Evolved Versus Designed Standards

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1. Introduction

The Financial Accounting Standards Board (FASB) establishes specific accounting standards based on its Conceptual Framework (codified in Statements of Financial Accounting Concepts).[1] FASB's Conceptual Framework was intended to reduce Board members' exposure to the criticism that their standards were *ad hoc* (Storey and Storey 1998, 83).[2] FASB uses extensive due process procedures (FASB 2009), and it has a monopoly on the production of accounting standards used in SEC filings (SEC Accounting Series Release No. 150, 1973). As the International Accounting Standard Board (IASB) harmonizes its standards with the FASB's, the FASB's approach to standard setting is being extended to other countries. Both FASB and IASB are institutions organized and managed from an explicit design perspective, which presuppose a well-specified objective function as well as complete knowledge of how these objectives can be best achieved (cf. Smith, 2003, 2008).

Earlier standard setters operated more on a case-by-case basis where broader principles were seen as conventions and customs (May 1946, 2). Conventions evolve spontaneously and require little or no centralized planning, and several scholars suggest that broader principles can be induced from evolved conventions (Paton and Littleton 1940; Littleton 1953; Hayek 1967; Sunder 2005). The spontaneous evolution of accounting norms in the early 20th century fits the convention-dependent nature of accounting described by May (1946). Early U.S. standard setters such as the Committee on Accounting Procedure (CAP) sought to codify "best practices" that had evolved from practice, but had no authority to compel their use (Storey 1964; Zeff 1984, 453-458). These institutions relied to a greater degree on an evolutionary perspective in determining standards than their successors.

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[1] Merriam-Webster's defines a standard as "something established by authority, custom, or general consent as a model or example." This definition generally comports with an accounting standard, which is a model or "best practice" that can guide firms when choosing between two or more accounting treatments for a given transaction.

[2] As noted by Storey and Storey (1998, 67), each Statement of Financial Accounting Concepts declares in its preface that FASB intends to use these concept statements to provide a "common foundation and basic reasoning on which to consider merits of alternatives."

A major question about these differing institutional arrangements is whether setting accounting standards by way of evolution or design is more economically efficient. *A priori* arguments based on institutional survival are not persuasive since standard setters are regulatory institutions whose survival is governed by selection pressures emanating from political processes (Watts 1977). It is also extraordinarily difficult to extract evidence on the efficiency of alternative standard setting bodies from the historical record. Regulatory outcomes are themselves endogenous to powerful forces that result from a path-dependent historical process that confounds identification of causality and consequences (Ball 1980; 1989). The consequence is that while standard setters argue for global convergence of accounting standards (Barth 2008), we still have no evidence that designed standards set by a single authority solve accounting problems more efficiently than evolved standards inferred from practice.

We provide evidence on the efficiency of alternative standard-setting institutions using an agent-based model.[3] We specify a standard-setting institution as a knowledge sharing arrangement in which a standard is based on solutions recommended by agents, some of whom have comparative advantage in solving the specific problem. While agent-based models have been used sparingly in the accounting literature (Davis *et al*. 2003; Dickhaut and Xin 2009), their use in other disciplines such as evolutionary biology is widespread (e.g., Bowles, *et al*. 2003). We use this technique because it allows us to (1) collect data that are not available in the naturally occurring world, (2) compare observed institutions with different institutions that could have emerged under a different historical path, and (3) control the environment while manipulating variables of interest.[4]

The tradeoffs faced by standard setters suggest that the efficiency of a given standard setting institution is not a foregone conclusion. To the extent that a decision is simple and the

[3] Similar to Jamal *et al*. (2003, 2005), we use a reasoning-by-analogy approach to evaluate alternative standard setting institutions.

[4] Agent-based models circumvent the problem that naturally occurring data can be used to address only what is rather than what isn't (Bastiat 1848; Hayek 1988; Smith 2003).

institution possesses a strong comparative advantage, then centralized standard setting will likely prove effective because it reduces costly duplication of effort among agents. However, if the choice setting is more complex, then multiple acceptable solutions may exist and centralization may eliminate powerful discovery incentives present under competitive conditions (Dye and Sunder 2001). This problem may be exacerbated when the underlying transaction is changed to circumvent the accounting standard that is established.

Our agent-based model involves a problem (represented by a maze) that agents try to solve (get through the maze) and a standard that describes a quicker path through the maze (a series of moves). We focus our initial analysis on two different standard setting mechanisms to guide agents in navigating the maze. The first allows local norms to emerge when agents share knowledge (derived from personal experience) with their proximate neighbors. This institution is intended to model the early 20th century U.S. situation in which norms and conventions emerged primarily through professional knowledge-sharing arrangements (Moonitz 1970; Sunder 2005). A second institution is intended to correspond to the centralized approach used by the FASB. In this setting, a single agent with superior comparative advantage in navigating the maze is empowered to set the single standard to be used by all other agents.[5] We refer to these as the *evolved* and *designed* institutions, respectively.[6]

Because of the preliminary nature of our analysis, firm conclusions are not possible at this stage. However, the results we offer here are intriguing in several ways. First, to the extent that designed institutions produce more effective standards, such effects are more likely present in

[5] We subsequently consider a hybrid institution that embodies features of both evolved and designed standard-setting institutions. This hybrid arrangement, which we refer to as the *competitive* institution, allows multiple agents to propose differing standards. These few competitive standard setters are more knowledgeable than the remaining agents in this setting, but they have less expertise individually than the single standard setter in the top-down approach just described.

[6] Our model does not address all possible benefits and costs of accounting standardization. For example, the model is silent on differences in coordination benefits that result from different institutions for setting standards. We also do not consider settings where the standard is directly applied to agents faced with different choice problems; however, the model does include heterogeneous preferences for how the agents prefer to solve the problem. Further, our models do not speak to issues that arise if a standard setter believes it has a higher level of comparative advantage than it in fact possesses. We discuss these issues in more detail in section 3 when we describe the specifics of the model.

simple environments. In addition, the extent to which standards are robust appears to be a function of the nature of mutations present in the environment. Strategic mutations that attack key features of the standard are more likely to result in "drift" away from more efficient solutions for a designed standard than for an evolved one. Nonetheless, these conclusions are at best preliminary at this stage, and await refinement through additional analysis.

The rest of the paper is organized as follows. Section 2 links the history of U.S. accounting standardization to the three types of standard setters considered in the agent-based model. Section 3 describes the details of the agent-based model. Evidence on the efficiency of alternative standard setting arrangements is provided in section 4. Concluding remarks are offered in section 5.

2. The History of Alternative U.S. Standard Setting Institutions

For present purposes, we define a "standard" as a description of "best practices" that excludes some potential practices. A standard can specify a single preferred alternative, or it may allow multiple alternatives. The measurement of liabilities for defined-benefit pension plan obligations is an example of a single preferred method. Depreciation is an example of the latter where firms can use either a straight-line method or one of several accelerated methods.

Different types of institutions have set accounting standards in U.S. history. In this section, we identify major differences between these institutions in order to specify our agent-based model.[7] We first describe early standardization through norms and customs in the period before the Securities Acts in the 1930s. We then discuss the main differences among the three organizations that have been granted broad standard-setting authority: Committee on Accounting Procedure (CAP; 1939-1959), Accounting Principles Board (APB, 1959-1973), and Financial

[7] Our objective is not to comprehensively review historical U.S. standard-setting as such reviews are already available (Previts and Merino 1998; Zeff 1972, 1984)

Accounting Standards Board (FASB, 1973-present). We conclude this section by discussing broad features of standard setting institutions that we incorporate in the agent-based model.

2.1. Emergent Norms and Customs in the Pre-SEC Period

A standard can develop spontaneously as a norm or custom even when there is no authoritative body to define the standard (Hayek 1973).[8] One definition of a norm is a "behavioral regularit(y) that generate(s) social expectations without any moral obligations" (Hechter and Opp 2001).[9] Social norms and customs help regulate conflicts in larger groups when there is no central authority to rigorously define the norm (Axelrod 1986). It is likely that accounting norms served this function in the pre-SEC era (May 1946; Sunder 2005).

Knowledge-sharing arrangements developed by the accounting profession likely were a critical proximate mechanism in enabling accounting norms. Professions are often characterized by a specialized body of knowledge and reduced competition through barriers to entry motivated by a "public service" mission (Abbott 1988; Friedson, 2001). Professions exist to cultivate and sustain a body of valuable expert knowledge (Friedson 2001). Barriers to entry shift competitive focus from a rivalry over customers to a contest for individual professional prestige, which increases an agent's willingness to share valuable knowledge (Friedson 2001).[10]

Early U.S. accountants shared knowledge of railroad costing methods in the mid-19th century, and since railroads published annual reports, these methods spread to industrial companies (Chandler 1977, 115-120).[11] A larger influence was the emergence of a U.S.

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[8] Hayek (1967) distinguishes between three sources or causes of phenomena: natural being wholly independent of human action, human design, and human action not of human design. It is to this third class that we refer.

[9] This is in contrast to social norms that dictate behavior on the basis of morality or that appeal to a sense of oughtness (e.g., do not steal or kill).

[10] Analytical work demonstrates that knowledge sharing can also occur in a competitive environment when strong information complementarities are present (Stein 2007).

