Max Boisot, Ron Sanchez*

Organization as a Nexus of Rules: Emergence in the Evolution of Systems of Exchange**

This paper seeks to explain the evolution of human systems of exchange through the *emergence* of both fundamental forms of organization (such as firms and markets) and specific instances of organization (such as individual firms and other economic or social entities) for engaging in exchange. We develop a combined systems, evolutionary, cognitive, and game-theoretic perspective on organizing that broadly represents organizations as *systems of exchange* founded on *rules and routines* for ordering exchange (broadly construed) between agents. We characterize the evolution of systems of exchange as an *evolutionary cognitive process* in which agents learn from their exchange experiences to adapt and improve rules and routines that improve the systems of exchange in which they participate. An evolutionarily stable form or instance of organization is achieved when a nexus of rules and routines emerges that offers a Pareto preferable system of exchange that attracts agents to its way of organizing exchange. We identify key aspects of rules that determine their relative attractiveness and thus their potential to be perceived as Pareto preferable by agents. We describe how trial-and-error learning by agents as they apply and seek to improve rules and routines in processes of exchange leads to the emergence of innovative forms of organizing (distinguished by their distinctive new nexus of rules) and to their dissemination, further evolution, and perhaps eventual extinction within a population of agents. We also distinguish the nexus-of-rules perspective on organization developed here from the nexus of contracts perspective common in the economic view of organization.

Key words: **systems of exchange, organization, emergence, evolutionary theory, cognitive processes**

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* Max Boisot, ESADE, University of Ramon Llull. E-mail: boisot@attglobal.net.

Ron Sanchez, Department of Innovation and Organizational Economics, Copenhagen Business School, Kilevej 14A _ 3rd Floor, DK – 2000 Frederiksberg, Denmark. E-mail: sanchez@cbs.dk (address of correspondence).

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1. Introduction

Much economic and social theory seeks to explain *why* various forms of organization exist by identifying the benefits that organizations in various forms (firms, markets, societies, etc.) may bring to agents[1] who participate in them (e.g., Williamson 1975; Etzioni 1964; Giddens 1984). Thus far, however, concepts for explaining *how* either basic or specific forms of organization are innovated have not been explicitly incorporated into established economic and social theories. Recent advances in our understanding of self-organizing processes and complex adaptive systems (Maturana and Varela 1980; Holland 1975, 1998) suggest that organizations may be viewed less as the product of design by hyper-rational, far-seeing entrepreneurs and managers, and more as systems that *emerge* from recurrent interactions between agents. In this paper we draw on systems, evolutionary, cognitive, and game-theoretic perspectives on the behaviors of agents to explain (in important part) how both fundamental forms of organization (e.g., firms) and specific instances of organization (e.g., a specific firm) are innovated and emerge from recurrent interactions between agents.

In our analysis, we broadly characterize forms of organization as *systems of exchange*[2] in which participating agents may seek to benefit by exchanging some resources (abilities, money, time, energy, loyalty, etc.) for other resources with functional, financial, social, and professional benefits that a given form of organization may provide (Scott 1986; Sanchez and Heene 1996, 1997, 2004; Biggart and Delbridge 2004). Individual instances of organization can be distinguished by the specific kinds of opportunities for exchange of resources that each offers to participating agents.

Our approach characterizes the innovation of both basic forms and specific instances of organization as outcomes of evolving processes of exchange among agents that occur in tandem with human cognitive processes of rule making and procedure routinization (Burns and Flam 1987; Weber 1968). We characterize the process of organizational innovation as a dialectical, cognitive evolutionary process driven by trial-and-error learning by agents seeking to improve on currently available exchange op-

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1 We use the term *agents* to refer to any individuals or other transacting and decision-making entities (e.g., families, clans, firms, nations) that may elect to participate in any system of exchange (see also footnote 2).

2 *Exchange* as used in our analysis is a broad concept that includes the full range of explicit and implicit contractual and commitment arrangements, including those pertinent to economic transactions. Thus, we use the term *exchange* to include transactions based on legitimate expectations for fulfillment of mutual obligations, not just exchanges that are purely contractual in nature. Note that these expectations may result from the exchange of specific commitments made in an explicit contracting process (as commonly represented in current economic theory) or from assumptions by agents that certain obligations implicit in a set of rules and routines will obtain and will be honored in a specific exchange context (which we suggest may include both economic and social exchange contexts). These may include, for example, assumptions of fair treatment and continuity in exchanges between individuals and other entities (such as employment arrangements) or assumptions that actions taken by parties to an exchange process will be based on "good faith" in maintaining relationships between individuals and/or other entities.

portunities. Through experience and experimentation with various approaches to ordering exchange, some agents may begin to imagine modified or even alternative systems of exchange – defined by an improved set of *rules and routines* for ordering exchange – that they believe would be beneficial, either generally or in a specific exchange context. Some agents may then engage in entrepreneurial, managerial, or collective social innovation to put in place a new set of rules and routines for ordering exchange that gives rise to a new form or instance of organization. As agents gain experience in exchange ordered according to a new set of rules and routines, some rules and routines may be regarded by agents as effective and will therefore be retained, while other rules and routines regarded as less effective either will be modified in an effort to further improve the benefits they offer or will be "selected out" of the agents' repertoire of rules and routines. As such, cognitive processes of rule-making and routinization and economic and social processes of exchange can be seen as distinct but complementary phases in a co-evolutionary process of transactional hypothesis creation, testing, revision, and refinement (Popper 1972; Campbell 1974).

This evolutionary process will from time to time innovate sustainable new organizational forms by generating procedural "memes"– rules and routines that some agents may choose to "mimic" (Dawkins 1982) – that appear to lead to more efficient, Pareto-preferable solutions to recurring exchange situations that agents face. Basic forms of organization (e.g., firms, markets, collectivities, political systems, social systems) are innovated when fundamentally new sets of rules and routines emerge from this evolutionary, hypothesis-generating-and-testing process and begin to be applied and followed by transacting agents in a broad exchange context. Specific instances of organization (a given firm, market process, collective enterprise, political process, or social context) emerge as local, idiosyncratic variations on a more widely emulated set of rules and routines.

Both basic and specific forms of organization compete in an evolutionary context in which some innovated forms of organization are perceived by agents as offering more beneficial exchange opportunities and so attract agents and their resources to their rules and routines for ordering exchange, while other forms of organization are perceived as less beneficial and fail to attract agents. Innovated forms of organization that are successful in attracting agents in a given exchange context are retained and survive. Innovated forms of organizations that are less successful in attracting agents must either adapt their rules and routines in ways that succeed in attracting agents and their resources, or they will be extinguished by being selected out of the population of basic and specific organizational forms. In effect, a given set of rules and related routines for ordering exchange – which henceforward we refer to simply as a *nexus of rules* – acts like a force field that competes with other nexus of rules and either attracts or fails to attract agents. Thus, in this conception of organizations, various forms of markets, firms, collectivities, and other kinds of organization have a "boundary" that is coincident with the limits attractive or "reach" of their individual nexus of rules.

Endogenizing cognitive adaptive processes in characterizing the process of organizational innovation leads to an institutional view of organization as originating in and constituted by an evolving nexus of rules that is accepted and followed by consenting agents in ordering their exchanges. In this view, the nexus of rules that distinguishes a

given form of organization may encompass a spectrum of possibilities from a set of informal or implicit normative expectations about how agents should behave, to a formalized set of contracts or other institutional instruments (e.g., laws and regulations) that explicitly define the rules and routines applicable in a given exchange context, or (quite commonly) some combination thereof. Whether formal or informal or both, a given nexus of rules provides a framework for ordering exchange that guides agents in conducting exchanges, both among themselves and collectively with other agents or organizations willing to engage in exchange according to a given nexus of rules.

