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Recordkeeping and Human Evolution

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SYNOPSIS: We seek to characterize the evolutionary role played by the transactional record that is the foundation of modern accounting. We theorize that systematic recordkeeping crystallizes memory and, along with other institutions (e.g., law, weights, and measures), promotes the trust necessary for large-scale human cooperation. Our theory yields two predictions: (1) permanent records emerge to supplement memory when complex intertemporal exchange between strangers becomes more common and (2) systematic records and other exchange-supporting institutions co-evolve and feed back to increase gains from economic coordination and division of labor. Many aspects of ancient Mesopotamian recordkeeping are consistent with these hypotheses, suggesting that our evolutionary theory is plausible. We outline ways to directly test our predictions with experiments, ethnographies, and agent-based models, and describe other techniques that can be used to explore the co-evolution of accounting with the human brain, language, and law.

Keywords: verifiable history; dispute resolution; strong reciprocity; cultural selection; prefrontal cortex.

JEL Codes: D74; D83; M4; O31.

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> As one moves up the evolutionary ladder in neural complexity, game-playing behavior becomes richer. The intelligence of primates, including humans, allows a number of relevant improvements: a more complex memory, more complex processing of information to determine the next action as a function of the interaction so far, a better estimate of the probability of future interaction with the same individual, and a better ability to distinguish between different individuals.
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> —Axelrod and Hamilton (1981, 1392)

> Implicit in financial statements under historical cost is a supporting record of all actual transactions in the past.
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> —Ijiri (1975, 86)

INTRODUCTION

Modern humans live much more comfortably than they did 10,000 years ago, let alone humans who lived in the distant past. Ancient humans lived in small hunter-gatherer groups that foraged for food and were prey to the vagaries of nature. In contrast, people today can consume a broad array of food delicacies in climate-controlled comfort throughout the year, even though very few people work directly in agriculture and construction. Global exchange opportunities coupled with highly specialized production yields vastly improved food and shelter. However, scholars still have not identified all the critical institutions and processes that made possible this vast improvement in human welfare.

Ancient civilizations used transaction records several thousands of years before double-entry bookkeeping emerged (Schmandt-Besserat 1995, 1996). This raises a fundamental question: What role does a permanent record of exchange fulfill, independent of its other functions in the accounting process? In this paper, we theorize that recordkeeping is a culturally evolved institution that enables complex economic interaction and plays an integral and pervasive role in human evolution. More specifically, we hypothesize that systematic recordkeeping outside an individual brain is a necessary condition for the emergence of extended economic cooperation that ultimately leads to complex human societies, markets, and economic organizations.

The basic recordkeeping function embodied in the modern journal entry lies at the core of all accounting systems. Internal controls and verification by auditors transform transactional records into ''hard'' information that later makes it ''difficult for people to disagree'' (Ijiri 1975, 36). The hard transactional record institutionalizes memory of past exchanges and enables third-party verification of prior events and obligations to resolve *ex post* disputes. Institutionalized memory via immutable, verifiable records of past exchange, combined with norms of honesty embodied in law and other exchange-supporting institutions, are needed to sustain the trust that enables complex economic cooperation between strangers over time. Opportunities for exchange, in turn, promote the extensive division of labor as well as the larger, more complex societies that are the primary causes of modern wealth generation (Smith 1776, Book I, Chaps. 1 and 2). Indeed, the ''paper trail'' generated by economic exchange is ubiquitous in modern advanced economies.

Our theory yields two predictions that can be empirically tested. First, when people start engaging in numerous and complex reciprocal exchanges, formal recordkeeping emerges to supplement imperfect human memory, which cannot accurately track many partners' past behavior. Thus, the more a social group depends on complex economic coordination and division of labor, the more pervasive and better organized its transactional records will be. Second, recordkeeping, communications technologies, and law co-evolve in larger complex human groups and feed back to increase gains from more complex coordination and division of labor.

We discuss several ways to evaluate our theory. We briefly review findings about ancient Mesopotamian recordkeeping, and we infer that this archaeological evidence is broadly consistent with our predictions. While this is not a formal statistical test, it suggests that our theory is at least plausible and that additional investigation is warranted. We then describe how laboratory experiments, cross-cultural analyses of ethnographic data, and agent-based computer simulations can be used to directly identify the antecedents and consequences of systematic recordkeeping. We also propose explorations of many open questions about the historical co-evolution of accounting, the human brain, language, and law.

If our evolutionary theory is empirically validated, then it can alter fundamentally how we envision the role of accounting in economic arrangements. Under the traditional stewardship and valuation perspectives, causality runs primarily from firms and markets to accounting, i.e., the demand for accounting arises from the existing economic arrangements governing production and exchange. In contrast, our evolutionary theory suggests a nuanced two-way causal relation in which a core recordkeeping technology must exist before complex cooperative agreements can emerge. Stated differently, *modern organizations and markets would have been impossible if humans had not mastered the basic recordkeeping technology that lies at the heart of modern accounting.*

THE EVOLUTIONARY ROLE OF RECORDKEEPING: AN OVERVIEW

We argue that simple transactional records have played an important, and unfortunately underappreciated, role in human evolution. Evolution is neither a purposeful nor a smooth process.[1] Although modern man (*Homo sapiens sapiens*) emerged as an anatomically distinct species about 150,000 years ago, it was only one among many competing primate species.[2] Man has gradually become the dominant animal species, and most of this rise has occurred during the last 10,000 years, with the emergence of recordkeeping and complex human culture. We argue that learning how and why basic transaction records contributed to human achievement will reconnect us to the core benefits of accounting and help us better understand why even apparently simple recordkeeping is a very important economic activity.[3]

Our evolutionary story begins with the observation that species that coordinate activity are more likely to compete successfully in the evolutionary battle over resources. Compared to other species, humans have evolved more complex forms of large-scale voluntary exchange, in part because our large, highly connected brains remember and analyze

[1] We think of evolutionary processes as long-run changes in environmental fitness induced by selection on variable traits that are passed down across generations. The evolutionary processes we describe reflect biological processes acting directly on genes and, more important for present purposes, cultural evolution acting indirectly on genes through practices that affect the fitness of the groups that adopt them. Within the perspective of gene-culture co-evolution, the core recordkeeping function of accounting is an enabling technology that is necessary for fitness-enhancing economic exchange and division of labor.

[2] Scientists often add the second ''*sapiens*'' to classify modern man as a subspecies that is distinct from its evolutionarily recent ancestors and close relatives like the Neanderthals.

[3] Our analysis builds on past research on the importance of recordkeeping. Hatfield (1924) asserted the importance of basic bookkeeping, and Littleton (1933, 1953, 36–37) and Potter (1952) recognized accounting as an evolved institution that stores memory of past transactions. Ijiri (1975) constructed a comprehensive theory of accounting and accountability around the insight that hard transactional records form the foundation of historical cost accounting systems. Demski (1993) introduced the metaphor of the ''accounting library'' as a repository of hard, verifiable information, and Sunder (1997) has broadly theorized accounting as an evolved cultural institution that generates enduring social benefits. Mattesich (2000), Brown and Palmrose (2005), and others have recognized the prehistoric origins of accounting. We contribute by explicating the evolutionary function of the hard transactional record that lies at the core of modern accounting. Our paper parallels ideas of Sombart (1919), who theorized that double-entry bookkeeping was necessary to enable large-scale capitalism.

exchange-related data efficiently. We hypothesize that memory of past dealings promotes greater cooperation because it helps actors identify trustworthy partners. Thus, human brains that are better adapted for social exchange and cooperation give man a crucial evolutionary advantage over other species.

As the scale and complexity of exchange transactions grows, at some point even the most developed brain becomes overwhelmed. Accounting records are abstract physical representations of past exchange and cooperative endeavor, and they act as backup and/or primary memory for economic agents engaged in large-scale complex exchange. By expanding memory capacity far beyond the biological constraints of the human brain, accounting records vastly increased the scale and scope of human cooperation. Combined with language, law, and other coordination-supporting institutions, hard transactional records helped human civilizations to emerge.

Figure 1 illustrates how recordkeeping fits into the canvas of human evolution. We divide human evolution into three stages represented in three columns:

- ancient hominids (human-like animals) similar to modern great apes such as chimpanzees,
- pre-historic humans who foraged for food like contemporary primitive societies, and
- recent large-scale human civilizations.

A "+" sign in a cell indicates that the listed features are observed in addition to those in cells to the left representing earlier evolutionary stage(s), and an empty cell indicates that no major advances occurred during that evolutionary stage.

