### ECONOMIC HISTORY AND GAME THEORY

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Abstract

This paper surveys the small, yet growing, literature that uses game theory for economic history analysis. It elaborates on the promise and challenge of applying game theory to economic history and presents the approaches taken in conducting such an application. Most of the essay, however, is devoted to studies in economic history that use game theory as their main analytical framework. Studies are presented in a way that highlights the range of potential topics in economic history that can be and have been enriched by a game-theoretical analysis.

Keywords

economic history, institutions

JEL classification: C7, N0
1. Introduction

Since the rise of cliometrics in the mid-60s, the main theoretical framework used by economic historians has been neo-classical theory. It is a powerful tool for examining non-strategic situations in which interactions are conducted within markets or shaped by them.\(^1\) Game theory enables the analysis to go further by providing economic history with a theoretical framework suitable for analyzing strategic, economic, social, and political situations. Among such strategic situations are: economic exchange in which the number of participants is relatively small, political relationships within and between states, decision-making within regulatory and other governmental bodies, exchange in the absence of impartial, third-party enforcement, and intra-organizational relations. Such situations prevail even in modern market economies and were probably even more prevalent in pre-modern economies.

Furthermore, game-theoretic insights have provided support to the economic historians' long-held position that history matters. While neo-classical economics asserts that economies identical in their endowment, preferences, and technology will reach the same equilibrium, economic historians have long held that the historical experience of various economies indicates the limitations of this assertion. Game theory augmented this position by providing a theoretical framework whose insights reveal a role for history in economic systems. Game theory points, for example, to the potential sensitivity of outcomes to rules and hence to institutions, the possibility of multiple equilibria and hence the potential for distinct trajectories of institutional and economic changes, the crucial role of expectations and beliefs and hence the potential importance of the historical actors, and the possible role of evolutionary processes and change in equilibrium selection. In short, game theory indicates that within the framework of strategic rationality, different historical trajectories are possible in situations identical in terms of their endowment, preferences, and technology.\(^2\)

Applying game theory to economic history can also potentially enrich game theory. History contains unique and, at times, detailed information regarding behavior in strategic situations, and thus it provides another laboratory in which to examine the relevance of the game-theoretic approach and its insights into positive economic analysis. Furthermore, historical analyses guided by game theory are likely to reveal theoretical issues that, if addressed, would contribute to the development of game theory and its ability to advance economic analysis.

This essay surveys the small, yet growing, literature that employs game theory in economic history. Section 2 briefly elaborates on the promise and challenge of applying game theory to economic history and presents the approaches taken in conducting such applications. Section 3 presents studies in economic history that either utilize

\(^1\) On the Cliometric Revolution, see Williamson (1994). Hartwell (1973) surveys the methodological developments in economic history. For the many contributions generated by the neo-classical line of research in economic history, see McCloskey (1976). For recent discussion, see the session on “ Cliometrics after Forty Years” in the AER 1997 (May). I further elaborate on these issues in Greif (1997a, 1998a).

\(^2\) See Greif (1994a) for such a comparative game-theoretic analysis of two late medieval economies.
game theory as their main analytical framework or examine the empirical relevance of game-theoretical insights. This section contains two sub-sections. The first discusses economic history studies that use only general game-theoretical insights to guide the analysis. The second discusses economic history studies that use a context-specific game-theoretic model as their main theoretical framework. In either sub-section the studies are presented according to the issues they examine in economic history.

Clearly, it is impossible to elaborate on a myriad of papers in such a short essay, so a brief description of each paper is provided with only a few described in detail. Their (subjective) selection is influenced by their relative complexity, methodological contribution, or representativeness. Finally, since the goal of this essay is to survey applications of game-theoretical analysis to economic history, it does not systematically evaluate their arguments (although references to published comments on papers are provided).

2. Bringing game theory and economic history together

Economic history can benefit greatly from a theory enabling empirical analysis of strategic situations since issues central to economic history are inherently strategic. For example, economic history has always been concerned with the origin, impact, and path dependence of non-market economic, social, political, and legal institutions. Indeed, this concern with non-market institutions logically follows from Adam Smith’s legacy and the neo-classical economics which often identify the rise of the modern economic system with the expansion of the market system. This view implies, however, that an analysis of non-market situations is required to understand past economies, their functioning, and why some of them, but not others, transformed into market economies. Hence, a theoretical framework of strategic, non-market situations can expand our comprehension of issues central to economic history.

The ability of game theory – the existing theoretical framework for analyzing strategic situations to advance an empirical and historical study – should be judged empirically. Yet, certain conclusions of game-theoretical analysis make its application to economic history both challenging and promising. Game theory indicates that outcomes in strategic situations are potentially sensitive to details, that various equilibrium concepts are plausible, and (given an equilibrium concept) multiple equilibria may exist. Thus, applying game theory to economic history may be challenging since economic history is, first and foremost, an empirical field and economic historians are trying to understand what has actually transpired, why it transpired, and to what effect. One may argue that a theoretical analysis, whose conclusions regarding outcomes are non-robust

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3 For a discussion of the methodological differences between economic history and economics, see Backhouse (1985, pp. 216-221). For institutional studies during the nineteenth century in the German and English Historical Schools, see, for example, Weber (1987 [1927]), Cunningham (1882). On the general theory of path dependence see David (1988, 1992). See also Footnote 1.
and empirically inconclusive (in the sense that many outcomes are consistent with the theory), provides an inappropriate foundation for an empirical study.

Interestingly, however, the game-theoretical conclusions regarding non-robustness and inconclusiveness are in accordance with the conceptual foundations of historical analysis – namely, that outcomes depend on the details of the historical context, that “economic actors” can potentially matter, and that the non-economic aspects of the historical context, such as religious precedents or even chance, can influence economic outcomes. Game theory provides economic history with an explicit theoretical framework that does not lead to the ahistorical conclusion that the same preferences, technology, and endowments lead to a unique economic outcome in all historical episodes. The conclusions of game-theoretical analysis that challenge its empirical applicability make it a particularly promising theory for historical analysis since it can be used for analyzing strategic situations in a way that is sensitive to, and reveals the importance of, their historical dimensions.

Studies in economic history that use game theory have differed in their responses to the challenge and promise presented by the potential non-robustness and inconclusiveness of game-theoretical analysis. They all began with a historical study aimed at formulating the relevant issue to be examined. They used general game-theoretical insights – such as the possibility of coordination failure, the importance of credible commitment, or the problem of cooperation in a multi-person prisoners’ game situation – to “frame” the analysis, that is to say, they explicitly specify the issues needing to be addressed, provide an organizing scheme for the historical evidence, or highlight the logic behind the historical evidence. Some studies went so far as to undertake a game-theoretic analysis of various issues and they responded to the non-robustness and inconclusiveness problems in one of two (not mutually exclusive) ways.

Some studies responded to the non-robustness and inconclusiveness by basing the historical analysis only on those game-theoretic insights that are conclusive and robust. The empirical investigation was thus guided by generic insights applicable in situations with such features. An example of such general insights would be that bargaining in the presence of asymmetric information can lead to negotiation failure. Reliance on general insights comes at the cost of limiting the ability to empirically substantiate a hypothesis. Without an explicit model it is difficult to enhance confidence in an argument by confronting the details of the historical episode with the details of the theoretical argument and its implications. In particular, without specifying the strategies employed by the players, it is difficult to empirically substantiate the analysis. Yet, the potential benefit of relying on general insights is the ability to discuss important situations without being constrained by the ability to explicitly model them.

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4 See, for example, North ([1981], Chapter 3) and Kantor (1991). “The power of game theory – and it’s the way I’ve used it – is that it makes you structure the argument in formal terms, in precise terms…” [North (1993), p. 27].

5 For a somewhat similar approach in the Industrial Organization literature, see Sutton (1992).
Other studies found it useful to confront non-robustness and inconclusiveness differently. A detailed empirical study of the historical episode under consideration was conducted and it provided the foundation for an interactive process of theoretical and historical examination aimed at formulating a context-specific model that captured an essence of the relevant strategic situation. This interactive historical and theoretical analysis sufficiently constrained the model's specification, basing it on assumptions in which confidence can be gained independently from their predictive power, and ensured that the analysis did not impose the researcher's perception of a situation on the historical actors. The resulting context-specific model provided the foundation for a game-theoretical analysis of the situation whose predictions could be compared with the historical evidence. At the same time, the model extended the examination of the extent to which its main conclusions are robust with respect to assumptions whose appropriateness is historically questionable. In short, these studies confronted non-robustness and inconclusiveness by utilizing a context-specific model. Such models enhance "general insight" analysis by generating falsifiable predictions, as well as the ability to check robustness and to gain a deeper understanding of the issues under consideration. Yet, despite these advantages, analysis based on a context-specific model is restricted to cases where such models can be formulated.

Economic history studies utilizing a game-theoretic, context-specific model mostly utilized two basic equilibrium concepts: Nash equilibrium and sub-game perfect equilibrium. These two concepts have the advantage of including most other equilibrium concepts as special cases, as well as having intuitive, common-sense interpretations. Using these inclusive equilibrium concepts implies, however, that multiple equilibria are more likely to exist and the analysis is more likely to be inconclusive. In other words, it amplifies the two problems for empirical historical analysis associated with inconclusiveness, namely, identification and selection. Studies have differed in their responses to these problems.