Our discussion of the process of organizational innovation as the emergence of a new nexus of rules for ordering exchange is developed in the following way. In Section 2, we explore more fully the characteristics and interrelationships of rules, routines, and exchange that are central to our analysis. In Section 3, we introduce the Information-Space or *I-Space*, a conceptual framework for the analysis of information flows and social learning processes that take place within and across populations of agents (Boisot 1995, 1998). We draw on the model to elaborate the evolutionary processes of rule and routine generation, dissemination, and modification that lead to the emergence of forms of organization within a population of agents. In the I-Space framework, we elaborate the roles of rules and routines as devices for economizing on the cognitive tasks of data processing and information transmission by agents, thereby both facilitating organization (coordination) of exchange among agents and abetting the emergence of new forms of organization. In Section 4, we discuss important ways in which the nexus of rules perspective differs from the economic "nexus of contracts" approach in theorizing about the organization of firms. Section 5 provides some concluding comments on the implications of the nexus of rules perspective for further theorizing and research into the innovation of organization forms.

2. The nature and interrelationships of rules, routines, and exchange

2.1 Processes of emergence and evolution

In our analysis of how the evolution of rules and routines leads to the emergence of innovative forms of organization, rules are characterized as essentially *prescriptive* in nature, while routines are represented as *descriptive*. Rules embody basic *principles* to which exchanges undertaken in a given context should conform, while routines define *specific ways and methods* for conducting exchange that are consistent with the principles embodied in a set of rules. In effect, within a system of exchange, rules prescribe the kinds of actions that a participating agent will be obliged to undertake in a categorical exchange context, while routines describe specific actions and procedures an agent could follow to conform to a set of rules in a given exchange context.[3]

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[3] Ordinary English usage may include a descriptive aspect of rules and a prescriptive aspect of routines. However, as will become evident further on in our discussion, within the framework of our analysis there is an important conceptual distinction to be gained by characterizing rules as essentially prescriptive and routines as descriptive.

Rules arise as a human response to recurrent kinds of exchange situations. Rules embody and codify principles[4] that at least some people believe will help to order and manage recurrent exchange situations in beneficial ways. Rules and the categorical obligations they imply for various kinds of exchange contexts are more abstract and fundamental than, for example, contracts, which are often posited as the basis of organization in economics (e.g., Aoki 1984; Hart 1995). In this regard, the concept of *rules* in our analysis is analogous to the concept of *genotypes* in biology – generic blueprints for action that an organism will follow in certain kinds of circumstances. Similarly, routines are analogous to *phenotypes* – specific expressions of a genotype in an organism's behavioral repertoire that may be elicited in a particular circumstance (Hodgson 1999; Granovetter 1985).

As we shall discuss below, however, the hierarchical conceptual progression from principles to rules to routines and thence to agent actions in an exchange context is not a one-way street. As agents gain experience in enacting routines, they may imagine and improvise new routines that they believe will improve the benefits they can derive from exchange in a given context. Improvised routines – if tried and judged more efficient, effective, or otherwise desirable than prior routines – may also lead agents to infer new or modified rules, which may in turn invite adoption of new or modified principles.[5] Changes in how agents think and behave in their exchange interactions thus occur through co-evolutionary cycles of deductive reasoning from the general to the specific (e.g., from principles to rules to routines) and inductive generalizing from the specific to the general (from routines to rules to principles). Agents' reflections on exchange experiences thus lead to organizational innovation through an evolving cognitive process of hypothesis emergence and testing carried out within a hierarchy of interdependent conceptual and logical relationships, as suggested in figure 1.

Clearly, figure 1 is schematic and simplifies the complex and contingent nature of the deductive and inferential reasoning processes described here. There may be considerable variation, for example, in the specific rules that can be deduced from a given set of principles and in the range of routines that a given set of rules could give rise to. Similarly, inductive generalizing processes could lead to many different variations in modifications of routines and rules. The intent of figure 1 is simply to suggest that evolutionary processes of variation, selection, and retention operate at each step in any specific evolutionary path emergent within a population of agents.

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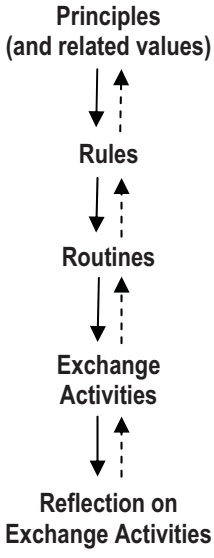
4 We use the term *principles* here to refer to fundamental and usually deeply held beliefs of agents that comprise the foundation of their worldview (*weltanschauung*). However, in our analysis we do not undertake to formally define or develop the concept of an agent's principles, or to speculate on their origins or evolution. Rather we simply begin with the premise that agents will have such principles and with the assumption that any rules that an agent will consider conforming to in an exchange context will reflect those principles.

5 Given our focus on the evolution of rules and routines in this paper, we do not attempt here to elaborate the processes through which changes in rules may lead to changes in agents' principles. However, we feel it is important to place the evolution of rules and routines that is the basis of organizational innovation in the broader context of human social and economic evolutionary processes driven by trial-and-error learning arising through social and economic interactions.

Figure 1: Hierarchy of interdependent conceptual and logical relationships in cognitive evolutionary processes of organizational innovation



Endowing agents with cognitive powers of deduction and induction that may lead to changes in principles, rules, routines, and actions in exchange endogenizes the processes of variation, selection, and retention in the evolution of forms of organization. This approach thus provides a framework for introducing adaptive conceptual learning by agents into both evolutionary theories of the firm (Nelson/Winter 1982) and population ecology models of organization (Hannan/Freeman 1989; Carroll/Hannan 2000).

As they evolve, sets of rules and routines act as *attractors*. Agents may be attracted to an exchange context (ordered according to a given set of rules and routines) that promises more satisfactory outcomes than other available exchange contexts. In this sense, borrowing the language of evolutionary game theory, attractive rules are not so much "truces" between players (Nelson/Winter 1982) as they are evolutionarily stable strategies (ESS) for mediating agent interests – Nash equilibria that evolve through repeated games played out between numbers of agents (Axelrod 1984; Maynard-Smith 1970; Binmore 1994). As agents are attracted to more satisfactory (Pareto preferable) sets of rules and routines, new systems of exchange embedded in and enabled by new organizational forms – both fundamental and specific – that offer better prospects for exchange outcomes attract increasing numbers of participating agents, while less attractive systems lose their participating agents. In this way, organizational forms and their supported systems of exchange compete to attract participating agents. Such competition among evolving organizational forms determines which forms of organization survive and which do not.

In the balance of this section, we examine more closely some important aspects of the nature and interrelationships of rules, routines, and exchange activity that frame

the evolution of organizational forms. Section 2.2 elaborates some important intrinsic characteristics of rules, including their scope of applicability, ease of communication, and ease of application. Section 2.3 invokes basic game theory concepts to identify aspects of rules that affect their ability to act as attractors. We consider how the perceived benefits of a nexus of rules can vary with the distribution of payoffs under the rules, the number of participating agents, the expected number of plays, and whether the rules create positive-sum or zero-sum games. We also consider the effect on a rule's perceived value of the compatibility of a rule with an agent's current principles and habits.

2.2 Intrinsic properties of rules

Rules may be specific or general. A rule is specific when its scope of applicability is narrow and thus contextually delimited. A rule is general to the extent that its scope of applicability is broad and thus contextually unlimited. Rules may also be conditional (of the "if-then" variety) or unconditional (as in Kant's categorical imperative). Rules also differ in their intended reach (i.e., the number or kinds of agents intended to be subject to a rule), which in turn will influence the potential rate and extent of diffusion of a rule in a population of agents. Finally, rules may vary in their compactness – a measure of the amount of information that has to be structured, processed, articulated, and transmitted before a rule can be understood and used by agents.[6]

We next briefly summarize how acceptance of and adherence to a rule in a population of agents depends on the rule's scope of applicability, ease of communication, ease of application, and compatibility with agents' current principles and habits. (Subsequently, in Section 3 we elaborate more fully the impacts of the compactness and reach of a nexus of rules on the emergence and dissemination of new organizational forms in a population of agents through use of the I-space model.)

