detail how a particular spontaneous order, that of science, functions.

Hayek's prominent role in the socialist calculation debate and the argument against central planning in general during the 1930s provided common cause with Polanyi. In Hayek's Inaugural Lecture at LSE he, albeit somewhat tentatively, rehabilitated the idea of spontaneous order with a restatement of Menger's principal points in Book Three of his 1883 monograph.[31] While Polanyi pushed ahead with his critique of central planning in science during the 1930s and 1940s, Hayek did something similar in his economics,[32] but more obliquely, as seen in his "knowledge papers". But much of his post-WW II work, especially TCL and LLL, can be seen in terms of an ongoing research agenda that drew deeply on spontaneous order and evolutionary elements.

The issues we raise here do not detract from the contributions of Polanyi and Hayek; rather, we see their analyses as not going far enough in developing the theoretical analysis of complex adaptive systems in general and especially that of spontaneous orders in the social realm.

4.2. The introduction of normative criteria

Both Polanyi and Hayek, in defending the autonomy of market and science, found it necessary to cast their analyses in the context of broader social theory.[33] In so doing, issues concerning the justification of unhampered market and science were couched by them in terms of their conceptions of liberalism. While their scientific arguments against central planning are cogent, locating their analyses within a broader social theory required reliance on increasingly more normative claims and criteria that supervene on particular spontaneous orders.[34]

Polanyi (1964, chapter II; 1962) argued that maintaining a well-functioning spontaneous order, such as science, requires communities in which authority is vested in various institutional structures. These include journal editors and scientists who have secured sway among colleagues and peers. Polanyi is keenly aware that these provide the essential feedback for self-corrective science; yet, he sees these also as necessary disciplinary mechanisms serving a higher good: the preservation of transcendent scientific ideals.[35] In this way, Polanyi's approach to science as a spontaneous order—an approach crucially based on the primacy of and requirement for transcendent and tacitly held ideals—introduces unnecessary normative criteria which mar his analysis.

We see this in Polanyi's distinction between "private" and "public" liberty, a notion reflecting no doubt the culture of pure science as he experienced it, but one which adds a complicating layer of normative claims to the analysis. Importantly, Polanyi believed "public liberty" required—in a prescriptive sense—that scientists adhere to certain duties in implementing transcendent ideals, such as a commitment to truth, and in accepting the evolved standards and traditions of science embedded in existing institutions. Such ideals for Polanyi function much like a "Constitution of Science" in prescribing certain values and practices scientists must hold and submit to, even if that means intrusive constraints on an individual's otherwise noncoercive actions.

Polanyi claimed that scientists' commitment to the pursuit of truth is among the enabling transcendent values required for science. While this motive, indeed, may apply to scientists, we dispute whether it is a necessary condition for the growth of knowledge on the grounds that it is the procedures of science that are determinative in establishing scientific knowledge and that such knowledge is an emergent *system-level* property of the scientific order. The psychological motives of scientists, including their understandings of what truth is and their sincerity in pursuing truth, are independent of the growth of knowledge because it is the "inter-subjective error-correcting network" of scientists that "subjects theories to empirical testing and potential refutation" (Harper 2016).[36] What matters are the critical procedures[37] deployed by the community of scientists that ignore, reject, or tentatively accept knowledge claims, and not the noble psychological intentions of scientists.

Polanyi is led to favor a proactive stance to preserve the ideals and traditions by which they are transmitted. But this represents a failure to appreciate fully the ordering capabilities of the spontaneous orders he himself has done so much to elucidate. Polanyi emphasized the role of tutoring, textbooks, training, working in labs, and the role of editors in publishing research, and these transactions, executed repeatedly under the feedback from previous transactions, would be expected to produce (and have in fact produced) inter-

nally not only an emergent "ordering" of scientists based on their scientific accomplishments and reputations but also various enforcement mechanisms. Contra Polanyi, science's "constitution" can be seen as an emergent byproduct of the functioning of the scientific order; rigidly specifying these institutions as normative preconditions of science is a typical constructivist mistake.

Hayek also populates his positive analysis of spontaneous order with normative criteria. He claimed on the one hand that "it is this submission to undesigned rules and conventions whose significance and importance we largely do not understand, this reverence for the traditional, that … is indispensable for the working of the free society" (1960, p. 63), but on the other hand (perhaps more tellingly) he also raised the problem of spontaneous order "dead ends"—outcomes that he deemed to be inconsistent with normative criteria endemic to liberalism. In the context of a discussion of Western law and its spontaneous origin in the customary law of England, Hayek (1973, ch. 4) contended that "the spontaneous process of growth may lead into an impasse from which it cannot extricate itself by its own forces or which it will at least not correct itself quickly enough", which "therefore does not mean that we can altogether dispense with legislation" (1973, p. 88). His particular reason for this conclusion was his concern that the application of the doctrine of *stare decisis* binds a judge to uphold precedent "although he may clearly recognize that another rule would be better, or more just" (1973, pp. 88-89). But Hayek is confusing modern common law, where the judge is the central actor in interpreting precedent while being cognizant of the downstream societal consequences of his ruling, with pre-19th century common law and the customary law which proceeded it. As Hasnas (2005) points out, the spontaneously evolved "law of liberty" which Hayek was trying to describe was in fact a system in which the case decisions of juries[38] were not strongly constrained by precedent, would tend to depart from it in the interest of present justice, and were concerned only with the justice of the decision at hand and not its presumed future social impact. Modern common law, on the other hand, is the older customary and common law blanketed with constructivist arrangements which have produced the "dead ends" that Hayek was rightly concerned about. If Hayek had had a clearer grasp of the history of the common law he could not have applied his critique to the actual "grown law" and, by implication, to spontaneous orders in general.