[11] While there were no authoritative U.S. standard-setting mechanisms of national scope before the 1930s, accounting in some industries was regulated in connection with price regulation. These industries included banks, railroads, and electric and gas utilities. Miranti (1989), Jarrell (1979), Previts and Merino (1998), and Sivakumar and Waymire (2003) describe direct regulation of U.S. accounting before 1930.

accounting profession in the last two decades of the 19th century (Miranti 1986; Previts and Merino 1998, 131-150). Many early U.S. accountants emigrated from Great Britain where professional societies and professional competence requirements already existed (Edwards, 1960). Similar institutions were created in the U.S. in the form of state professional societies (starting with New York in 1882) and state licensing requirements to practice accountancy (New York passed the first Certified Public Accountant law in 1896). The profession was organized nationally in 1887 when the American Association of Public Accountants (AAPA,) was formed.[12] The AAPA adopted a code of ethics in 1908, and client solicitation restrictions were added to this code during World War I.[13]

Education and professional publications were the primary forms of knowledge sharing in the nascent U.S. accounting profession (Previts and Merino 1998). The former involved CPA examinations, university programs in accounting, and textbooks written for educational purposes. The latter included professional publications such as the *Accountant's Handbook*, trade publications like the *Journal of Accountancy* (and its various departments), and books and brochures published by the AAPA and the American Institute of Accountants (AIA), as the AAPA was renamed in 1917.[14]

The first edition of the *Accountant's Handbook* was published in 1923. Its preface describes it as "a compendium of fact-material for use in dealing with the thousands of questions that come up in [the accountant's] everyday work" (Saliers 1923, p. v). It compiled the material used by practicing accountants into a single reference manual.[15] The second and third editions of

[12] http://www.aicpa.org/About+the+AICPA/Understanding+the+Organization/History+of+the+AICPA.htm
[13] http://www.answers.com/topic/american-institute-of-certified-public-accountants
[14] For example, *The Journal of Accountancy* commenced publication in November 1905 with the goal of enabling accountancy to take the "stand on the plane of medicine and law" as an established profession ("Purpose and Scope of this Journal," *The Journal of Accountancy*, November 1905, 57-59).
[15] Previous reference works such as the 24-volume *Modern Business* series (Alexander Hamilton Institute, 1918-19), edited by J. F. Johnson, Dean of the New York University School of Commerce, Accounts and Finance included volumes dedicated to accounting (e.g. Vol. 9 *Accounting Principles*, Vol. 10 *Cost Finding*, Vol, 21 *Accounting Practice and Auditing*, Vol. 22 *Financial and Business Statements*), other topics with some relevant accounting content (e.g. Vol. 23 *Investment*), and many non-accounting topics (e.g. Vol. 7 *Salesmanship and Sales Management*).

the *Accountant's Handbook* were published in 1932 and 1943 (both edited by W. A. Paton) and it presently is in its 11th edition. Madsen (2009) analyzes the authoritative citations provided in the *Accountant's Handbook* (which presumably legitimize contemporary practices) and documents that the earliest editions rely heavily on norms and customs as justifications for various accounting practices.

The AIA began publishing "Special Bulletins" in January 1920 and 33 such bulletins were published between 1920 and 1929 (Moonitz 1970). The Special Bulletins chronicle correspondence between practitioners and the Institute's Library and Bureau of Information providing information about various accounting methods used in practice. The bulletins (1) encouraged practitioners to ask questions about accounting practice, (2) publicized the knowledge resources available to AIA members, and (3) gave practitioners a forum to debate the answers supplied in prior bulletins (Moonitz 1963).[16] These bulletins, and the Bureau of Information more generally, provided a non-authoritative, knowledge-sharing mechanism to identify and debate widely used accounting practices.[17]

The "Student's Department" of *The Journal of Accountancy* was established in January 1914 to supplement accounting education and also to induce "practical accountants to express themselves in print with regard to the many important subjects with which they are constantly required to deal" (Walton 1914, 70). Similar to the AIA Special Bulletins, the Students Department allowed practitioners to inquire about accepted accounting treatments for various transactions. The editor consulted experts, textbooks, and general knowledge of accounting customs to answer specific questions. Once published in *The Journal of Accountancy*,

[16] As cited by Moonitz (1970, 149), the AIA Librarian described these bulletins as follows: "The opinions expressed are those of one, two, or three accountants of good standing who have set forth their views in response to request from the Bureau of Information. The opinions are transmitted under the distinct understanding that they are purely advisory and in no sense intended to be dictatorial."

[17] Ball (1989) interprets the Special Bulletins as a franchising attempt by the AIA. Modern analogues to the Special Bulletins include managed wikis and discussion forums where an administrator defines the main topics, but users can post questions to clarify an answer or share views that challenge the original conclusion.

practitioners could submit additional questions or critiques of the editor's response. The editor of The Student's Department expressed the view "'In a multitude of counselors there is wisdom,' and it is only by the clash of minds that valuable truths can be brought out and firmly established" (Walton 1914, 71).

Table 1 describes the content of questions and answers in the Student's Department from its inception in January 1914 through December 1922. The unit of analysis is the individual published article (i.e., a question and response form one observation). We identified 425 questions supplied by practitioners or students ("external") and 84 provided by the editor ("editor").[18]

<Insert Table 1 Here >

Panel A of Table 1 shows the number of these articles that include the word "principle" in either the question or answer for the "external" and "editor" categories. "Principle" is used less frequently in the questions (only 19 of 425, or 4%) than in the answers (58 of 425, 14%). References to "principle" are also less frequent in the responses for external questions (10%) than for editor's questions (27%). These differing frequencies suggests that contemporary practitioners were (relative to the editor) more focused on finding answers to specific problems than identifying broad accounting principles.

Panel B shows that the answers relied little on authoritative citations; 80% (333 of 425) include no formal citations in the answer. Citations are included more often in answers to the editor's questions (40%) than the external questions (17%). Panel C indicates that the focus of the external questions is narrower. For example, 40% of the external questions are industry-specific compared to only 18% of the editor's questions.

The historical record suggests several mechanisms that would promote accounting standardization through norms and customs before the 1930s. Practitioners encountered practical

[18] A third type of entry in the Student's Department included questions that had appeared on the CPA Exam during the period. There were 390 of these entries in the period we examined.

problems in accounting for specific transactions and actively sought relevant knowledge from other experienced accountants. The profession, through mechanisms such as Special Bulletins and the Student's Department of *The Journal of Accountancy* facilitated the sharing and dissemination of knowledge among its members. Knowledge sharing could cause the expansion of a norm through the typical processes of copying and imitation, either based on social pressures or the revelation of new information in others' choices (Richerson and Boyd 2005; Reppenhagen 2009). The result was that spontaneously shared knowledge about accounting norms helped professionals identify acceptable accounting treatments for a given transaction (May 1946; Sunder 2005).

2.2. Formal U.S. Standard-Setting Before FASB

The Securities and Exchange Act of 1934 created the Securities and Exchange Commission (SEC) and authorized it to establish accounting standards for U.S. companies listed on national securities exchanges. The SEC delegated this authority to the accounting profession in 1938 (Cooper and Robinson 1987).[19] The AIA reorganized an existing committee and empowered it to fill this role (The Committee on Accounting Procedure or CAP).

CAP viewed "principle" as synonymous with "convention." Conventions were "postulates derived from experience and reason," which "have proved useful, and become generally accepted" (CAP 1940). CAP operated on a case-by-case basis that resembled British Common Law (Storey 1964, 50). George O. May, chairman of CAP, advocated this approach throughout his career (May 1946, 37-50).

The CAP was replaced in 1959 when the American Institute of Certified Public Accountants (AICPA, as the AIA was renamed in 1957) established a new body, the Accounting

[19] The delegation of authority for setting accounting standards by the SEC was indirect in that they would evaluate accounting practices on whether they had "substantial authoritative support." Accounting Series Release 4 did not require that "substantial authoritative support" come necessarily from any recognized body of professional accountants.

Principles Board (APB). One factor that led to the demise of CAP was its lack of a conceptual framework to guide the development of specific accounting standards (Zeff 1984, 458-462). Other factors included lack of input from affected parties before implementation of a new accounting standard. CAP also faced serious threats from the newly-formed SEC, academic accountants in the form of the American Accounting Association, and leaders from the major accounting firms whose firms had taken advocacy positions on specific accounting issues.

Unlike the CAP, the APB initially supported attempts to establish a conceptual framework. However, when resistance arose from practitioners early in APB's tenure, these efforts were abandoned (Previts and Merino 1998, 312-315). These conceptual framework initiatives included Accounting Research Study No. 3 by Sprouse and Moonitz (1962), which was rejected by APB as being too radical (Zeff 2007, 56). Also, the APB was criticized for lengthy delays in writing new accounting rules, faced intense pressure from firms affected by its rules, and some APB Opinions led to political disputes with the SEC (Zeff 1984, 462-466). Ultimately APB met the same fate as CAP and was replaced with the Financial Accounting Standards Board (FASB) in 1973. FASB remains responsible for determining U.S. accounting standards today.

Table 2 shows that the CAP's tenure was 233 months, APB's was 166 months, and FASB has now operated for 424 months (as of October 2009). CAP and APB were much larger bodies than FASB, and their members were drawn mainly from the ranks of public accounting. This is not surprising since both CAP and APB were committees of the AIA or AICPA, whose Executive Committee chose their members.