Figure 1 also categorizes different institutions that play key roles in our evolutionary story in three panels. Since our focus is on recordkeeping, we show the characteristics of transactional records at each evolutionary stage in Panel A.[4] Early in human evolution, all information had to be remembered mentally. We hypothesize that as humans learned to keep records outside individual brains, the complexity and scale of economic coordination increased as depicted in Panel B. We use the term "coordination" to encompass both voluntary and involuntary (i.e., forcible) organization of joint economic activity. Panel C encompasses all coordination-supporting institutions, a few of which we list. We recognize explicitly that recordkeeping is just one component of complex human culture that facilitates large-scale exchange and coordination.

Moving from the first column of Figure 1 to the second captures the first distinct break in human evolution: the separation of hominids (human ancestors) from primates (great apes) around 6 million years ago. During the period represented by the second column, humans evolved several physiological advantages over other primates, which included, most importantly, changes in the vocal tract and larger, more complex brains that enabled spoken language (see Panel C). Specifically, a vastly enlarged prefrontal cortex likely aided the emergence of the mind, expressed in expanded consciousness, self-control, abstract reasoning, language, memory, and culture. Control of fire, improved hunting tools, and intra- and intergroup cooperation allowed humans to dominate other hominids and animals.

Despite these differences, the small human groups in the second column still resembled other primate groups in many ways: hierarchies led by charismatic, strong "alpha males," cooperative food production through hunting and gathering, and rituals promoting social

[4] We view recordkeeping as the collection and maintenance of evidence of transactions, i.e., journals and vouchers in modern parlance. Modern accounting systems do much more such as maintain ledgers of accounts and produce financial statements. While simpler in form and technique, recordkeeping is the foundation of all accounting systems, and its function (like that of accounting) is to foster accountability and trust in exchange.

FIGURE 1
Emergence of Formal Recordkeeping and Its Subsequent Co-Evolution with Other Coordination-Supporting Institutions

GROUP SIZE AND SPECIES →

	Small: Chimpanzee	Small: Human	Large: Human
Panel A: Recordkeeping			
Storage medium	mental/internal	+ oral history, notches	+ physical/external
Permanence	soft		+ hard
Duration	short term	+ long term	+ multi-generational
# of accounts	few	more than a few	many
Panel B: Complexity and Scale of Economic Coordination			
Coordination modes:			
Coercion	physical	+ moral/religious	+ legal
Sharing	hunt/meat	+ complex ritualized	
Trading	limited barter	+ extensive barter	+ money economy
Trading partners	kin group	+ clan/tribe	+ strangers
Time to complete trade	more immediate	+ short term	+ (very) long term
Tradable services	grooming, protection	+ music, arts, medicine	+ complex cultural
Tradable goods	fresh food	+ tools, handicrafts	+ animals, housing, mass manufactures
Panel C: Economic Coordination-Supporting Institutions			
Brain/Mind			
Brain size	big	very large	
Memory	short term	+ intermediate term	+ permanent
Consciousness	secondary	+ tertiary	
Causal reasoning	direct	+ indirect	+ hidden/extended, abstract reasoning
Cultural Institutions to Support Economic Coordination			
Food production	hunter/gatherer		+ agriculture, animal domestication
Communication	nonverbal and limited verbal	+ spoken language	+ written language
Law givers	alpha male	big chief	rulers, courts
Time scale	days	+ solar, lunar cycles	+ intra-day, multi-year
Number scale		nominal, ordinal	+ cardinal, integer ratio
Weights and measures			standardized

A "+" sign in a cell indicates that the listed features are observed in addition to those in cells to the left representing earlier evolutionary stage(s), and an empty cell indicates that no major advances occurred during that evolutionary stage.

cohesion. In addition, nomadic hunter-gatherer groups were likely wary of non-group members, and, like chimpanzee bands, were more likely to fight other groups than to cooperate with them. Thus, attempts at recordkeeping would have been minimal at best; the smaller kin-based groups would have had no need for the structured records found in modern civilizations.

A second distinct break in human evolution occurred with the first agricultural settlements about 10,000–12,000 years ago (depicted in the third column of Figure 1). Domestication of plants and animals accelerated humans' control of their local physical environment, which improved provision of food, shelter, and other basic needs. Agriculture generated food surpluses that permitted specialized production of non-food goods and services and led to increased barter between group members. Economic institutions evolved to support coordination within groups, and facilitated trade between groups; these institutions included verifiable records to track transactional performance.

As groups became larger and their production and coordination technologies became more complex, group members were more likely to forget their past interactions using only unaided memory. As a consequence, larger groups would fragment back into smaller groups unless they developed institutions to sustain large group coordination. Our argument is that systematic recordkeeping outside individual brains is one such institution. Thus, the subsequent road to modern civilization—with all its ups, downs, and geographical variation—has been built upon improvements in and additions to the culturally evolved institutions like recordkeeping that support exchange and specialized division of labor (Smith 1776).

MEMORY, COOPERATION, AND GROUP SIZE

Our goal in this section is to analyze more deeply the argument above that expanded mental and physical memory contributed to the evolutionary success of *Homo sapiens sapiens*. We also discuss how our greater intelligence gave rise to and then benefited from recordkeeping.

The Role of Memory in Enabling Small Group Cooperation

In this subsection, we argue that mental memory increases small group cooperation using three steps. First, humans face significant barriers to sustaining cooperative endeavor, and the ability to remember past interactions with specific persons plays a central role in enabling cooperation. Second, human cooperative tendencies have resulted in part from selection forces acting on genes, which have produced adaptations that include improved memory and communications skills. Finally, humans evolved greater ability to produce complex culture that leads to norms of behavior and social sanctions for departing from cooperative norms. The broader importance of this subsection is to illustrate that the antecedents of evolved institutions like recordkeeping have deep roots in the distant past of beneficial human group interactions.

We consider cooperation to be joint activity between multiple organisms where one organism's actions can produce benefits to other organisms, and repeated interaction over a long period yields total benefits (net of all relevant costs) exceeding those available when each acts independently of the others. For example, cooperation improves a group's (and by implication, group members') fitness by providing a common defense. Similarly, coordinated hunting of large game animals yields higher protein foods than individual hunting of small game.

Better cooperation likely explains why man beat out other hominids and primates that were competing for similar ecological niches (i.e., a comparison of the first and second columns in Figure 1). Chimpanzees, much like small human hunter-gatherer groups, exhibit

cooperative behaviors involving direct communication, meat sharing, and other rituals that strengthen interpersonal ties (de Waal 1997; Snowden 2001; Stanford 2001).[5] Nonetheless, closely related adult chimpanzees are less empathetic, altruistic, and cooperative than humans, including small children and infants (Silk 2006). This supports Smith's (1776, Book I, Chap. 2) contention that humans have an innate ''propensity to truck, barter, and exchange,'' and suggests that sustained human cooperation could arise, at least in part, from inherent evolved proclivities for social interaction, reciprocal behavior, and even altruism (see also, Smith 1759).

Evolutionary processes likely selected genes that enable greater cooperation in humans. Cooperative abilities likely increased because cooperative groups adapt better to their environments and, therefore, members of such groups are likely to live longer and produce more offspring (Darwin 1859). Natural selection thus caused genes favoring cooperation to be passed down across generations via kin selection or reciprocal altruism (Hamilton 1964; Williams 1966; Trivers 1971).

Despite what seem to be obvious benefits of cooperation, organisms must expend effort to discover when cooperation is beneficial and find ways to begin and continue it.[6] Sustaining cooperation requires the ability to recognize other living organisms, communicate with them, and recall their past behavior from memory (Trivers 1971; Dawkins 1976, Chap. 10; Axelrod and Hamilton 1981). That is, cooperation is more likely to be sustained in repeated interactions between organisms that can ''recognize other individuals and keep score'' (Ridley 1996, 83).[7] Selection of genes for intelligence likely caused human brains to grow to three times the size of chimpanzee brains and become much more interconnected (Hawkins and Blakeslee 2004, 98–104).[8] Since brain tissue is extremely costly (e.g., large brain organisms have longer maturity periods requiring greater parental investment), large human brains are likely an adaptation that enhances human survival in a broad range of environments (Aiello and Wheeler 1995).

The evolved human brain allows us to better communicate our own trustworthiness and assess others' trustworthiness (Cosmides and Tooby 1992), increasing the potential for gainful cooperation. An inherent ''language instinct'' helps humans to communicate better (Pinker 1994), and improved communication helps humans to sustain larger groups and

[5] A meat-sharing arrangement allows for establishing a ''consumption hierarchy'' that can be used to reduce conflict by smoothing food consumption (Rubin 2002, 96–100). Such arrangements require at least a minimal ''mental accounting'' of rewards and sacrifices in order to sustain themselves.

[6] Cooperative strategies often perform relatively well in repeated-play, two-person Prisoner's Dilemma computer simulations (Axelrod 1984). These results suggest that cooperation can take hold and stabilize if individuals are ''programmed'' to cooperate through genes and/or culture (Axelrod 1986; Simon 1990; Henrich and Boyd 2001).