Scope of applicability: The scope of applicability of a rule – its generality *versus* specificity – determines the range of interests that can be pursued by agents in a system of exchange based on the rule. Rules may address interests that range from universalistic interests relevant to all agents to particularistic interests of concern to only a few agents. The more general a rule is, the wider the range of situations in which the rule can be applied, the larger the number of agents that may find the rule useful, the more useful the rule will prove to individual agents, and thus (*ceteris paribus*) the more likely that a rule will be perceived as attractive and adopted by large numbers of agents.[7]

Ease of communication: The ease with which a rule can be communicated among agents depends both on the intrinsic complexity of the rule and on the extent to which a rule has been articulated in compact, parsimonious form without loss of precision in meaning. For a rule to be communicated effectively, the rule must be articulated in a form that constrains the range of interpretations that agents may derive from it. For a rule to be able to serve as a basis for coordinating agent interactions, it

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6 The compactness and complexity of a rule are thus inversely related (Chaitin 1991).

7 This aspect of rules also reflects the issues of altruism *versus* kin-selection in human societies that are raised at a more general level by evolutionary theory (Wilson 1980; Margolis 1982; Binmore 1994).

must be capable of being communicated with sufficient clarity that agents who act in accordance with the rule can be confident that their respective interpretations of the rule and resulting actions will be convergent and therefore will lead to predictable and consistent exchange outcomes.

Ease of application: The ease of application of a rule depends on its intrinsic complexity and the resulting cognitive effort agents must expend to implement the rule. Simple rules are generally easier for agents to understand and apply than complex rules. Algorithmic rules can generally be implemented easily, often more or less mechanically and mindlessly, and may sometimes even be automated (Simon 1962). Heuristic rules, on the other hand, may require significant sense-making and interpretation to implement (Orton and Weick 1990), and may therefore impose a greater burden of cognitive effort on agents.

The cognitive effort required to implement a rule also depends on the degree to which the rule is interdependent with other rules. A higher level of interdependency with other rules is likely to require greater cognitive effort by agents to find a way to apply a rule that is not in conflict with other rules. A rule that is relatively decoupled from and independent of other rules, however, will thereby be easier for agents to implement. Moreover, rules that are independent of other rules in essential respects will have greater combinatorial potential – i.e, they can be used concurrently and in parallel with other rules in evolving new nexus of rules.[8]

2.3 Characteristics of rules that affect their perceived value and attractive force

A nexus of rules may act as an attractor for agents – and thus is more likely to be selected by agents – to the extent that agents perceive that a system of exchange based on the nexus of rules offers more valuable opportunities for exchange than competing systems based on other nexus of rules. Rules may become attractors by aligning and coordinating agent interests and interactions in ways that lower costs of agent transactions (including costs of search and problem-solving), by increasing the productivity of transactions through specialization of agent roles and activities (Smith 1981), and by enabling opportunities for transacting that agents would not otherwise have (e.g., by creating a marketplace for trading new kinds of contingent claims).

We next invoke some basic game theory concepts to summarize important aspects of rules that will typically affect their attractive force. We consider how the perceived benefits and resulting attractive force of a nexus of rules can vary with the distribution of payoffs under a given set of rules, with the number of participating agents, with the expected number of plays, and with the potential for the rules to create positive-sum or zero-sum games. We also consider how the compatibility of a rule with agents' current principles and habits affects a nexus of rule's perceived value and thus attractive force.

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8 Independent rules with high combinatorial potential are the basis of emergent new modular organization forms, for example (Sanchez 2001, 2005; Sanchez/Mahoney 1996; Boisot et al. 1996).

Game theoretic perspective on rules: Rules express basic norms of behavior that agents who wish to transact in a system of exchange must honor. Recurrent transactions within a system of exchange in effect constitute repeated games between agents.[9] If agents believe that adhering to a nexus of rules that is the basis of a system of exchange would bring benefits that would be sufficiently attractive to all participating agents to induce them to honor the nexus of rules in their transactions, the system of exchange may take on the character of a self-organizing Nash equilibrium in which agents engage in repeated transactions while voluntarily conforming to the nexus of rules that is the basis of the system of exchange. When agents are aware of and have access to competing systems of exchange offering different kinds of Nash equilibria, they will be attracted to the system of exchange that each agent judges will offer the greatest net benefits.[10]

In effect, a nexus of rules will have attractive force to the extent that systems of exchange based on the nexus offer agents stable opportunities for repeated transactions, the perceived net benefits of which individual agents are not able to improve on by transacting in other systems of exchange, at least in the short term. Of course, not all nexus of rules will give rise to Nash equilibria within a population of agents. To the extent that agents believe they can derive greater benefits by following other rules in other systems of exchange, a given nexus of rules will fail to become internalized in – i.e., will be "selected out" of – agents' behavioral repertoires, and will not become the basis for the emergence of new patterns of agent interactions that comprise some new form or instance of organization.

Several aspects of rules significantly affect their attractiveness and thus their ability to give rise to Nash equilibria in which repeated games are played according to patterns of transactions consistent with a nexus of rules (Binmore 1994).

(i) Agents must be capable of knowing or correctly imagining the *distribution of payoffs* available to individual agents playing a game (i.e., to each agent following some rules in transacting with other agents in a system of exchange). Moreover, the distributions of payoffs that agents perceive to be available from transacting in one system of exchange must be greater than the payoffs they perceive to be available from transacting in alternative systems of exchange, less any perceived costs of switching their norms for exchange from one set of rules to another set of rules.

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9 We recognize here, but do not specifically address, the possibility that a given system of exchange may present some or all agents with opportunities for end-game scenarios that could lead to agent behaviors that would be different from their behaviors in repeated games. Our discussion therefore concerns systems of exchange in which the incentives for continued participation are sufficiently robust to discourage end-game behaviors (Axelrod 1984).

10 Of course, agents may differ in their principles and derived values and preferences, their discount rates, and their abilities to "calculate" the net benefits of transacting in alternative systems of exchange. These differences will affect the relative attractiveness that individual agents will perceive in alternative systems of exchange, and thereby will determine which systems of exchange are perceived as Pareto-preferable Nash equilibria by individual agents, and which are not.

(ii) The *number of agents* eligible to participate in a game must be sufficient to promise attractive payoffs to participating agents, but payoffs must not be seen as dependent on participation by an excessively large number of agents. When a system of exchange requires large numbers of participating agents to realize its promised exchange benefits, the large scale of the system may lead to complexity and difficulty in calculating likely payoffs and may increase the perceived risk that payoffs may not be realized. Of course, as imagined payoffs increase in magnitude, the amount of cognitive effort and risk that agents will be willing to bear – and thus the size and complexity of the systems of exchange they will be willing to enter – may increase.

(iii) The *expected number of plays* of the game must be sufficiently large to render end-game strategies unattractive relative to continued adherence to a given set of rules in current exchanges.

(iv) In general, agents may perceive rules that lead to positive-sum *cooperative* games as more attractive and thus more sustainable than rules that lead to zero-sum *non-cooperative* games, *ceteris paribus*.

When a system of exchange brings greater net benefits to agents transacting according to its nexus of rules than the benefits available from competing nexus of rules, participation in that system of exchange improves *agent fitness* – the ability of agents to survive in their environments. Thus, a nexus of rules may improve its chances of survival in an environment of competing nexus of rules not just by offering transactional benefits that attract willing participants (Maynard-Smith 1970), but also by improving the fitness of its current and future participants to survive in their individual competitive environments.

Compatibility with current agent principles and behaviors: A rule will be more attractive to agents the more it is compatible with agents' current principles and habitual ways of behaving. A nexus of rules that requires significant change in an agent's principles or habitual behaviors would impose psychological switching costs that reduce the net benefit an agent would receive by conforming to a new set of rules, thereby reducing the attractiveness of those rules. In the cognitive domain, rules that embody satisficing behavior (March and Simon 1958), for example, will be more attractive to agents who by nature or by habit tend toward satisficing behaviors than rules that require efforts to achieve optimization in exchange.

3. An information processing framework: The I-Space

We now introduce and apply the I-Space model, a conceptual framework for analyzing information flows within a population of agents, to illuminate the ways in which rules (as forms of information) emerge in a population of agents and become the basis for innovations in the organization of agents' exchange interactions. We first define concepts of *information diffusion, codification, and abstraction,* and then elaborate how information diffuses in a population of agents and how the rate of diffusion of rules as information varies depending on whether a given rule is substantive or procedural in nature. We describe the learning dynamics of agents that drive both the emergence of rules as the basis for specific systems of exchange and the co-evolution of rules and

routines within a system of exchange, leading to emergence of new forms of organization and attendant institutions.