Some studies, whose aim was to understand the logic beyond a particular behavior, considered the analysis complete when they revealed the existence of an equilibrium corresponding to that particular behavior. They did not aspire to substantiate that the behavior and expected behavior associated with that particular equilibrium were those that prevailed in the historical episode under consideration. If they attempted to account for cooperation, for example, they were satisfied with arguing that an equilibrium entailing cooperation existed. By and large, they neither tried to substantiate that this particular equilibrium – rather than another one entailing cooperation – indeed prevailed,

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6 Clearly, the essence of the issue that is captured should be both important and orthogonal to other relevant issues.
7 For example, the King of England, Edward the First, noted in 1283 that insufficient protection to alien merchants' property rights deterred them from coming to trade. His remark enhances the confidence in the relevance of a model in which commitment to alien traders' property rights can foster their trade [Greif et al. (1994)].
8 For an introduction to these concepts, see, for example, Fudenberg and Tirole (1991) or Rasmusen (1994).
nor did they examine how this equilibrium was selected or compare their analysis with a possible non-strategic account for cooperation. In other studies the need to identify a particular strategy was avoided by concentrating on the analysis of the set of equilibria. This approach was adopted particularly in studies that examined the impact of changes in the rules of the game on outcomes.

In other cases when the argument revolved around the empirical relevance of a particular strategy, the problem of identification was confronted by employing direct and indirect evidence to verify the use of this particular strategy (or some subset of the possible equilibrium strategies with particular features). Direct evidence of the historical relevance of a particular strategy is explicit documentary accounts reflecting the strategies that were used, or were intended to be used, by the decision-makers. Such explicit documentary accounts are found in such diverse historical sources as business correspondence, private letters, legal procedures, the constitutions of guilds, the charters of firms, and records of public speeches.

Clearly, statements about intended courses of action can be just talk, but indirect evidence can enhance confidence in the empirical relevance of a particular strategy. Indirect evidence is an empirical confirmation of predictions generated under the assumption that a particular strategy was employed. The predictions generated by various economic history studies utilizing game theory cover a wide range of variables, such as price movements, contractual forms, dynamics of wealth distribution, exits, entries, price, and various responses to exogenous changes. In some studies it was possible to test these predictions econometrically but in others, because of the nature of their predictions, such tests could not be performed. For example, the analysis of labor negotiation presented in Treble (1990), as discussed below, predicts that labor disputes should be a function of bargaining procedures. Because different procedures were in effect in the historical episode under consideration, this prediction could have been examined econometrically. The analysis in Greif (1989), which is also discussed below, predicts that traders' social structures should be a function of the strategy merchants used to punish an overseas agent who cheated a merchant. The analysis predicts in particular that a strategy of collective punishment would lead to a horizontal social structure in which traders would serve as both merchants and agents. While this prediction can be objectively verified, it cannot be econometrically tested. The advantage of confirming predictions based on an econometric test is that this test provides a significance level. Such analysis, nevertheless, is restricted only to issues that generate econometrically testable predictions. But one can increase the confidence in a hypothesis also by comparing its predictions – without using econometrics and hence having a significance level – with predictions generated under alternative hypotheses.

9 See, for example, Greif et al. (1994), particularly Proposition 1.
10 E.g., Milgrom et al. (1990); Greif et al. (1994).
11 For an example of the extensive use of such evidence, see Greif (1989).
So far, economic history has studied the problem of equilibrium selection entailed by multiple equilibria in a way that has been influenced more by the conceptual foundations of historical analysis rather than by game-theoretical literature dealing with refinements or evolutionary game theory. Most authors accounted for the selection of a particular equilibrium by invoking aspects of the historical context. One paper cited the public commitment of Winston Churchill to a particular strategy as being fundamental in the selection of a particular equilibrium.\footnote{Maurer (1992).} Other papers pointed out that factors outside the game itself had influenced equilibrium selection. Among these were immigration that provided information networks, political changes that determined the initial set of players, and focal points provided by religious and social attitudes.\footnote{E.g., Greif (1994a).} Some authors, particularly those interested in comparing two historical episodes, theoretically identified the range of parameters or variables that were required for one particular equilibrium to prevail rather than another. This theoretical prediction was compared with the empirical evidence regarding these variables in the historical episodes under consideration.\footnote{E.g., Rosenthal (1992); Greif (1994a); Baliga and Polak (1995).}

3. Game-theoretical analyses in economic history

This section presents studies in economic history that use game theory. In line with the above discussion of the methodology employed by such studies, they are grouped according to those that use “generic insights” (Section 3.1) and those that use “context-specific models” (Section 3.2). In both sub-sections the presentation is organized by historical topics but it implicitly suggests the potential benefits of economic history studies using game theory to further empirical evaluation and to extend various aspects of the theory itself. I will return to this issue later in the section. Space limitation precludes a detailed examination of all the papers in either section. But to illustrate the methodological differences between the papers in the two sub-sections, I will provide a somewhat longer presentation of a study [Greif (1989, 1993, 1994a)] that uses a context-specific model.

3.1. The early years: Employing general game-theoretical insights

The first economic history papers that used general insights from game theory were published in the early 1980s. They examined such topics as regulations, market structure, and property-rights protection. As for their game-theoretic method, they used nested games, a situation in which the rules of one game are the equilibrium outcome of another game. Furthermore, they provided empirical evidence of problems encountered...
in bargaining under incomplete information and suggested that off-the-path-of-play ex-
pected behavior might indeed influence economic outcomes, as formalized in the notion
of sub-game-perfect equilibrium.

Regulations: Economic historians have for a long time emphasized the importance of
the historical development of regulatory agencies and regulations in the US. Davis and
North (1971), for example, argued that regulations were a welfare-enhancing process of
institutional changes driven by the potential profit from regulating the economy. In con-
trast, using a game-theoretical analysis of endogenous regulations, Reiter and Hughes
(1981) have argued that the process was not necessarily welfare-enhancing. In their for-
mulation, economic agents and regulators are involved in a non-cooperative dynamic
game with asymmetric information in which the regulators pursue their own agendas.
To advance their agendas, they are also involved in a cooperative game with political
agents in which they try to influence the political process through which the next pe-
riod’s legal and budgetary framework of the non-cooperative game is determined. While
Reiter and Hughes did not attempt to explicitly solve the model, it provided them with
a paradigm to discuss the emergence of the “modern regulated economy” as reflecting
redistributive considerations, efficiency-enhancing motives, and political factors.

Interestingly, around the same time David (1982) combined cooperative and non-
cooperative game theory in the opposite direction to examine “regulations” associated
with the feudal system. His analysis used the Nash bargaining solution to examine trans-
fers from peasants to lords of the manor. This analysis was incorporated within a broader
game in which the feudal system itself reflects an equilibrium of the repeated game be-
tween peasants and a coalition of lords.

Eichengreen (1996) used game theory to examine the regulations that, according to
his interpretation, were crucial to Europe’s rapid post-World War II economic growth.
The basic argument is inspired by the concept of sub-game perfection. Following the
war there was a very high return on capital investment, but inducing investment required
that investors were assured that ex post, after they had made a sunk investment, their
workers would not hold them up and reap all the gains. At the same time, for workers
not to find it optimal to act in this way they had to be assured that in the long run they
would gain a share in the implied economic growth. Credible commitment by workers
and investors alike was made through state intervention. The state acted as a third-party
enforcer of labor relationship regulations and social welfare programs that ensured a
sufficiently high rate of return to investors and workers alike.

Market structure: A market’s structure is fundamental in determining an industry’s
conduct and performance. Traditionally, economic historians have not considered that
the structure of a market can be influenced by strategic interactions. Yet Carlos and
Hoffman (1986) argued that strategic considerations determined the structure of the fur
industry in North America during the early nineteenth century. The two companies that
operated in this industry from 1804 to 1821 (the Northwest Company and the Hudson’s
Bay Company) could have benefited from collusion or merger and there was no antitrust
legislation to hinder either. Yet, both companies were engaged in an intense conflict that
led to a depletion of the animal stock. Carlos and Hoffman argued that the persistence of
this market structure reflects the difficulties of bargaining with incomplete information. General insights from bargaining models with incomplete information indicate that it is possible to fail to reach an \textit{ex post} efficient agreement because each side attempts to misrepresent its type, players are likely to bargain over distributive mechanisms rather than allocations, and disagreement may result from a player’s commitment to a tough strategy. Indeed, although the correspondence between the companies indicates that both recognized the gains from cooperation, each was trying to mislead the other. Furthermore, the two companies did not bargain over the allocation of joint profits but tried to reach a merger. After failing to merge, they bargained over a distribution of the territory that each would exploit as a monopolist. Also, negotiations prior to 1821 broke down partially because of the Hudson’s Bay Company’s commitment to a particular, very demanding strategy. The impetus for their final merger was the intervention of the government following a period of intense and ruinous competition. Hence, Carlos and Hoffman’s analysis indicates that strategic considerations influenced the market’s structure and provided “empirical evidence on the problems encountered in bargaining under incomplete information” (p. 968).\footnote{The analysis is based on Myerson’s (1984a, 1984b) work on a generalized Nash bargaining solution and Crawford’s (1982a) model in which it is costly (for exogenous reasons) to change a strategy after committing to it. As Carlos and Hoffman (1988) later recognize in their response to Nye (1988), subsequent theoretical developments provided models better suited to capturing the essence of the historical situation.}

\textit{Security of property rights:} Financing the government by issuing public debt is one of the peculiar features of the pre-modern European economy. Arguably, this type of financing facilitated the rise of security markets \cite[e.g., Neal (1990)]{Neal1990} and provided the foundation for the modern welfare state. Yet, for a pre-modern ruler to gain access to credit he had to be able to commit to repay it despite the fact that he stood, roughly speaking, above the law. How could rulers commit to repay their debts? Why in some historical episodes did rulers renounce their obligations and in others respect them? Clearly, in a one-shot game between a ruler (who can request a loan and renounce after receiving it) and a potential lender (who can decide whether or not to make a loan), the only sub-game perfect equilibrium entails no lending.