In defense of Hayek, Morison (2007a, p. 212)[39] claims that "Hayek's purpose was to persuade his readers of the moral imperative of reinvigorating the normative political ideals of classical liberalism", for the purpose of (ibid) "maximizing individual liberty within the rule of law". In a manner very reminiscent of Polanyi's insistence on the necessity for the adherence to transcendent values for free science, Hayek himself (1973, p. 56) claimed that, in the process of making law, "if the separate steps are not guided by a body of coherent principles, the outcome is likely to be a suppression of individual freedom". Hence, he is willing to countenance the intervention of judges as a means to ensure adherence to classical liberal ideals. While Hayek might be right that "judge-made" law is preferable in this regard to legislation, his argument begs the question of whether either is preferable to a spontaneous system of customary law.

Hayek's reservations about fully spontaneous orders are also found in explicit discussions that attempt to describe the relevant boundaries between legislative design and the market order consistent with liberal principles, particularly that of the rule of law and its three criteria for legislation: "true laws" must be "general, abstract rules", "must be known and certain", and must be enforced equally to all (Hayek 1960, pp. 208-209). These criteria in Hayek's hands clear a large swath for possible government actions. Hayek's resolution of the boundary lines was to evaluate government actions based on his conception of the liberal order, and that allowed him to deflect his attention away from the analysis of spontaneous order and toward policy issues. Our criticism is not with that direction nor the policy positions that Hayek endorses; our concern is that to secure his normative ends directly he cuts short the budding analysis of spontaneous orders.[40]

That predisposition can be seen in his Introduction to *Collectivist Economic Planning* (1935) and continuing with remarks in the *The Road to Serfdom* (1944) claiming that *laissez faire* "is a highly ambiguous and misleading description of the principles upon which a liberal policy is based" (p. 81).[41] Hayek would later develop this theme in greater detail in TCL and LLL in claiming:

> The range and variety of government action that is, in principle, reconcilable, with a free system is thus considerable. The old formulae of laissez-faire … do not provide us with an adequate criterion for distinguishing between what is and is not admissible in a free system. There is ample scope for experimentation and improvement within that permanent legal framework to operate most efficiently. ... But the continuous growth of wealth and technological knowledge which such a system makes possible will constantly suggest

> new ways in which government might render services to its citizens and bring such possibilities within the range of the practicable (Hayek 1960, p. 231).

Hayek sanctions several kinds of particular measures of government that refer to the provision of collective goods that are "clearly desirable but which will not be provided by competitive enterprise" (Hayek 1960, p. 223).[42] Such services rendered by government must also be evaluated, Hayek emphasizes, on the basis of expedience and net benefits, and, just as importantly, he rejects artificial barriers being erected to maintain the government monopoly. So, while the scope for government activity is large in principle for Hayek, he also includes provisos that as a practical matter clearly constrain such activities. But the result is that, in the hope of coming to closure on the relation between the spontaneous order of the market and deliberate legislative design, we are swept into an ambiguous and muddied realm anchored in normative beliefs and lacking an analysis of the extent to which past interventions have contributed to the perceived need for current government activity—in short, an approach which prematurely closes the path toward a fuller understanding of spontaneous orders.

Both Polanyi and Hayek, in their different ways, allowed certain normative claims to inform their analyses of spontaneous orders and in doing so both come to advocate inroads by which spontaneous orders should be subject to government intervention and remediation. It is our contention that, in both cases, the introduction of normative considerations was not only unnecessary but also undercut the theory of spontaneous order, leaving it open to misunderstanding and confusion.

4.3. The question of science funding

There is a second issue, relevant to spontaneous orders such as science that require external funding institutions, that evidences a lack of full appreciation of the ordering capabilities of unhampered arrangements. Here again, with respect to the problem of science funding, Polanyi endorses a clear-cut position while Hayek's is more difficult to pin down. But both Polanyi and Hayek emphasized that scientists themselves were unlikely to have the resources to fund pure research and hence believed, reasonably enough, that science required external funding. As was common in their age (largely before WW II), research scientists were ordinarily affiliated with research universities and supported by them via funding from government and its research institutes.

In addition, as Polanyi unabashedly mentioned, scientists also received extensive funding from private enterprises who saw some commercial gain from pure and applied research. In the heated days of Polanyi's critique of central planning, the main question was to preserve the autonomy (or freedom) of science from its destruction by central planning. The question of financing science was assumed to be a public responsibility that could be supplemented by private sources. Most importantly, the matter of financing science was not at issue in the debate in Britain waged by Polanyi and John Baker over centrally planned science versus the autonomy of science. Although their efforts with the Society for Freedom in Science won the day in 1946, that resolution presumed that scientific research would be largely funded by government and, in effect, determined within the political sphere. Polanyi's singular interest was to preserve freedom in science and he did not consider the source of funding problematic.[43]

Hayek's discussion of the funding of science emphasizes concerns that are somewhat different from Polanyi's. In TCL, he does not directly advocate government funding of science but speaks instead to the virtues of many decentralized sources and private endowments, as noted above. He also notes that public funding of science provides a channel for political control over science. That said, the overall tenor of TCL, in which he essentially denies the usefulness of what he had earlier (1944, p. 17) called a "wooden insistence on laissez-faire", might lead us to suggest that Hayek would be receptive to *some* public funding of science. It is not clear if this possible ambiguity in Hayek's thinking can be resolved. However, neither Polanyi nor Hayek attribute to science the neoclassical claim of market failure. The justification for public funding of science by Polanyi and possibly for Hayek rests more on ensuring the preservation of free science than on solving a presumed market failure.[44]

All the same, that justification does not take into account the many issues surrounding government or centralized funding regimes.[45] As Hayek was well aware, centralized funding provides for the application of external intervention and control, and anyone with the power to intervene occasionally is apt to get around to intervening frequently, and not necessarily from disinterested motives.