<Insert Table 2 Here >

FASB has been about twice as prolific as either CAP or APB when measured by the average number of pronouncements per month of tenure. FASB also instituted elaborate due process procedures that allow parties to comment on drafts of proposed standards before they are implemented. These procedures dwarf those used by CAP and APB (Zeff 1984, 462-466). CAP Bulletins had no means of formal enforcement whereas auditors were required to disclose

departures from APB Opinions and the SEC today requires use of FASB standards in SEC filings.

FASB has also produced seven Statements of Financial Accounting Concepts that represent the corpus of their Conceptual Framework. The Conceptual Framework, coupled with the SEC grant of monopoly power to FASB in requiring that their standards be used in SEC filings and FASB's outreach efforts, have likely lessened external criticism (see e.g., Zeff 1986). As a result, FASB is perceived to use their deductive framework to set standards and rely less on the case-by-case approach used by CAP and APB. These factors likely account, at least in part, for FASB's survival long beyond the tenures of its predecessors.

2.3. Implications for the Agent-Based Model

Perhaps the most important question raised by the history of U.S. accounting standards is: Have changes in the institution used to determine standards improved standards? At the most general level, this question is impossible to answer solely through reference to the historical record, either in qualitative or quantified analyses based on the output of standard setters and economic variables likely affected by standards. The fundamental problem is that a path dependent historical process has generated such data and identification of causal effects is thus confounded by severe endogeneity problems. We employ an agent-based model to circumvent these problems.

At the same time, our agent-based model of standards is only an approximation of reality whose ultimate value hinges on the extent to which features of our model capture important forces that influence accounting standardization. We therefore incorporate three aspects of current and prior U.S. accounting standard-setting arrangements into the design of our agent-based model.[20] The first feature of our model is that we compare standard setting institutions that range

[20] Two caveats are warranted. The differences in U.S. standard-setting arrangements are in many ways differences in degree rather than kind. For example, the FASB is not a pure "top-down" institution in that

from spontaneous customs arising in a bottom-up process ("evolved" institution) to a single standard used by all that is designed by an institution with strong comparative advantage in identifying effective standards ("designed" institution).

A second important feature of our model is that we study the impact of feedback obtained by applying the standards, which then can be further adapted based on this experience. Our evolved institution incorporates an important feature of pre-FASB U.S. standards in that agents could apply standards more flexibly. The result is that the standard itself can change dynamically in response to varying circumstances of application. The issue of uniformity versus flexibility has been a central question in accounting standard setting dating back to at least the 19th century (Merino and Coe 1978).

A third important feature of our model is the possibility of environmental change. This is important because it allows us to evaluate the efficiency of a standard when first established as well as a standard's robustness to environmental changes. We consider both random environmental changes and "strategic" changes that alter the environment at points where the standard is most vulnerable. This second type of change is relevant for today's world where transactions are often strategically "structured" to defeat the primary purpose of the standard (Nelson, Elliott and Tarpley, 2002).

3. Specifics of the Agent-Based Model

In this section, we describe specific parameters of the agent-based model. We first discuss the problem to be solved and then the endowed abilities of agents who try to solve the problem. We next describe features of the specific standard-setting institutions examined in the model, the subsequent evolution of standards under each institution, and the nature of

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they survey practice through comment letters and their Emerging Issues Task Force. Second, the set of differences we elaborate here are not exhaustive.

environmental uncertainty. Table 3 summarizes specific features of the model we describe in this section.

<Insert Table 3 Here >

3.1. Nature of the Problem

We consider a problem that can be solved in more than one way (see Panel A of Table 3). The specific problem is a 2-dimensional rectangular "maze" made up of an N x N matrix of nodes. A node can be connected to between zero and four neighboring nodes. A connection between two neighboring nodes allows the agents to travel between them. All agents enter the maze in the bottom left corner (node [1, 1]) and exit the maze in the top right corner (node [N, N]). Mazes have differing degrees of connectivity. A completely connected maze is one in which 100% of possible connections exists; others may have connectivity that ranges from zero to 99%.

We consider two mazes where the degree of connectivity is either 90% or 70%.[21] In the 90% case, 10% of the possible connections in the entire maze are not available. In the 70% case, 30% of the possible connections are not available. These two cases reflect an experimental manipulation of complexity where the 70% connectivity case reflects greater complexity.

3.2. Agent Abilities and Preferences

Each agent can move from a given node across connections to neighboring nodes, recognize the exit when reached, and remember its prior moves (see Panel B of Table 3). Agents' preferences are heterogeneous, so there may be no globally optimal solution. Each agent prefers to travel either above or below the diagonal between the entrance and exit. Agents are randomly assigned with equal probability to move according to one of these preferences. As a result, moves in the less preferred half of the maze are more costly to them than moves in the preferred half of

[21] We use 70% as the lower bound because mazes below this level are often unsolvable.

the maze. A cost of using less preferred moves is implemented by adding one step to the agent's movement record for every four steps taken in the non-preferred half of the maze.

In the process of running the maze, an agent may arrive at a given node more than once. This means that they have traveled in a loop and the steps taken between their first and second arrival at the node were wasted. Agents are able to recognize such loops and "erase" the wasted steps from their memory, which is one form of learning. As a result, the path the agents remember and communicate to others can be shorter than the actual path traveled.

An agent may also be able to "smell" the maze exit, meaning that it knows which of its available connections will move it physically closer to the maze exit. However, moving closer does not always result in a shorter route to the exit. Agents vary in how often they can smell. In our initial model, we consider two types of agents. "Brilliant" agents can smell accurately at 90% of the nodes they reach in their path to the exit. "Dumb" agents cannot smell at any node in the maze. In all simulations, we consider worlds populated by 50 "dumb" agents that use the standard transmitted to them via social knowledge sharing. "Brilliant" agents are used when we specify standards identified within the designed institution.

The efficiency of an agent's run through the maze is calculated as the number of moves taken to move from the entry point to the exit (removing moves that occur with a loop). This measure is increased by moves in the agent's less preferred half of the diagonal.

3.3. Alternative Standard Setting Institutions

We specify a standard setting institution as a knowledge sharing arrangement between the agents (see Panel C of Table 3). That is, a standard arises after agents share knowledge of the maze gathered as a result of experience in actually running it. After knowledge is shared, agents again run the maze with updated knowledge to evaluate whether the standard allows them to run the maze in fewer steps.

We consider two kinds of standard-setting institutions. In the evolved institution, all 50 dumb agents run the maze initially and then share their information with their immediate neighbors after they exit the maze. Their neighbors are randomly selected (without replacement) from the population of 50 dumb agents. The selection of neighbors is done in advance of the initial run of the maze where each agent is randomly placed into one of five groups of ten dumb agents each. Following the initial run, each agent follows the path of its group member with the same preference that used the fewest moves to run the maze. If no other agent in the group has the same directional preference, then the agent follows the path run by the agent (with different preferences) that used the fewest moves through the maze.

The designed standard setting institution has the brilliant agent (with 90% smell ability) run the maze initially. All dumb agents then use the path identified by the brilliant agent in subsequent runs of the maze.

3.4. Subsequent Evolution of Standards

When a centralized institution selects a standard that all agents are required to use, other agents cannot update the standard on their own. With institutions that merely recommend, but do not require preferred paths, agents can update their knowledge based on experience in subsequently applying the standard. We build this possibility into our model by allowing the dumb agents to share knowledge after each of five subsequent runs of the maze using the standard (see Panel D of Table 3).

As already noted, the evolved institution is one where dumb agents share information with local neighbors after their first run of the maze. They then run the maze again armed with the knowledge acquired from a subset of other dumb agents after the first run. We then repeat the same knowledge sharing after the next run except that agents are placed into new randomly selected groups. They then update their paths if they identify a path through the maze that

promises a faster route to the exit. As a result, the dumb agents can improve their performance based on successive iterations of the standard they discover while navigating the maze.

3.5. Introducing Uncertainty Through Mutation

We introduce mutations that can be either random or strategic (see Panel E of Table 3). In the random case, the nodes to be disconnected are chosen at random. With strategic mutations, those connections that have been most often used are erased. The purpose of adding mutations to the maze is to evaluate the robustness of standards to environmental changes. The real world analogy to strategic mutations is "transaction structuring" where the character of transactions change endogenously in response to a constraint imposed through a standard.

Mutations are introduced at pre-specified time intervals. To illustrate, the standard is set in the first run under either the evolved or designed standard-setting institutions. The dumb agents then run the maze for five subsequent periods with knowledge sharing among dumb agents after each round under the evolved standard-setting institution. Mutations occur after this fifth set of runs by the dumb agents. If the mutation is random, then a new maze with the same level of connectivity is generated by randomly selecting a set of links which are erased and replaced by a new set of randomly placed links. Under strategic mutation, the two most travelled links are erased and replaced by two randomly chosen links.

Immediately following a mutation, the standard is re-specified with the same process used to initially specify standards. With the designed institution, the brilliant agent runs the new maze to set the path to be followed by dumb agents until the next mutation. Having the dumb agents run the new maze to gather information and set a new path sets the evolved standard. The following periods then proceed as before where dumb agents share knowledge after subsequent runs under the evolved institution.

3.6. Simulating the Agent-Based Model

Panel F of Table 3 describes the procedures used to simulate the agent-based model for each of four types of mazes: (1) 90% connectivity, random mutation, (2) 90% connectivity, strategic mutation, (3) 70% connectivity, random mutation, and (4) 70% connectivity, strategic mutation. For each of these four types of mazes, we evaluate the performance of the two standard setting institutions independently. Thus, we have eight possible combinations of connectivity, nature of mutation, and type of standard setting institution.