Veitch (1986) has argued, based on Telser’s (1980) idea of self-enforcing agreements, that repetition and potential collective retaliation by lenders enlarged the equilibrium set and enabled rulers to commit to repay their debts, and hence to borrow. He has noted that in medieval Europe rulers often borrowed from members of a particular group, such as Jews, Templars, or the Italians, while debt repudiation was often carried out against the group as a whole rather than against particular members.\footnote{Or against a particular sub-group such as an Italian company.} Veitch argued that this indicates that repudiation was curtailed by the threat of collective retaliation by the group. The threat was credible due to the ethnic, moral, or political relations among the lenders. The threat was effective as long as the ruler did not have any alternative group to borrow from, implying that the emergence of an alternative group would lead to
repudiation against the previous group, as indeed was often the case.\footnote{This analysis is insightful and novel but it is incomplete. For example, it is mistaken in arguing that a self-enforcing agreement among the Italian companies is a necessary condition for a sub-game perfect equilibrium in which the ruler does not repudiate.} Similarly, Root (1989) argued that during the 17th and 18th centuries corporate bodies, such as village communities, provincial estates, and guilds, enabled the King of France to commit to pay debts. They increased the opportunity cost of a breach, thereby restraining the king’s ability to default and enabling him to borrow. Indeed, the rise of corporate bodies that loaned to the king in the eighteenth century is associated with a lower interest and bankruptcy rate relative to the seventeenth century.

North and Weingast (1989) and Weingast (1995) further expanded the study of the relations between credible commitment, property-rights security, and political power. If indeed security of property rights is a key to economic growth (as conjectured by North and Thomas (1973)), how was such security achieved in past societies governed by kings with military power superior to that of their subjects? North and Weingast argued that the Glorious Revolution of 1688 enabled the King of England to commit to such security, thereby providing institutional foundations for growth. During this revolution and the years of civil war prior to it, the Parliament established its ability and willingness to revolt against a king who abused property rights. This enabled the king to commit to the property rights of his subjects. Furthermore, to enhance the credibility of this threat and to limit the king’s ability to renege, various measures were taken. The king’s rights were clearly specified to foster coordination among members of the Parliament regarding which of the king’s actions should trigger a reaction. The Parliament gained control over taxation and revenue allocation, an independent judiciary was established, and the king’s prerogatives were curtailed. In support of the view that the Glorious Revolution enhanced property-rights security, North and Weingast pointed to the rise, during the eighteenth century, in sovereign debt and in the number and value of securities traded in England’s private and public capital markets and the general decline in interest rates.\footnote{Carruthers (1990) criticized the claim that placing limits on the king enabled England to borrow, while Clark (1995) cast doubts on the claim that property rights were insecure prior to 1688. He examined the rate of return on private debt and land, and the price of land from 1540 to 1800, and was unable to detect any impact from the Glorious Revolution. Weingast (1995) applied the model of Greif et al. (1994) to further examine how constitutional changes during the Glorious Revolution enhanced the king’s ability to borrow by increasing his ability to commit.}

3.2. Coming to maturity: Explicit models

3.2.1. Exchange and contract enforcement in the absence of a legal system

Neo-classical economics has long emphasized that an impartial legal system fosters exchange by providing contract enforcement. Yet even in contemporary developed and
developing economies, much exchange is conducted without relying on contract enforcement provided by the state. (See further discussion in Greif (1997b).) This phenomenon has been even more prevalent in past economies where, in many cases, there was no state that could provide an impartial legal system. Yet, the institutional foundations of exchange in past societies were not studied in economic history before the introduction of game theory because there was no appropriate theoretical framework.

Some of the first economic history papers that utilized context-specific, explicit models were those that employed symmetric and asymmetric information repeated game models to examine institutions that provided informal contract enforcement in various historical episodes. They provided such enforcement by linking past conduct and future economic reward. Although such games usually have multiple equilibria and the equilibrium set is sensitive to their details, they were found to facilitate empirical examination when the analysis concentrated on the equilibrium set, and when the historical records were rich enough to constrain the model and enable identification of the equilibrium that prevailed. Apart from indicating the empirical relevance of repeated games (with perfect or imperfect monitoring), these studies show that game-theoretical analysis can highlight diverse aspects of a society, such as the inter-relations between economic institutions and social structures. They indicate how third-party enforcement can be made credible even in the absence of complete information, or a strategy that punishes someone who fails to punish a deviator. Finally, the studies indicate that it is misleading to view contract enforcement based on formal organizations and on repeated interaction as substitutes, since formal organizations may be required for the long hand of the future to sustain cooperation.

"Coalitions" and informal contract enforcement: Much of the spectacular European growth from the eleventh to the fourteenth centuries is attributed to the Commercial Revolution – the resurgence of Mediterranean and European long-distance trade. The actions and explicit statements of contemporaries indicate the important role played by overseas agents who managed the merchants' capital abroad. Operating through agents, however, required overcoming a commitment problem since agents who had control over others' capital could act opportunistically. To establish an efficient agency relationship, the agent had to commit \textit{ex ante} to be honest \textit{ex post} and not to embezzle the merchant's capital that was under his control (in the form of money, goods, and expensive packing materials). It is tempting to conclude, as Benson (1989) has argued, that an agent's concern about his reputation – namely, his concern about his ability to trade in the future – permitted such a commitment. Yet, this argument is unsatisfactory since it presents an incomplete theoretical analysis and, worse, since it implicitly claims that it is enough to comprehend a historical situation by examining only a theoretical possibility without examining any empirical evidence. Comprehending if and how the merchant-agent commitment problem was mitigated in a particular time and place requires detailed empirical research and a context-specific theoretical analysis.

A satisfactory empirical and theoretical analysis should address at least the following issues. If repetition enabled cooperation, should the model be of infinite or finite horizon? If an infinitely repeated game is appropriate, how was the unraveling problem
mitigated (that is, why wouldn’t an agent cheat in his old age)? Should the model be an incomplete-information model? Should it include a legal system? How was information acquired and transmitted? Should the set of traders and agents be considered exogenous? Could an agent begin operating as a merchant with goods he had embezzled? Who was to retaliate if an agent embezzled goods? Why was the threat of retaliation credible? What were the efficiency implications of the particular way in which the merchant-agent commitment problem was alleviated? Why did this particular way emerge?

Greif (1989, 1993, 1994a) examined these and related questions with respect to the Jewish Maghribi traders who operated during the eleventh century in the Muslim Mediterranean. The historical and theoretical evidence indicates that agency relations were not governed by the legal system and that the appropriate model is an infinitely repeated game with complete information. (Greif (1993) discusses why an incomplete-information model was ruled out and below I discuss how the unraveling problem was mitigated.) Specifically, it argues for the relevance of an efficiency-wage model with two particularly important features: matching is not completely random but is conditioned on the information available to the merchants, and sometimes a merchant has to cease operating through an honest agent.20 A model incorporating these two features shows that a (sub-game perfect) equilibrium exists in which each merchant employs an agent from a particular sub-set of the potential agents and all merchants cease operating through any agent who ever cheated. This collective punishment is self-enforcing since the value of future relations with all the merchants keeps an agent honest. An agent who

20 Specifically, the model is that of a One-Sided Prisoner’s Dilemma game (OSPD) with perfect and complete information. There are M merchants and A agents in the economy, and it is assumed that M < A. Players live an infinite number of periods, agents have a time discount factor β, and an unemployed agent receives a per-period reservation utility of ϕ_u > 0. In each period, an agent can be hired by only one merchant and a merchant can employ only one agent. Matching is random, but a merchant can restrict the matching to a sub-set of the unemployed agents that contains the agents who, according to the information available to the merchant, have previously taken particular sequences of actions. (The following assumes that the probability of re-matching with the same agent equals zero for all practical considerations.) A merchant who does not hire an agent receives a payoff of κ > 0. A merchant who hires an agent decides what wage (W ≥ 0) to offer the agent. An employed agent can decide whether to be honest or to cheat. If he is honest, the merchant’s payoff is y - W, and the agent’s payoff is W. Hence the gross gain from cooperation is γ, and it is assumed that cooperation is efficient, γ > κ + ϕ_u. The merchant’s wage offer is assumed credible, since in reality the agent held the goods and could determine the ex post allocation of gains. For that reason, if the agent cheats, the merchant’s payoff is 0 and the agent’s payoff is α > ϕ_u. Finally, a merchant prefers receiving κ to being cheated or paying W = α, that is, κ > γ - α. After the allocation of the payoffs, each merchant can decide whether to terminate his relations with his agent or not. There is a probability σ, however, that a merchant will be forced to terminate agency relations and this assumption captures merchants’ limited ability to commit to future employment due to the need to shift commercial operations over places and goods and the high uncertainty of commerce and life during that period. For a similar reason, the merchants are assumed to be unable to condition wages on past conduct (indeed, merchants in neither group did so). Hence, attention is restricted to an equilibrium in which wages are constant over time. (For an efficiency wage model in which this result is derived endogenously, see MacLeod and Malcomson (1989). Their approach can be used for this analysis as well but is omitted to preserve simplicity.)
has cheated in the past and thus is not expected to be hired by merchants will not lose this value if caught cheating again. Thus, if a merchant nevertheless hires such an agent, the merchant has to pay a higher (efficiency) wage to keep the agent honest (relative to an agent who did not cheat in the past). Each merchant is thus induced to hire only honest agents – agents who are expected to be hired by others.