5. BEYOND SPONTANEOUS ORDER

5.1. Wherein lies the problem

The broader social theory which Polanyi and Hayek have left us, while greatly deepening our understanding of such systems as market and science in a most fertile way, has two

major flaws which we see as impediments to progress. It is obvious enough that both market and science, as systems of social interaction, have been successful in lifting mankind out of a subsistence existence and opening up knowledge of a vast and interesting cosmos.[46] While the catallactic theory of markets provides deep insights concerning the way markets work, our understanding of why science and also markets have been so successful has often been elusive and contentious. In particular, it is neither good enough to say that they are successful because they have evolved spontaneously nor that they are desirable arrangements because they have survived. Other major systems of social interaction, such as modern governance and law, while their beginnings may indeed have had considerable elements of rational design, have evolved spontaneously and, by the criterion of survival, have been immensely successful arrangements.

Despite their achievements, Polanyi and Hayek did not provide a fully worked out explanation for the obvious success of the spontaneous orders with which they were concerned. Instead, they both fell back on normative considerations—the desirability of scientific and economic freedom and classical liberalism—to bolster their broader social theory. This is the first problem. And, since they could not point to internal mechanisms by which their ideals could be attained, the second flaw followed—they both, Polanyi in the case of science and Hayek in the case of law and other "collective goods", countenanced coercive interventions to ensure that the results they approved of would obtain.

Our critique of Polanyi and Hayek is that, by introducing normative elements into their broader social theory, they short-circuited the positive analysis of emergent social systems as objects of scientific study. Contrast this with the success of economics as a value-free branch of knowledge: while there are normative elements in economics, such elements are for the most part independent of economic theory and typically enter as implications of positive analysis. But since social orders function in a context of various rules and practices, it is clear that normative issues inevitably will arise—after all, social science does not study inert physical phenomena like protons or chemical reactions. The importance of how we go about understanding or, if necessary, remediating such issues is critical in the social realm and as a practical matter important normative issues will inexorably tend to command considerable attention. However, there is a time and place for such considerations. We hold that, in studying social systems, normative claims most usefully follow after the positive analysis has been pushed as far as possible. We do not contest the normative turn by Polanyi and Hayek; we simply argue that it has muddied the waters at the expense of further positive analysis. And we claim that the theory of adaptive systems provides the context for this further positive analysis, particularly with relation to the implications for stability and adaptability in the structural characteristics of such systems.

It is often stated that markets work uniquely well to coordinate behavior in a societally beneficial way because markets alone possess a price system.[47] But this doesn't get to the heart of the matter—the price system is indeed crucial in markets in that it is the vehicle through which the feedback effects of prior transactions act on current and contemplated ones. Yet it is, in turn, an emergent effect of those transactions and therefore depends on the ways in which those transactions interact within the market context. At the most general level, what is crucial is not the specific ability to form prices but the ability to generate feedback effects which constrain self-interest while at the same time encouraging innovation and growth. There are no prices generated within science, and yet there is coordination of behavior in a societally beneficial way because the feedback effects from the transactions of publication and citation on scientific reputation both constrain scientists in their departures from conventional wisdom and encourage competent creativity. It is the structure of the system that matters and the capability of that structure to adapt to changes in external environment and to grow in a stable manner which is sustainable in the long term. Attention to the structural characteristics of systems not only provides an analysis of how the effects of the intra-system transactions work to generate the observed emergent systemic properties but also how the system as a whole might react to particular external influences applied to it. And, most importantly, it can provide a firm basis for comparative systems analysis aimed at eliminating normative criteria.

5.2. Adaptive systems theory

In the years since Polanyi and Hayek made the concept of spontaneous order a respectable and interesting one in social theory, "systems thinking", often under the rubric of "complex adaptive systems", has had a growing influence on social theory.[48] Treatments of economies and other social arrangements as adaptive systems with emergent properties have been published in complexity theory, sociology, and law—see, for example, Kauffman (1993, pp. 395-402)[49], Buckley (1998), Elder-Vass (2010), and Ruhl (2008). In economics, the number of papers dealing with complex systems, emergence, and agent-based modeling is growing fast with acces-

sible works by Krugman (1995), Tesfatsion (2006), Kirman (2011), Arthur (2015), and many others.[50] For our purposes here it is sufficient to skim over the details of this literature and to state some generalizations about the characteristics of the adaptive systems of market and science[51] in order to illustrate the aspects of the transactions within the systems that contribute to stability and growth and also to provide a basis for comparative systems analysis.[52]

Such systems have several salient features. Nowhere in the descriptions of them do you find a controlling authority identified, because power is distributed across the population of participants. They explicitly cater to the self-interest of all of the participants—not in the sense of providing a free lunch, but in competition for scarce benefits. They exhibit observable side-effects stabilized by negative feedback, and this stabilization is not such as to preclude variation of the side-effects in response to environmental changes. These relatively stable side-effects provide not only general and nondiscriminatory benefits (even to nonparticipants) but also the incentive for a positive feedback effect on entry of new individuals into the system. Finally, and very importantly, they allow voluntary "exit" at all levels, from entrepreneurial deviation from local rules to a decision to cease participation in the system as a whole, as a mechanism for reaction and adaptation to changed circumstances or new ideas. In short, these systems are geared to grow and adapt, but in a stabilized manner.

It is worth emphasizing the importance for stable adaptation of the option for voluntary exit at all levels. Hayek himself (1960, pp. 62-63) said it very well:

> It is this flexibility of voluntary rules which in the field of morals makes gradual evolution and spontaneous growth possible, which allows further experience to lead to modifications and improvements. Such an evolution is only possible with rules which are neither coercive nor deliberately imposed. … The existence of individuals and groups simultaneously observing partially different rules provides the opportunity for selection of the most effective ones.