For each of these eight combinations, we proceed as follows:

1. Agents that determine the standard run the maze initially at t = 0.
2. All agents run the maze at t = 1 following the standard. They communicate if called for.
3. Step 2 is repeated five times.
4. Maze mutation occurs. If the mutation is random, a set of randomly selected links are closed and a set of randomly selected new links are opened. For 70% connected mazes, 75 links are changed. For 90% connected mazes, 105 links are changed. When a strategic mutation occurs, the two most travelled links in the maze are closed and two new randomly chosen links are opened.
5. Steps 1 through 3 are repeated on the new maze. In total, this process continues until 10 mazes have been examined; one is the original maze and nine are subsequent mutations. Thus, each initial maze generates 60 data points representing a run through a maze.

This process is repeated 30 times for each of the eight combinations of maze connectivity, mutation type, and standard setter.

4. Results

In this section, we describe the preliminary results generated to date. These results are preliminary in that we have yet to complete all analyses for this revision of the paper.

4.1. Primary Results to Date

4.1.1. Initial Performance Differences

Our initial analysis considers performance of the evolved and designed institutions in the first six periods before any mutations are introduced. Figure 1 shows plots of the averages of

mean number of steps to exit the maze in periods 1 – 6. These plots are based on averages aggregated across the random and strategic mutation conditions. Panel A provides the plots for the 90% connectivity case while Panel B shows analogous plots for the 70% connectivity case.

<Insert Figure 1 Here >

Three aspects of Figure 1 are informative. First, the plots for the evolved institution (dashed line) intersect the vertical axis at approximately 36.5 steps whereas the designed institution (solid line) intersects the vertical axis at just fewer than 31 steps with 90% connectivity and slightly over 33 steps with 70% connectivity. This indicates that, not surprisingly, the designed institution produces more efficient standards on the first run of the maze.

Second, the lines for the evolved institution are downward sloping and convex. This suggests that the evolved institution yields standards that become progressively more effective, but are subject to diminishing marginal returns. That is, the second run of the maze produces more positive marginal gains than the fourth run of the maze. At least for the 90% and 70% of the cases, the evolved institution yields marginal improvements close to zero after the second run that are essentially zero.

Third, increasing maze complexity leads to an upward shift in the plots. For instance, the average of the mean number of steps for the designed institution is under 32 for the 90% case compared to over 33 for the 70% case. A similar upward shift for the evolved institution is present at t=6, although the shift is smaller in magnitude. In fact, while the superiority of the designed institution is apparent at t=6 in the 70% case, the two institutions produce indistinguishable performance in the 70% case after only two runs of the maze.

To summarize, the results in Figure 1 indicate that the superiority of the designed institution over the evolved institution is likely a function of environmental complexity. The evolved institution produces it largest marginal gains in the first two runs and works better in the more complex setting where the best solution may be harder to identify.

4.1.2. The Effects of Mutation

Analysis of the effects of mutation indicates that the immediate effects of a mutation are generally dampened by use of a designed institution compared to an evolved institution. Figure 2 shows plots of the one-period change in the average of mean steps taken by agents for the evolved (dashed line) and designed (solid line) institutions. Separate plots are shown for the four cases as follows: 90% connectivity, random mutation (Panel A); 70% connectivity, random mutation (Panel B); 90% connectivity, strategic mutation (Panel C); and 70% connectivity, strategic mutation (Panel D).

<Insert Figure 2 Here >

Note first that the dashed lines in all panels remain positive for each of the nine mutations. This indicates that the immediate effect of mutation with the evolved institution is to *increase* the mean number of steps taken by dumb agents to exit the maze. In contrast, the solid lines for the designed institution take on negative values in at least one period for each of the four cases. For instance, the average of the mean number of moves taken actually declines for the fifth, eighth, and ninth mutations when a designed institution operates in the presence of greater complexity (70% connectivity) and strategic mutation (Panel D).

However, as documented in the first six periods, the evolved institution is associated with improved performance after the dumb agents have learned better routes through the maze. Figure 3 shows plots analogous to Figure 2 except that now the change is measured on a long-run basis. The plots in Figure 3 represent the change in average mean steps in period +6 relative to the period before the mutation. Because agents' behavior is unchanged under the designed institution, the solid lines in Figure 3 are identical to those in Figure 2. However, because learning is possible under the evolved institution, the dashed lines vary across Figures 2 and 3. The plots in Panel A of Figure 3 indicate that both institutions are effective in the 90% connectivity condition when mutations are random. In both cases, the plotted lines show little variation around zero.

<Insert Figure 3 Here >

More variation is evident with 70% connectivity and random mutation (Panel B), but only in one period does the long-run change in the average of means fall outside the bounds of +1 and -1 for the evolved institution (t=8, +1.19). In contrast, the long-run change falls outside these same bounds in six of nine cases for the designed institution. The same pattern is evident given strategic mutations and both 90% connectivity (Panel C) and 70% connectivity (Panel D).

The data in Figure 3 suggest that the superior short-run performance of the designed institution evaporates when agents have more than one period to respond to mutations in environment and adjust their behavior in response. This long-run change is starkly evident in Figure 4, which shows the average of the mean number of steps taken in all 60 rounds. As with the past two figures, the evolved and designed institutions are shown by dashed and solid lines, respectively. Panel A of Figure 4 shows that the "saw tooth" appearance of the evolved institution (apparent in Figure 1) as it experiences large increases in average mean steps during mutation periods, which then decline dramatically before the next mutation. The evolved institution in contrast shows little variation through time. Relative to the other settings represented in Panels B – D, the designed institution clearly does better than the evolved institution when the environment is simpler. However, the results in Panel B show no clear superiority for one institution over another.

<Insert Figure 4 Here >

Panels C and D show results for the strategic mutation settings. The evolved institution again shows the "saw tooth" appearance that is not present for the evolved institution. What is interesting is the apparent upward drift in the performance of the designed institution that accompanies a series of strategic mutations. One possible interpretation is that standards drift, much like genetic drift in small isolated populations, arises in part because selection forces are constrained from working.

4.1.3. Overall Performance Differences and the Extent of Standardization

We conducted two final analyses to determine whether the differences in standard setting institutions were significant in statistical terms and also the extent to which dumb agents under the evolved institution exhibited standardized behavior. Panel A of Table 4 shows the average of the mean number of steps by agents in each of the ten cycles of six periods (i.e., from the start of the cycle to the next mutation). These data confirm that the designed institution mean for the 90% connectivity case with random mutations (30.69 steps) is lower than the comparable evolved institution mean (32.32 steps). The means for the evolved institution are also significantly lower than the comparable designed institution means for the 70% connectivity case with either random or strategic mutations. Differences in the institutions' means are not significant at conventional levels for the 90% connectivity case with strategic mutations.

<Insert Table 4 Here >

Panel B shows a substantial consistency in terms of the paths chosen by dumb agents in running the maze. Aggregating all observations together, the most frequently traveled path is chosen in 48.14% of cases, and the two most popular paths are chosen in over 82% of the cases. This suggests that even high levels of standardization are possible when allowing for modest knowledge sharing among agents.

4.2. Additional Tests

4.2.1. Performance of a Hybrid Institution

We also examined the performance of a third institution that is a hybrid of the designed and evolved institutions. This mechanism, which we label the "competitive" institution, allows multiple standard setters to compete in making recommendations that may be used by agents in the economy. Dye and Sunder (2001) suggest that competition among standard setters may enhance the performance of standards that are selected by persons using the standards. The U.S. analogs to our competitive institution are the CAP and APB arrangements where multiple actors (e.g., large accounting firms and academic organizations) sought to identify and advocate specific

accounting practices that could be recognized as "best practices" by the standard setter (Zeff 1986).

To set the standard under the competitive institution, multiple smart agents (with 70% smell accuracy) run the maze initially to specify subsequent dumb agents' moves under the competitive standard setting institution. Following initial runs of the maze by ten smart agents, each smart agent communicates his path with five dumb agents selected randomly without replacement. The dumb agent then uses this path in his next run of the maze.

In subsequent periods, dumb agents again gossip by sharing knowledge of their path with nine other dumb agents chosen randomly without replacement. Each agent then chooses the path of the other dumb agent who ran the maze the fastest in the second round. In this way, standards compete against each other to be "selected" by dumb agents in future runs of the maze. The consequence is that standards can diffuse within the population of dumb agents and can broadly influence their behavior even though a particular agent may have had no direct interaction with the smart agent that discovered the standard. Details about implementing the competitive institution are provided in Table 5.

<Insert Table 5 Here >

Figure 5 provides evidence on the short-run performance of the competitive institution. This figure is a reproduction of Figure 1 except that the competitive institution is plotted along with the evolved and designed institutions. The competitive institution performs better than the others in the 90% connectivity case, and mirrors the performance of the evolved institution in the 70% connectivity case.

<Insert Figure 5 Here >

Figure 6 shows plots of the long-run performance measure for the competitive institution compared to the evolved and designed institution. (This figure is identical to Figure 4 for the evolved and designed institutions.) With random mutations and 90% connectivity (Panel A), the competitive institution performs similarly to the designed institution. With 70% connectivity and

random mutations (Panel B), the competitive standard more closely resembles the evolved standard with its "saw tooth" appearance. The evidence in Panels A and B of Figure 6 suggests that the competitive standards provide robust performance across different levels of connectivity in a setting with random mutations.