Acquiring and transmitting information during the late medieval period was costly, and hence the model should incorporate a merchant’s decision to acquire information. Since merchants could gather information by forming an information-sharing network, suppose that each merchant can either “Invest” or “Not Invest” in “getting attached” to such a network before the game begins, and that his action is common knowledge. Investing entails a cost at each period in return for which the merchant learns the private histories of all the merchants who also invested; otherwise, he knows only his own history. Under the collectivist equilibrium, history has value and thus merchants are motivated to invest even though cheating does not occur on the equilibrium path.

The effectiveness of a collective punishment in inducing efficiency-enhancing agency relationships is undermined if an agent who cheated is not restricted from using the capital he embezzled as profitably as the merchant he cheated. If an agent can use the capital he embezzled as profitably as the merchant by becoming a merchant himself and hiring an agent, his lifetime expected utility is higher following cheating relative to a situation in which he cannot. This implies that to induce honesty, a merchant has to pay a higher wage to his agent. As a matter of fact, this wage has to be so high that it would be better for an individual to be an agent rather than a merchant. Agents would have to be paid more than half of the return on each business venture. The need to pay such a high wage, in turn, increases the set of situations in which merchants would not initiate efficiency-enhancing agency relationships, finding them to be unprofitable.

However, there is no historical evidence that agents were restricted exogenously from investing capital in trade. Such a restriction can be generated endogenously, however, under collective punishment. In particular, an agent who himself also acts as a merchant (and invests his capital through agents) can be endogenously deterred from embezzling under collective punishment (even when his share in a business venture is less than that of a merchant). When an agent also acts as a merchant, a strategy specifying non-punishment of agents who cheated a merchant who had cheated while acting as an agent is both self-enforcing and further reduces the agent’s gain from cheating. It potentially enables hiring agents despite their ability to invest the capital they embezzled in trade.

When agency relations are governed by a “coalition” – by a group of merchants using the above strategy with respect to a particular group of agents – the collective punishment enables the employment of agents even when a specific merchant and agent are not expected to interact again. The gains from cooperation within the coalition (compared to hiring agents based on bilateral punishment), and the expectations concerning future hiring among the coalition’s members, ensure the coalition’s “closeness”. Coalition members are motivated to hire and to be hired only by other members, while non-
members are discouraged from hiring the coalition's members. Similarly, since membership in the coalition is valuable, an overlapping generations version of the model in which sons inherit their fathers' membership and support them in their old age, shows how the unraveling problem can be avoided. Holding a son liable for his father's actions can motivate a father to be honest even in his old age.

The above theoretical discussion provides some of the conditions for and implications of governing agency relations by coalitions. Some of these implications are distinct from those generated by a bilateral efficiency-wage model [Shapiro and Stiglitz (1984)] or a model of incomplete information about agents' types. For example, within the coalition agency relations are likely to be flexible – merchants shift among agents and hire agents even for a short time in cases of need. Merchants also prefer hiring other merchants as their agents, perhaps through forms of business associations that require agents' capital investments. Further, members of the coalition are likely to be segregated from other merchants in the sense that they will not establish agency relations outside the coalition even if these relations – ignoring agency cost – are more profitable. Similarly, the sons of coalition members are likely to join the coalition.

Indeed, the geniza documents that reflect the operation of the Maghribis reveal the above conditions for, and implications of, governing agency relations by a coalition. They reflect a reciprocity based on a social and commercial information network with very flexible and non-bilateral agency relations. There was no merchant or agent "class" among the Maghribis while merchants hired other merchants as their agents and utilized forms of business associations that required agents' investments. Furthermore, the Maghribis did not establish agency relations with other (Jewish or non-Jewish) traders even when these relations were considered by them to be very profitable. To begin operating in a new trade center, some Maghribis immigrated to this center and began providing agency relations. Finally, traders' sons indeed supported their fathers in their old age and inherited membership in the coalition and family members were held morally (but not legally) responsible for each other. Notably, these observed features among the Maghribis did not prevail among the Italian traders who operated (particularly from the twelfth century) in the same area as the Maghribis, trading in the same goods, and using comparable naval technology. Bilateral, rather than collective, punishment was the norm that prevailed among Italian traders. (See further discussion below.)

In addition to this indirect evidence for the governance of agency relations among the Maghribis by a coalition, the geniza contains direct evidence on various aspects of the coalition. Explicit statements reflect the expectations for a multilateral punishment, the economic nature of the expected punishment, the linkage between past conduct and future employment, the interest that all coalition members took in the relations between a specific agent and merchant, and so forth. Further, the geniza reveals the existence of a set of cultural rules of behavior that alleviated the need for comprehensive agency contracts and coordinated responses by indicating what constituted "cheating".

21 See, in particular, Greif (1994a).
The factors leading to the selection of this particular strategy are also reflected in the historical records, which suggest that multilateral punishment prevailed among the Maghribis because of a social process and cultural traits. The Maghribis were descendants of Jewish traders who left the increasingly politically insecure surroundings of Baghdad and emigrated to North Africa during the tenth century. Arguably, this emigration process, as well as their cultural background which emphasized collective responsibility, provided them with an initial social network for information transmission and made the collective punishment strategy a focal point. This particular social process and cultural background led to the governance of agency relations by a coalition, while the economic incentives generated by the coalition strengthened the Maghribis' distinct social identity. Indeed, the Maghribis retained their separate identity within the Jewish population until they were forced, for political reasons, to cease trading. This interrelation between social identity and the economic institution that governed agency relations suggests that the Maghribi traders' coalition did not necessarily have an efficient size. But because expectations regarding future employment and collective punishment were conditional on a particular ascribed social identity, there was no mechanism for the coalition to adjust to its economically optimal size.

Clay (1997) studied the informal contract enforcement institution that prevailed among long-distance American traders in Mexican California. Her evidence suggests that, in contrast to the situation among the Maghribis, the traders did not sever all their relations with an agent who cheated any of them. To understand this difference, Clay noted that an agent among these traders had a monopoly over credit transactions with members of a particular Mexican community. Since contract enforcement within each community was based on informal social sanctions, in order to sell on credit a trader had to settle in a community, marry locally, raise his children as Catholics, and speak Spanish at home. Furthermore, the small size of the Mexican communities implied that it was profitable for only one retailer to integrate in this way.

Clay incorporated this feature in an infinitely repeated game with imperfect monitoring, and found that the strategy of permanent and complete punishment of a trader who cheated in agency relations would have been Pareto-inferior. Such a strategy barred all the traders from operating in the community where the cheater had a monopoly over contract enforcement. A strategy entailing a partial boycott for a limited time following a first instance of cheating Pareto-dominates the complete boycott strategy. The boycott is partial in the sense that it does not preclude transactions requiring the use of the cheater's local enforcement ability. A complete boycott follows only after an act of cheating during a boycott. Direct and indirect evidence indicates that such a strategy was utilized by the traders. Hence, an environment different from that of the Maghribis led to a different Pareto-superior strategy.

Contract enforcement among "anonymous" individuals: Two studies examined contract enforcement over time and space among "anonymous" individuals. Such contract

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22 More accurately, the exchange modeled in this line of research is "impersonal". See discussion in Greif (2000a).
enforcement over time was required at the Champagne Fairs in which, during the twelfth and the thirteenth centuries, much of the trade between northern and southern Europe was conducted. Milgrom, North and Weingast (1990) argued that in the large community of merchants who frequented the fairs, a reputation mechanism could not enable traders to commit to respect their obligations since such a large community lacked the social network required to make past actions known to all. Furthermore, the fairs’ court could not directly impose its decision on traders after they left the fairs. Milgrom, North and Weingast suggested that a *Law Merchant* system, in which a court supplements a multilateral reputation mechanism, can ensure contract enforceability in such cases. Suppose that each pair of traders is matched only once and each trader knows only his own experience. Further assume that the court is capable only of verifying past actions and keeping records of traders who cheated in the past. Acquiring information and appealing to the court is costly for each merchant. Despite these costs, however, there exists a (symmetric sequential) equilibrium in this infinitely repeated, complete-information game in which cheating does not occur and merchants are induced to provide the court with the information required to support cooperation. It is the court’s ability to activate the multilateral reputation mechanism by collecting and dispensing information that provides the appropriate incentives. Furthermore, there exists an equilibrium in which the traders’ threat to withdraw from future trade is sufficient to deter the court from abusing its information to extort money from the traders. However, the paper does not go far enough in establishing the historical validity of its argument; it only points out that the fairs’ authorities controlled who was permitted to enter the fairgrounds.