[7] The ability of an organism to recall past interactions with its environment and adjust behavior accordingly is of first-order importance to its survival. This ability is important even for single cell organisms like *E. coli* bacteria (Allmen 2000, 3–8).

[8] Economists model the evolution of human hunter-gatherers' increased brain size and longer life expectancy as endogenous (Robson and Kaplan 2003). The extinction of Neanderthals is thought to result from their limited mental ability to organize exchange and the division of labor (Horan et al. 2005). Biologists and economists have long shared evolutionary ideas—e.g., Darwin's views on natural selection were built on ideas advanced earlier by Thomas Malthus and Adam Smith (Hodgson 1993). Recent research also links economics and biology (Alchian 1950; Simon 1962; Becker 1976; Hirshleifer 1977; Smith 1992; Robson 2001), and ''neuroeconomics'' researchers now use brain imaging technologies to directly examine how the human brain functions while making economic decisions (Camerer et al. 2005).

more complex cooperative arrangements than other primates (Dunbar 2001).[9] Evolutionary psychologists argue that nonverbal behaviors such as smiling and laughing evolved to signal cooperative intent (Owren and Bachorowski 2001). Man's highly evolved brain also has allowed him to achieve consciousness, mentally simulate the environment, appreciate others' individuality, have expanded mental memory, and later develop symbolic thought and communication (Dawkins 1976, 46–65; Donald 1991; Klein et al. 2002).

Using their increased intelligence, prehistoric human groups evolved social norms that foster and reinforce cooperation. Informal methods to deter cheating help to stabilize cooperative norms in small highly ''compact'' groups such as a clan that is tightly interlinked through kin relations or a dense social network like a small village (Demsetz 2002, S661). Thus, peers frequently ridicule deviators from a commonly held norm, resulting in the offender ''losing face,'' and people prefer gossip that promotes adherence to social norms (Barkow 1992). Small group norms are usually enforced by establishing an informal ''pecking order'' with a dominant ''alpha male'' and/or ''matriarch'' at the top of the hierarchy. More generally, Johnson and Earle (2000, 42–43) indicate that informal and unwritten norms in small kin-based groups ''constrain powerfully and pervasively through social understandings of what is respectful, proper, and courageous.'' Conformity to emerging cooperative norms ultimately makes individual behavior more predictable when repeated encounters are routine.

Unlike all other animals, humans willingly bear costs to punish third-party offenders even though they might never directly benefit from this action. Fehr and Fischbacher (2003, 785) define strong reciprocity as ''a combination of altruistic rewarding, which is a predisposition to reward others for cooperative, norm-abiding behaviors, and altruistic punishment, which is a propensity to impose sanctions on others for norm violations.'' Because strong reciprocators reward those who cooperate and punish those who defect, this helps to explain why human strangers tend to cooperate even when they know they might never meet again. However, conditional cooperation strategies such as strong reciprocity require that individuals' behavior be observed, remembered, and shared with others in the social network (Bolton et al. 2005). In addition, for strong reciprocity to be sustained, third-party observers must correctly distinguish between altruistic punishment and selfish motives for a current noncooperative action, and such discrimination requires higher-order information processing and association ability. Thus, culturally evolved strong reciprocity norms favor biological selection for more intelligent brains (Nowak and Sigmund 2005).

In other words, cultural processes likely fed back to select physiological capabilities in our evolutionary past. Human culture represents a socially based mechanism that promotes the emergence and evolution of institutions that enable wealth creation and alter group and individual biological fitness.[10] The result is a co-evolution of genes and culture that fundamentally alters the environment faced by humans (Wilson 1975, Chap. 27; Dawkins

[9] Marcus and Fisher (2003) review recent research isolating a genetic basis for evolved human language mechanisms. Lai et al. (2001) identified the *FOXP2* gene on chromosome 7, which if broken significantly disrupts speech and language skills in humans as well as vocalization in mice (Shu et al. 2005). Enard et al. (2002) find 2 mutations on the *FOXP2* gene in humans that chimpanzees and gorillas do not share, indicating that some human language capabilities are recently evolved. Other scholars hypothesize a nuanced process where individual language skills emerge and develop when an innate proclivity for language is activated through cultural experience (Tomasello 1999; Greenspan and Shanker 2004).

[10] Tylor (1871, as quoted in McGrew 2001, 233) defines culture as ''that complex whole which includes knowledge, belief, art, law, morals, custom, and any other capabilities and habits acquired by man as a member of society.'' Sunder (2002, 182) discusses the role of culture in promoting common knowledge within organizations via the use of accounting.

1976), and ultimately leads to more rapid evolution for humans than other species (Bowles et al. 2003; Henrich 2004; Richerson and Boyd 2005, 199–236).[11]

The Role of Formal Recordkeeping in Enabling Large Group Cooperation

While several other highly social species like ants, bees, and naked mole rats are known, humans are unique in regularly cooperating with non-relatives and forming stable large groups of distantly related individuals. Large groups provide extensive markets that allow individuals to prosper by specializing full-time in providing specific goods and services. Adam Smith emphasized that the gains from the division of labor have been the primary source of mankind's improved material well-being. Specialized production lets an individual exploit his comparative advantage(s) and use market exchange to acquire items that he does not produce, often from complete strangers (Smith 1776, Book I, Chap. 1). Accordingly, we focus on how recordkeeping promotes voluntary cooperative exchange, since exchange is the focal point for expanding specialized division of labor (Buchanan 1964; Kohn 2004; Axtell 2005).

Sustaining complex cooperation between people who are initially complete strangers in a large social network requires new institutions to store and disseminate information about each person's past cooperative behavior. We hypothesize that verifiable recordkeeping is an institution that is necessary (but not sufficient) for the emergence of large-scale human cooperation in less compact groups. We believe the importance of this cannot be overstated—without institutions that store and disseminate reliable information about a person's honesty and trustworthiness, extensive market exchange and a complex division of labor would not evolve.

We argue that systematic records increase available memory and enable large-scale human cooperation in two main stages: the emergence of systematic recordkeeping as a memory aid, and the subsequent cultural co-evolution of recordkeeping, exchange complexity, and other exchange-supporting institutions. We argue that external recordkeeping emerges because (1) the evolved human brain that enables cooperation in small groups cannot alone sustain large-scale cooperation, and (2) social groups can grow and stay large when systematic external records can store historical transactional data similarly to how we mentally store the same information. That is, hard external records allow exchange parties to mutually track performance in transactions involving future obligations, which is critical in sustaining cooperation in repeated interactions among initially complete strangers who can develop reputations (Bolton et al. 2005).[12]

In addition, we theorize that recordkeeping co-evolves with other exchange-supporting institutions so that these institutions collectively become better suited for large-scale cooperation than their historical antecedents. Because evolution occurs with small changes, many institutions that survive in large groups will likely resemble (via trait inheritance) the

[11] Cultural evolution also differs from natural selection acting solely on genes in that maladaptive practices (i.e., cultural practices that reduce fitness) can persist longer. This occurs because these practices can spread through imitation of behaviors that are fashionable but negatively correlated with fitness (Richerson and Boyd 2005). Because the effects of cultural evolution can (at least in the short run) be maladaptive, our analysis speaks primarily to long-term average effects rather than universal effects.

[12] We emphasize the economic benefits of systematic recordkeeping. Using durable external records in lieu of human memory incurs the direct costs of recordkeeping. Indirect costs of recordkeeping include dysfunctional behaviors that come with a formal economic relationship and the exploitation of records by third parties for wealth expropriation. These offsetting costs reduce the net benefits of recordkeeping and could inhibit large-scale cooperation and the extent of recordkeeping.

institutions performing similar functions in small groups. For example, the formal transaction records, open judicial proceedings, and legal sanctions used to resolve disputes in large societies have functional parallels in the mental memory, resolution of disputes by a ''wise man,'' and informal social sanctions (e.g., ostracism) used to punish departures from small group cooperative norms.[13] The remainder of this section further develops these two components of our argument.

The Emergence of Recordkeeping as a Mnemonic Device

As noted previously, increased intelligence and communication ability enable hierarchically organized large human groups with a complex division of labor and sedentary food production to emerge. Behavioral norms enforced with local oversight can sustain modest increases in group size. Such arrangements do not *per se* require extensive and complex recordkeeping because cultural norms (e.g., religious customs) can shape values and the hierarchy allows close monitoring of individual behavior. However, intragroup communication does not enable unbounded group size because oral information gets ''garbled'' in repeated transmission (i.e., informed gossip can quickly mutate into unfounded rumor).