<Insert Figure 6 Here >

Panels C and D of Figure 6 show analogous graphs for the 90% and 70% connectivity cases with strategic mutations. The competitive institution again shows the "saw tooth" feature of the evolved institution with random mutations, but it also reflects the tendency towards "drift" evident in the designed institution. In this sense, the robust performance of the competitive institution under random mutations does not extend to strategic mutations.

4.2.2. The Impact of Altering the Designed Institution's Comparative Advantage

The results we present are obviously dependent on the parameters we have selected. A major parameter is that we assume that the standard setter under the designed and institution reflects a strong comparative advantage. In our model, this is represented by the "brilliant" agent's ability to smell the direction of the exit at 90% of the nodes where they land. But, what if that percentage were lower? Panels A and B of Figure 7 provides evidence on the short-run performance of the designed institution in the 90% and 70% connectivity cases, respectively, for varying levels of smell ability (100%, 70%, and 50%). In no case is the short-run performance of the designed institution measured relative to the evolved institution changed by altering the brilliant agent's ability over this range.

5. Future Work

As noted at the outset, our conclusions at this stage must be tentative and preliminary. We do find evidence that evolved standards that improve on designed standards likely arise from greater environmental complexity and strategic mutation. In addition, we find evidence that

designed standards tend to drift away from earlier effective solutions in the presence of strategic mutations. However, additional work is needed before any firm conclusions can be reached based on an agent-based model of standards.

Accordingly, we envision that our immediate focus in additional work will be in the following areas:

1. *Maze homogeneity*. The present analysis is based on randomly-generated mazes that can differ across conditions. This will be changed in future drafts to be sure we are running true apples-to-apples comparisons.

2. *Increasing generality of the benchmark analysis*. In particular, we are interested in investigating the impact of changing parameters of the evolved institution. Possible changes include: (a) modest improvements in the ability of dumb agents (e.g., 10% smell capability), changes in the scale of the dumb agent network (e.g., 25 or 75 dumb agents instead of 50), and changes in the scope of communication within the dumb agent network (e.g., 3 vs. 5 vs. 10 vs. 50 agent groups for communication). As part of this analysis, we also intend to identify the incidence with which a dumb agent discovers a path that is shorter than that specified by a designed institution.

3. *Fitness consequences of standards use by agents*. As presently specified, there are no immediate fitness consequences to ineffective standards. We plan to analyze this in future drafts by introducing agent mortality for those who do not exit the network in a maximum number of steps. We expect this will have material effects on the speed with which effective standards are identified since it will alter fundamentally the nature of feedback gathered in successive applications of a standard.

4. *Effect of prestige-biased copying in dumb agent networks*. As the model is presently specified, the nature of information transmission between dumb agents is based entirely on effectiveness in running the maze. However, research on cultural evolution suggests that norms can arise from prestige-biased and conformist forms of social learning, which can sometimes lead to

maladaptive outcomes. We intend to examine the robustness of the evolved institution to these kinds of effects in future drafts.

5. *Agent heterogeneity*. Presently we allow for heterogeneous agents by way of varying dumb agents' preferences in navigating the maze. We intend to conduct analyses that allow us to say something about inefficiencies in application of standards to agents with heterogeneous preferences – i.e., the number of steps added by following a standard discovered by someone with differing preferences. We also intend to vary agent heterogeneity more broadly to get a sense of what effect this has on the effectiveness a standard.

6. *Drift in standards*. The drift inherent to standards specified by the designed institution and to a lesser extent, the competitive institution suggests that there is something about a centralized institution that increases the risk of applying a standard in a setting where strategic mutations occur. In particular, we expect this is driven by the lack of feedback about alternative standards that could be used.[22] This analysis will also consider possibilities where a designed institution could factor in possible attacks from strategic mutations.

[22] In particular, we believe this may be analogous to the concept of genetic drift where small variations in phenotype can persist and expand within a population that is cut off from external sources of new genetic material (Wilson 2000, 64-66).

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Table 1
Characteristics of Questions Posed and Answers Supplied in the *Journal of Accountancy* Student's Department from January 1914 to December 1922

This table presents descriptive evidence collected from The Student's Department of *The Journal of Accountancy* from 1914-1922. 'External' represents questions submitted by practitioners or students and 'Editor' describes questions or topics raised solely by the editor of the department.

A: Use of "Principle" in Question and Answer

	External	*Editor*	*TOTAL*
"Principle" in Question	17 of 341 (5%)	2 of 84 (2%)	19 of 425 (4%)
"Principle" in Answer	35 of 341 (10%)	23 of 84 (27%)	58 of 425 (14%)

B: Number of Authoritative Citations Provided in Answer

# Citations	*External*	*Editor*	*TOTAL*
Zero	283 (83%)	50 (60%)	333 (80%)
One or More	58 (17%)	34 (40%)	92 (20%)

Panel C: Number of Questions with an Industry-Specific Focus

	External	*Editor*	*TOTAL*
# Questions with an Industry-Specific Focus	135 (40%)	15 (18%)	150 (35%)

Table 2
Characteristics of Different US Accounting Standard-Setting Organizations

	CAP *Committee on Accounting Procedure* **233 Months** (May1939 – Sept 1959)	**APB** *Accounting Principles Board* **166 Months** (Sept 1959 to June 1973)	**FASB** *Financial Accounting Standards Board* **423 Months** (July 1973 to Present)
BOARD CHARACTERISTICS			
Board Size	22 members on original board	18 members on original board	7 members on original board, reduced to 5 in 2008.
Who Appoints Members?	AICPA	AICPA	Financial Accounting Foundation (FAF)
Member Backgrounds	Either practicing or academic accountants.	Greater diversity than CAP to include financial executives, analysts, and government accountants.	Only two of the five present members of FASB were practicing CPAs. One is a former academic, another was an investment banker, and the final member has expertise in forensic accounting.
STANDARD-SETTING OUTCOMES, PROCESS, & FORMAL ENFORCEMENT			
# Standards	51 Accounting Research Bulletins (.22 per month)	31 Opinions (.19 per month)	168 Statements of Financial Accounting Standards (.40 per month)
Deductive Conceptual Framework	Minimal	Attempted but unsuccessful	Seven Concepts Statements
Due Process Requirements	Minimal	Greater than CAP but still less extensive than FASB	Extensive due process prior to passage of a new standard
Are standards enforced?	No formal enforcement	In 1964, AICPA required that departures from APB Opinions be disclosed in annual report or audit opinion.	In 1973 SEC states in ASR 150 that FASB standards have "substantial authoritative support" and should be used in SEC filings.
GENERAL APPROACH & EXTERNAL THREATS			
General Approach	Pragmatic & piecemeal approach based on conventions akin to Common Law.	Deductive approach supported in initial attempts, but reverted to piecemeal approach previously followed by CAP.	Greater emphasis on deductive approaches typified in FASB Conceptual Framework.
Competitive Threats	SEC, Major CPA Firms, Academics	Same as CAP	Fewer threats because of SEC monopoly grant and outreach efforts to academics & other standard-setters

Table 3
Parameters of the Initial Agent-Based Model of Standardization

A: The Problem
15 x 15 maze with entry at southwestern corner and exit at the northeastern corner of the maze. Two types of mazes with differing levels of connectivity are possible. One has 90% of all connections among nodes open for travel whereas the other allows travel across 70% of possible connections.

B: Agent Abilities
All agents can move between any two nodes in the maze where the path between the nodes is open, remember past moves, and communicate their route to other agents after erasing their memory for repetitive loops taken inside the maze. Some agents can "smell" the direction of the maze exit, which allows them to identify moves that take them closer in distance (but not necessarily number of moves) to the exit.
BRILLIANT agents: can accurately smell the exit at a given node with 90% probability.
DUMB agents: can never smell the exit at a given node – i.e., they can smell with 0% probability.

C: Alternative Standard Setting Institutions
EVOLVED: The standard is established for a new maze by having all 50 dumb agents run the maze initially and then possibly identify faster paths by sharing knowledge with a subset of other dumb agents.
DESIGNED: The standard is established for a new maze by having a single brilliant agent run the maze.

D: Subsequent Evolution of Standards
EVOLVED: The 50 dumb agents gather to "gossip" about their experience after running the maze. Each agent gossips with the subset of agents in its group of 10 that share its preference for travelling in either the top or bottom half of the maze. When agents communicate, they compare the number of steps it took them to get through the maze. The faster agent then explains its path to the slower agent, who forgets the path it took and memorizes the faster path that has been explained to it. If an agent finds that no other agent in the group shares its preference, the agent copies the path of a fastest agent available in the group. The set of paths extant in agents' memories after they communicate is the decentralized standard.
DESIGNED: All agents use the standard set by the brilliant agent until there is a new maze. Thus, there is no subsequent change in agent behavior in the six periods after a new standard is established.

E: Nature of Mutations
RANDOM: Over 10% of the previously open connections are randomly selected for closing and an equal number of previously closed connections are opened.
STRATEGIC: The two most frequently travelled connections in the maze are closed and two previously closed connections are opened instead.