Court and other historical records from western and southern Europe dating back to the mid-twelfth century indicate the operation of another mechanism that enabled anonymous contracting over time and place. Traders applied a principle of community responsibility that linked the conduct of any trader with the obligations of every member of his community. For example, if a debtor from a specific community failed to appear at the place where he was supposed to meet his obligations, the lender could request the local court to confiscate the goods of any member of the debtor’s community present at that locality. Those whose goods were confiscated could then seek a remedy from the original debtor. Traders used intra-community enforcement mechanisms to support inter-community exchange.

Historians have considered this “community responsibility system” for contract enforcement to be “barbaric” since it sometimes led to “retaliation phases” in which an accusation of cheating led to the end of trade between two communities for an extended time. Further, some other facts about the system – such as regulations aimed at increasing the cost of default to a lender, attempts of wealthy merchants from large communities to be exempt from the system, and its demise at the end of the thirteenth century – remain unexplained. Greif (1996a, 2000a) used a repeated, imperfect-monitoring game that captures the essence of the situation to explain these features as well as evaluate the pros and cons of the system.
The analysis indicates the rationale behind the costly retaliation phases as an on-the-equilibrium-path-of-play behavior required to maintain cooperation. They reflect asymmetric information between two local courts which, at times, reached different conclusions regarding the fulfillment or non-fulfillment of the contractual obligations. The regulations that increased the cost of default to the lender, and the attempts of wealthy merchants from large communities to be exempt from it, reflect the moral hazard problem generated by the system. Efficiency required that a lender verify the borrower’s creditworthiness. But the system implied that he also considered the future possibility of obtaining compensation from the borrower’s community, leading to misallocation of credit. Increasing the lender’s cost of default mitigated this problem, while well-to-do members of wealthy communities were particularly interested in being exempt from the system since their community’s wealth and size fostered the moral hazard problem. While they had the personal reputation required to borrow without community responsibility, their wealth enabled less creditworthy members of their community to borrow as well. These wealthy merchants thus had to pay the cost required to enable other members of their community to borrow and they gained less and paid more for the community responsibility system and therefore they wanted to be exempt from it. The model and historical evidence suggest that the decline of the system followed an increase in its cost in terms of retaliation phases and the moral hazard problem. The cost increase was due to the rising number of trading communities, the increased wealth of some communities, and social and political integration that enabled one to falsify his community’s membership.

3.2.2. The state: Emergence, nature, and function

The European states were important economic decision-makers and the competition among them is often invoked to account for the rise of the Western World. Several studies used dynamic and repeated games with complete information and dynamic games with incomplete information to examine the relations between economic factors and the origin and nature of the European state. They indicate the importance of viewing a state as a self-enforcing institution, and the role of intra-state organizations in enhancing cooperation among various elements within the state, and they advance new interpretations of the parliamentary system. Finally, they reveal a reason why wars may occur even in a world with symmetric information and transferable utility.

The emergence and origin of the state: Among the most intriguing cases of state formation in medieval Europe is that of the Italian city states. They were formed through voluntary contracts and many of them experienced very rapid economic growth from the eleventh to the fourteenth centuries. Genoa is a case in point. It was established around 1096 for the explicit purpose of advancing the profits of its members, and indeed it emerged from obscurity to become a commercial empire that stretched from the Black Sea and beyond to northern Europe. Advancing the economic prosperity of Genoa required cooperation between Genoa’s two dominant noble clans (and their political factions). They could militarily cooperate in raiding other political units or acquiring commercial rights from them, such as low customs or parts of ports which yielded
rent every period after their acquisition. The acquisition of such rights was the key to the city’s long-term economic prosperity. Yet, for cooperation to emerge, each clan had to expect to gain from it despite each clan’s ex post ability to use its military power to challenge the other for its share in the gains. No clan made such an attempt from 1096 to 1164, but from 1164 to 1194 inter-clan warfare was frequent. Was inter-clan cooperation in acquiring rights prior to 1164 limited by the need to ensure the self-enforceability of the clans’ contractual relations regarding the distribution of gains? Why did inter-clan warfare occur after 1169? Did the clans attempt to alter the rules of their game to enhance cooperation after 1164? These questions have been raised by historians but could not be addressed without an appropriate game-theoretical formulation.

Greif (1994a, 1998c) analyzed this situation as a dynamic game with complete information regarding the clans’ military strength, but uncertainty regarding the outcome of a military conflict. The analysis indicates that self-enforceability may limit cooperation in the acquisition of rights. If the clans are at a mutual-deterrence equilibrium with less than the efficient number of rights, it may not be in a clan’s interest to cooperate in acquiring additional rights. In a mutual-deterrence equilibrium with less than the efficient number of rights, neither clan challenges the other since the expected cost of the war and the cost implied by the possibility of defeat outweigh the expected gains from capturing the other clan’s share. With additional rights, the increase in the expected benefit for a clan from challenging may exceed the increase in the expected cost of potential defeat, leading to either a military confrontation or a clan being forced to increase its investment in military ability. This “political cost” of acquiring rights implies that each clan may find it optimal to cooperate in acquiring less than the efficient number of rights.

The above analysis is incomplete since in the case of Genoa there is no justification for taking the clans’ share in the gains as exogenous. Can the clans necessarily overcome the economic inefficiency implied by the political cost by re-allocating the gains? Suppose that one clan finds it beneficial to challenge the other given its share in the gains and military strength. Although the game is one of complete information, there still may be no other Pareto-superior equilibrium in which inter-clan war is prevented. It may not exist due to the uncertainty involved about military conflicts and the clans’ ability to use its share in the gains to increase its military strength. Increasing the share in the gains of the clan that is about to challenge decreases the gains from a victory but increases the chance of winning. The other clan may thus be better off fighting while retaining its original allocation. Hence, the ability of Genoa’s clans to cooperate could have been constrained by the extent to which their relations were self-enforcing.

But was this historically the case? Did the need for self-enforceability constrain the clans’ economic cooperation? Under the assumption that it did, the model yields various predictions, such as the time-path of cooperation in raids and the acquisition of rights, investment in military strength, and responses (including inter-clan military confrontation) to various exogenous changes. These predictions are confirmed by the historical records. It was only in 1194 that a process of learning and severe external threat to Genoa motivated the clans to establish a self-enforcing organization which was known as a podestà (that is, a “power”). It altered the rules of the political game in Genoa to
increase the set of parameters (including the number of rights) under which inter-clan cooperation could be achieved as a mutual deterrence equilibrium outcome. Furthermore, the podesteria coordinated on such an equilibrium. Essentially, the podestà was a non-Genoese hired for one year to govern Genoa and supported by his own military contingent. The podesteria’s self-enforcing regulations were such that the podestà could commit to use his military power (only) against any clan attempting to militarily challenge another. It was under the podesteria, which formally lasted about 150 years, that Genoa reached its political and commercial apex. Understanding Genoa’s commercial rise requires comprehension of its political foundations.23

Green (1993) analyzed the emergence of the parliamentary government of England during the thirteenth century, an event which arguably contributed to England’s subsequent growth. His analysis supports the conjecture that a shift to parliamentary government alleviates the cost of communicating private information. The existing balance-of-power theory that views changes in governmental systems as indicative of changes in the technology of capturing or defending property, fails to explain a central provision in the Magna Carta (1215). Instead of requesting tax cuts, the English barons insisted that the king should request their consent for new taxes. Green argues that this request reflects the benefit of communication and exchange between the parties.

The loss of the English Crown’s possessions in France shortly before 1215 and the growing complexity of European politics increased the threat of an external invasion of England and implied that the king had better information regarding such an invasion. To see why such an external threat and private information might make a political system based on communication Pareto-optimal, Green analyzed the following model. Consider a one-period game in which a ruler can always expropriate (at most) half of the subject’s crop. There is some probability of an external threat to the whole crop which the ruler can successfully confront by (a) taking a costly action such as assembling an army, and then (b) confronting the threat (without any additional cost). If there is no threat the ruler prefers half the crop over taking the costly action. If there is a threat the ruler prefers taking the action if provided with two-thirds of the crop rather than not taking the action and getting no share at all. The subject can provide the ruler with two-thirds of the crop between the time of events (a) and (b). Whether the external threat is about to materialize or not is the ruler’s private information. In this model there is a Bayesian Nash equilibrium in which the ruler communicates that the external threat has materialized by taking the costly action and the subject provides him with two-thirds of the crop. Despite the cost of the communication, this equilibrium Pareto-dominates the equilibria in which there is no communication. Hence, a shift to parliamentary government may reflect the benefit of such costly communication.

Committing to respect property rights: The five bankruptcies of the Spanish Crown (1557, 1575, 1596, 1607, and 1627) during the height of Spanish economic and political dominance are often used to demonstrate the limitations of a pre-modern public

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23 See also Rosenthal (1998), who examined how the game between kings and nobles in France and England influenced economic and political outcomes.
finance system [Cameron (1993), p. 137]. The rulers’ inability to commit to the property rights of their lenders hindered their ability to borrow. In a detailed historical and game-theoretic analysis, Conklin (1998) advanced a different interpretation of these bankruptcies as reflecting a routine realignment of the king’s finances. In other words, they do not reflect the failure of a system but its effective operation. These bankruptcies were not a wholesale repudiation of obligations to creditors. They were initiated by the Genoese, the king’s foreign lenders, who ceased providing him with credit. In response, the king ceased paying the Genoese and negotiated a partial repayment of his debt to them with debt obligations directly linked to particular tax-generating assets the king had in Spain. The Genoese could sell these obligations to Spain’s elite, namely, the king’s local lenders. After this realignment, the Genoese resumed lending.