And, we would add, it is a real solution to Hayek's problem of the "dead end", which encompasses considerations of "dead ends" from both external environment changes rendering spontaneously adopted procedures problematic and interventions which compromise the operation of spontaneously adopted procedures. Hayek's (1973, p. 100) own solution (in the context of law) of the occasional intervention of a legislator, and Polanyi's tolerance in certain cases for prescriptive adherence of scientists to certain practices as if one could apply constitutional rules to science, both resort to interventionist means to shore up against perceived problems in spontaneous orders without consideration of the side-effects of the externally imposed constraints and interventions. But both constitutional and legislative rules, no matter how well-intentioned and how generally they apply, have two major conceptual defects: (1) they are static, one-size-fits-all, and in varying degrees not easily adjusted to perform well in local conditions, and (2) they are the product of the knowledge possessed by the individuals or small groups that design them and do not deploy the adapting systemic knowledge generated within the system in which they are intended to apply.

On the other hand, the working of voluntary exit is obvious in the normal procedures of science, a system which is notable for its ability to remain intact even while accommodating shifts in foundational theory—the generation of new scientific knowledge requires this. While the underlying procedures and conventions of what it means to do science are generally widely accepted and followed by practitioners, the content of scientific knowledge and its methodological norms and theoretical concepts are always up for grabs and in flux. In science, individuals have the opportunity to convince other scientists that a better theory or way of seeing reality is available and that the existing explanation is false or incomplete and must be discarded. Similarly, the opportunity for voluntary exit is also vital in market interactions, being at the heart of a wide range of adaptive activity, from the creative destruction of entrepreneurial innovation to the purging of bankrupt firms. When we turn to other areas of social order like law, for example, the exit option that we see in markets and science seems just as applicable there. Allowing individuals to adopt a different set of rules while not requiring others to do likewise and not inhibiting the free movement of individuals into other jurisdictions are conditions that are basically the analogs to the exit option that operate in science and market. Where normal procedures of remediation are inadequate, the availability of voluntary exit may either literally purge the base of support for the offending rule or induce an exodus of individuals to a more hospitable jurisdiction.

This is not to say that real-world adaptive systems, including real-world markets and science, perfectly fit such an idealized pattern as we have described here. The point is, rather, that the characteristics highlighted are ones that provide for stabilized growth, and that it may be fruitful to concentrate

on these aspects in assessing the functioning of existing systems. The presumed criterion of the capability for stabilized growth—for both adaptability in the face of external change and ability to attract participation—while obviously in need of far greater elaboration than is possible here, is neither ill-defined to the point of meaninglessness (as is, for example a maximum welfare criterion) nor fraught with contested value judgements (as is, for example, an individual freedom criterion). The idea is simple: if you want systems of social interaction that can survive, adapt, and grow stably on their own merits, then these are the sorts of good characteristics for them to have. If actually existing systems lack one or more of them, or depart from them to a significant degree, then problematic trends can be predicted.[53]

5.3. Comparative structural analysis.

Rules (more particularly, the transaction routines that embody them) have to be judged in the context of the entire system: bad rules contribute to systemic maladaptation and stasis or eventual shrinkage, good rules to adaptation and stable long-term growth. The question becomes, then, what general structural characteristics of adaptive systems would enable such systems to attract and keep the participation of individual members, to adapt to changes in their environment without widespread systemic disruption, and to sustain growth within the bounds of the resources available. The following list of stabilized growth characteristics expands on the summary given above. They are still rather abstract specifications, but ones that are clearly operative[54] in the major societal systems of market and science:[55]

1. Most obviously, there is no mechanism of central control. Such power as is available within the system to effect change is widely distributed, and to the extent that there is power to gain access to resources within the system it is earned by successful performance in adherence to the prevailing system norms.

2. The normal transactions within the system are compatible with, and supportive of, the pursuit of happiness of the individuals in the system. By no means is every transaction *ex post* successful in this regard for an individual, but there is a reasonable expectation that, with participation, desires can be satisfied.

3. The constraints on behavior which the system transactions implement are fair, i.e., they apply generally. This removes a source of internal disruption and defaulting because of injustice and envy. The generality of application also applies to the norms of the system typically invoked in responding to default.

4. The repetition of the system's transactions produces emergent effects which represent a "good enough" picture, i.e., knowledge, of relevant aspects of the system's environment in a form that is perceptible to the individuals in the system. This is the source of short-term adaptability of the system. It is useful information to the system participants, and is stabilized within the system by negative feedback to participants attempting transactions which are not compatible with it.

5. The repetition of the system's transactions may also produce effects within the system beneficial to many or most of the system's participants—and also to individuals not participating in the system—independently of action on their part, i.e., there are positive externalities.

6. The internal structure of the system is, to some extent, mutable in that it is open to bottom-up, entrepreneurially-induced change. There is the ability to voluntarily deviate from established norms, procedures, and transaction modes, or indeed to secede from the system as a whole. As with any entrepreneurial action, there may be negative consequences to be borne, but the choice is voluntary. This is the source of long-term adaptability, in which the system itself evolves.

We present these criteria not as "transcendent values" which need to be implemented and enforced, but simply as features of an idealized complex social system which would be effective in promoting stabilized growth, and therefore as a possible means for comparing different social arrangements, theoretical and actual.[56] It is not suggested that real-world social arrangements fully meet these criteria, although the actual arrangements of modern science do come close, as do those of markets in cases where outside interference is absent. We note, however, that most of the more specific criteria listed in Ostrom (1990, p. 90) which summarize the characteristics of long-lasting common pool resource institutions are very compatible with the list given here. We believe that it is work like this, focusing on the structural characteristics of complex social systems, which provides a way forward in the study of spontaneous order—a way that has empirical basis in actual systems, provides a theoretical

base for the comparative analysis of systems, and avoids reliance on normative presuppositions or ideals.