3.1 Diffusion, codification, and abstraction of rules as information

The I-Space model is a conceptual framework developed to interrelate the properties of information and the dynamics of information flows in a population of agents (Boisot 1995, 1998). In the I-Space model, the rate at which information flows between agents – i.e., the rate of *diffusion* of information – depends jointly on the degrees of *codification* and *abstraction* in the classification schema available to agents for interpreting and communicating information.

Codification is the articulation of perceived conceptual differences between observed phenomena – things, processes, and events – that enable agents to distinguish one kind of phenomena from other kinds of phenomena. Codification occurs when agents use some sense-making schema for defining *conceptual boundaries of categories* in classifying the phenomena they experience. Boundaries are well codified when they are sufficiently clear and unambiguous to agents to enable them to unproblematically assign observed phenomena to specific categories – a process we call *coding*. A good codification schema assists agents' information creation and processing by facilitating and speeding up their coding (classification) of the phenomena they encounter and wish to communicate to other agents.

Following the I-Space model, we characterize the degree of codification in a classification system as being *inversely* related to the amount of "data processing" – data gathering and interpretation – that an agent would have to undertake to determine to which category an observed thing, process, or event should be assigned.[11] The greater the degree of codification in the classification schema used by agents, the less intellectually taxing and faster agent coding of phenomena becomes.

Abstraction, by contrast, enables the parsimonious creation and use of categories. Dretske (1981) defines abstraction as treating things that are different as if they were the same (within some context of analysis). Abstraction conceptually groups observed phenomena in ways that establish *hierarchically ordered categories* for classifying and referring to phenomena. Highly abstract descriptions use broad, encompassing categories – and thus relatively fewer categories – to characterize phenomena. Less abstract, more concrete descriptions use narrower – and thus relatively more numerous categories – to characterize phenomena. The greater the degree of abstraction in agents' classification schema, the fewer categories agents may invoke, and thus the more parsimonious their representations of phenomena will be. In applying abstract categories to represent concrete phenomena, agents benefit from the conceptual parsimony of abstrac-

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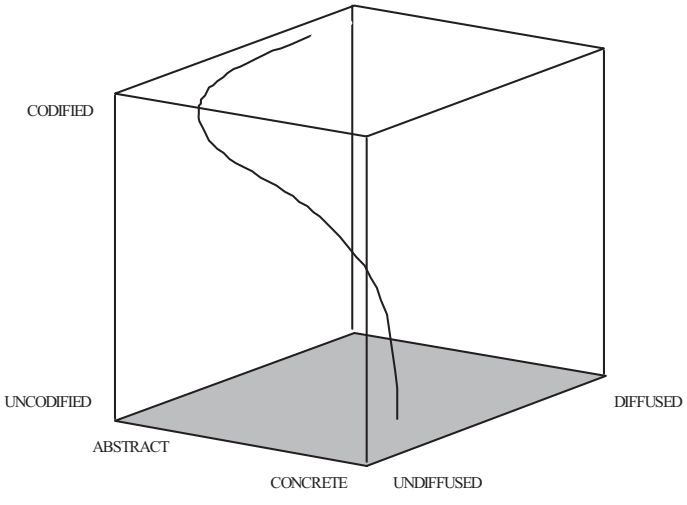
[11] In our discussion, *data* are categorical representations of observed phenomena that an agent uses to describe, communicate, and (at least in part) remember phenomena. *Information* is some meaning derived by an agent from interpretations of data through processes of comparison across time and contexts to discover patterns in data. *Knowledge* is belief of an agent in cause-and-effect relationships between categories of phenomena that the agent has inferred from observations of correlations among repeated patterns in data representing observed phenomena. (See Sanchez 2001, Chapter 1).

tion when it reduces the mental effort and time they must expend to code phenomena.[12]

The I-Space model uses a three-dimensional space to represent the relationships between the diffusion of information and the codification and abstraction schema used by agents to formulate and communicate information (see Figure 2). As suggested by the lowest point on the curve depicted in Figure 2, information formulated by an agent without the benefit of a well-developed codification and abstraction schema is likely to remain relatively undiffused within a population of agents because of the relative cognitive difficulty and effort involved in communicating more concrete and less codified representations of phenomena to other agents. By contrast, the availability to agents of sense-making schema with higher degrees of codification and abstraction reduces the cognitive processing task involved in articulating representations of phenomena, and thereby facilitates the more rapid and widespread diffusion of information to a larger number of agents, as indicated by the high point on the curve in figure 2.[13]

Figure 2: The codification-diffusion-abstraction curve in the I-Space



12 Codification and abstraction thus play distinct roles in hierarchical categorization schema. The degree of codification determines the *sharpness of the boundaries* that (horizontally) separate various categories of phenomena, while the degree of abstraction determines the *conceptual level* in which a phenomenon is placed in the (vertical) structure of a hierarchy of categories.

13 Note that the curve shown in Figure 2 only describes the *potential* for diffusion of information in a population of agents. Whether an instance of information will actually diffuse as suggested by the curve in Figure 2 will depend on the extent to which the sense-making schema that agents in the population use for codification and abstraction have enough conceptual commonality to enable communications of information between agents to be understood.

3.2 Diffusion of rules in an agent population

Rules communicate information about expected norms of behavior by agents transacting in a given system of exchange. As with other forms of information, the rate at which and the extent to which rules diffuse in a population of agents depend in part on the degrees of codification and abstraction of a given set of rules.

The degree of codification of a rule refers to the degree of clarity and definiteness with which the categories of phenomena invoked by the rule are expressed – i.e., is it clear to an agent to which kind of phenomena a rule pertains and should be applied? The greater the degree of codification employed in a rule, the easier it is for agents to identify the categories referenced by the rule and hence to comprehend its domain of applicability. The degree of abstraction of a rule corresponds to the degree of generality versus specificity of the information that composes a rule – i.e., is the rule intended as a general prescription applicable to broad categories of phenomena, or is it a specific prescription for dealing with more narrow, specific categories of phenomena? The greater the degree of abstraction of a rule, the broader the scope of agent interests and exchange situations addressed by the rule.

The rate and extent of diffusion of a rule as information in a population of agents will depend on the degrees of codification and abstraction embodied in a rule.[14] As Figure 2 suggests, rules whose information content is more codified and abstract – i.e., more clear as to which categories of phenomena the rule applies to, and more broadly applicable – will tend to diffuse more rapidly than rules whose information content is less codified and more concrete.

3.3 Procedural rules versus substantive rules

Herbert Simon (1954) noted that people in organizations, when confronted with the complexity of the problems that organizations must try to solve, will tend to adopt procedural forms of rationality rather than substantive rationality in decision making. The abstraction and codification dimensions of the I-Space framework, which suggest that rules based on procedural *versus* substantive rationality will diffuse at different rates and to different extents, help to explain this tendency.

Procedurally rational rules define acceptable procedures for making decisions across a variety of contexts (i.e., *how* decisions should be made), while substantive rules essentially determine *what* the outcomes of decision-making should be in a specific context. Because procedural rules may be applicable to a broad range of situations, they are likely to be more abstract than substantive rules that are applicable to specific kinds of situations and thus are likely to be more concrete. For example, an organization may follow a (procedurally rational) rule of calculating economic net present values (NPV) when making investment decisions, but the (substantively rational) rules the organization uses to identify and evaluate the factors to be included in calculating the NPV of an investment project are likely to vary considerably in their details from one investment situation to another.

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[14] Note that we are concerned here only with the diffusion of a rule *as information* in the population of agents. The acceptance and following of a rule by agents depends on criteria discussed in Sections 2.2 and 2.3.