For this analysis, Conklin used a repeated game with state variables, an important component of which is that the king “cares” about the welfare of his Spanish lenders. The justification for this specification was the king’s dependency on these elite Spaniards for tax collection, administration, and military operations. Solving for a Pareto-optimal, sub-game-perfect equilibrium using a computer algorithm indicated that financial realignment should have occurred when the king reached the limit of his ability to commit to the Genoese. Shifting some of this debt to his elite to whom he could commit was a prerequisite for additional lending. This interpretation gains additional support, such as the particularities of the tax collection system and the king’s willingness to prey on the wealth of particular Spaniards while continuing to pay his local debt.

3.2.3. Within states

Game theory facilitated the analyses of historical market structures (the number and relative size of firms within an industry), financial systems, legal systems, and development. At the same time, these analyses used historical data sets that enabled the examination of game-theoretical industrial organization models, confirmed game-theoretical predictions regarding the relations between rules and behavior, suggested the role of banks and the distribution of rent in initiating a move from one equilibrium to another, and inspired new game-theoretical models of financial and market structure.

Market structure and conduct: Business records from the period prior to and following the Sherman Act provide unique data sets for examining the relations between strategic behavior and market structures. Their analysis substantiated the importance of predation and reputation in influencing market structures, enabled empirical examination of models of tacit collusion, indicated limits of using only indirect (econometric) evidence in examining inter-firm interactions, and suggested that existing models of market structures are deficient in ignoring the multi-dimensionality of inter-firm interactions.

\[24\] In the process the Genoese had to bear some losses.
Burns (1986) examined the role that a reputation for predatory pricing played in the emergence of the tobacco trust between 1891 and 1906. An econometric analysis of the purchases of 43 rival firms by the old American Tobacco Company indicated that alleged predation significantly lowered the acquisition costs, both for asserted victims and, through reputation effects, for competitors that sold out peacefully. Similarly, Gorton (1996) examined the formation and implication of reputation in the Free Banking era (1838–60) during which new banks could enter the market and issue notes. Economic historians noticed, but found it difficult to explain, that “wildcat” (“fly by night”) banking was not a pervasive problem during this period. The Diamond (1989) incomplete-information model suggests that if some banks were wildcats, some were not, and some could have chosen whether to be wildcats or not. A process of reputation formation may have deterred banks from choosing to become wildcats. Due to information asymmetry, all banks initially faced high discount rates, but following the default of the wildcats the discount rate declined due to the reputation acquired by the surviving firms. This decline, in turn, further motivated firms that could choose whether or not to be wildcats. Gorton conducted an econometric analysis of various aspects of these conjectures (particularly whether new banks’ notes were discounted more and if this discount depended on the institutional environment), which confirmed the importance of reputation in preventing wildcat operations.25

Weiman and Levin (1994) combined direct and indirect (econometric) evidence to examine the development and implication of the strategy employed by the Southern Bell Telephone Company to acquire a monopoly position between 1894 and 1912. In contrast to the usual assumption in industrial organization, the strategic variable that enabled it to become a monopoly was not only price but also investment in toll lines ahead of demand, isolating independents in smaller areas, and influencing regulations by increasing the cost of competition to the users. Similarly, Gabel (1994) substantiated that between 1894 and 1910 AT&T acquired control over the telephone industry through predatory pricing. Despite its short-term cost, price reduction enabled AT&T to deter entry and to cheaply buy the property of independents. This strategy was facilitated by rate regulations and capital market imperfections that prevented independents from entering on a large scale.26

In a classic study, Porter (1983) examined collusion of a railroad cartel (the “Joint Executive Committee”) established in 1789 to set prices for transport between Chicago and the East Coast. Using data from 1880 to 1886 the study tested and could not reject the relevance of Green and Porter’s (1984) theory of collusion with imperfect monitoring and demand uncertainty. (The alternative was that price movements reflected exogenous shifts in demand and cost functions.) According to the Green and Porter theory, price wars occur on the equilibrium path due to the inability of firms to distinguish between

25 See also Ramseyer’s (1991) study of the relations between credible commitment and contractual relations in the prostitution industry in Imperial Japan.
26 See also Nix and Gabel (1994).
shift in demand and a firm's defection. A sufficiently low price triggers a price war of some finite length, and although all firms realize that no deviation has occurred, punishment is required to retain collusion. Similar results were obtained by Ellison (1994), who compared the Green and Porter model with that of Rotemberg and Saloner (1986) in which price wars never transpire and on-the-path prices exhibit a counter-cyclical pattern.

The Green and Porter model also provides the theoretical framework used by Levenstein (1994, 1996a, 1996b) to examine collusion in the pre-WWI US bromine industry. An econometric analysis could not reject the Green and Porter model, indicating that price wars stabilized collusion. Yet, Levenstein (1996a) claimed that this conclusion is misleading. Using ample direct evidence, Levenstein substantiated that only a few wars stabilized collusion in the Green and Porter sense and these were short and mild. Long and severe price wars were either bargaining instruments aimed at influencing the distribution from collusion, or a profitable deviation from collusive behavior made possible by asymmetric technological changes. Finally, similar to the studies discussed above, her paper casts doubt on the empirical relevance of the strategic models of collusion which assume that price is the only strategic variable. In the bromine industry, collusion of firms was facilitated by altering the industry's information structure and marketing system [Levenstein (1996b)].

Financial systems and development: The nature and role of financial intermediaries that functioned prior to the rise of banks and securities markets have hardly been examined, limiting our understanding of pre-modern financial markets. Furthermore, the relations between development and distinct financial systems (differentiated by the nature and relative importance of banks and securities markets) have been examined by economic historians [Mokyr (1985), p. 37]. Only recently has the application of game theory to historical research facilitated the analysis of alternative intermediaries, enabled exploring the origins and implications of diverse financial systems, and suggested a heretofore unexamined role for banks in coordinating development.

Hoffman, Postel-Vinay, and Rosenthal (1998) used a repeated-game model and an unusual data set from Paris (1751) to theoretically and econometrically examine the operation of a credit system as an alternative to banks and security markets. In Old Regime France, notaries had property rights over the records of any transaction they registered. Hence, they had a monopoly over the information required for screening and matching potential borrowers and lenders. Their ability to provide credit market intermediation, however, could have been hindered by a "lock-in" effect. Unless they were able to commit not to exploit their monopoly power, potential participants in the credit market would have been deterred from approaching them. A game-theoretical formulation of this problem revealed that it could have been mitigated by an equilibrium in which notaries shared information with each other to reduce each notary's monopoly power over his clients. Indeed, the data confirms the behavior associated with this equilibrium.

There is a consensus among economic historians that different financial and industrial systems prevailed in the first and second major industrialized European countries
– namely, England and Germany. English firms were relatively small and tended to be financed through tradeable bonds and arm’s-length lending. The German firms, however, were large and tended to be financed by loans from particular banks which closely monitored them. Motivated by this difference, Baliga and Polak (1995) attempted to explore its origins and rationale using a dynamic game capturing the moral hazard problem inherent in industrial loans. Entrepreneurs would provide only second-best effort levels in the absence of monitoring, while costly monitoring induces more effort. Monitoring exhibits internal economies of scale while markets for tradeable loans exhibit external economies of scale.

The analysis provides the foundation for potentially beneficial future empirical analysis. It leads to comparative statics predictions regarding the relations between exogenous factors (such as base interest rates, firm size, and the lender’s bargaining power) and the entrepreneur’s choice of financial arrangements. Furthermore, it indicates the possible impact of the entrepreneurs’ wealth and the market in government securities on the efficiency and selection of financial arrangements. When the analysis is further extended to an entry game in which entrepreneurs choose a firm’s size and banks choose whether to acquire monitoring ability, multiple equilibria exist, indicating a possible rationale for the emergence and persistence of different systems.

The role of banks in coordinating development is suggested by the “big-push” theory of economic development [Murphy et al. (1989)]. When externalities make investment profitable only if enough firms invest at the same time, failure to coordinate on such a simultaneous investment may lead to an “underdevelopment trap”. Inspired by this model and the positive historical correlation between rapid industrialization and large banks with some market power or with large equity holdings in industrial firms, Da Rin and Hellmann (1998) developed a model of the role of banks in coordinating a transition to an equilibrium in which firms invest. Utilizing a dynamic game with complete information they suggested that this positive correlation reflects the role of large banks in initiating a move from one equilibrium to another. A necessary condition for banks to coordinate industrialization is that at least one bank (or coordinated group of banks) is large enough to initiate a big push by subsidizing the investment of a critical mass of firms to induce them to invest. A bank’s monopoly power or capital investment is required, however, to motivate that bank to coordinate by enabling it to benefit from the industrialization it triggered.

Law, development, and labor relations: Game-theoretical models were used to evaluate the impact of legal rules and procedures on development and labor relations in various historical episodes. Rosenthal (1992) established that, despite the efficiency of several potential drainage and irrigation projects in France from 1700 to 1860, they were not carried out. In contrast, efficient projects were undertaken in England during this period, as well as in France after the French Revolution. The efficient projects were

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27 Some recent papers doubt this difference; see Fohlin (1994) and Kinghorn and Nye (1996).
28 See also Milgrom et al. (1990) and Greif (1996a, 2000a).
not carried out since the village which had some *de facto* or *de jura* property rights over the land, and the lord who wanted to initiate the project, failed to reach an agreement regarding the distribution of the gains. Rosenthal conjectured that the distinct legal features of Old Regime France accounted for this failure.