6. SUMMING UP

While Both Polanyi and Hayek employed the concept of spontaneous order to expose the unintended consequences of government control, neither put forward a fully internally consistent theory of the sorts of social arrangements implied by the characterization of spontaneous order. Polanyi not only favored prescriptive rules for science but also, in arguing that government funding would be helpful in enabling scientific research to proceed unhampered, seemed oblivious to the unintended effects that could arise from such funding. Hayek, influenced by both Polanyi and the "general systems" ideas of Bertalanffy, later tried to generalize the spontaneous order concept from markets to other social orders, but his use of the idea in the defense of classical liberalism introduced normative elements that betrayed the basic scientific thrust of his approach.

Notwithstanding these problems, our main conclusion is that it is possible to build on their work by casting it into the domain of complex adaptive systems. We believe there can be a fully positive and robust approach to the study of social order which advances the understanding of spontaneous order in general, allows for comparative systems analysis, and is grounded in generalizations from observable structures and characteristics of actual social systems.

Our specific criticism of Hayek and Polanyi is that they provide a useful theory of spontaneous order up to a point, but when they cannot see a way forward they introduce elements that do not follow from what they have already established. The need for intervention is introduced as a *deus ex machina*, a quick patch that comes without serious analysis, neither of the system which is the source of that intervention nor of the (perhaps unintended) downstream consequences of its application. And the invocation of normative ideals just muddies the analysis and offers an obvious target for disagreement and ideological dispute. This critique is not the same thing as a castigation of them for being insufficiently *laissez faire*—indeed, such a charge would be nothing more than the substitution of one normative ideal for another.

One point stands out clearly: if social science is going to seriously treat the interactions of different complex systems (science and government, for example) then a first step is to include in the analysis that government is indeed a complex system with its own characteristic structure, internal transaction types, and emergent effects. It is not good enough to point to a possible defect in one system and assume that another system can be deployed at will to fix that defect—with government in the fixing role this is just the implicit invocation of the benevolent dictator model.

Finally, if we may leave the domain of system analysis and advocate for general methodological principles, we think, first, that an important and often overlooked requirement for the execution of studies of social phenomena is to approach them from a positive standpoint and to refrain, as best one can, from introducing normative elements. There is no doubt that positive analysis of social phenomena will often carry normative implications; however, we believe the default position should always be to push the positive analysis forward at every opportunity. And second, while it is abundantly clear, as Wagner (2016) explains in detail, that in the real world we are confronted with social systems that are deeply "entangled", we believe that it is necessary as a prelude to understanding the nature of the entanglements and their ramifications that we develop workable theoretical models of the operations of the systems in isolation so that there is a basis on which to introduce, in a manageable fashion, the inter-system interactions that constitute the entanglements. Abstraction of this sort is our best hope for coping with the complexity of the social world.[57]

NOTES

1 Polanyi used the term "dynamic order" to refer to arrangements observed in physical, biological, psychological, and social realms that spontaneously emerged from mutual adjustment between the relevant elements stemming from free interactions, contrasting this form of ordering with deliberately "planned order". See Polanyi (1941, p. 431 *et seq.*). Hayek (1937; 1945) employed a very similar idea in an economic context in contrasting central planning with the localized planning that involves the "spontaneous interaction" of people possessing only "divided knowledge", i.e., "the knowledge of the particular circumstances of time and place". Hayek (1960, pp. 159-161), quoting Polanyi, is even more explicit, and there he deploys the term "spontaneous order".

2 The investigation of the background of the term "spontaneous order" is an area of some controversy. For documentation of Röpke's terminological priority, see Bladel (2005), who quotes Röpke (1937, pp. 4-5).

Earlier, Jacobs (1998; 1999) had argued for the priority of Polanyi (1948), and before that Hamowy (1987) gave Hayek (1960) the credit. But see Hayek (1955, p. 30) in which he credits Polanyi (1951, p. 114 *et seq*. & p. 154 *et seq*.) for employing the phrase "spontaneous formation of a polycentric order". For a comprehensive treatment of the issue, see D'Amico (2015).

3 See Mandeville (1714, pp. 68-69), Ferguson (1767, p. 187), Hume (1740, pp. 490, 529, 579), Smith (1776, pp. 24-32, 484-485), and Menger (1870, pp. 257-285; 1883, 139-159, 223-234). See Barry (1982), Hamowy (1987), and Ames (1989) for detailed histories.

4 See Woodger (1929), Weiss (1925), and Bertalanffy (1928). For short biographies and a detailed exposition of the intellectual connections between these biologists and their contemporaries and predecessors, see Drack *et al*. (2007). For Gestalt psychology's influence on Hayek, see De Vecchi (2003) and Lewis (2016a). See also Bertalanffy (1950), Weiss (1977), Weckowicz (2000), and Lewis (2016a; 2016b).

5 See Köhler (1930) for a full exposition of Gestalt theory. For a discussion of Wundt's influence on Hayek as early as 1920, see Lewis (2016a). For Kohler's influence on Polanyi, see Mullins (2010). See also Drack *et al*. (2007) for documentation of the exchange of ideas between the Gestalt psychologists and the organicist biologists, particularly Bertalanffy.

6 Although Polanyi and Hayek did not meet until 1938 when both attended Walter Lippmann's Le Colloque in Paris, their intellectual positions were not in full agreement but compatible in broad-brush terms. Both were consciously incorporating the idea of spontaneous order into their theorizing, both employed it in their opposition to the calls for central planning (whether of science or the economy), both read and commented on each other's work, and both incorporated elements of the other's work into their own. For an extended discussion of their interactions and intellectual cross-fertilization, see Howard (2008).

7 Since our focus here is at the level of complex social systems (in line with Hayek and Polanyi) we see "spontaneous orders" as self-organizing social systems displaying properties emergent from the interactions of the people composing them and distinct from the properties of their components. We make no distinction between spontaneous order and emergent order, a distinction, as Harper and Endres (2012) show, is necessary at lower levels of organization.