By their nature, procedural rules do not provide "contractual completeness." They lack the substantive rationality necessary to specify *ex ante* – for example, in the form of specific contractual provisions – all possible contingencies associated with agent transactions. Far from aiming at contractual completeness, procedural rules constitute an alternative rule-based approach to ordering agent transactions that avoids the high (and perhaps impossible) degree of substantive rationality required to order agent transactions through complete contracts. If well considered, procedural rules may provide sufficient guidance for ordering agents' transactions that they narrow the range of possible transactional outcomes in an exchange context in ways that are attractive or acceptable to agents, while at the same time allowing the emergence of specific context-dependent transactions that cannot be fully anticipated *ex ante*.

When procedural rules invoke broad (highly abstract) categories that are also unambiguously and clearly stated (well codified), they will generally be easier for agents to understand, remember, follow, and communicate than substantive rules whose requirements for context-dependent specificity typically make much greater demands on agents' substantive rationality. In essence, the information in procedural rules is less likely to contain the finely nuanced and contextually idiosyncratic information that is integral to the articulation, comprehension, and application of a substantive rule.[15] Thus, to the extent that procedural rules embody greater degrees of abstraction and codification that economize on the bounded rationality of agents (Williamson 1985), they will tend to diffuse more rapidly and extensively in a population of agents than substantive rules.[16]

3.4 Learning dynamics in the emergence of rules

Information is not confined to any single location in the I-Space and over time may evolve in various ways within the I-Space. The information embedded in a rule may start out as the tacit, concrete, idiosyncratic understanding of an individual agent, and may by degrees become articulated in more codified and abstract terms that enable such understanding to take on the character of a rule that can diffuse to and be understood by many or all agents in a population. No less important is the possibility for movement in the opposite direction in the I-Space. Rule-embedded information that is abstract, widely diffused, and generally understood within a population of agents may be interpreted and applied by various agents in idiosyncratic ways in their particular situations, leading to cumulative tacit understandings about a rule that are specific to each agent. As agents engage in exchange, their efforts to relate abstract rules to their particular situations may lead some agents to imagine and adopt new variations on general rules that seem to produce better outcomes in a given context. In an effort to improve their ability to communicate their new variations on rules to other agents as a basis for more beneficial exchange, some agents may succeed in elevating the information in their rule variations into formulations that are more codified and more abstract, and thus more likely to be diffused to and understood by more agents. In this

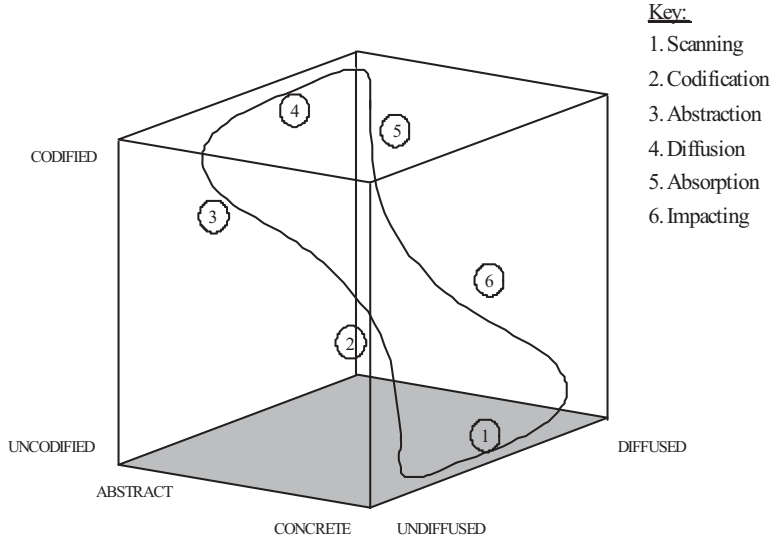
15 This point is implied by the well-known legal maxim that "single cases make bad law."

16 In this sense, abstraction and codification may be thought of as promoting universalistic rather than particularistic transactional norms (Parsons 1951).

manner, the co-evolution of deductive reasoning and inductive generalizing (represented in Figure 1) drives agent learning, the emergence of new rules in a population of agents, and the innovation of new organizational forms embedding newly emergent rules and routines.[17]

As this co-evolutionary process generates new knowledge (i.e., new rule-based information about cause-and-effect relationships that can form the basis for agent roles and actions in exchange – see footnote 11), the transformation of information flows will evolve through what we refer to as the Social Learning Cycle[18] in the I-Space, as shown in figure 3. Both generative and selective forces are at work in the Social Learning Cycle. An agent's personal rule-based knowledge of how to order exchanges beneficially, generated by applying abstract rules to the agent's particular situation (region 1 of the Social Learning Cycle), has the character of a hypothesis that undergoes testing in an agent's exchange contexts. If agents' experiences in applying a rule in their exchange contexts suggest that it is a better basis for ordering exchange, some agents may succeed in articulating the rule with greater degrees of codification to provide more precise statements of how the rule should be applied in different contexts (region 2) and with higher levels of abstraction to broaden the scope of applicability of the rule (region 3). Through this process, a new rule variation may diffuse to other agents (region 4) who may try to apply the new rule in their exchange contexts (region 5).

Figure 3: The Social Learning Cycle (from Boisot 1995)



17 A similar duality of cognitive processes is also evident in the working of science as a process for discovering the rules (i.e., laws) of nature. Theoretical development drives empirical applications of theory, and empirical investigations stimulate theory development.

18 The Social Learning Cycle is described more fully in Boisot (1995).

Efforts to apply a rule in specific contexts – some of which may be new – lead to new explorations of the domain of applicability of the rule (region 6) and the beginning of a new cycle of hypothesis testing and rule articulation by agents in various contexts (region 1). Through this recursive process of trial-and-error learning, new rule-based knowledge about beneficial ways to order exchanges emerges as a new nexus of accepted rules that defines a population of agents' system of exchange.

Increasing the degree of codification and abstraction of a rule increases the likelihood that more agents will try to adopt and apply the rule in a wider range of situations. This process is represented by the downward movements in the Social Learning Cycle in which individual agents increase their tacit understanding of how the rule functions in different contexts and of the benefits to be derived from following the rule in various contexts. A rule that fails agent tests in certain situations, but works well in other situations, may lead to new understanding and may become more narrowly codified and thus more limited in the specific contexts in which agents accept and follow the rule. Thus, the Social Learning Cycle may also lead to a narrowing of a rule's perceived scope of applicability and to limitations on its degree of abstraction. Rules that fail agents' tests or that are judged less beneficial than alternative available rules in a given context of interest to agents will be selected out of the agent population's I-Space.

This cycle of rule-hypothesis generation, selection, and retention describes the evolutionary process of individual and collective learning through which rules emerge (or disappear) in a population of agents. When a collection of emergent rules within a population of agents reaches a "critical mass" of adequacy and coherence[19] (Thagard 1999; Lissack and Roos 1999) that provides an attractive and accepted basis for ordering interactions among agents, this emergent nexus of rules forms the basis for a new system of exchange – and for the innovated forms and instances of organization that embed the new rules. When a nexus of rules evolves into an accepted basis for broadly ordering agent interactions within a population of agents, the rate of evolution of rule-based information in the population may slow or even stop for a while, and the forms and instances of organization derived from the nexus of rules may enter a period of relative stability.[20]

3.5 Co-evolutionary interactions of rules and routines

We now briefly examine more closely the role of routines in driving the evolution of rules in the Social Learning Cycle.

In the evolutionary process of agent learning, rules act as *memes* – pieces of knowledge that are subject to social replication and selection processes (Dawkins

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19 Coherence within a nexus of rules is achieved when its rules are complementary, mutually reinforcing (rather than contradictory), and integrated sufficiently to enable the evolution of consistent routines for ordering recurrent transactions.