We assert that extensive impersonal exchange can be frequent, and a complex division of labor can be present, only when systematic recordkeeping also emerges spontaneously to sustain trust and social cohesion. Structured records are common among large-scale societies, even those lacking literacy. Systematic recordkeeping technologies include the Sumerian token dating back to 8,000 B.C., the ''tally stick'' used for centuries in England and China as well as in rural France as recently as 1970, the ''knotted string'' used in both ancient and modern civilizations, and the journal entry (Robert 1956; Ifrah 2001, Chaps. 5 and 6). We view the widespread use of organized records in many civilizations as suggesting the possibility that systematic recordkeeping is a necessary condition for the emergence of large-scale complex societies.

Although we will never know what prompted some ancient ancestor to first keep economic records, we can speculate that, like many other accounting innovations, it was probably in response to a crisis. Perhaps there was a drought, famine, or war that necessitated rationing of common food stocks for a large group, and the distributor found it advantageous to temporarily pile pebbles or make scratches in the earth or on rock to make sure that each group member received a ''fair'' share. Once a creative distributor discovered such a mapping or correspondence technology, she would find that these piles or scratches reduced the cognitive burden of remembering who received what and when. The new technology could then gradually be adapted to other uses such as tracking domesticated animals. Over time, it could evolve into a number system and arithmetic, permanent exchange records with symbolic representation, and, eventually, writing. That is, the first bookkeeper's invention could evolve serendipitously into the ''three Rs'' of elementary school: reading, 'riting, and 'rithmetic!

Like mental memory, transaction records can distill the essence of exchange particulars, can be organized hierarchically, and can be used to reconstruct past events given a few particulars. Structured records supplement human memory and provide a verifiable history (i.e., a hard record) of past exchange that can help enforce any remaining obligations. Systematic records function like diary entries that aid recall of particular past events that

[13] The Chinese and Arabic words for ''contract'' derive from their words for ''notched sticks'' (Ifrah 2000, 66), and the English word ''stock'' for equity comes from the name of the larger piece of paired tally sticks that was retained by lenders. This etymological evidence is consistent with modern economic institutions having evolved from or replacing older institutions performing similar functions.

are often repeated and individually not salient. Systematic recordkeeping systems provide reliable information about past transactions when (1) self-interested strangers exchange goods and services and (2) past exchange is difficult to recall from memory and may be subject to future dispute.[14] Most importantly, accounting records enable the tracking of transactional performance through time, such as when debts are to be paid off through labor.

Cultural Co-Evolution of Recordkeeping, Exchange, and Other Institutions

While increased intelligence enabled the development of systematic recordkeeping to facilitate large-scale exchange, our theory explicitly recognizes that human evolutionary success required other exchange-supporting institutions. Recordkeeping and related institutions serve as enabling (i.e., leveraging) devices for large-scale exchange and a complex division of labor—i.e., they enable ''multiplier effects'' in network expansion (Wilson 1975, 11–13 and 569–570). These institutions are interdependent in that recordkeeping can be formalized via law and subsequently encouraged further by the emergence of complex production hierarchies that require more sophisticated control mechanisms (Rubin 2002, 100–104).

A major evolutionary achievement of humans is our ability to sustain large-scale cooperation through contracts, both implicit and explicit (Wilson 1998, 186–187). This outcome is due to unique culturally evolved economic institutions that support cooperative behavior and spread via social processes that are rooted in learning through imitation and knowledge transfer (Hayek 1979, 153–163). We view systematic recordkeeping as a culturally evolved economic institution that facilitates communication in complex exchange and division of labor.

New intra- and intergroup exchange opportunities are possible when a group grows in size; these likely enable a more complex division of labor if more complex coordination-sustaining institutions are available. North and Thomas (1973) and North (1990) provide powerful analyses of how economic institutions evolve to capture gains from trade and the division of labor. Accounting and auditing play important roles in this process (Seabright 2004, 147–149; North 1990, 106). More generally, a well-functioning property rights system requires that ownership be recorded when someone invests resources to develop or to improve an asset (de Soto 2000). Recordkeeping and accounting co-evolve with the scale of exchange, complexity in the division of labor, and changes in law and other economic institutions that sustain cooperation.

Most exchange-supporting institutions are virtually invisible in modern transactions because we take them so much for granted. To illustrate, suppose someone goes to the grocer and buys several pounds of meat for a weekend barbeque. The cost is $9 per pound and he pays with a credit card, which represents a promise to reimburse a third party within 30 days. The third party will directly pay the grocer and collect from the customer without involving the grocer further. Someone else likely produces and processes the meat (e.g., a farmer and a butcher) and an intermediary (e.g., American Express) assumes the risk that the customer will not pay. Credit providers, in turn, rely on credit history suppliers like Equifax when they issue credit cards. A transaction record such as a receipt will likely be helpful in *ex post* disputes—e.g., what happens if the meat is spoiled, one of the customer's

[14] The mnemonic value of recordkeeping suggests that records would likely be kept even in the absence of strategic interaction between self-interested parties. For instance, an individual alone in a desolate location might maintain records to aid in recall of past behaviors that increased food production. This is consistent with Defoe's (1719) fictionalized account of Robinson Crusoe.

guests dies, and the customer files a lawsuit against the grocer? And finally the transaction also requires definitions of terms like ''dollar,'' ''pound,'' ''day,'' and ''nine.''

Even simple exchange requires humans to have worked out basic matters like money, timekeeping, arithmetic, weights and measures, and means of dispute resolution when promises are not kept (Menger 1892).[15] These issues are usually resolved through the trial-and-error process that characterizes man's continual search for ''a better mousetrap.'' Further, this process usually occurs in several technologies simultaneously. That is, we do not work out the details of one institution before moving on to the next. Thus, innovation in exchange-enabling institutions likely coincides with expanded trade, urban development, specialized production, and improved information technologies. Economists have long understood that market and legal institutions co-evolve spontaneously over extended periods, even in the absence of explicit planning (e.g., Hume 1737; Ferguson 1767; Hayek 1979). In similar fashion, accounting and law have become intimately linked over several centuries (Simon 1965; Dickerson 1966).[16]

HYPOTHESES AND PREDICTIONS

We theorize that hard transaction records originate as reliable memory aids, which help foster extensive cooperation, division of labor, and impersonal exchange in large human social groups. The possibility of *ex post* disputes among transacting parties suggests that the initial recordkeeping technology subsequently co-evolves with other exchange-supporting institutions such as language, law, and measurement technologies. Thus, the core recordkeeping function of accounting, observed so early in human civilizations, is likely a critical institution that is needed to support complex economic exchange and division of labor.

This evolutionary theory has two main implications that can be tested statistically. The first is that organized records emerged to supplement mental memory that could no longer keep full track of past cooperative behavior. Thus, systematic recordkeeping will be more extensive when a group relies more on a specialized division of labor and complex exchange between strangers over time. A second implication is that formal recordkeeping, language, law, and other exchange-supporting institutions co-evolve and *feed back* to facilitate even more complex forms of exchange. That is, once systematic recordkeeping is in place, it will promote more extensive use of markets and greater specialization in production.[17]

Our evolutionary theory about recordkeeping origins provides a deeper and more nuanced perspective on the causal relation between economic organization and accounting institutions. Students are usually taught that both stewardship and valuation needs create a derived demand for accounting. By implication, accounting is seen to emerge as a by-product of the functioning of extant economic organizations and markets—that is, causality runs mainly from organizations and markets to accounting. Watts and Zimmerman (1986,

[15] Research in monetary economics hypothesizes a ''memory'' function for fiat money (Townsend 1989; Kocherlakota 1998). The intuition is that money allows for a direct measure of trustworthiness in exchange when exchange is modeled as a series of gifts that require reciprocation at a later date. The establishment of a reliable form of fiat money could thus reduce the need for recordkeeping. This theory suggests that early records such as tokens and tally sticks could have served an important monetary role.

[16] Recent accounting papers that recognize the spontaneous nature of accounting institutions include Ball (2001), Jamal et al. (2003, 2005), Basu (2004), and Barton and Waymire (2004).

[17] In addition, these subsequent economic innovations could lead to further accounting improvements. Clearly, some accounting innovations (e.g., double-entry bookkeeping) were adapted to more complex exchange and organization. However, such innovations occurred many thousands of years after humans had developed hard transactional records.

180) summarize this view when they suggest that managers ''demand management and debt contracts that restrict the actions that he or she can take as manager. This demand, in turn, produces a demand for accounting and auditing.''[18]

Our evolutionary theory reverses this causality by suggesting that modern organizations and markets would not be possible if humans had not devised the systematic recordkeeping technology that lies at the core of modern accounting. In other words, *the core recordkeeping technology of accounting is necessary for the emergence of complex exchange and the sophisticated markets and economic organizations that presently characterize advanced human economies*. Even though modern accounting is more complicated, systematic records promote bilateral trust by providing accountability in exchange. This view resonates with Sombart's (1919) theory that double-entry bookkeeping enabled capitalism; it is different from Sombart's theory, however, in that it asserts that the necessity of basic accounting records for complex human economic interaction is evidenced in human prehistory thousands of years ago.