8 See Bernal (1939), especially ch. X "The Reorganization of Research", ch. XII "The Finance of Science", ch. XIII "The Strategy of Scientific Advance". Bernal's book contains several appendices that provide figures on university faculties, advanced students in science, university income and sources of funds, financing needs for scientific research, proposals for restructuring research, and policy platforms for the British Association of Scientific Workers. Of particular interest is Appendix VI "Note on Science in the U.S.S.R.", written by M. Ruhemann, a former Research Director of the Physico-Technical Institute in Kharkov, U.S.S.R., which provides an uncritical account of Soviet science and its organization.

9 Polanyi's interest in social theory and philosophy and economics was evident even prior to his arrival in Manchester. Nye (2011, p. 155) notes that in 1930 Polanyi published his first economics article in a scholarly German journal, Der deutsche Volkswirt, in which he argued for the importance of pure science even though the benefits of fundamental research may not be apparent. As recounted in detail by Nye (ch. 5), Polanyi had by 1928, when he visited the Soviet Union via an invitation by a colleague, exhibited an active interest in economics. Upon returning to Berlin after that trip, he began attending a seminar organized by Jacob Marschak, even delivering a paper on the Soviet economy. In early 1930 he organized his own study group for the purpose of bringing together scientists at the Institute with economists that included notables such as Leo Szilard, Marschak, John Von Neumann, and Gustav Stolper. He also continued to visit the Soviet Union in the early 1930s and, as Nye points out, witnessed the threat to fundamental research that Soviet central planning of science entailed.

10 In addition, it is interesting to note Polanyi's view that "applied science"—or what he called "practical knowledge"—is not science at all because it does not represent a "body of valid ideas" certified as such by the standards of the scientific community. Also see Polanyi (1941, p. 428).

11 Mention must be made of John Baker, an Oxford University zoologist, and his critical role in defending science from central planning in England. In 1940, Baker and Polanyi created the Society for Freedom in Science to counter widespread calls from within the scientific community (and elsewhere) for centralized direction of science. Virtually singlehandedly, they thwarted

the efforts to centrally plan science in the aftermath of WW II. See McGucken (1978) for a detailed discussion of the Society for Freedom in Science.

12 Polanyi's discussion is simultaneously also a critique of the attempt to centrally plan science since scientists (and, of course, the central planners) cannot know *a priori* what adjustments they should make in their research as new advances are discovered.

13 For an exposition of the same idea in a market context, see Buchanan (1982).

14 Note the commonality with Hayek's well-known claim that certain kinds of knowledge (in particular, the knowledge of availabilities, scarcities, and opportunities reflected in market prices) simply would not exist absent the market process.

15 See Polanyi (1941, pp. 446-447). Also see Nye (2011, ch. 2) on Polanyi's support from the private sector. While taking public support and funding as a necessary given, Polanyi's (1962, p. 61) major concern is not the source but who controls the distribution: "It does not matter for this purpose whether the money comes from a public authority or from private sources, nor whether it is disbursed by a few sources or a large number of benefactors. So long as each allocation follows the guidance of scientific opinion, by giving preference to the most promising scientists and subjects, the distribution of grants will automatically yield the maximum advantage for the advancement of science as a whole."

16 For example, see Mirowski (1999).

17 Despite the economic terminology and comparisons Polanyi uses in several of his writings about science, perhaps most famously in "The Republic of Science" (1962), he was careful not to merge them. Polanyi (1941) and elsewhere distinguished among various kinds of spontaneous orders found in the social realm. He saw the market order organized around the pursuit of individual gain, while he saw science as a byproduct of values based on transcendent ideals and convictions. He did not see science as a market order and did not see the marker order as the "archetype of spontaneous coordination" (Allen 1998, p. 156). In addition, Polanyi did not invoke the market failure argument regarding science; this also applies to Hayek. One of the most serious conflations of economics and science concerns the economic theory of public goods in which the outputs of science are commodified and available to all. From this, it is trivially correct to infer a market failure in science. See Butos and McQuade (2006) for a critique of these claims.

18 In this way, the success of modern science has solidified around widely accepted standards as to what it means to do science. This, of course, only circumscribes the activity in terms of scientific procedures but does not predetermine outcomes those procedures uncover.

19 While adherence to truth-seeking is the primary ideal, Polanyi (1945, p. 142) also cites the secondary norms of admiration for scientific "courage and reliability" and scorn for the "commonplace and fanciful". Such informal moral norms underlie science practice in much the same way as the norms of trust and promise-keeping underlie market practice. (We thank Paul Lewis for this insight.) But these secondary norms are distinct from those ideals that are *required* (1941, p. 438) to maintain science as a "dynamic order". Polanyi's scientist functions in the world of public liberty—freedom to do research but only by practicing the traditions of liberalism, a tradition that is learnt tacitly by practicing it. Polanyi, however, is quite vague on what exactly is "liberalism", as he sees it as revealing itself as is practiced. It is not a "protected domain" libertarianism nor even rule-utilitarianism, but it does bear an affinity to Hayek's conception of liberty in its stress on the importance of tradition.

20 "Private liberty" is seen by Polanyi as "personal freedoms" that enable individuals to autonomously operate within a defined and protected sphere of activity in pursuit of private interests. In *The Logic of Liberty* he refers to private freedom as a "class of individualistic manifestations which do not contribute to any system of spontaneous order in society" (1951, p. 157). He goes on to note that "A free society is characterized by the range of public liberties through which individualism performs a social function, and not by the scope of socially ineffective personal liberties" (1951, p. 158). These "public liberties" lift and justify personal freedom and are preeminent by virtue of the underlying transcendent ideals these traditions support.