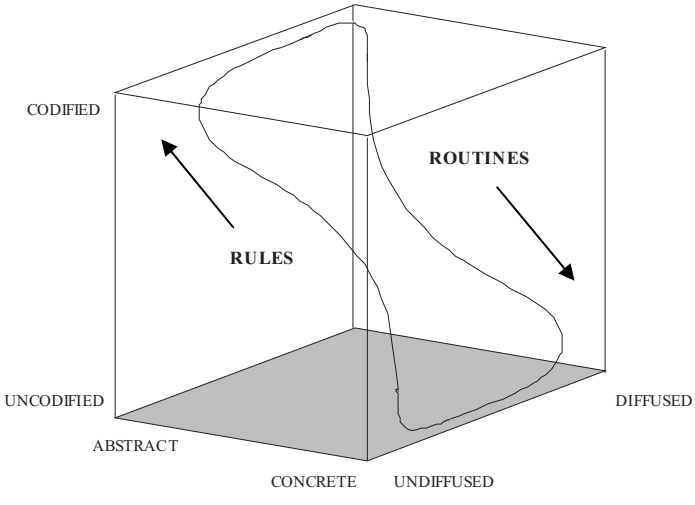
20 If the testing and evolution of a set of rules stops altogether in an agent population, a collective cognitive stasis ensues – the cognitive evolutionary equivalent of "falling into a success trap" – that can be a significant source of organizational inertia (Hannan and Freeman, 1989).

1982, 1986) – and evolve through processes akin to Lamarkian adaptation rather than Darwinian random mutation.[21] The generation of new rules through agents' adaptive learning processes is driven by co-evolutionary interactions between new routines deduced from existing rules and new or improved rules inferred from successful new routines.

New routines emerge as agents try to apply existing rules to solve practical problems of transacting in various situations. Typically, many different routines can be logically derived from a rule. As agents generate and test various routines, the routines that are perceived by agents as the most satisfactory ways of applying accepted rules in various transactional contexts will be adopted and integrated into the nexus of rules that forms the basis of their system of exchange. Less satisfactory routines are selected out.[22] In this way, successful routines consistent with a given set of diffused rules become recurring features of agent transactions within a given system of exchange.

Among the rules and routines that compose a given nexus of rules at any point in time, rules that have emerged as abstract and well-codified rules are analogous to genotypes: They are easily transmissible rules for action that are broadly applicable to various categories of things, processes, or events. Like true genotypes, such rules will tend to maintain their identity in the diffusion process and to persist in a nexus of rules followed by an agent population. Routines, by contrast, are more like phenotypes:

Figure 4: Rules and routines in the I-Space



21 Like Darwin, Lamark held that characteristics acquired by a phenotype that improve survivability could be passed on to offspring.

22 The generation of routines, like the generation of rules, is not done with perfect foresight. Not only may some routines prove to be less satisfactory ways of applying rules, but some routines initially thought to be consistent with a set of rules may eventually be discovered to lead to outcomes that are not consistent with one or more rules in a nexus of rules – for example, by resulting in unanticipated unacceptable externalities.

They communicate specific ways of acting that are consistent with some rule or set of rules and that are well adapted to the circumstances of a specific context. Like true phenotypes, routines are more likely to evolve new variations as circumstances change. Because of the significant differences in the information characteristics of rules and routines, they will be evolutionarily active in different regions of the Social Learning Cycle and will evolve in different directions within the overall I-Space, as illustrated in figure 4. In this regard, rules and routines are essential complements in the co-evolutionary cognitive processes that comprise the Social Learning Cycle.

3.6 Emergent organization and institutions

As better rules and routines emerge in an agent population and offer opportunities to improve agent fitness compared to currently prevailing rules and routines, emergent rules and routines combine with any pre-existing rules that are retained to form a new nexus of rules from which new forms of organization and attendant institutional processes and structures will emerge.

The agent experimentation and learning that drives the co-evolution of rules and routines also drives the emergence and evolution of institutions that support systems of exchange. The initial emergence of a nexus of rules in a new exchange context makes possible the evolution of exchange from agent transactions realized through single-play games under conditions of high transactional uncertainty to widely mimicked kinds of transactions carried out in repeated games. The wide and repeated use of certain kinds of exchange transactions enabled by a nexus of rules invites a process of *structuration* (Giddens 1984) around the nexus of rules – the creation and institutionalization of processes and structures to support such kinds of transactions. Institutionalized processes and structures bring an important additional measure of predictability to recurrent agent transactions by imposing constraints on the interpretations and actions of individual agents engaging in those transactions, and may also lower transacting costs by facilitating transactions conducted within such constraints (North 1981, 1990). To the extent that they reduce the uncertainty and costs of agent transacting, institutional processes and structures may create positive-return effects (Arthur 1994) that increase the attractive power of a nexus of rules in competing for agents against other nexus of rules and their attendant institutions.

The promise of greater predictability and lower costs in recurrent transactions creates incentives for individual agents to internalize institutionalized transactional norms, and this "self-institutionalization" of transactional norms further stabilizes agent expectations and behaviors. The progression from single to repeated transactions in agent interactions – and hence to acting consistently in accordance with some institutionalized set of norms – is essential to achieving Nash equilibria within a nexus of rules. In effect, the evolution of rules (Axelrod 1984) through processes of diffusion, testing, and internalization within a population of agents is the essential cognitive process that enables a population of agents to progress beyond risky transactions conducted as single-play, zero-sum games and to evolve institutions in which predictable transactions can be carried out within repeated-play, positive-sum games.

To survive in the long run, a nexus of rules must be stable enough and sufficiently enforceable through its institutional structures and processes to be effective in

constraining agent behaviors (Williamson 1975), yet they must also be capable of evolving and adapting to changing circumstances (North 2005). To evolve successfully through the Social Learning Cycle, nexus of rules and their attendant institutions must navigate "on the edge of chaos" between excessive rigidity ending in fossilization and excessive fluidity leading to disintegration. Systems of exchange with institutions that tolerate or even promote organizational "learning cycles" (Sanchez 2001, 2005) can better adapt themselves to changing circumstances by encouraging learning at the level of routines that can lead to changes in rules and attendant institutions. Systems of exchange with institutions that frustrate or prevent experimentation with new routines will largely remove the basis for evolution of better rules and institutions. In this regard, institutional processes and structures can be seen as dissipative structures[23] that absorb cognitive energy in an agent population in ways that either promote or constrain the evolution of its underlying nexus of rules – and thereby either improve or diminish the fitness and survivability of a system of exchange in its environment.

4. Nexus of rules *versus* nexus of contracts perspectives on organization

We now undertake to clarify three important ways in which the nexus of rules perspective for understanding the emergence of innovative organizational forms differs from the traditional nexus of contracts perspective on the economic organization of firms. In fundamental respects, the nexus of rules perspective is intended to be more realistic and thus more theoretically complete and satisfactory in representing both the *origin* and the *nature* of organizations – not just in the economic domain, but equally in social, political, and other organizational domains. This more theoretically complete and satisfactory view of organization is perhaps best exemplified by differences in the two perspectives' representations of human cognitive processes and of organizational "boundaries" and by the scope of applicability of the two perspectives.

4.1 Human cognitive processes

In neoclassical economics, a firm is represented as a well-oiled machine (a production function) ready to do the entrepreneur's bidding (by fiat) in transforming productive factors sourced at market-determined prices into outputs and quantities determined by the entrepreneur. Current theories of the firm generally extend the neo-classical view of firms by introducing efficiency (cost minimization) benefits of firm organization and by characterizing economic organizers as entrepreneurs who undertake to write complete contingent claims contracts for the essential inputs to a productive process (Arrow/Debreu 1954). Thus, the essential view of organization in theories of the firm is that a firm consists of a *nexus of contracts* arranged by the organizing entrepreneur

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23 We also characterize a nexus of rules as a dissipative structure that requires external inputs of energy from agents to maintain itself over time (Prigogine/Nicolis/Babbyantz 1972; Prigogine 1980; Prigogine/Strengers 1984; Nicolis/Prigogine 1989). From an evolutionary perspective, if a nexus of rules is to continue to attract agents, it must offer credible prospects for improving the fitness of agents in sustainable ways, so that the energy (efforts and costs) that agents must expend to create, maintain, and evolve a nexus of rules promises to be more than compensated for by the increased capacity for economic and/or social benefit realization that those rules make possible for all involved agents.

(Aoki 1984; Hart 1995). Contracts and the relative economic benefits and risks of alternative contractual arrangements are therefore taken as the focus of analysis and theorizing about economic organizing (Williamson 1975; Cheung 1983).

