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Benefit sharing for BIM implementation: Tackling the moral hazard dilemma in inter-firm cooperation

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Abstract

Building information modeling (BIM) plays an important role in furthering value-creation of construction projects by advocating the inter-firm cooperation. When implementing BIM, however, individual firms inherently safeguard their self-interests regardless of the fact that inter-firm cooperation might reap joint BIM benefits for a project overall, which epitomizes a typical problem of moral hazards in project-based organizations. This paper develops an outcome-linked benefit sharing model that considers sharing joint BIM benefits among stakeholders including designers, contractors, and clients for tracking moral hazards therein. By modeling stakeholders' behaviors as evolutionary games within a principal–agent formalism, it has been deducted that (1) designers/contractors could be incentivized to cooperate had each stakeholder received a share higher than the quotient of BIM costs over value-creation in the design/construction phase; and (2) how joint BIM benefits can be more than noncooperation outcomes is key for clients to support BIM implementation.

Keywords: Building information modeling; Inter-firm cooperation; Moral hazards; Principal–agent theory; Evolutionary game model

1. Introduction

The tremendous construction demand has kindled a global interest in implementing building information modeling (BIM) in the architecture, engineering and construction (AEC) industry (Chen et al., 2015). Confronting intense competitions, sharp cost pressures, and the value-creation demand, AEC firms find it difficult to develop so far as the project fragmentation is concerned (Ceric, 2012), particularly in the Design Bid and Building (DBB) model prevailing in the industry (MacLeamy, 2004). BIM offers a platform for information sharing between firms, and is recognized as able to add value to projects by enhancing management interoperability, integration, efficiency, and effectiveness (Eastman et al., 2011). As such, BIM could help move the project management from intra-firm order towards inter-firm cooperation (Eadie et al., 2013), and is described to be so advantaged that it will bring a paradigm shift to the AEC industry (Eastman et al., 2011).

Despite its virtues, BIM has not yet made a decisive step from pilot-alike or particular-purposed cases to widespread applications, wherein the euphoria around BIM is yet to be seen. It immediately begs the question of why AEC firms stand aloof from using BIM notwithstanding its advantages reported by researchers. To some extent, existing studies have addressed BIM implementation barriers such as technological factors (Redmond et al., 2012), human elements (Bryde et al., 2013), and financial influences (Son et al., 2015). Nevertheless, there leaves a sense of lacking attentions to the conflict between individual maximization and inter-firm cooperation. On the basis of economics and organization theories, firms are self-interested individuals and behave in a way that best serves their own utilities (Hatch and Cunliffe, 2013). Meanwhile, firms' activities are limited by their imperfect information, cognitive limitations and finite time, involving costly safeguarding

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of, and competition for, individual maximizations (Williamson, 1973; Simon, 1982). For implementing BIM, it engages clients and AEC firms that mainly fall into designers and contractors. Whilst clients often play a dominant role in promoting BIM, they actually rely on AEC firms' expertise and resources for BIM implementations—such ties are typical principal–agent (PA) relations, where bounded rational AEC firms (agencies) focusing on self-interests may well act inappropriately from the client's (the principal's) viewpoint, where their interests not aligned (Ross, 1973; Postrel, 2009).

Firstly, as information sharing is indispensably required, using BIM is often associated with revealing firms' proprietary information. Firms are apt to presume that by doing so would invite intensified competitions and monitoring from other firms, and cause losses to their vested benefits that are known as the proprietary cost (e.g. Berger and Hann, 2007). Being required to use BIM, AEC firms thus are facing tradeoffs between BIM benefits and their proprietary costs. When BIM benefits are uncertain in comparison with present pictures of proprietary costs, decisions favoring using BIM would be very unlikely. Secondly, as one profound purport of BIM is to offer a commonly accessible information platform (Hess and Ostrom, 2003), implementing BIM encounters the puzzle of 'common-pool' resources in a narrow path. In the relevant literature, given 'common-pool' resources, inefficient outcomes are frequently found, predominantly owing to individuals' free-riding and over-competition (e.g. Camerer, 2003; Duffy and Ochs, 2009). Given a BIM-based information platform, AEC firms are also inclined to free-riding and over-competition for obtaining possibly higher benefits than before. These firms, meanwhile, would try for safeguarding their gained benefits. Because free-riding, self-interest safeguarding, and over-competition are all costly behaviors (Williamson, 1973), in any event, firms' previous cost–benefit equilibria could become unbalanced and probably move to lower levels. Consequently, no firm would genuinely cooperate even though corporately using BIM is desired from the collective view. This epitomizes a classical problem existing in project-based organizations, as being labeled by scholars as the moral hazard dilemma, which can be prejudicial to both joint outcomes and individual utilities (Gintis, 2009).