21 Hayek does not cite Menger in "The Trend of Economic Thinking", although he was certainly familiar with Menger's 1883 monograph (see Menger 1883, bk. 3, ch. 1 & 2, pp. 127-159). Hayek published an essay on "Carl Menger" in *Economica* in 1934 that served as the "Introduction" to the four-volume *Collected Works of Carl Menger* edited by Hayek and published (in German) in 1934. His discussion of Menger's 1883

book in the 1934 essay is revealing: "Probably it did more than any other single work to make clear the peculiar character of the scientific method in the social sciences". Hayek then goes on to say, "But to me … its main interest to the economist in our days seems to lie in the extraordinary insight into the nature of social phenomena. … Discussions of somewhat obsolete views, as that of the organic … interpretation of social phenomena, give him an opportunity for an elucidation of the origin and character of social institutions which might, with advantage, be read by present-day economists and sociologists" (Hayek 1992, p. 79).

22 For recent summaries of the trend of Hayek's thinking beginning with the "knowledge papers", see Caldwell (2014) and Lewis & Lewin (2015).

23 Several summaries of Hayek's cognitive theories are available. See, for example, Weimer (1982), Yeager (1984), Steele (2007). Butos & McQuade (2015a) review the literature on Hayek's cognitive theory.

24 In *Law, Legislation and Liberty, v. 3*, Hayek reflects on TSO as a work that "helped me greatly to clear my mind on much that is very relevant for social theory. My conception of evolution, of a spontaneous order and of the methods and limits of our endeavors to explain complex phenomena have been formed largely in the course of the work on that book" (Hayek, 1979, n. 26, p. 199).

25 "The Abandoned Road" is the title of Chapter 1 of *The Road to Serfdom* (Hayek 1944).

26 Also see, for example, Hayek (1960, p. 30) where he says "all institutions of freedom are adaptations to this fundamental fact of ignorance".

27 In *The Fatal Conceit* (1988), Hayek contended that "the close connection between population size and the presence of, and benefits of, certain evolved practices, institutions, and forms of human interaction" implied "that socialism constitutes a threat to the present and future welfare of the human race, in the sense that neither socialism nor any other known substitute for the market order could sustain the current population of the world" (1988, pp. 120-121).

28 On Hayekian grounds, in the catallaxy the absence of particular ends governing the overall order and the impossibility of interpersonal utility comparisons render standard welfare economics irrelevant. Hayek's own normative criterion turns on a coordination norm regarding the probability of a randomly selected individual achieving his ends (1978, p. 184). Later, Hayek (1988, p. 132) explicates this criterion in terms of sustaining population growth and emphasizes the process by which rules are selected that are compatible with that criterion: "Yet if the market economy did indeed prevail over other types of order because it enabled those groups that adopted its basic rules the better to multiply, then the calculation in market values is a calculation in terms of lives: individuals guided by this calculation did what most helped to increase their numbers, although this could hardly have been their intention."

29 Polanyi, by contrast, parlayed his own deep involvement within the scientific community into a detailed understanding of the structure and operation of science in explaining the growth of knowledge.

30 Hayek does not directly claim science to be a spontaneous order, although his close and mutually supportive relationship with Polanyi, especially during the 1930s and 40s, likely provides sufficient ground to infer that Hayek generally agreed with Polanyi's views. As Hayek increasingly turned toward evolutionary themes, his treatment of spontaneous orders, as seen for example in "Cosmos and Taxis" (ch. 3 of LLL, 1973), would quite clearly apply to science as instantiating a particular spontaneous order as a self-organizing, self-correcting, and adaptive system of freely interacting individuals in the sense of Polanyi. More recently, several researchers have built on Hayek and Polanyi to treat science as a spontaneous order; see Lavoie (1985, especially Chapter 3), Wible (1998, ch. 8), Butos and Koppl (2003), and McQuade (2007; 2010).

31 Menger (1883). While Menger's book has been seen as mainly a statement affirming the status of theoretical work in economics, Hayek, in his lecture "The Trend of Economic Thinking" (1933), presciently directed attention to the part on spontaneous orders.

32 To be fair, Hayek had his plate quite full during that time, becoming embroiled in several noteworthy debates– on socialist calculation, with Knight on capital theory, and with Keynes on money and cycles.

33 Particular social structures and orders function within broader contexts and do not exist independently of those contexts. The catallactic theory of the market is nested in a set of institutions pertaining, for example, to the existence and enforcement of property rights and contracts, but these conditions can and should be taken as given if we wish to understand the role of price formation. Although exogenous conditions will

certainly affect how the catallaxy functions, viewing the catallaxy in positive terms as a complex adaptive order is the lens by which such outside conditions can be analyzed.

34 We have previously developed this issue in some detail in Butos & McQuade (2002).

35 Also see Polanyi (1945, pp. 143-44).

36 Also see Popper (1972, ch. 3), Musgrave (1974), Weimer (1979, ch. 5), Bartley (1984, ch. 5), and Harper (1995, pp. 58-60).

37 By "critical procedures" we mean the transactions of publication and citation, whose effects constitute feedback, both positive and negative, due to their effect on scientific reputation. Repeated iteration of these transactions in the context of feedback produced by earlier transactions results is the major stabilizing mechanism for the system of science and the source of the emergent product we call "scientific knowledge".

38 It was not "judge-made" law—judges were necessary elements in ensuring that proper procedure was adhered to, but it was the jury who were expected to decide the case in a manner that was fair given the particular circumstances and expectations involved. See Hasnas (2005, pp. 89-92).

39 Morison contends Hasnas's claims as to Hayek's confusion of common and customary law, and Hasnas (2007) rebuts this critique. See also Morison (2007b), in which Hasnas's general points (if not all his historical specifics) are conceded.

40 Our criticism of Hayek's treatment of legal institutions echoes that of the more extended discussions in Stringham (2015, ch. 13) and Zywicki & Stringham (2012). As Stringham (2015, p. 218) points out, "Hayek [in his discussion of legal institutions] treats as normative concepts what are fundamentally questions of positive analysis and institutional design".