ARCHAEOLOGICAL EVIDENCE ON ANCIENT MESOPOTAMIAN RECORDKEEPING

In this section, we first describe the origins of ancient Mesopotamian recordkeeping as a memory aid, and then analyze the correspondence between changes in Mesopotamian recordkeeping, economic coordination, and exchange-supporting institutions. Accounting scholars have previously described ancient Mesopotamian recordkeeping in highlighting accounting's prehistoric contributions to writing and human cognition (e.g., Keister 1963; Mattesich 1987, 1994; Mouck 2004). We add to this research by interpreting the Mesopotamian records in light of our coordination-based evolutionary account of recordkeeping's origins.

Mesopotamian Recordkeeping as a Mnemonic Aid

The earliest known use of systematic transaction records is in ancient Sumeria (the southern portion of Mesopotamia, an area in present-day Iraq) around 8000 B.C.[19] Table 1 summarizes Mattesich's (1994) chronology of the evolution of Mesopotamian recordkeeping from 8000 B.C. to 3000 B.C. The Sumerians devised ways to permanently record

TABLE 1
Five Phases in Mesopotamian Recordkeeping[a]

Period	Recordkeeping Technology
8000 B.C.	Plain clay tokens of various shapes
4400 B.C.	More complex incised tokens for manufactured goods
3250 B.C.	Sealed aggregation devices
3200 B.C.	Surfaces of envelopes impressed with each token to be enclosed and proto-Cuneiform
3100–3000 B.C.	Emergence of Cuneiform writing

[a] This table is adapted from Mattesich (1994, Appendix A).

[18] See also Beaver (1989, 5–6), Christensen and Demski (2003, 2–10), and Scott (2006, 11–13).

[19] Unless otherwise noted, our summary of Mesopotamian society is based on Saggs (1989), Diamond (1997), Snell (1997), Van De Mieroop (1999, 2004), and Roaf (1990).

transactions several millennia before they invented writing.[20] They began using stone and baked clay ''tokens'' between 8000 and 7500 B.C. to symbolically represent agricultural commodities that had been physically transferred. By 4000 B.C., complex incised tokens were used to signify manufactured goods (Nissen et al. 1993; Schmandt-Besserat 1995, 1996).

Shortly before 3200 B.C., tokens began to be sealed inside hollow clay balls (''*bullae*'') that protected against fraud by imprinting ''signatures'' of the transacting parties and witnesses (via seals) on the envelope's exterior (Figure 2).[21] The *bullae* were then baked, making the records permanent and difficult to alter. The *bullae* are ''hard,'' as defined by Ijiri (1975, 36), in that transactional data are recorded so that *ex post* it ''will be difficult for people to disagree.'' Over the next 200 years, the tokens also began to be impressed on the *bullae* exteriors, the hollow *bullae* gave way to solid tablets, and the token impressions were replaced first by pictographs (proto-Cuneiform) and finally Cuneiform writing (Figure 3).[22]

Archaeologists interpret the Mesopotamian token as a ''mnemonic device by which to handle and store an unlimited quantity of data without risking the damages of memory failure'' (Schmandt-Besserat 1995, 2100). In discussing Cuneiform writing, Vanstiphout (1995, 2190) notes that advantages of a written record include: (1) ''listing, which unburdens human memory,'' (2) ''classification, difficult in speech or memory when the unclassified mass of factual information is great and complex,'' and (3) ''reciprocal tabulation, which would be cumbersome when not visible or easily retrievable.'' Thus, the archaeological evidence suggests that the Mesopotamians' records originated to counteract human memory limitations in storing information about past events that are numerous, repetitive, and lack salience.[23]

Mesopotamian Recordkeeping, Exchange, and Economic Complexity

Permanent transaction records like the Sumerian tokens and Cuneiform tablets allow information to be stored and later interpreted, which can expand the scope and scale of economic activity even when a written language and number system are not universally understood. For example, shepherds could verify stewardship of their flock merely by breaking open the *bulla* and physically matching the tokens with the sheep brought back from pasture (Ifrah 2001). Consistent with this argument, major Sumerian recordkeeping innovations coincided with the emergence of agriculture, urban centers, and complex organizational structures (Schmandt-Besserat 1995, 2104). Cuneiform writing coincided with the emergence of business contracts between Sumerian families (Baskin and Miranti 1997, 29);

[20] While the Sumerian token system is the earliest known instance of structured recordkeeping, it may not be the first. Accounting records could have been kept even before a specialized recordkeeping medium (baked clay) was developed, but such records have not survived. For example, notches on bones and stones dating back 35,000 to 75,000 years ago could have served as economic records (Ifrah 2001, Chap. 4).

[21] The items shown in Figure 2 are from the Louvre Museum. The photo is available online at http://www.humanities-interactive.org/ancient/mideast.

[22] The photo is available online at http://www.nb.no/baser/schoyen/5/5.21/ms1717.jpg. The translation is from Nissen et al. (1993, 36–7).

[23] Virtually all surviving Cretan Linear B tablets (c. 1550–1250 B.C.) are accounting records in archaic Greek, and most surviving Incan quipus are thought to be tax records, providing further evidence that accounting recordkeeping is intimately tied to the origins of writing. Li et al. (2003) found incised signs on tortoise shells in ancient Chinese graves (c. 6600–6200 B.C.) that resemble later signs on pottery (c. 5000–4500 B.C.) and the first known Chinese writing on ''oracle bones'' (c. 1700 B.C.). Li et al. (2003) argue that the tortoise shell signs were used for early divination rituals. However, Li et al. (2003, Table 2) shows that the tortoise shells were often found with groups of black and/or white pebbles, which could have functioned like Mesopotamian tokens. Thus, we speculate that the tortoise shells could be Chinese equivalents of Mesopotamian *bullae*.

FIGURE 2
A *Bulla* Impressed with Witnesses' Cylindrical Seals and the Seven Tokens Contained Inside (removed and displayed in front)
Susa, Iran
Circa 3300 B.C.

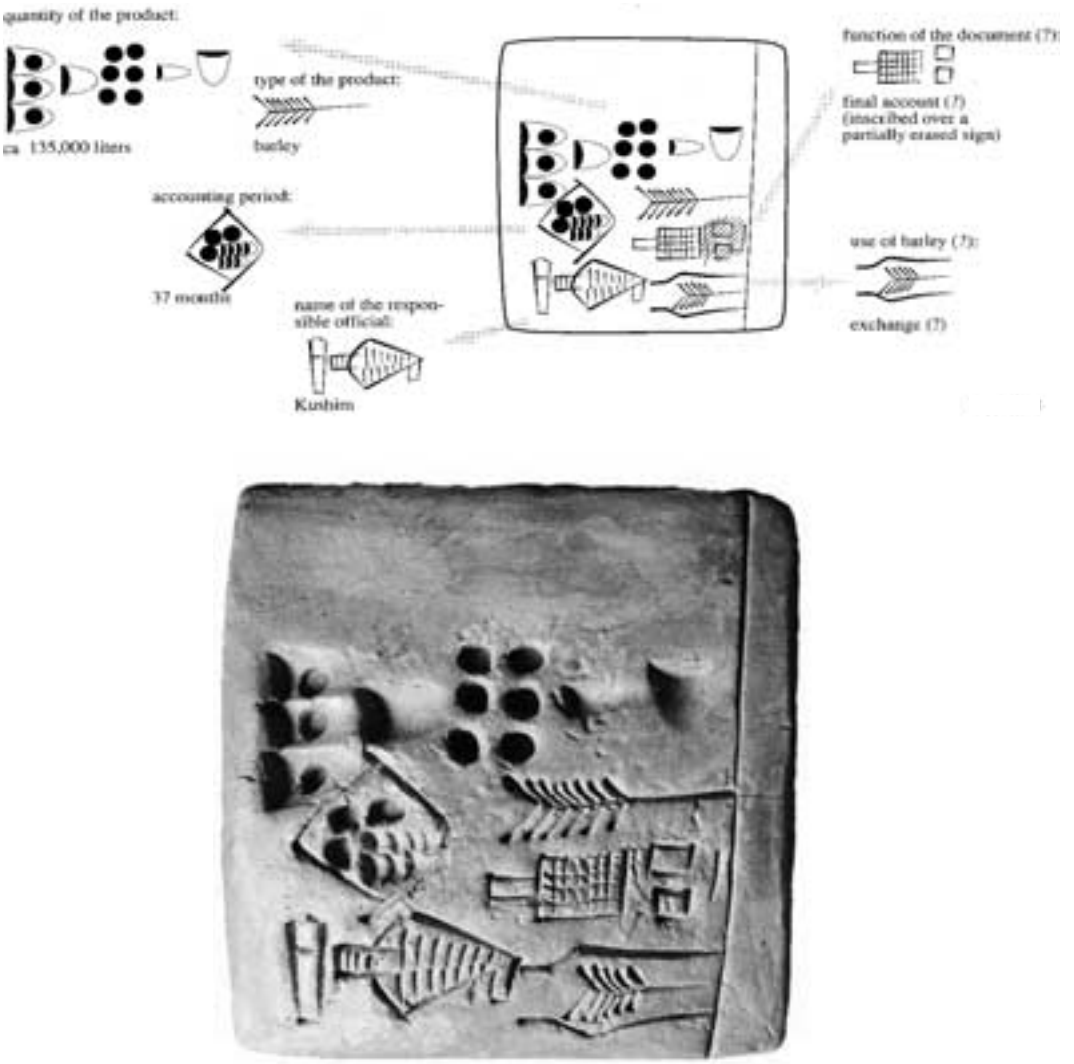
by 1800 B.C., the Assyrians had developed complex partnership agreements that reflect terms similar to a modern venture capital fund (Micklethwait and Woolridge 2003, 3).