How to tackle moral hazards in a PA relation has long been a challenging problem for scholars (Hess and Ostrom, 2003; Obloj and Zemsky, 2015). Researchers unanimously consent that cooperation is intricately associated with communications, norms, and institutions. While norms and communications actually motivate firms to obey institutions (Arrighetti et al., 1997), incentives and punishments are core issues of institutional arrangements (Hess and Ostrom, 2003). This paper hence resorts to incentive-alignment for encouraging inter-firm cooperation for BIM implementation. An outcome-linked benefit sharing model (OLBSM) is developed by modeling stakeholders' behaviors as evolutionary games within a principal–agent formalism. The OLBSM considers sharing joint BIM benefits among stakeholders (i.e. designers, contractors, and clients) for delivering DBB projects. Being subject to a determined environment, this study has both methodological and practical implications to other settings purposing on promoting BIM.

2. Existing incentives of using BIM and emerging challenges

The BIM implementation literature has sprung up over recent years. These studies are mainly geared towards inductive models for technological, organizational, or financial-based initiatives to overcome barriers to BIM adoption. Among these studies, Redmond et al. (2012) strive efforts to expand BIM applications by introducing a web service. Cao et al. (in press) propose four categories of BIM incentives from regulation, cooperation image, and revenue based upon experiences of China. Son et al. (2015), Arayici et al. (2011) and many other scholars study organizational factors such as the firms' culture that could hinder them from adopting BIM. Scholars also inspiringly argue that, as using BIM is costlier during design phases but more profitable for construction phases (Lu et al., 2014), a fee structure change for stakeholders fairly assuming BIM costs could offer proper incentives (Bryde et al., 2013). Another inspiring approach is to apply the integrated project delivery modeling (IPDM) to BIM-based projects (e.g. Sebastian, 2011), where the key has been recognized as aligning stakeholders' incentives and goals of BIM implementation (Chang, 2014).

As insightful as previous studies are, there are still deficiencies that require further exploration. Firstly, existing approaches including fee structure changes and the IPDM fail in characterizing their functions with details. Secondly, while there are scholars arguing that firms' different targets prevent them from coalition (e.g. Manu et al., 2015), they stop before going deeper into essential reasons. Thirdly, existing models for promoting BIM do not explicitly include firms' self-interests and bounded rationalities, resulting in consequences diverging from their original intentions. For instance, under cost-switching policies, a firm may increase the BIM budget only for obtaining higher profits instead of truly using it, as an increased BIM budget might be borne by other firms.

Above discussions trenchantly point out that, what is lacking is the attention to moral hazards in BIM implementation and illuminating coping strategies. What will be useful is a managerial concept that helps AEC firms overcome strong temptations to moral hazard behaviors. What is currently needed thus is a risk-free and costless method of demonstrating effects of sharing joint BIM benefits on stakeholders' behaviors when implementing BIM.

3. Methodology and research strategy

3.1. Methodology

This study seeks for developing an outcome-linked benefit sharing model (OLBSM) to incentivize inter-firm cooperation in the context of BIM implementation. The model development is grounded in the principal–agent (PA) theory and follows the deductive reasoning approach. The OLBSM is regarded as an *ex-ante* approach of sharing *ex-post* joint BIM benefits between clients (the principal) and designers/contractors (i.e. AEC firms, agencies). Among methods for governing PA relations, evolutionary game models have produced optimal collaboration results in laboratories (e.g. Groves and Ledyard, 1977; Camerer, 2003). In a similar vein, this study models BIM