Widely recognized limitations in human cognitive abilities (e.g., incomplete information and bounded rationality), however, limit the ability of entrepreneurs to actually write complete contingent claims contracts (Simon 1954). Human cognitive limitations in creating complete contracts in turn limit the ability of nexus of contracts theories to explain *how* a firm comes into existence as a form of organization.

By contrast, the nexus of rules perspective developed here is much less demanding of agent rationality. In addressing the formation of firms, organization (of firms, markets, networks, etc.) is broadly characterized as an information-based phenomenon that emerges from agents' cognitive processes as they seek to identify more beneficial ways of ordering exchange (rules) through recurrent patterns of transactions (routines) and in which agents act locally to hypothesize, test, and adopt or modify routines and rules. When agents engaging in such trial-and-error learning discover, articulate, and communicate rules and routines that appear to offer Pareto-preferable ways of ordering exchange (some of which may include various kinds of contracts), a nexus of rules may then be imitated more widely or even globally within a population of agents. In this cognitive evolutionary process that leads to the emergence of various forms and instances of organization, no agents need possess greater intellect or knowledge than is available in ordinary populations of humans.

Thus, within the nexus of rules perspective, Hayek's (1945) process of *discovery* applies just as forcefully to what goes on organizationally inside firms or other transacting and decision-making entities as it does to market processes. Analogically, if markets (in the neo-classical view) are mechanisms for discovering prices that can be used to coordinate transactions to achieve Pareto-optimal outcomes, then firms and other forms of organization can be understood as mechanisms for discovering rules that can be used to order exchange in ways that achieve Pareto-preferable outcomes when an inability to write complete contracts limits the use of price to coordinate agent transactions. In representing all forms of organization in which agents voluntarily participate as an achievement that is fundamentally brought about by evolutionary trial-and-error learning processes, we endogenize a knowledge-creation process that leads to the formation of firms, markets, and other forms of organization through processes of rule discovery that are largely self-organizing (Weick 1979).

In this perspective, rules for ordering agent interactions are not secondary appendages to some "core" nexus of contracts that is the economic *raison d'être* for the firm. Rather, from the perspective of agents who are attracted to the exchange benefits that can be obtained within a particular nexus of rules, rules for ordering exchange are in a very real sense the *raison d'être* that leads to the organization of a given firm (or any other form of organization).[24] Within our perspective, a particular nexus of contracts is only one – albeit usually a visible – expression of a firm's fundamental nexus

[24] In saying this, we are effectively applying at the firm level an argument first put forward by Douglass North to explain economic development at the regional or national level (North 1981).

of rules at work. Because a nexus of rules acts like a set of prescriptive memes for replicating behaviors in a population of agents (Dawkins 1982, 1986), agents' beliefs about their obligations within a given nexus of rules may lead to coordinated agent behaviors – i.e., routines – that are not fully articulated in contracts and that may evolve outside formal contracting processes as environmental circumstances change. To the extent that rules as memes condition agents' behaviors, a nexus of rules can generate and guide agent behaviors in myriad ways that are useful in sustaining beneficial agent interactions in evolving circumstances, but that would normally exceed human cognitive capacities to fully specify *ex ante* in contracts.

4.2 The "boundary" of an organization

The view of organization as a system of exchange based on an evolving nexus of attractive rules and routines raises interesting questions as to where, exactly, the "boundaries" of a firm (or market, network, or other form of organization) based on such rules would actually reside. Indeed, as we now explain, the nexus of rules perspective leads to a fundamental question about the appropriateness of a concept of "boundary" for any form or instance of organization (Sanchez, forthcoming).

A contract creates mutual commitments by contracting agents to specific rights and responsibilities. Thus, a firm conceived as a nexus of contracts is essentially a governance structure for the protection and enforcement of agent rights and responsibilities arising from contracts. Because the number of agents that are party to a firm's contracts will always be finite in number, and because the rights and responsibilities specified in contracts will always be delimited, viewing firms as a nexus of contracts enables identification of a firm's boundary by determining the agents that are parties to the firm's contracts and by specifying the rights and responsibilities they have agreed to.

An organization viewed as a nexus of rules, however, does not imply the existence of a clear boundary. Rather, a nexus of rules as basis for ordering actual and potential exchanges acts more like a *force field* of a Pareto-preferable Nash equilibrium that attracts agents in various ways, to varying degrees, and at various times by promising attractive exchange opportunities. While a nexus of contracts view focuses on specific transactional rights and responsibilities created by enforceable contracts, a nexus of rules view encompasses not only specific contracts, but also a firm's potential for engaging in future exchanges, whether through contracting or less formal relationships. In effect, a nexus of rules perspective can see beyond the limits of a firm's current contracts to the *real options* for future exchanges that the attractiveness of a firm's nexus of rules makes possible (Sanchez 1993, 1995, 2003). The significant potential value of a firm's real options for future exchange is reflected in the view that a firm's resource base consists not just of the firm-specific resources it has internalized or otherwise controls through contracts, but also the *firm-addressable resources* with which it can engage in exchanges when circumstances make it advantageous to do so (Sanchez/Heene/Thomas 1996; Sanchez/Heene 2004).[25] Thus, the nexus of rules per-

[25] We find echoes of this difference in Marx's distinction between the "sphere of exchange" and the "sphere of production". The property rights approach to the theory of the firm

spective – which views firms as evolving force fields whose attractiveness to and resulting interactions with agents extend along gradients that reach in myriad ways into the population of agents and that may fluctuate in their attractiveness to various agents as circumstances and the nexus of rules that distinguishes a firm co-evolve – suggests new possibilities for re-conceptualizing the nature and the limits of organization (Arrow 1974).

From an evolutionary perspective, the real options created by a nexus of rules are likely to result from significant combinative and self-organizing capabilities that distinguish a nexus of rules from the purely additive properties that typically characterize a nexus of contracts. A fruitful metaphor for thinking about both contracts and rules is that they are functionally equivalent to genes – i.e., they are replicable and transmissible instructions (Nelson/Winter 1982) for ordering exchange. In evolutionary genetics, a conception of genes as independent, self-contained hereditary components within ensembles of genes (chromosomes) – the so-called "gene frequency model" (Fisher 1930) – is the analogue of the nexus of contracts perspective, in which the individual terms in a contract are expected to lead to predictable, specifiable outcomes. In genetics today, this conception is being replaced by a view of genes as highly interrelated and capable of configuring and combining with each other to produce many possible inherited characteristics (Sewall-Wright 1986; Dobzhansky 1962; Depew / Weber 1995; McGrath/Boisot, 2005). Like gene complexes in this more contemporary view, a nexus of rules may behave like a "genome" whose primary components (rules) enjoy substantial combinatorial possibilities for the generation of novel new routines and transactional possibilities. In this sense, a firm seen as a nexus of rules suggests a greater capacity for *strategic flexibility* (Sanchez 1997) in generating new kinds of routines and exchange opportunities to meet changing environmental demands for requisite variety (Ashby 1956) than a firm in which a hyper-rational entrepreneur must continuously generate specific new contracts to accomplish each new adjustment to environmental change.

4.3 Scope of applicability

While the nexus of contracts perspective is focused on explaining the nature of a *firm* as an instance of economic organization,[26] the nexus of rules perspective is intended to address the origins and nature of *all* forms of (voluntary) organization.

Various forms of organization and attendant institutions – including markets and networks – may emerge from the cognitive processes for evolving rules for ordering exchange in a population of agents. A *market* form of organization emerges when a set

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often focuses on the distribution of rights within the sphere of production being organized by the entrepreneur – at the expense of exploring the attractive forces that draw agents in various ways to a firm's sphere of exchange (Marx 1970).