41 "To say that partial planning [in a capitalistic society] of the kind we are alluding to is irrational is, however, not equivalent to saying that the only form of capitalism which can be rationally advocated is that of complete laissez-faire in the old sense. There is no reason to assume that the historically given legal institutions are necessarily the most 'natural' in any sense" (Hayek 1935, pp. 21-22). In "Planning, Science, and Freedom" Hayek says: "The alternative [to central planning] is, of course, not laissez-faire, as this misleading and vague term is usually understood. Much needs to be done to ensure the effectiveness of competition; and a great deal can be done outside the market to supplement the results" (1941, p. 83).

42 Examples mentioned by Hayek include a sound monetary system, a system of weights and measures, the dissemination of statistics and other information, supporting and organizing education, sanitary and health services, safety regulations, roads, and public works, which he says should be financed by taxes (Hayek 1960, pp. 222-226, 257-260). Support of the indigent, the unemployed and sick "has long been accepted as a duty of the community" (p. 285), yet Hayek argues that an obvious corollary" would be "to compel them to insure … against those common hazards of life" (p. 286). Also see Hayek's extensive discussion of government financing, though not necessarily the provision, of collective goods (1979, ch. 14) and his insistence that such services should not "be reserved to government if other means can be found for providing them" (p. 47).

43 Polanyi's most complete statement on the funding of science appears in "The Republic of Science" (1962). In a remarkable section of this paper he says: "Subsidies should be curtailed in areas where their yields in terms of scientific merit tend to be low, and should be channeled instead to the growing points of science, where financial means may be expected to produce work of higher scientific value. It does not matter for this purpose whether the money comes from a public authority or from private sources, nor whether it is disbursed by a few sources or a large number of benefactors. So long as each allocation follows the guidance of scientific opinion, by giving preference to the most promising scientists and subjects, the distribution of grants will automatically yield the maximum advantage for the advancement of science as a whole" (pp. 60-61). Also see Polanyi (1945, p. 145).

44 This claim is consistent with Polanyi and Hayek both seeing science as a nonmarket order.

45 See Butos & McQuade (2006; 2012; 2015b).

46 This is not to say that there have not been serious critics of the market order—from Carlyle and Marx to Pigou and Keynes to Stiglitz and Piketty—who point to less-than-benign effects which they attribute to the unhampered market order. But even they would be hard pressed to deny the massive increase in wellbeing that McCloskey (2010) eloquently documents.

47 See, for example, Barry (1982, par. B.112): "In a market there is a mechanism, the price system, which does co-ordinate the actions of economic agents to produce an

efficient order … but there is no similar mechanism at work in a legal system."

48 Hayek himself went quite far in this direction (not a surprise, since *The Sensory Order* is essentially the description of a very particular complex adaptive system)—see for example (Hayek 1967, pp. 66-81) where he asserts that "there is no reason why a polycentric order in which each element is guided only by rules and receives no orders from a center should not be capable of bringing about as complex and apparently as 'purposive' an adaptation to circumstances as could be produced [in a more hierarchically organized system]". What is perhaps surprising is that he did not fully follow the idea through to purge it of a normative bias and to pursue its logical consequences for the development of applications throughout social realm.

49 Kauffman (1993, pp. 173-235; 1995, pp. 71-92), discussing "the twin sources of order", makes the important point that, in biological systems, natural selection is not the only source of order, for the tendency in certain systems to self-organization is, in a sense, "order for free".

50 See also Oprea & Wagner (2003), Axtell (2007), Rosser (2012) and especially Harper & Endres (2012), Harper and Lewis (2012), and Harper (2014). Modestly, we cite our own contributions to this trend: Butos & McQuade (2002; 2012; 2015a), McQuade & Butos (2003; 2005; 2009), and McQuade (2007).

51 We understand that treating market and science as stand-alone systems is a simplification that cannot be maintained in a more complete treatment of these systems. Clearly, both systems are critically dependent for their functioning on arrangements external to them—for markets, on arrangements that support the implementation of the institutions of property and contract, and for science, on arrangements that provide funding for research and facilitate publishing and distribution. Changes in the underlying systems in which science and market are embedded will, potentially, have consequences for the performance of their internal transactions and the characteristics of their emergent properties. And such changes may in turn depend on ideas and ideology, as McCloskey (2010) maintains.

52 See McQuade & Butos (2009) for a discussion of idealized features of complex adaptive systems. Also see Harper & Endres (2012) and Harper & Lewis (2012). Interestingly, all of the characteristics of adaptive systems described there are consistent with Hayek's (1952a) description of the brain, with neurons as the active elements interacting physically via their axons, and the appropriate physical and chemical effects impinging on neurons as a result of their activity and location being the analogs of incentives and benefits.

53 There is no doubt that systems that do not closely adhere to the stabilized growth criteria can persist and grow for extended lengths of time. An obvious example is the system of representative government in the U.S., which has grown from very small beginnings over 200 years ago to now dominate the broader society. But the system has a structural problem in that the constraints thought sufficient to severely limit its growth—the separation of powers, the institutionalized competition between factions, and the ability of the electorate to replace its representatives—have been, in the long run, ineffective in generating feedback sufficient to stabilize the system sufficiently to keep it within the contemplated bounds.

54 They are operative at least to the extent that they are allowed to function in the face of constraining interventions, particularly in the case of the market system.

55 For a fuller discussion, see McQuade (2007, pp. 73-76).

56 We are certainly not suggesting here that such criteria form a basis for large-scale social engineering. It is one thing to identify bad rules and unstable or degenerating systems, but it is another to turn around and promote well-intentioned interventions to "solve" the problem. There are only two ways in which "bad" rules (and even the systems in which they operate) can be changed without interventions and their snowballing side effects, and they are both bottom-up: first, by ignoring them or withholding participation and letting them die (or lose their normative power) from misuse, and second, by entrepreneurial action to propose, at risk to the entrepreneur, new ways of doing things that amount to improvements to or replacements of existing rules and transaction modes. And both of these are feasible only in an environment in which there is, if not outright respect for, then at least some tolerance of, people of independent ideas who are prepared to implement those ideas.

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