F: Simulation Procedures
For each of the eight combinations of maze connectivity (90%, 70%), type of mutation (random, strategic), and standard setter (evolved, designed), we simulate as follows:
1. Agents that determine the standard run the maze at $t = 0$.
2. All agents run the maze at $t = 1$ following the standard and communicate, if required.
3. Step 2 is repeated five times.
4. Mutation occurs.
5. Steps 1 through 3 are repeated on the new maze. In total, this process continues until 10 mazes have been examined; one is the original maze and nine are based on subsequent mutations.

Table 4
Summary Statistics on the Performance of the Evolved Institution

A: Mean Number of Steps Across All Six-Period Cycles for Each Complexity-Mutation Combination

Connectivity	Mutation Type	N	Evolved Mean	Designed Mean	Difference in Means	two-tailed p-value
90%	Random	10	32.318	30.695	1.623	< 0.001
	Strategic	10	32.654	33.930	-1.276	ns at 0.10
70%	Random	10	33.338	35.463	-2.124	< 0.001
	Strategic	10	34.359	36.991	-2.632	0.006

B: Degree of Standardization under the Evolved Institution
Measured as the Average Proportion of Agents in Evolved Simulations Following the Five Most Popular Agents

Path Rank	Proportion	Cumulative Proportion
1	48.14%	48.14%
2	34.06%	82.20%
3	7.03%	89.23%
4	3.35%	92.58%
5	2.12%	94.70%

Table 5
Parameters of the Competitive Institution

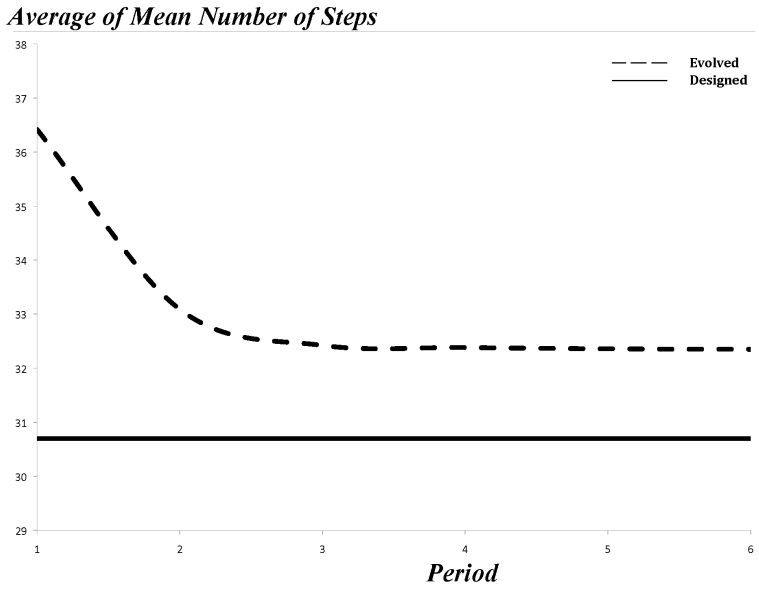
Agent Abilities
SMART agents: can accurately smell the exit at a given node with 70% probability.

Standard Setting Institution
COMPETITIVE: The standard is established for a new maze by having ten smart agents run the maze. These ten standards are communicated to five dumb agents, who then use the standard in their next run.

Subsequent Evolution of Standards
COMPETITIVE: After their first run of a new maze using their assigned standard-setter, the agents gather in groups of 10 to gossip similar to the evolved mechanism. They gossip with the subset of agents in their group of 10 that share their preferences. If an agent learns that another agent with the same preference got through the maze more quickly, it will begin following that agent's standard-setter. As with the evolved institution, if agent A finds itself in a group in which no other agents share its preference, it engages in one-way communication with the group. If agent A finds that the fastest agent in the group (agent B) was faster than it, it will begin to follow agent B's standard-setter. However, if agent A's path was faster than agent B's, agent B and the rest of the agents in the group will not follow the path of the off-preference agent A.

Figure 1
Performance of Evolved and Designed Institutions in Initial Periods
Random and Strategic Mutation Conditions Pooled

A: Average Mean Number of Steps for Periods 1 - 6 – 90% Connectivity



B: Average Mean Number of Steps for Periods 1 - 6 – 70% Connectivity

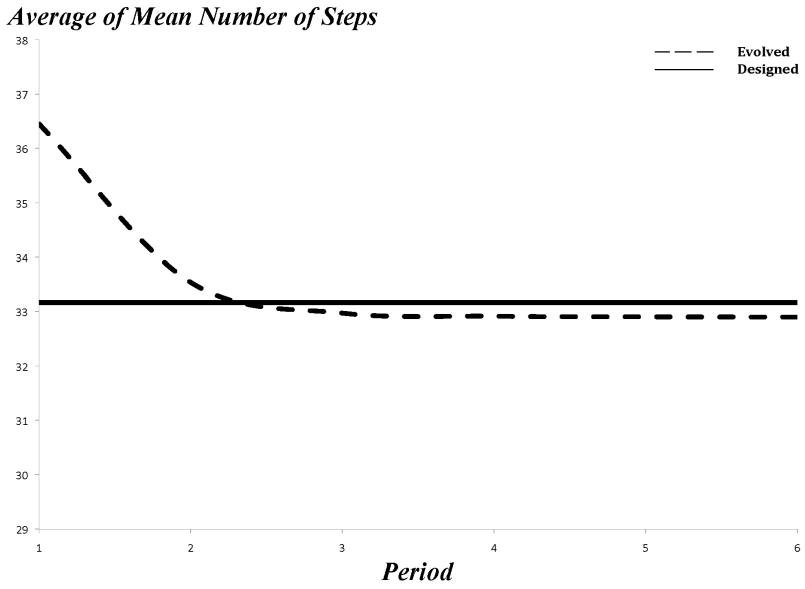
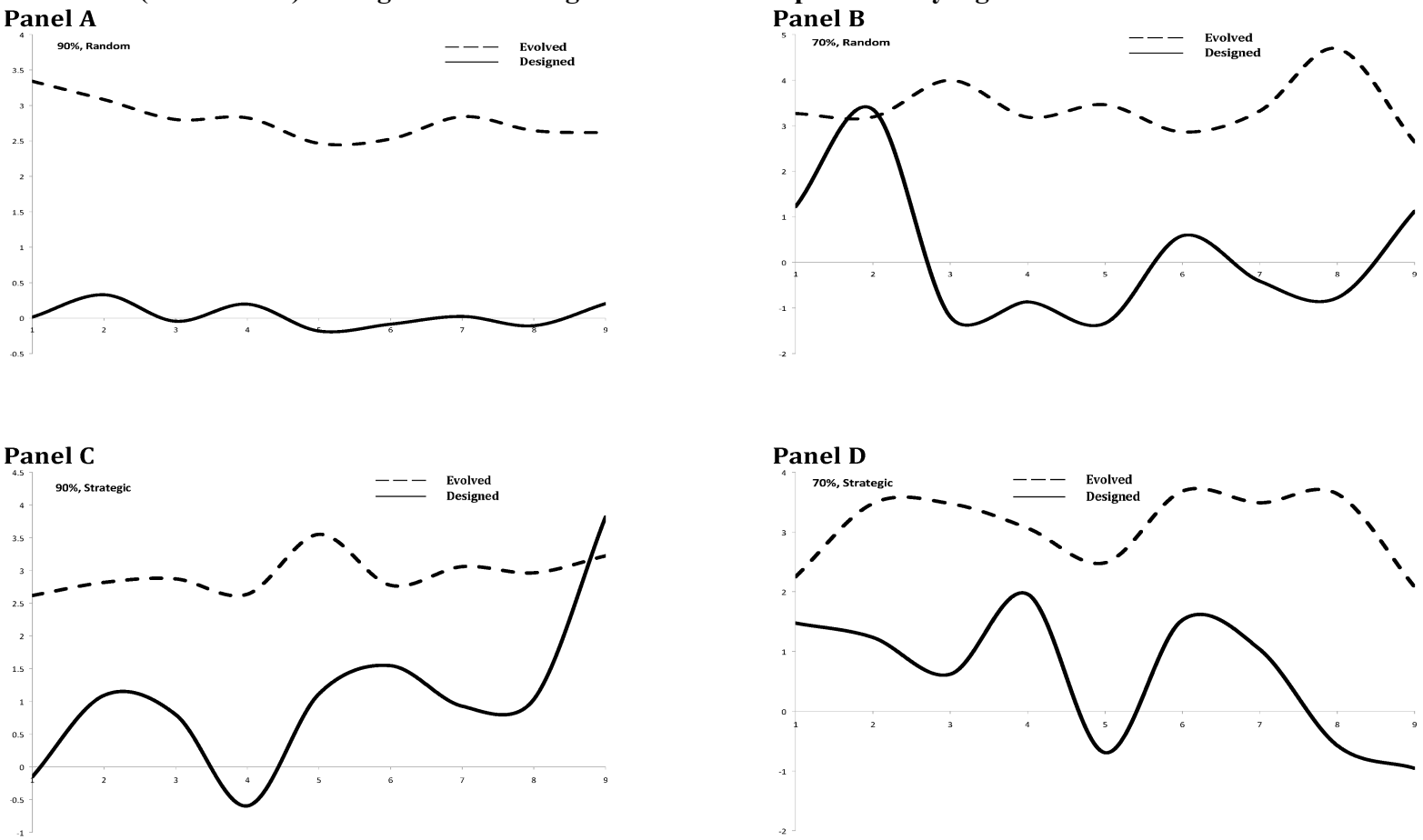
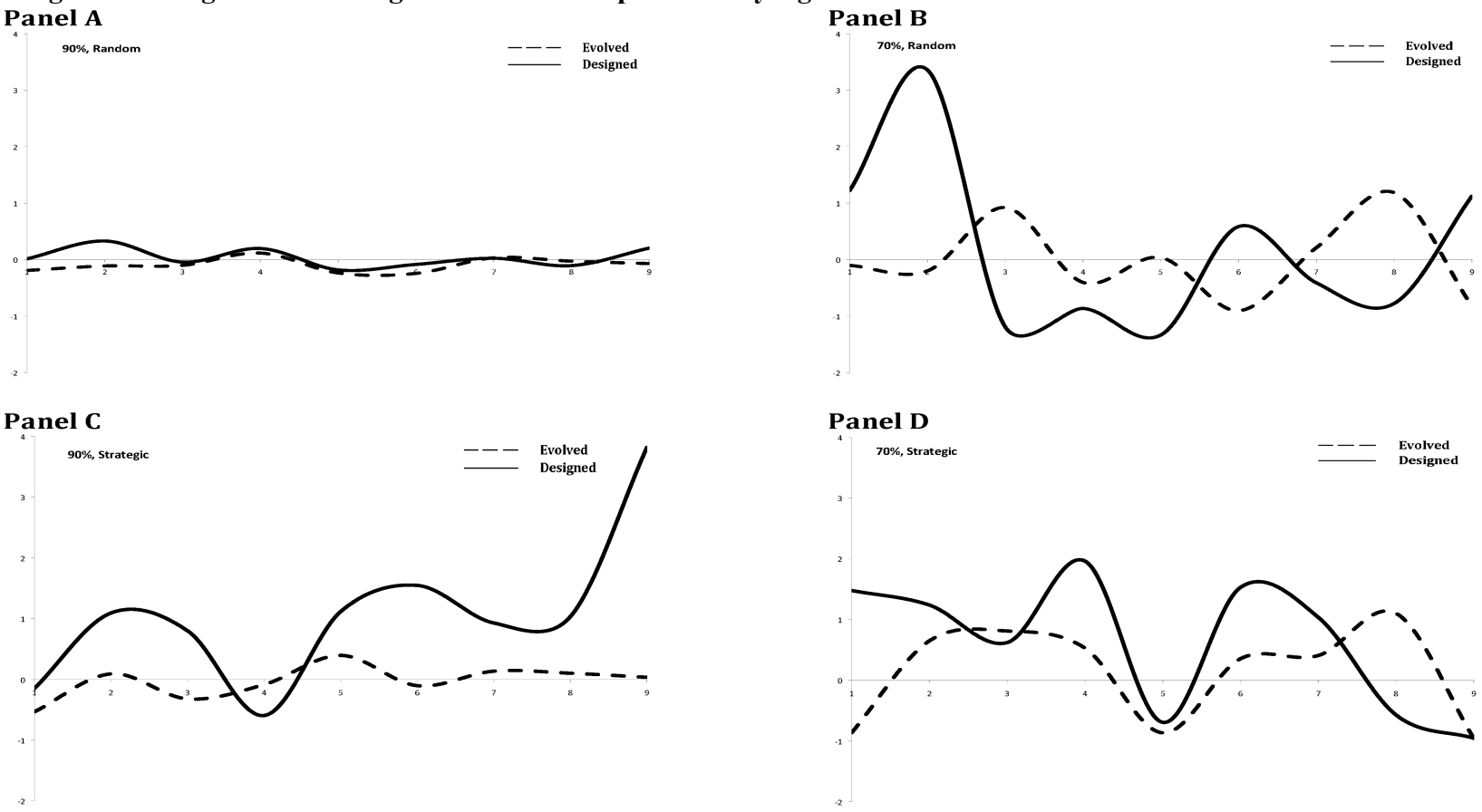