26 We recognize that the nexus of contracts perspective may be invoked to represent non-firm organizations, such as families and other forms of social organization. Such invocations are only possible, however, by redefining "contracts" to include many kinds of informal commitments to honor norms of behavior in those exchange situations. We suggest that such non-contractual commitments are more correctly represented by the concepts of rules and routines included in the nexus of rules perspective.

of abstract and well-codified rules for making spot, arms-length transactions has been widely diffused and adopted in a population of agents. Depending on the ability and interest of agents to infer, conceptualize, and articulate better rules (i.e., rules that contribute more to agent fitness), the nexus of rules that defines a market may range from a minimal "Buyer beware" rule (the "Law of the Bazaar") to elaborate sets of rules based on well defined concepts and criteria for contract formation, full disclosure, implied warranties, adequate performance, liquidated damages, and other underpinnings of market transactions in advanced market economies (as, for example, in the Uniform Commercial Code in the United States). Agents participating in markets may also evolve institutional structures and processes that are answerable to and serve all agents (such as courts and arbitration boards) for facilitating and enforcing agent behaviors in accordance with a market's rules. The particular nature of the rules in a market's nexus of rules and its attendant institutional processes and structures distinguish one instance of market organization from another.

In an analogous way, a *network* – Williamson's (1975) hybrid or quasi-integrated form of organization – may be characterized as a nexus of rules that allows fluid participation in exchange by agents (firms and/or individuals) willing to conform to the network's nexus of rules. Individual agents that expect to engage in repeated transactions with other network participants may then undertake to devise appropriate processes and structures (e.g., voluntary standards setting) to provide institutional support to agents wishing to engage in sustained transactions with each other within the general framework of the network's nexus of rules.

A *firm* as a form of organization emerges when some agents in a given population can be induced to engage in transactions coordinated by an authority hierarchy that is committed to ordering its internalized exchanges in accordance with its nexus of rules. The institutional processes and structures of a firm are then fundamentally distinguished from markets or networks by the use of the employment contract.[27] Typically, employment contracts, which may be explicit or implicit, commit an employed agent generally to follow the directives of the authority hierarchy and to observe the rules of the firm, and commits the firm's managers to issue directives that are compatible with the nexus of rules that defines the firm. Thus, an employment contract is an institutional device that actually seeks to convert the basis of internal agent transactions from strict adherence to contract to a commitment to follow the directives of an authority hierarchy promulgated within the norms embodied in a nexus of rules. The resulting employment relationship thus spares transacting agents the burdensome (and likely impossible) task of specifying complete contracts for ordering their transactions, while providing a basis for engaging in coordinated economic activities within the scope of a given nexus of rules. The specific nature of the rules in a firm's nexus of rules – and its associated processes and structures for facilitation and enforcement of

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[27] Although hierarchically coordinated, a firm may choose to promote "internal market" processes within its boundaries, although such processes will typically be institutionalized in ways that differ significantly from the institutions that support external market processes – for example, in the means of policing internal *versus* external market transactions (Boisot 1986).

its rules, especially with respect to its employment contracts – then distinguish one type of firm from another as instances of organization.

Each form of organization, with its distinctive nexus of rules and institutional contractual apparatus, represents a different kind of possible Nash equilibrium for value creation by and distribution to agents. A firm's nexus of rules and supporting institutionalized management processes and structures are essential elements in an organization's *strategic logic* for competing and cooperating in its environment (Sanchez/Heene/Thomas 1996; Sanchez/Heene 1997). When the fundamental aspects of a successful nexus of rules and attendant institutional processes and structures become widely adopted by firms within an industry, they become an integral part of the *dominant logic* for competing in that industry (Boisot 1995; Prahalad/Bettis 1986; Boisot/Child 1988, 1996).[28] Thus, because virtually all forms of organization are "open systems" that depend on flows of resources obtained through interactions with other organizations (Sanchez/Heene 1996), the strategic logics of individual organizations and any dominant logics followed by organizations in an industry or other exchange context typically include some common rules that make possible *inter-organizational Nash equilibria* in transacting for essential inputs and outputs, whether realized through contractual or less formal means.

5. Conclusion

The nexus of rules perspective that we develop here differs from current theories of organization in several respects. Most fundamentally, the nexus of rules perspective differs from most economic and social explanations of organization by explicitly seeking to explain *how* new forms of organization are innovated, not just *why* various forms might exist.[29] We now conclude by summarizing some further points of difference in both focus and scope.

The nexus of rules approach differs from neoclassical economic theories of the firm that treat an organization as a unitary rational actor by recognizing emergent patterns of interactions between the human agents that populate firms or other forms of organization, as well as by allowing for emergent patterns in interactions between firms as organizational entities (Mirowski 2002). Behavioral theories of the firm (Cyert and March 1963), on the other hand, do recognize human interactions in organizations, but unlike the nexus of rules approach presented here, behavioral theories do not suggest why or how the interactions of individual agents lead to the innovation of

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28 Rules that are replicated by a sufficiently large number of organizations may then create a logic for the broad public ordering of agent transactions, creating dominant logics that span across industries and give rise to laws, regulations, and other elements of political-legal systems. Such evolutions towards *mimetic isomorphism* have been observed in many kinds of ecosystems, including economic systems (Meyer/Scott 1994; DiMaggio/Powell 1983; Powell/DiMaggio 1991).

29 Of course, the incentives (presented by improved prospects for transacting) that would explain *why* a particular form of organization exists are also part of a nexus-of-rules explanation of *how* forms of organization emerge. But as our discussion of evolutionary processes has hopefully made clear, incentives for organizing are just part of the explanation of the emergence of organization.

new forms and instances of organization, nor do they address the fundamental role of agent learning processes in shaping those interactions.

Coasian theories of economic organization offer an explanation why firms come into existence – i.e., when incomplete contracting, bounded rationality, and concern for opportunistic behavior in markets make it more efficient to "internalize" certain transactions (Coase 1937), in effect substituting an authority hierarchy for market prices as the mechanism of coordination (Williamson 1975, 1985). However, neither the Coasian tradition nor the derived nexus-of-contracts view of the firm (Cheung 1983) addresses the cognitive processes of human interaction within which concerns about incomplete contracting both arise and may be resolved.

By contrast, the nexus of rules approach invokes an evolutionary interplay of rules and routines as the basis for the emergence of any instance of organization and any attendant modes of contracting. Moreover, because both rules and routines are subject to evolutionary selection, our unit of analysis is not contracts themselves, but rather the evolutionary processes that agents engage in that give rise to various kinds of transactions, including contracts. In essence, in the nexus of rules view, the human cognitive processes of rule-making and routinization are seen as providing the conceptual and practical foundations for transacting in many forms. Within this perspective, markets, firms, hybrids, and other forms of organization can all be understood as contextually dependent outcomes of fundamentally similar evolutionary information processes.

As a perspective that incorporates evolutionary and game-theoretic concepts, the nexus of rules approach differs from evolutionary theories of the firm that focus on analysis of evolving routines (Nelson/Winter 1982). Instead, the nexus of rules perspective characterizes recurrent transactions as the locus of agent learning (through hypothesis testing and refinement) that leads to an evolving set of rules and routines for ordering exchange transactions, from which new institutionalized approaches to contracting and new contracts may result.[30] The nexus of rules approach developed here also differs in its scope from the purely economic game-theoretic representations of agent behaviors commonly developed in industrial economics (Tirole 1988) by drawing on and integrating concepts about information processing, agent learning, and internalized normative constraints on agent behaviors (Maynard-Smith 1970; Axelrod 1984, Binmore 1994; Harsanyi/Reinhard 1988).

Just as neoclassical economic theories of organization were influenced by physics as the dominant science of their day, so perhaps it would be useful for organizational theories today to be open to influences from the newly ascendant sciences of information (Mirowski 2002; Zurek 1991) and complexity (Cowan/Pines/Melzer 1994). These fertile and active fields of theory development are providing organization theorists with new concepts that both call for and support a rethinking of our current inventory of ideas about the phenomenon of organization. In particular, we need much better representations of the ways in which evolving human understanding and related in-

30 We address here rules that guide agent behaviors in all kinds of exchange interactions, including rules that have no direct economic or explicit contractual implications, such as rules affecting inter-agent social relations.

formation flows can create emergent opportunities for innovating new forms and instances of organization within a population of agents. We suggest that the nexus of rules perspective developed here offers some basic directions and first steps for researching how human cognitive processes, information flows, and the exchange experiences of agents interact – not just in organizing production, but also in producing organizations.

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