To demonstrate that the legal features of the Old Regime could have inhibited reaching an agreement, Rosenthal used a dynamic incomplete-information game. Central to the model is asymmetric information regarding the legal validity of the village’s rights over the land and the “burden of proof” rule, namely, whether the property rights will be assigned to the lord or the village if neither party is able to establish *de jura* rights over the land. The analysis indicates that legal prohibition on out-of-court settlements, the burden of proof rule that favored the village, and the high cost of using the legal system, increased the number of efficient projects that lords would find unprofitable to initiate. All these features of the legal system prevailed in Old Regime France but not in England or post-revolutionary France.\(^{29}\)

Treble (1990) examined the impact of legal regulations on wage negotiations in the British coal industry from 1893–1914. These negotiations were conducted in “conciliation boards”, and in cases of disagreement an arbitrator had to be used. The number of appeals made to arbitrators differed greatly among coal fields, and ranged from as low as 11 percent to as high as 56 percent (per number of negotiations). The economic historians’ traditional explanation of these differences is that they reflected differences in the negotiators’ personalities. Treble, however, modeled the bargaining process as a game which [unlike many other bargaining models, such as Farber (1980)] generated predictions regarding the frequency of appeals to arbitration. Treble’s analysis predicted that because delay in reaching an agreement had a strategic value, the more the constitution of a particular conciliation board permitted delay without arbitration, the less arbitration would be used. When this hypothesis and the alternative, that appeal depended on personalities or reflected asymmetric information regarding the arbitrator’s preference [Crawford (1982b)], was placed under econometric analysis, it could not be rejected.

Moriguchi (1998) has utilized a game-theoretic framework to conduct a comparative study of the evolution of labor relations in Japan and the US from 1900 to 1960. She modeled the relationships between potential employers and employees as a repeated game and examined the resulting set of equilibria for various parameter values. Furthermore, she examined the political ramifications of various equilibria and how, in turn, they influenced the endogenous political formation process of labor regulations. This framework enabled her to provide a novel interpretation of the evolution of labor relationships. The combined theoretical and historical analysis highlights, for example, the essence of employer paternalism as a mechanism to move from one equilibrium to another, and the importance of the Great Depression in causing a bifurcation of the equilibrium selected in each economy. Furthermore, the analysis indicates the importance

\(^{29}\) See also Besley, Coate, and Guinnane (1993), who studied the evolution of laws governing provisions for the poor.
of various factors that led to the persistence of each equilibrium after the Great Depression, such as coordination cost and sunk investment in complementary regulations and technology.

3.2.4. Between states

Applying repeated and static games to historical analyses has indicated the importance of non-market institutions in influencing the historical process through which long-distance trade grew and the empirical relevance of the ideas behind renegotiation-proof equilibrium. It has also lent support to the New International Trade Theory, by indicating the implications of the intra-firm incentive structure on inter-firm strategic interaction, how strategic international relations impact domestic economic policy, how cooperation can evolve, and what the relations are between equilibrium selection and credible, public communication.

*International trade:* Greif, Milgrom, and Weingast (1994) examined the operation and implications of an institution that enabled rulers during the late medieval period to commit to the security of alien traders’ property rights. Having a local monopoly over coercive power, any medieval ruler faced the temptation to abuse the property of alien merchants who frequented his realm. Without an institution enabling a ruler to commit *ex ante* to secure alien merchants’ rights, they would not have come to trade.

Since trade relationships were expected to be repeated, one may conjecture that a bilateral reputation mechanism in which a merchant whose rights were abused ceased trading, or an uncoordinated multilateral reputation mechanism in which a subgroup larger than the one that was abused ceased trading, could surmount this commitment problem. This conjecture, however, is wrong. Although each of these mechanisms can support some level of trade, neither can support the efficient level of trade. The bilateral reputation mechanism fails because, at the efficient level of trade, the value of future trade of the “marginal” traders to the ruler is zero, and hence the ruler is tempted to abuse their rights (irrespective of the distribution of the gains from trade and the ruler’s discount factor). In a world fraught with information asymmetries, slow communication, and different possible interpretations of facts, the multilateral reputation mechanism is prone to fail for a similar reason. Hence, theoretically, a multilateral reputation mechanism can potentially overcome the commitment problem only when the merchants have some organization to coordinate their actions. Such a coordinating organization implies the existence of a Markov-perfect equilibrium in which traders come to trade (at the efficient level) as long as a boycott is not announced, but none of them come to trade if one is announced. The ruler respects the merchants’ rights as long as a boycott is not announced, but abuses their rights otherwise. When a coordinating institution exists, trade may plausibly expand to its efficient level.

30 The discussion above regarding agency relations and anonymous trade also relates to the institutions and long-distance trade. For an elaboration of the insights provided by game-theoretical analyses of long-distance trade in history, see Greif (1992).
Although the strategy just described leads to a perfect equilibrium, the theory in this form remains unconvincing considering the ideas behind renegotiation-proof equilibrium. According to the above equilibrium strategies, when a coordinating institution declares an embargo, merchants will pay attention to it because they expect that the ruler will abuse a violator’s property rights. But are these expectations reasonable? Why would a ruler not encourage embargo-breakers rather than punish them? Encouragement is potentially credible since during an effective embargo the volume of trade shrinks and the value of the marginal trader increases; it is then possible for bilateral reputation mechanisms to become effective. This possibility limits the potential severity of an embargo and potentially hinders the ability of any coordinating organization to support efficient trade. In such cases, the efficient level of trade can be achieved when a multilateral reputation mechanism is supplemented by an organization with the ability to coordinate responses and ensure the traders’ compliance with boycott decisions.

Direct and indirect historical evidence indicates that during the Commercial Revolution an institution with these attributes – the merchant guild – emerged and supported trade expansion and market integration. Merchant guilds exhibited a range of administrative forms – from a subdivision of a city administration, such as those of the Italian city-states, to an inter-city organization, such as the German Hansa. Yet, their functions were the same: to ensure the coordination and internal enforcement required to make the threat of collective action credible. The nature of these guilds and the dates of their emergence reflect historical as well as environmental factors. In Italy, for example, each city was large enough to ensure that its merchants were not “marginal” and its legal authority ensured their merchants’ compliance with the guild’s decisions. In contrast, the relatively small German cities had to organize themselves as one guild through a lengthy process to be able to inflict an effective boycott.

Irwin (1991) utilized a game-theoretical model to examine the competition between the English East India Company and the Dutch United East India Company during the early seventeenth century. The Dutch were able to achieve dominance in the trade in pepper brought from the Spice Islands of Indonesia, although both companies had similar costs and sold the pepper for the same price in the European market. To understand the sources of Dutch dominance, Irwin argued that the nature of the competition in the pepper market resembles Brander and Spencer’s (1985) model of duopolistic competition in which two companies exporting a single good are engaged in a one-period Cournot (quantity) competition. The English and Dutch companies competed mainly in the market for pepper and both were state monopolies whose charters could have been revoked (de jure or de facto) in any period. If this was indeed the situation, Brander and Spencer’s analysis indicates that any trade policy shifting one company’s reaction function outward increases its Nash equilibrium profit while reducing that of the other. The policy that seems to have shifted the Dutch company’s reaction function was instituted through its charter. It specified that its managers’ wages should be a function of the company’s profit and volume of trade, thereby shifting the company’s reaction func-
tion outward [as in Fershtman and Judd (1987)]. The intra-firm incentive structure influenced inter-firm competition.

**International relations:** Maurer (1992) conducted a case study of the Anglo–German naval arms race from 1912 to 1914, providing an interesting example of actual equilibrium selection and the “evolution of cooperation” [Axelrod (1984)]. During this period the arms race resembled a repeated prisoners’ dilemma game as both countries recognized the high cost it entailed. Some informal cooperation had been achieved when, in 1912, the First Lord of Britain’s Admiralty, Winston Churchill, publicly announced a tit-for-tat strategy. Beyond the number of battleships already approved for building in Germany and Britain, Britain would build two battleships for each additional German battleship. The Germans adopted their best response of not producing additional battleships after testing the credibility of Churchill’s announcement. Thus the arms race and public spending were diverted in other directions, such as construction of destroyers, the build-up of ground troops, and enhancing the battleships’ features. Negotiation over a formal and broader arms-control agreement failed, however, particularly because both parties were concerned that the discussion would worsen their relations by raising the contentious security issues reflected in the naval competition and its link to the wider issue of the European balance of power.

3.2.5. **Culture, institutions, and endogenous institutional dynamics**

A long tradition in economic history argues that culture and institutions influence economic performance and growth. The study of the inter-relations between institutions and culture, however, has been hindered by the lack of an appropriate theoretical framework. This has limited the ability to address questions that seem to be at the heart of developmental failures: Why do societies evolve along distinct institutional trajectories? Why do societies fail to adopt the institutional structures of more economically successful ones? How do past institutions influence the rate and direction of institutional change? Game theory provides a theoretical framework that facilitates addressing these questions and revealing why institutional dynamics is a historical process.

Greif (1994a, 1996b) integrated game-theoretical and sociological concepts to conduct a comparative historical analysis of the relations between culture and institutions.

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31 Irwin argues that this result supports the view of mercantilism as a strategic trade policy. Arcand and Brezis (1993) take a similar stand.