Figure 2
Short-Run (One-Period) Change in the Average of the Mean Steps Taken by Agents After Mutation



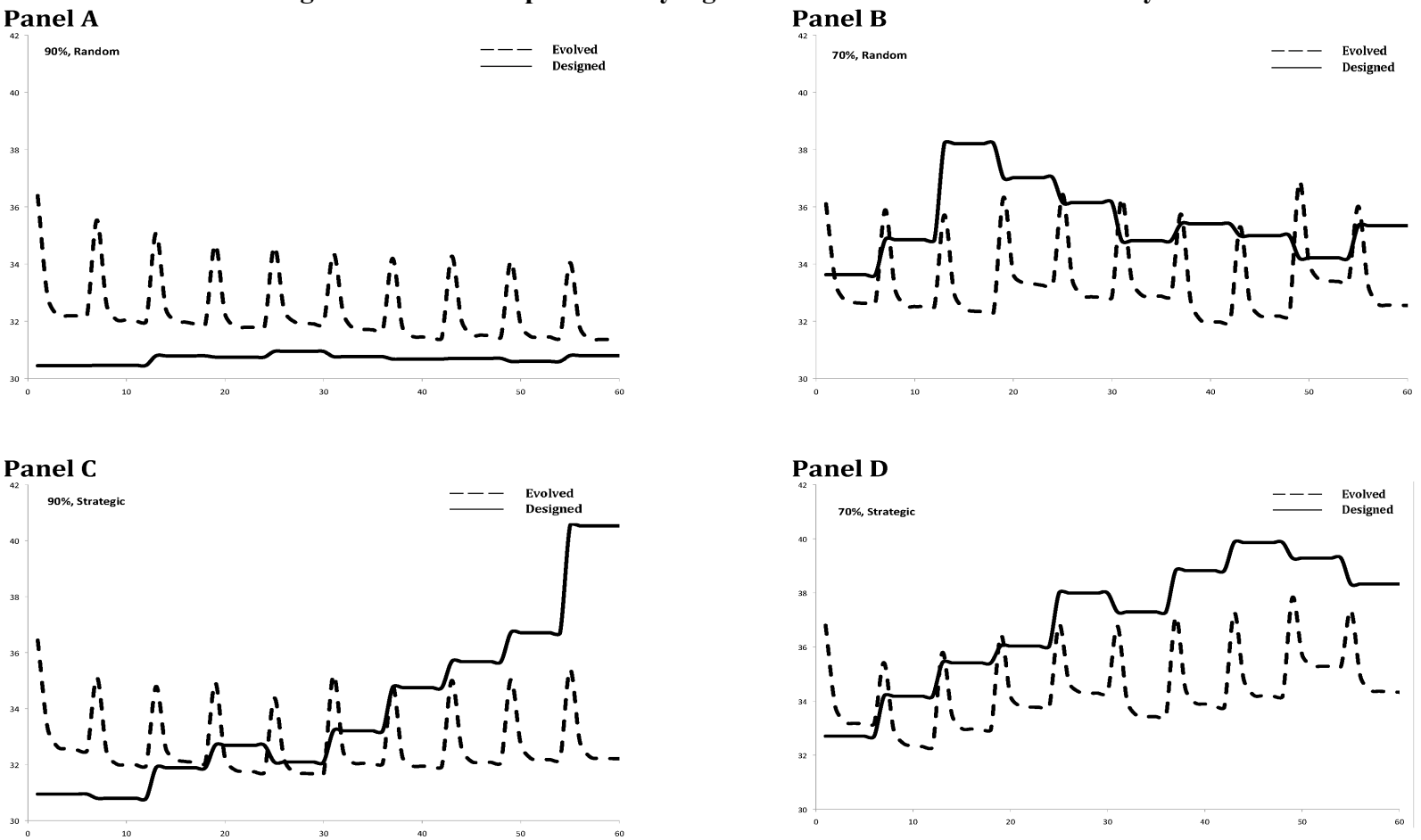
All panels show the one-period change in the average number of steps taken to exit the maze after a mutation occurs. Each plot shows nine values, one for each mutation sequentially. Panels A and B apply to random mutations in the 90% and 70% connectivity conditions, respectively. Panels C and D apply to strategic mutations in the 90% and 70% connectivity conditions, respectively

Figure 3
Long-Run Change in the Average of the Mean Steps Taken by Agents After Mutation



All panels show the long-run change in the average number of steps taken to exit the maze after a mutation occurs. The long-run change is measured as the difference in the average number of steps taken to exit the maze five periods after the mutation versus the period just prior to the mutation. Each plot shows nine values, one for each mutation sequentially. Panels A and B apply to random mutations in the 90% and 70% connectivity conditions, respectively. Panels C and D apply to strategic mutations in the 90% and 70% connectivity conditions, respectively.

