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Understanding the complexity of project team member selection through agent-based modeling

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Abstract

Previous research has recognized the significance of a team's work capacity and suggested the selection of team members based on individual skills and performance in alignment with task characteristics. However, work teams are complex systems with interdependence between workers and the social environment, and exhibit surprising, nonlinear behavior. This study utilizes Agent-Based Modeling (ABM) to understand the complexity of project team member selection and to examine how the functional diversity of teams and worker interdependence affect team performance in different economic conditions. Data for model validation was collected from 116 construction projects for the period from 2009 to 2011. The results show that teams with higher functional diversity can enhance the overall firm performance when the economy is in a downturn. This study suggests managers using knowledge of worker interdependence to protect higher-performing workers by minimizing disruption of interdependence in team member selection for improving firm performance.

Keyword: Team member selection; Diversity; Interdependence; Complexity; Agent-based modeling

1. Introduction

Businesses are using teams for project-based tasks with greater frequency because teams have high potential, high motivation, good problem-solving capability and flexibility which are important work structures for success (Baykasoglu et al., 2007; Gerard, 1995; Gordon, 1992). A team is typically defined as a small group of people working in an interactive manner toward a common goal (Ilgen 1999; Wageman et al., 2012). The success of these project teams is highly dependent upon the people on the team. While the literature has focused on other methods for improving team performance, such as training and feedback, team member selection and member replacement are the tools that managers use the most often (Solow et al., 2002).

Previous research has recognized the significance of a team's work capacity and suggested the selection of team members based on individual skills and performance in alignment with task characteristics. However, work teams are complex systems with interdependence between workers and the social environment, and exhibit, surprising, nonlinear behavior. In order to understand the complexity of project team member selection, this paper first reviews the relevant literature both in project management and organization science. Agent-based modeling (ABM) was selected to model team member selection because it especially designed to model interactions between agents and environments. For empirical comparison, this study uses a small design firm to examine the performance of a variety of team member selection approaches. Project data, task assignment, and team performance information were collected for the period of 2009–2011 and used

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to validate the developed ABM team member selection model. Using simulation, together with insights derived from complex systems, this study then illustrates that ABM provides a suitable platform for the creation of robust and accurate "what-if" scenarios within team member selection settings. This approach can simulate multiple alternative configurations of teams to predict and evaluate their performance, which in turn, can provide a decision support tool for tactical and operational decision-making in the context of project team member selection.

2. Project team member selection

Although research on project teams has increased in recent years (Bartsch et al., 2013; Buvik and Rolfsen, 2015; Ding et al., 2014; Savelsbergh et al., 2015), any researchers doing a study of project teams may struggle to describe exactly what kind of project team is the focus of his or her study. According to the dimensional scaling framework for describing teams which developed by Hollenbeck et al. (2012), the project team that discussed in this research can be classified as Long-term project teams. The long-term project team is a team that is a stable and permanent unit in an organization. Compared to short-term project team, the task requirements may be more stable, and distribution of tasks and roles also be more clearly defined (Joshi and Roh, 2009). In terms of temporal stability, the long-term project teams are defined for those who work together up to a year on specific projects.

During the 1980s and 1990s, several researchers focused on selecting team members based on complementing personalities (Barry and Stewart, 1997; Hogan et al., 1988; Smith-Jentsch et al., 1996). Moreover, the self-efficacy for teamwork and self-monitoring has been shown to impact team effectiveness, but the relationship between these attributes and individual team performance has not yet been investigated (McClough and Rogelberg, 2003). Past research demonstrated that personality-based selection is useful in general; however ability-based selection strategies have historically been more successful in predicting performance (Hunter et al., 1990; Schmitt et al., 1984).

Although it is simpler to study team performance as an accumulation of individual contributions and assuming each person's contribution is independent of others, many researchers have realized the importance of interdependence and non-additive contributions (Hinds et al., 2000). Tziner and Eden (1985) discovered in their study of military tank crews, highly skilled teams far outperformed the levels predicted from summing their skill levels, and low-skilled teams performed well below the predicted levels of their summed skills. They used these observations about synergistic performance to offer detailed recommendations for building three-man tank crews from the existing candidate pool. They also noted that switching operators between crews was not a zero-sum game in which one team lost what the other gained. Instead, some combinations of players performed disproportionately better or worse than others. Thus, optimizing individuals to fit activities without taking interdependencies into account is unlikely to yield a high performing team. Otherwise, obtaining empirical data about the effects of different team member selection orientations on team performance can require a prohibitive time commitment. This study instead utilizes a computational model to understand the complexity of project team member selection and to maximize performance across workers and teams in different contexts.

3. Complex systems and agent-based modeling

A complex adaptive system (CAS) is a special kind of complex system since it has the property of adaptation, meaning that it has the "ability to consciously alter its system configuration and influence its current and future survival" (McCarthy, 2003). An agent in a CAS may be a person, a molecule, a species, or an organization, or any number of other object types. These agents act based on local knowledge and conditions. A central body, master neuron, or a project manager does not control the agent's individual moves. A CAS often has a densely connected web of interacting agents, each operating from its own schema or local knowledge. In a construction project context this means that the entities in the system are responsive, flexible, reactive and often deliberately proactive in response to inputs and signals from other nearby entities. Many business processes and phenomena are non-linear, self-organizing, changing and rationally bounded, and so CAS can yield unique insights into these processes and phenomena. While insights from CAS can improve our understanding of project team member selection and provides a helpful framework for modeling, some kind of method is needed in order to apply this approach and achieve tangible and understandable results, particularly from a management perspective.

Agent-based modeling (ABM) represents a new paradigm in the modeling and simulation of dynamic systems distributed in time and space (Jennings and Bussmann, 2003; Lim and Zhang, 2003). ABM enables the application of CAS approaches to address the behavior of each of the participants within a complex system (North et al., 2005). There is a growing interest in using ABM in several business-related areas, such as manufacturing (Kotak et al., 2003; Zhou et al., 2003), logistics and supply chain management (Kaihara, 2003; Santos et al., 2003), marketing (Rand and Rust, 2011), and operations research and management science (Davis et al., 2007). ABM is considered important for developing industrial systems (Davidsson and Wernstedt, 2002; Fox et al., 2000; Karageorgos et al., 2003) and it provides a pragmatic approach for the evaluation of management alternatives (Swaminathan et al., 1998). The simulation of teams has been undertaken by several researchers, reflecting the large number of team-based activities available (Fan and Yan, 2004), but just a few in project organization (Aritua et al., 2009; Kim and Kim, 2010; Watkins et al., 2009).

In ABM, the focus is on agents and their relationships with other agents or entities (Axelrod, 1997; Cicirello and Smith, 2004). An organization is a collection of agents that interact and produce some form of output. Organizations have output and deliver some measure of performance. Performance may be measured by profit or may involve specifying a particular target