32 E.g., North (1981). For an elaboration on various concepts of institutions in economics and economic history and the contribution of the game-theoretic perspective, see Greif (1997c, 1998b, 2000b). Similar to the above papers, institutions are defined here as non-technologically determined factors that direct and constrain behavior while being exogenous to each of the individuals whose behavior they influence but endogenous to the society as a whole. (Hence, an institution can reflect actions taken by all the individuals whose behavior the institution influences or actions taken by other individuals or organizations, such as the court or the legislature.)
The analysis considers the cultural factors that led two pre-modern traders' societies – the Maghrabis from the Muslim world and the Genoese from the Latin world – to evolve along distinct institutional trajectories. It builds on a distinction between two elements of institutions – expectations and organizations – which is made possible by game theory. A player's expectations about the behavior of others are part of the non-technologically determined constraints that a player faces. Organizations such as the credit bureau, the court of law, or the firm, can potentially constrain behavior as well by changing the information available to players, changing payoffs associated with certain actions, or introducing another player (the organization itself). Clearly, organizations can be either exogenous or endogenous to the analysis (as discussed in Greif (1997c)). When they are endogenous their "introduction" means that they are transformed from being an off-the-path-of-play recognized or unrecognized possibility to an on-the-path-of-play reality. This framework enables the explicitation of a role of culture in institutional dynamics.

Specifically, as mentioned above, the different cultural heritages and social processes of the Maghrabis and the Genoese seem to have led to a selection of distinct equilibria in the merchant-agent game. The Maghrabis reached a "collectivist equilibrium" that entailed a collective punishment, while the Genoese reached an "individualist equilibrium" that entailed bilateral punishment. What is more surprising, however, is that a game-theoretical and empirical analysis indicates that once the distinct expectations associated with these strategies were formed with respect to agency relations they became "cultural beliefs" and transcended the original game in which they had been formed. They transcended it in the sense that they influenced subsequent responses to exogenous changes in the rules of the game and the endogenous process of organizational development, or, in other words, they became a cultural element that linked games.

Classical game theory does not say much about such inter-game linkages: actions to be taken following an expected change in the rules of the game are part of the (initial) equilibrium strategy combination, while an equilibrium that will be selected following an unexpected change in the rules of the game has no relation to the equilibrium that prevailed prior to the change. Yet, comparing the responses of both groups to exogenous changes indicates that the equilibria selected following unexpected changes in the rules of the game had a predictable relationship to the equilibria that prevailed prior to the change. Cultural beliefs provided the initial conditions in a dynamic adjustment process through which the new equilibria were reached. Furthermore, the initial equilibria were related in a predictable manner to subsequently historical organizational innovations. Differences in organizational innovations among the two groups regarding organizations such as the guild, the court, the family firm, or the bill of lading, can be consistently accounted for as reflecting incentives generated by the expecta-

33 Similar results emerged in experiments. See Camerer and Knez (1996).
tions that following an organizational change, the original cultural beliefs will still prevail.\textsuperscript{34}

The analysis of institutions among the Maghribis and Genoese in the late medieval period suggests the historical importance of distinct cultures and initial organizational features in influencing institutional trajectories and economic development. Interestingly, the cultural and organizational distinctions among the Maghribi and Genoese societies resemble those found by social psychologists and development economists to differentiate contemporary developing and developed economies.

In any case, the analysis indicates how cultural traits and organizational features that crystallized in the past influence the direction of institutional change. Societies evolve along distinct institutional trajectories because past cultural beliefs and organizations transcend the particular situation in which they were formed and influence organizational innovations and responses to new situations. Furthermore, societies fail to adopt the institutional structures of more economically successful ones because they can only adopt organizational forms and formal rules of behavior. The behavioral implications of these, however, depend on the prevailing cultural beliefs, which may not change despite the introduction of new organizations and rules.

The analysis of agency relationships among the Maghribis and Genoese also sheds some light on the sources of endogenous institutional change. The rate of institutional changes depended on organizational innovations while their particular cultural beliefs provided members of each group with distinct incentives to invent new organizational forms.

Other studies that applied game theory to historical analysis indicate additional ways that past institutions influenced the rate of institutional change. As elaborated in Greif (2000b), existing institutions cause endogenous institutional change by directing processes through which "quasi-parameters" change. Quasi-parameters are institutional and other features – such as preferences, technological and other knowledge, and wealth distribution – that are either part of the rules of the game or can be taken as exogenous in a study of institutional statics because (or when) they change slowly and only their cumulative change causes institutions to change.\textsuperscript{35} Existing institutions and their implications direct the process through which quasi-parameters change, and thereby they can, over time, cause existing institutions no longer to be an equilibrium – i.e., self-enforcing. In other words, processes caused by existing institutions can lead, over time, to endogenous institutional change.

\textsuperscript{34} Yet, the theory cannot account for the timing of these organizational changes. Historically, it took a long time to introduce an organization despite the incentives and possibility of an earlier introduction.

\textsuperscript{35} The main reasons for this discontinuous influence are that the mapping from quasi-parameters to an equilibrium is a set-to-point mapping and that institutions coordinate behavior. Because a particular equilibrium can prevail for a large set of quasi-parameters, there is a range in which they may change and equilibrium will still exist. At the same time, because changes in the cultural beliefs associated with the prevailing equilibrium – the shared expectations that coordinate behavior on it – require coordination, that equilibrium is likely to persist despite the changes in quasi-parameters. See further Greif (2000b).
To illustrate endogenous institutional change, consider again the above discussion of the community responsibility system that supported inter-community "anonymous" exchange during the late medieval period [Greif (2000a)]. During the late thirteenth century, attempts were made throughout Europe to abolish this system and to establish alternative contract enforcement institutions based, in particular, on a legal system administered by state that held a trader, and not his community, liable for his contractual obligations. A game-theoretic and historical examination of the transition away from the community responsibility system suggests that, ironically, it reflects the system's own implications. The community responsibility system was eroding the quasi-parameters that made it self-enforcing. It enabled trade to expand and merchants' communities to grow in size, number, and economic and social heterogeneity. These changes implied that over time the community responsibility system was no longer an equilibrium. The increase in intra-communities' economic heterogeneity, for example, implied (as discussed previously) that some community members had to bear the cost of the community responsibility system without benefiting from it. Hence, they used their political influence within their community to abolish the system.

3.3. Conclusions

Although all the above studies integrate game-theoretical and economic history analyses, they differ in their objectives, their methodologies, and the weight placed on theory versus history. Yet, they forcefully indicate the potential contribution of combining economic history, game theory, and economics. Game theory has expanded the domain of economic history by permitting examination of important issues that could not be adequately addressed using a non-strategic framework. It enabled the examination of such diverse issues as contract enforcement in medieval trade, the economic implications of legal proceedings in Old Regime France, trade rivalry between the Dutch Republic and England, bargaining in England's coal mines, and the process through which the industrial structure emerged in the US. It provided, among other insights, new interpretations of the nature and economic implications of merchant guilds, the Glorious Revolution, the role banks play in development, the structures of industries, and the free-banking era.

More generally, these studies indicate the promise of applying game theory to economic history to advance our understanding of a variety of issues whose study requires strategic analysis. Among them are the nature and implications of the institutional foundations of markets, the legal system, the inter-relations between culture and institutions, the link between the potential use of violence and economic outcomes, the impact of strategic factors on market structures, and the economic implications of organizations for coordination and information transmission. Further, although all the above studies used equilibrium analysis, they illuminated the sources and implications of changes and path dependence. Incentives and expectations on and off the equilibrium path indicate the rationale behind the absence or occurrence of changes, while institutional path dependence was found, for example, to be due to acquired knowledge and infor-
mation, economies of scale and scope associated with existing organizations or technology, coordination failure, distributional issues, capital market imperfections, and culture.  

Perhaps the most important contribution of analyses combining the game-theoretic and historical approaches is that they provide additional support for the importance of examining strategic situations and the empirical usefulness of game theory. Indeed, history provides an unusual laboratory in which to examine the empirical relevance of game theory since it contains unique data sets regarding strategic situations and the relationship between rules and outcomes. Interestingly, infinitely repeated games that have been considered by many as indicating the empirical irrelevance of game theory because they usually exhibit multiple equilibria, were found to be particularly useful for empirical analysis. Further, the studies discussed above also demonstrate the limitations of the theory and suggest directions for future development. For example, they indicate in the spirit of Schelling (1960) and Lewis (1969) that understanding equilibrium selection may require better comprehension of factors outside (the current formulation) of games, such as culture. Similarly, the study of organizations and organizational path dependence indicates the importance of considering the process through which the rules of the game are determined and the implications of organizations on the equilibrium set and equilibrium selection.

Finally, economic history analyses using game theory have enhanced our knowledge regarding issues central to economics, such as the nature and origin of institutions, the strategic determinants of industry structures and trade expansion, collusion, property rights, the economic implications of political institutions, labor relations, and the operation of capital markets. Hence, they provide an additional dimension to the long and productive collaboration between economic history and economics. Furthermore, these analyses indicate the need for and the benefit of combining theoretical and empirical research that transcends the boundaries of history, economics, political science, and sociology.

The application of game theory to historical analysis is still in its infancy. Yet, it seems to have already reaffirmed McCloskey's (1976) claims regarding the benefits of the interactions between economic history and economics in general. It has provided an improved set of evidence to evaluate current theories, suggested theoretical advances, and expanded our economic understanding of the nature, origin, and implications of various economic phenomena.

References


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