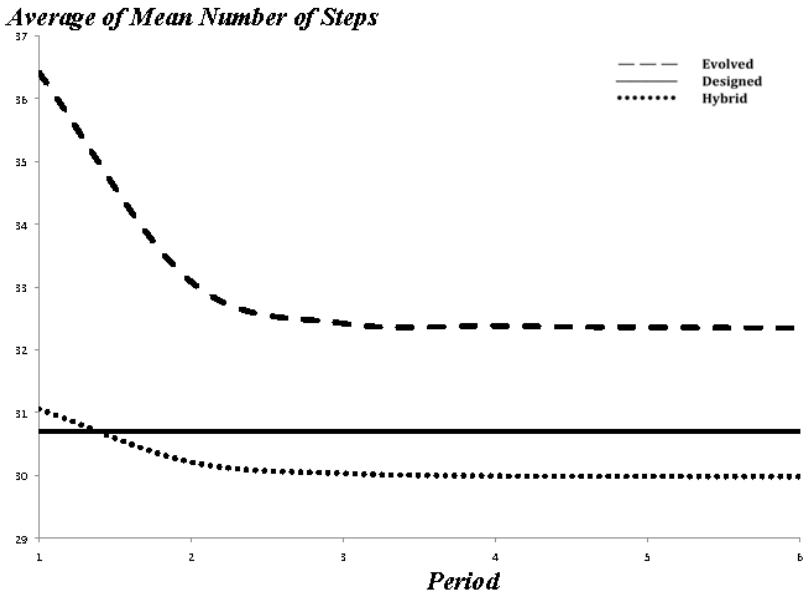
Figure 4
Time Series of the Average of the Mean Steps Taken by Agents Under Alternative Connectivity and Mutation Conditions



Each panel shows the time series of the average number of steps taken to exit the maze for each combination of connectivity and nature of mutation. Panels A and B apply to random mutations in the 90% and 70% connectivity conditions, respectively. Panels C and D apply to strategic mutations in the 90% and 70% connectivity conditions, respectively.

Figure 5
Performance of Competitive Institution in Initial Periods
Random and Strategic Mutation Conditions Pooled

A: Average Mean Number of Steps for Periods 1 - 6 – 90% Connectivity



B: Average Mean Number of Steps for Periods 1 - 6 – 70% Connectivity

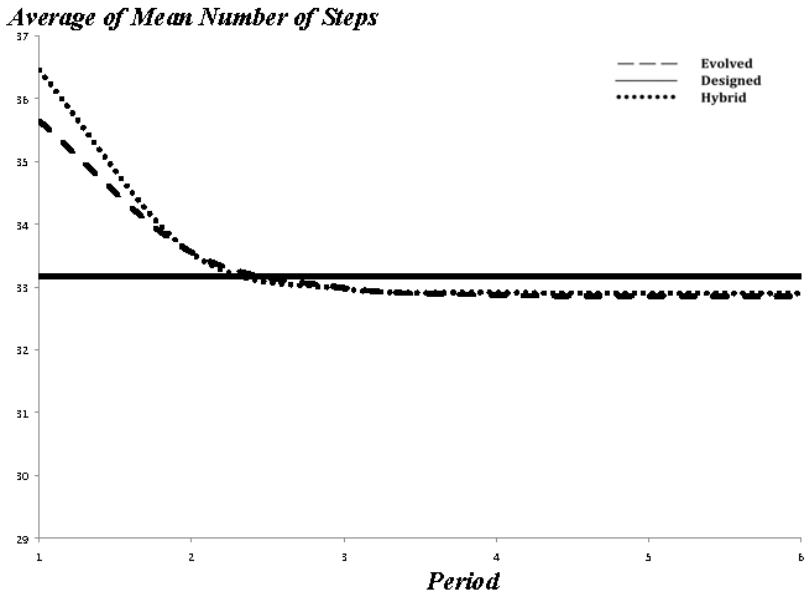
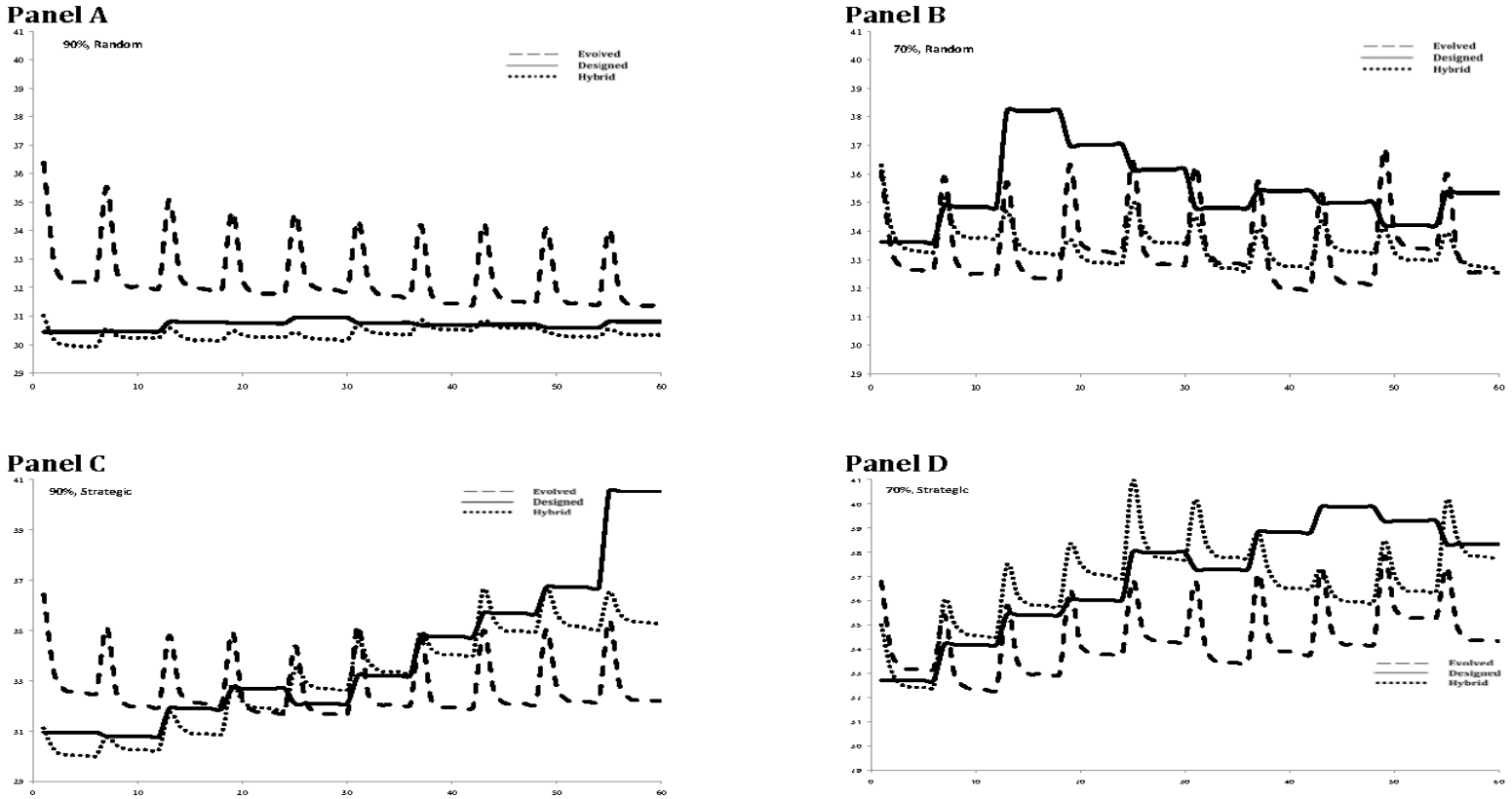


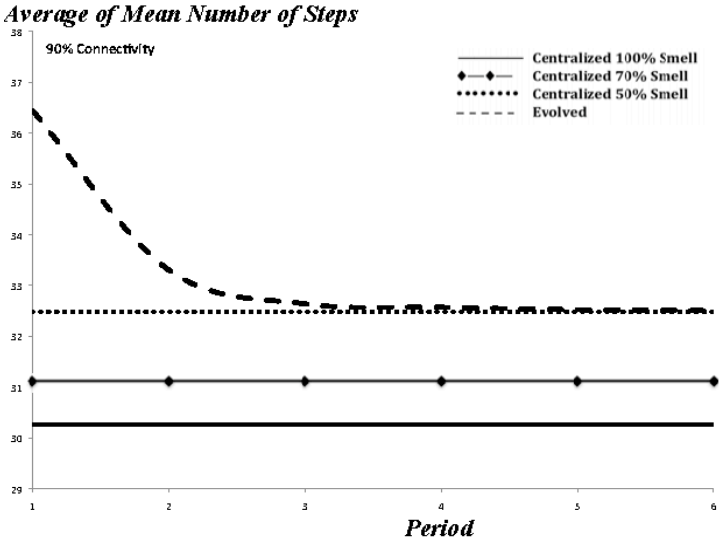
Figure 6
Time Series of the Average of the Mean Steps Taken by Agents Under Alternative Connectivity and Mutation Conditions Competitive Institution Versus Evolved and Designed Institutions



Each panel shows the time series of the average number of steps taken to exit the maze for each combination of connectivity and nature of mutation. Panels A and B apply to random mutations in the 90% and 70% connectivity conditions, respectively. Panels C and D apply to strategic mutations in the 90% and 70% connectivity conditions, respectively. The competitive institution is represented by the dotted line in each panel. The evolved and designed institutions are represented as solid and dashed lines, respectively.

Figure 7
Performance of Designed Institution in Initial Periods for Differing Levels of Standard Setter Ability
Random and Strategic Mutation Conditions Pooled

A: Average Mean Number of Steps for Periods 1 - 6 – 90% Connectivity with Differing Abilities for Designed Institution



B: Average Mean Number of Steps for Periods 1 - 6 – 70% Connectivity with Differing Abilities for Designed Institution