The earliest known tokens are found in Sumerian sites that date back to 8000 B.C. The historical origin of the token system coincided with the appearance of agriculture and dramatic increases in the size of human settlements with communal storage of grains (Schmandt-Besserat 1996, 29–33). The first tokens appeared as part of a hierarchical society characterized by the redistribution of agricultural surplus (Schmandt-Besserat 1996, 101–110). Used tokens were destroyed in the season of plenty and feasts following the harvest (Schmandt-Besserat 1996, 30). One interpretation of this pattern is that the larger cooperative group ventures organized by a charismatic leader (i.e., a ''Big Man'') required individual contributions for community storage of grains or for feasts that helped cement good relations with neighboring groups.[24] Within this context, tokens could signify that individuals had contributed to the community (i.e., ''taxes'').[25]

[24] The first tokens were not associated with trade, which, when it occurred, likely took place in face-to-face barter interactions where obligations were immediately settled (Schmandt-Besserat 1996, 102). These data suggest that organized markets likely did not spring into existence instantaneously, but that intermediaries like religious leaders were needed to sustain early cooperative arrangements. Pollock (2004, 78–116) describes features of the tributary economies that likely characterized Mesopotamia before 4000 B.C.

[25] These last two sentences summarize a conversation with Professor Schmandt-Besserat in October 2005. They are only informed guesses because archaeologists cannot completely reconstruct the daily lives of people in ancient cultures. It is currently impossible to identify the exact context within which the tokens were created.

FIGURE 3
A Pictographic Tablet of Beer Production Records
Uruk, Iraq
Circa 3100 B.C.
The actual tablet dimensions are 6.8 × 7.2 × 1.9 cm.



Between 6000 and 5500 B.C., larger permanent human settlements became common in southern Mesopotamia. The first known city (Uruk) experienced dramatic growth between 3500 and 3100 B.C., coinciding with the period and location of the earliest known use of writing (Roaf 1990, 58–70; Van De Mieroop 2004, 13–28). This is also when large-scale irrigation is first observed, likely introduced by the first Mesopotamian kings and financed by taxation.

The farming estates of families, temples, and palaces were the primary organizations in Mesopotamian society. Agriculture requires that resources be committed long before crops are harvested, the yield depends on human labor inputs, and the harvest requires processing, distribution, and storage prior to consumption. Agricultural cooperation often relies on sharecropping, which involves exchanging manual labor for a share of the harvest. Agriculture involves complex trade over time, rather than a simple contemporaneous barter of goods, and requires that up-front labor and capital inputs be tracked and that the harvest be subsequently divided as stipulated in an initial agreement.[26] A verifiable transaction history that recorded what the parties had provided and their remaining obligations was necessary for this system to work effectively (Mattesich 1987).

A system of laws also evolved to deal with matters of property, contracts, and trade (VerSteeg 2000, 143–195), and formal transaction records came to be used extensively in legal dispute resolution (Saggs 1989, 172).[27] Recordkeeping and law became intertwined over the long term to enable a vast expansion in exchange made possible by intertemporal trade, spanning years in some cases. Intertemporal trade, especially over longer time intervals, is a characteristic of advanced human civilizations that distinguishes them from both simpler human groups and other animal groups (Figure 1).

To summarize, archaeological evidence suggests that systematic recordkeeping originated concurrently with agriculture and later co-evolved with the nature of exchange and other exchange-supporting economic institutions. Along with evidence indicating that Mesopotamian records served as memory aids, this evidence suggests that our theory is plausible and that the gathering of additional evidence is warranted.

EVIDENCE FROM EXPERIMENTS, ETHNOGRAPHIES, AND AGENT-BASED MODELS

In an empiricist's perfect world, we would replicate human history from the start numerous times to estimate how well our theory predicts actual events. Since this is impossible, we instead suggest different ways to study approximations of the theorized evolutionary process that led to the origin and subsequent evolution of recordkeeping. We first discuss direct tests of our predictions about Panels A and B in Figure 1 using laboratory experiments, ethnographic databases, and agent-based models. In the next section, we describe how researchers could explore theorized links between accounting and the human brain, language, and law. These tests explore links between recordkeeping and other institutions (Panels A and C in Figure 1).

Experimental economists study behavior in trust games (e.g., Berg et al. 1995; Fehr and Fischbacher 2003) and anthropologists have conducted trust game experiments in different small societies around the world (Henrich et al. 2004). Accounting researchers also use trust games to understand how trust and cooperation are promoted in different information environments (Towry 2003; Coletti et al. 2005). Experiments show that cooperation is enhanced by providing measures (''scores'') of a person's past cooperative behavior

[26] Intermediaries evolved to perform many of the more specialized production and distribution tasks (Van De Mieroop 2002). In general, sharecropping arrangements entail significant information asymmetry and risk bearing. These factors presumably have exerted first-order effects on the specifics of sharecropping contracts and other risk-sharing arrangements that extend well back in time (Townsend 1993).

[27] The Code of Hammurabi (c. 1750 B.C.) is the most famous of these Sumerian systems (Saggs 1989, 157–160). The Ur-Nammu law code from the reign of King Shulgi (c. 2050 B.C.) in Ur is the oldest written law code discovered so far, although an even older law code of King Uragakina of Lagash (c. 2350 B.C.) is referenced in subsequent Mesopotamian law codes.

(Wedekind and Milinski 2000). These experiments could be extended to assess how information about a person's past honesty affects reputation and trust formation and, more generally, how public availability of hard information, dispute resolution records, or other forms of public recordkeeping help engender trust in laboratory markets (e.g., Sunder 1992). Indeed, Dickhaut and McCabe (1997) propose that the importance of transactional records be studied with experiments.

Basu, Dickhaut, Hecht, Tafkov, Towry, and Waymire (2006) test our predictions experimentally using computerized extensions of the Berg et al. (1995) investment game. Exchange complexity is manipulated by altering the number of exchange dyads (one versus five) that an individual participates in simultaneously. Each exchange dyad consists of a trading pair analogous to a given buyer-seller combination. Basu, Dickhaut, Hecht, Tafkov, Towry, and Waymire (2006) find that a recordkeeping technology, when available, is used more often in complex exchange settings than in simple exchange settings. Actors in complex exchange settings obtain greater gains from trade when they can all keep records than when they are not allowed to keep records. The increased gains from trade in the complex/recordkeeping condition (versus the complex/non-recordkeeping condition) arise from recordkeeping's dramatic effects in spontaneously generating economic order through norms of reciprocity and punishments for departing from cooperative norms. Future research can extend these experiments to evaluate differences between private versus public records or of one-on-one versus open communication.

Our theory can also be tested by estimating how strongly recordkeeping quality is associated with the nature and volume of exchange and the division of labor in less-developed societies. Anthropologists have collected and collated ethnographic data on indigenous peoples for several decades. A major attraction of these less-developed societies from a research viewpoint is that they are likely to provide greater variation than is present in accounting and recordkeeping practices in modern nations, which have been greatly influenced by colonization. Some foundational questions that can be explored with ethnographic data include:

- How do primitive societies begin to define notions of accountability?
- What are the minimum recordkeeping system requirements for different levels of accountability?
- What influence do recordkeeping systems have on the extent of economic exchange and the division of labor?

Readily available sources of ethnographic data include the Human Relations Area Files (http://www.yale.edu/hraf) and the Standard Cross-Cultural Sample (SCCS) developed by Murdock and White (1969). Preliminary research indicates strong positive correlations between the extent of recordkeeping and various measures of economic, legal, and social complexity in the SCCS data (Basu, Kirk, and Waymire 2006).

