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Organizational learning in production networks

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Abstract

If one accepts that a firm's behavior is determined by history-dependent capabilities that adapt in a goal-directed way, one would like to know how a firm's organizational structure influences the manner in which this distributed and partially tacit organizational memory evolves over time. In this paper, we study the impact that alternative information systems, incentive systems and modes of learning coordination have on the efficiency and generality of priority rules for job-shop scheduling which are learnt by a network of production agents modeled by neural networks. When modeling the alternative organizational structures by different input layers, feedback and training methods, we find that efficient rules evolve when global incentives and synchronized learning are employed even if the system state is only partially known to an agent. However, organizational learning fails when it is performed asynchronously with local goals. © 2002 Published by Elsevier Science B.V.

Keywords: Organizational learning; Job-shop scheduling; Agent system

1. Introduction

1.1. Contractual and evolutionary theories of the firm

Traditionally, economics judges an economic organization according to the efficiency of allocation obtained when employing it. There, an agent has to solve a given problem of optimization under constraints derived from the agent's capabilities and actions of other agents. Coordination of the actors is achieved either via the market mechanism through the adjustment of supply and demand or through the firm employing an organizational structure

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that provides problem decomposition, communication channels, and incentive mechanisms. The choice between coordination mechanisms is made according to the transaction costs involved, where the production costs are assumed to be unaffected by organizational arrangements (see, e.g. Williamson, 1975). A number of works on the different aspects of a firm's organization using this paradigm indicate that the hierarchy is the best way of keeping a firm's transaction costs low, as it economizes the costs of information and communication (Bolton and Dewatripont, 1994) and allows optimal coordination (Mesarovic et al., 1970). Consequently, Williamson titles his book on transaction cost economics "Markets and Hierarchies" equating the "firm" with "hierarchy". They describe a firm as a hierarchically ordered set of automata that process information in order to derive organizational actions. In the long run, only firms with the most efficient production and governance mode survive under perfect competition, i.e. differences between firms are transient and profits vanish except in the presence of market power. Hence, the purpose of strategy is the selection of suitable markets, the necessary organizational set-up being viewed as a subsequent step (Porter, 1985).

When looking at the software systems used in practice for production planning and control, one finds that this "information processing paradigm" is a rather good description of how firms operate: based on given product and process specifications laid down in bills of materials and work plans, enterprise resource planning (ERP) software packages typically start with coordinating sales and logistics via aggregate demand planning; on this basis, they then coordinate the production segments among each other and with the purchasing function by deriving production orders and purchase requirements which are subsequently detailed into schedules and orders, respectively (see, e.g. Scheer, 1998). However, the "information processing paradigm" neglects the aspect of innovation and thus cannot explain a number of empirical observations such as follows.

- Lawrence and Lorsch find that real-world organizations are the less hierarchical the more often they have to innovate. They conjecture that the hierarchy is not always the best way of organizing. Rather, this is contingent on the environment (Lawrence and Lorsch, 1986).
- Nelson reports persisting and substantive differences in organizational forms and performance among firms rather than a convergence to a single form (Nelson, 1991).
- Teece et al. show that successfully diversifying firms only move in areas close to the current field of operations, suggesting that a firm's strategy is historically constrained by the capabilities obtained in the current area of operations (Teece et al., 1994, see also Pennings et al., 1994).

Explanations for these phenomena are offered by evolutionary approaches. They view the firm as a "repository of capabilities" for developing, producing, and selling products which determine the current and possible future behavior (Loasby, 1998). Rather than static or publicly available, capabilities are largely tacit and have to be acquired in an idiosyncratic and path-dependent way via social learning by doing and imitation. They can be seen as the distributed "organizational memory", consisting of declarative frames of reference that determine how the organization "sees the world" and of procedures for performing tasks and coordination, both of which adapt incrementally to own or imitated foreign experience on the basis of feedback in a target-oriented way. From this point of view, a firm's organizational structure is to be judged according to the long-term competitiveness of the organizational

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