An agent-based computer simulation can be used to study the accounting evolutionary process in an environment with memory-constrained participants (Gjerstad and Dickhaut 1998; Davis et al. 2003). Such agent-based models could help evaluate how effective memory of past exchange promotes the origin and evolution of impersonal exchange over long time periods, building upon prior simulations featuring limited memory (Bicchieri et al. 2004). This method can help study how quickly economic cooperation builds when different memory and recordkeeping systems are available, especially in a world of competing strategies. Game theoretic research using the solution concept of sequential reciprocity equilibrium (Dufwenberg and Kirchsteiger 2004) could complement these analyses.

Simulations could also ultimately provide insights into how accounting norms and principles emerge, utilizing a complex adaptive systems approach (e.g., Simon 1962).[28] The traditional bookkeeping cycle encapsulates how double-entry accounting has evolved by hierarchically combining and recombining basic transactional data. Initially freestanding transaction records were first organized sequentially in journals, then cross-tabulated into accounts in ledgers, and ultimately aggregated in different combinations to produce quantified reports on different aspects of organizational performance. We believe that relatively unexploited agent-based simulations can help test dimensions and identify processes underlying our accounting evolution theory.

ACCOUNTING AND THE HUMAN BRAIN, LANGUAGE, AND LAW

In this section, we analyze a few links between recordkeeping (Panel A in Figure 1) and other exchange-supporting institutions (Panel C in Figure 1), and suggest alternative methods to test the resulting predictions. We theorize how recordkeeping, and more broadly accounting, co-evolves with the human brain, language, and law.

Accounting and the Human Brain

Our theory that memory constraints played a central role in accounting's origins raises several issues that would otherwise not be evident. We hypothesize that transaction records are created outside the brain when the mind is strained by the need to remember details of all past exchanges. The creation of external data storage systems permits the accurate storage of vast amounts of information (Donald 1991; Mouck 2004). These data storage systems likely parallel the brain's memory system in their design, because using a similar design would likely impose less cognitive costs on a mind that has co-evolved with the mental memory system. If this hypothesis is correct, then the structure of ''designed'' accounting recordkeeping systems should correspond to the evolved structure of memory within the human brain.[29]

A modern accounting system classifies and cross-tabulates transactions on multiple dimensions, and permits aggregation of multiple transactions on chosen dimensions. This organization eases the discovery of patterns between different events, similar to the brain's search for patterns in memory. While classification helps us simplify and make sense of a complex world, it also feeds back to influence how we perceive the world through consciousness (e.g., Hayek 1952). Mental classifications are encoded in language labels, so language should affect perception (the Sapir-Whorf hypothesis). Gilbert et al. (2006) show experimentally that language affects color perception much more in the left brain, which processes language, than the right brain, partially confirming these hypotheses. Thus, the evolving design of accounting systems likely reflects a bi-directional causality: accounting reflects economic actions and, more subtly, affects how human brains have evolved to analyze environmental data in making decisions.

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[28] GAAP is clearly a complex hierarchical system. Simon (1962) argues that the evolution of complex systems, in both nature and culture, is facilitated by hierarchically combining stable subsystems or building blocks that have adapted to the environment. In Simon's (1962) analysis, the emergence of better-adapted complex assemblies from stable-adapted subsystems is a rare event, and is more likely to occur if new raw materials or technologies become available in the environment. Successful stable innovations then diffuse through reproduction and imitation. This complex adaptive system approach could help evaluate competing historical hypotheses about critical events that led to major accounting innovations.

[29] We are especially grateful to John Dickhaut for several conversations that have helped us more clearly see possible links between accounting and the neural basis for economic decision making.

Most developed accounting systems standardize measurement conventions to facilitate systematic recordkeeping (Ijiri 1975). Human intelligence likely generates innovations in measurement technology as well as identification of measurement units for previously non-quantified attributes. An open question is whether the standardized measurements needed for more advanced recordkeeping alter the terms of exchange by preferentially changing or focusing the trading parties' attention on quantifiable attributes. This seems likely since Kadous et al. (2005) find that quantification can significantly affect how much people rely on disclosed information.

Cosmides and Tooby (2005) review the accumulated neurocognitive adaptations in the human brain that facilitate social exchange, including modules for cheater detection, reasoning, language, etc. Several recent studies show concordantly that human brain structure is related to our genomic heritage, and that genes affecting the brain are likely still evolving.[30] It is conceivable that recordkeeping needs and benefits have culturally selected for neurocognitive mechanisms that are detectable in human brain structure relative to other animals, as well as in the genes involved in brain structure and functioning. For example, we know that the need to quantify in economic recordkeeping led to improved symbolic representation of different amounts, which could affect brain function and the underlying genetics of the human brain.

Human decision-making based on accounting data can be studied with the physiological measurement technologies used in the emerging area of ''neuroeconomics'' (for reviews, see Chorvat and McCabe 2004; Zak 2004; Camerer et al. 2005). At a general level, we can envision analyses of how the nature and extent of exchange is influenced by informational technologies ranging from the abacus to electronic data storage and artificial intelligence. Ultimately, neuroimaging technologies such as brain scans may yield physiologically based measures of trust that can be linked with measures of accounting information hardness and credibility. In particular, these technologies may, in the long run, yield fundamental insights into how evolved accounting principles like Conservatism, Objectivity, and Matching yield quantitative information that enables trust in impersonal reciprocal exchange.

One implication of a possible link between accounting and the human brain is that ''longstanding'' accounting principles are longstanding because they parallel an evolutionary adaptation, i.e., accounting principles reflect how the human brain processes information and reaches decisions using methods that increased ancestral chances of survival and procreation. For instance, an evolutionary advantage likely accrued to those who remembered behaviors that aided survival in ancient environments after infrequent bad events such as floods and famines. If the human brain responded by (unconsciously) weighting bad surprises more heavily than good surprises in memory storage and processing, then this could provide the ultimate explanation for why accounting income today reflects bad news more quickly than good news.[31] Similarly, is the historical cost principle explained by the human brain's greater reliance on learned facts than hypothetical counterfactual scenarios in predicting future events? While these ideas may seem far-fetched today, we believe future research will likely produce insights into how the evolution of accounting as a specialized

[30] Evans et al. (2005) and Mekel-Bobrov et al. (2005) document that two genes causing primary microencephaly, a condition in which the brain is severely reduced in size, have continued to evolve via natural selection until very recently. They estimate that favorable mutations or alleles that arose as recently as 37,000 years ago (about the time of the explosion of symbolic behavior represented in European cave paintings), and 5,800 years ago (just before cities arose in the Near East) have spread widely through modern human populations.

[31] Zak (2004, 1742–1743) reviews recent neuroeconomic experiments that find that gains and losses are processed in different brain regions.

information storage and retrieval system contributed to humans' shared neurocognitive and genetic heritage.

Accounting and Language

Our analysis suggests avenues for exploring the relation between accounting and language. Virtually every financial accounting textbook has an obligatory sentence claiming that accounting is ''the language of business.'' Accounting scholars have mostly ignored the relation between accounting and language; Ijiri (1975, 14–16) is a notable exception. However, Stecher (2005) has recently analyzed the implications of accounting as a shared business language that facilitates trade. Considerable opportunities likely exist to empirically apply linguistic analysis to ascertain what distinguishes accounting from other languages and to discover what has made accounting uniquely customized to business use.

Accounting scholars could explore linguistic journals and import some of their analyses into accounting research. For instance, Core (2001, 452–453) suggests using natural language-processing techniques to develop cheaper and better measures of disclosure quality. Accounting scholars could also identify and systematize accounting grammar (e.g., the implicit rules for distinguishing between the correct and incorrect forms of a generic journal entry).

Since writing likely originated from recordkeeping, we recommend serious examination of the hypothesis that accounting and exchange needs led to spoken language. Infants communicate their food and comfort wants by screams, and toddlers typically first learn the names for comfort providers (mama, papa) and milk as they begin to distinguish ''self'' from others. Soon thereafter, they learn terms for control and property rights such as ''no'' and ''mine,'' and then learn terms such as ''give,'' ''take,'' and ''share'' that represent different forms of exchange and social interaction (e.g., Piaget 1936; Greenspan and Shanker 2004). These terms suffice for the simplest economic communication and transaction records. If accounting was one of the earliest languages to emerge in most societies, then a ''universal grammar'' of accounting, if it exists, would likely be very important to linguists seeking to understand the origins of language (e.g., Chomsky 1995). One way to explore these issues is to conduct experiments examining exchange and accounting reasoning in children at differing developmental stages (Harbaugh et al. 2003).

More importantly, analysis of the successes and failures of languages has implications for how we think about accounting standard setting. The English language has become the commercial language worldwide, despite not having standard setters. In contrast, the French have appointed language guardians, the Académie française, but the French language appears to be losing market share. Children learn to use language grammatically at an early age, even though they cannot formally describe the ''tacit knowledge'' they employ (Hayek 1948; Polanyi 1958; Tomasello 2004). Languages change continuously as users introduce new coinages and drop old locutions without any oversight. Why, if at all, does accounting as a business language require explicit regulation, whereas other older and more widespread languages do not?

Accounting and Law

Accounting's most basic recordkeeping function could be better understood by exploring how arbitration and court trials have historically set evidentiary rules as to the recordkeeping medium, the format of records, witnessing, and other safeguards to preserve data fidelity. Accounting records were used to resolve legal disputes in ancient times. For instance, the Code of Hammurabi (c. 1750 B.C.) specifies how receipts must be obtained and

used as evidence of consignment (¶ 104–107), as well as how contracts and witnesses can be used in proceedings before judges (¶ 122–124).[32] In that era, someone who failed to pay a legal debt could be sold into slavery or have a family member taken as a ''debt-hostage'' (VerSteeg 2000, 35–39). By the middle of the third century B.C., the Athenians maintained public archives of financial records, accounts, lease contracts, and wills (Sickinger 1999, 122–134), which could be and were used in legal dispute resolution. The archaeological evidence suggests that courts have historically considered recordkeeping requirements to be important, and that accountants likely pay attention to legal evidentiary rules when designing accounting systems.

The links between law and recordkeeping extend to modern times. Legal recordkeeping requirements in France evolved over several centuries to preserve integrity in the accounting records submitted as evidence in court cases (Howard 1932). Similar laws existed in 19th century Germany (Littleton 1953, 84) and in the 20th century United States (Shannon 1951, 98–130).[33] More recently, U.S. courts have ruled that inadequate recordkeeping provides no defense in product liability cases (*Kozlowski v. Sears, Roebuck,* 73 F.R.D. 73 D. Massachusetts, 1976), and section 1102 of the Sarbanes-Oxley Act of 2002 establishes penalties of fines and imprisonment for tampering with the transactional records of a firm subject to U.S. federal securities laws.

As recordkeeping has evolved from paper to electronic digital databases over the last half century, questions naturally arise about whether and how evidentiary doctrines changed in response. For example, have weaknesses in data fidelity, as identified by forensic accountants, changed data storage protocols for accounting records? Also, how do the recent Sarbanes-Oxley rules on data standards relate to weaknesses identified in electronic recordkeeping (e.g., hacking of computer databases by remote strangers or identity theft)?

Related research questions can also be investigated with historical data—for example, what are the different bodies of law that influence accounting records, and how have these changed along with accounting? Fiduciary law, tax law, and bankruptcy law have all likely contributed to standards for record maintenance. In a broader sense, what is the optimal length of time to maintain records, and how do the legal standards for ''good'' accounting differ from economic or other standards for evaluating recordkeeping quality?

Bankruptcy law has exerted a major historical impact on accounting and auditing practice. The term ''liquidation value'' for assets derives from the law that governs financial statement preparation in bankruptcy. The first British auditors worked as professional experts in bankruptcy and liquidation proceedings, and professional audit firms like Price Waterhouse originated in this manner (Littleton 1933, 259–287). The first mercantile credit and bond-rating agencies were set up following large financial crises, and financial ratio analyses were first used in attempts to predict bankruptcy (Horrigan 1968). The economic history of bankruptcy and financial crises and their effect on accounting practice are thus

[32] The translation of the Code of Hammurabi by L. W. King (1910) can be found at: http://eawc.evansville.edu/anthology/hammurabi.htm and http://www.wsu.edu/~dee/MESO/CODE.HTM.

[33] Kester (1930, 148) describes the evidentiary function of complete and accurate recordkeeping. When testifying in U.S. courts, the professional accountant is likely to face a legal counsel who ''expects from the accountant a familiarity with his evidence and the underlying records which approaches perfection'' (Hoffman 1952, 435), and the evidence sought by the court ''will include the name of the ledger, journal, report or other record, the page number if any, the date, if it is a transaction, and possibly the name of the person who prepared the record'' (Hoffman 1952, 439).

important areas for research.[34] In particular, researchers could examine how bankruptcy rates have affected the development of basic accounting principles like Objectivity, Conservatism, and Going Concern.

Law also influenced accounting evolution more broadly through the use of legal reasoning in developing U.S. accounting education and standards. Early U.S. textbooks like Hatfield (1927) cite case law precedents when arguing for an accounting procedure, and others like Briggs (1931) show how English and American court decisions shaped the accountant's professional responsibilities. Although modern auditing textbooks still survey recent case law, current financial accounting textbooks only recite the codified accounting standards issued by the FASB and its predecessors. This shift in coverage probably reflects our ignorance about how accounting practices evolve spontaneously in response to new legal precedents. Internal data on how major accounting firms factor in legal decisions when advising their clients could yield insights into how GAAP takes shape long before FASB codification. More broadly, research on how inductive legal reasoning has historically influenced accounting policy development could inform the recent reconsideration of principles-based accounting standards.[35]

TOWARD A SYSTEMATIC UNDERSTANDING OF ACCOUNTING EVOLUTION

Our goal is to explicate the evolutionary role of systematic recordkeeping that is the core of modern accounting. We argue, relying on recent research in the social and biological sciences, that the ability to communicate with others and recall past encounters enables cooperation in small human and animal groups. Recordkeeping, along with language, law, and other technologies, subsequently evolves to promote trust and enable significant expansions in the scale and complexity of human economic exchange and division of labor (Figure 1). Seen in broad terms, hard recordkeeping technology is fitness-enhancing because it enables human societies to generate greater resources through cooperative economic organization. If ultimately supported with empirical evidence, an evolutionary perspective can improve our understanding of how the core recordkeeping function of accounting has improved the human condition.

Documenting and tracing the links between accounting innovations and changes in the extent and nature of exchange, culture, and biology will thus help us identify the role accounting plays in the edifice of human achievement. While we only analyze the origins of hard external records, a co-evolutionary perspective can likely improve how we interpret the subsequent evolution of accounting with its numerous recent innovations. Within the timescale of Figure 1, we focus in this paper on changes in recordkeeping beginning with the agricultural revolution that took place 10,000–12,000 years ago and extending forward over the next few thousand years. We claim that hard external records supplemented soft mental memory and opened up new exchange possibilities. The reduced memory load made possible by expanded external records likely enabled rapid cultural innovation and reallocation of brain capacity as memory became increasingly stored in cultural artifacts such as

[34] Wars also likely generate accounting innovation. Extensive recordkeeping often accompanies war since major warfare requires massive coordination of resource flows across space and time. We expect that considerable accounting innovation occurs during wartime as well as during the subsequent return to peaceful conditions. Anecdotal evidence suggests that this was the case for the U.S. around the time of both World Wars (Previts and Merino 1998). Warfare and related policies clearly can exert first-order effects on population genetics through group selection (Wilson 1975, 572–574).

[35] Littleton (1953, Chap. 11) describes inductive approaches to accounting theory. The landmark Paton and Littleton (1940) monograph uses induction to lay out a basis for historical cost income measurement based on revenue realization and expense matching. Pre-FASB U.S. standard setting followed an inductive process that codified evolved practice into GAAP (Sunder 2005).

written texts. Modern historical cost accounting records embody the memory of past transactions and are, thus, a fundamental leveraging technology for human progress. We strongly urge further research that elaborates the relative advantages and disadvantages of historical cost compared to other measurement approaches taking explicit account of the evolved structure of the human brain.

We propose that a co-evolutionary perspective can be applied profitably to other major episodes in accounting history, such as the emergence of double-entry bookkeeping at the beginning of the Renaissance and of cost accounting systems with the industrial revolution (i.e., a finer division of human history, especially the most recent few thousand years). Such research is important because it could shed new light on the bidirectional causality that underlies the relation between accounting innovations and modern organizations and markets.

More generally, we advocate increased attention to accounting's evolutionary foundations in future research. Such research will embrace theory and methods from multiple disciplines to delineate more clearly the impact of recordkeeping and accounting on human biology, culture, and institutions. Tinbergen's (1963) conceptual framework can guide this ethological inquiry (involving study of animals in their natural environment). Tinbergen (1963) asserts that a complete evolutionary explanation for some trait of a species requires understanding how the trait (1) is structured and why it works as it does, (2) arises in the course of an individual's development, (3) is phylogenetically evolved from other species, and (4) fulfills a function that has resulted from natural selection. Answering Tinbergen's four questions for accounting will provide a far richer understanding of accounting's important role in the evolution of *Homo sapiens sapiens*.

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