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A CONCEPTUAL EXPLORATION OF A COLLABORATIVE ENVIRONMENT IN THE CONSTRUCTION INDUSTRY WHEN WORKING WITH TEMPORARY SOCIO-TECHNICAL PROCESSES

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ABSTRACT

Previous research on construction projects showed that low productivity characterizes the construction industry, repeatedly explained in terms of the industry's complex and fragmented nature. However, few studies have approached the production problem in terms of the entire industry. This paper consequently elaborates on the challenges and the importance of a collaborative environment in the construction industry because construction is complex, with the main operations produced within temporary and socio-technical systems. Through a conceptual exploration, this paper combines theories on networks, boundaries, open systems, and loose and tight couplings to assesses the consequences of temporality and how integrated project delivery (IPD) tighten couplings in the industry. Finding show that because projects are temporary, they challenge the multilevel connections of networks needed for the industry's evolution to become more productive. However, theories on open systems and tight and loose couplings indicate that IPD enable a cooperative network environment. Thus, the boundaries of cooperative delivery models will enable a stronger link between change and process, industry and projects, needed for a socio-technical process in construction.

KEYWORDS

Collaboration, time compression, loose and tight couplings, socio-technical systems, integrated project delivery (IPD).

INTRODUCTION

In this digital era, productivity growth in the richest countries has not matched investments in technology (Harris 1994; Rotman 2018). The term *productivity paradox* has been used to describe this phenomenon (Macdonald et al. 2000). To address the situation, previous research in the field of productivity has focused on single-level production (Harris, 1994)

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and how to increase productivity and the use of digital tools on individual, group, or organizational levels. A principal assumption has been that increasing productivity in one part of a network will contribute to the network's overall productivity.

Research on construction is often initiated from the project management discipline. The discipline is a fairly young research area, which first has been devoted to a project focus (Önday 2016; Skyttermoen & Vaagaasar 2015). From that perspective, a construction project is defined as the project organization, the process, and the finished product (Eikeland 2001), and for a limited time, the project is an agent of change in the construction firm. Furthermore, to untangle the productivity paradox, the previous decade of research on construction projects has broadened from its traditional focus on static processes to examine projects as an ongoing creation, as a verb not as a noun (Lundin & Söderholm 1995; Skyttermoen & Vaagaasar 2015). Hence, collaboration has become an important topic in the study of projects (Gohary & Karrbom Gustavsson 2012; Lahdenperä 2012), and new, collaboration-based delivery models have been introduced to solve the productivity paradox, leading to a need for collaborative environments in the construction industry.

Koskela (2000) stated that the construction industry has insufficient productivity, mainly due to project complexity: time limits and multilevel interdependent units are complex characteristics that have been discussed for several years (Dubois & Gadde 2002; Koskela 2000). Specifically, Gidado (1996) explained this complexity through a multitude of interactive elements, and this assumption has been studied through theories of organizational boundaries that assistant in a project, but it has not been studied at an industry level, where project boundaries interrelate (Gohary & Karrbom Gustavsson 2012).

Little attention has been paid to the need for collaboration between a construction project and its industry network to increase productivity (Skyttermoen & Vaagaasar 2015). This is partly due to a lack of focus on how organizational boundaries interact in the construction industry's network, and few attempts have been made to broaden knowledge about the link between intervention at one level and the impact on productivity at another level. Strengthening this understanding could provide an important step in transforming the construction industry more collaborative and productive, especially as projects become more complex and therefore work must be accomplished collaboratively.

In response to the need to investigate how the industry can become a collaborative environment, the research question is: *Can we talk about a collaborative environment in the construction industry when working with temporary socio-technical processes?* Two objectives were formulated to address the question raised: (1) assess the characteristics of temporality in the relationship between a project and the construction industry as a network, and (2) view integrated project delivery (IPD) through the boundary theory of loose and tight couplings.

The unit of analysis is a potentially collaborative construction industry, and the study is primarily concerned with coupling the construction industry with a network of projects. The study takes the ontological stance of Critical Realism. Hence, the aim is to elaborate the possibility of a collaborative environment in the construction industry, not to claim that the presented theoretical framework is the only explanation.

METHODS AND SCOPE

The method of this study is a semi-structured literature review guided by the research question. The review started with Scott's (2006) work on organizations and organizing. Theoretical and empirical papers were then identified through in-clouding keyword searches in databases and manually checking reference lists. Given the breadth of topics, the search was later limited to articles that explicitly targeted the construction industry. Limited studies were found on a collaborative environment in the construction industry, leading to a focus on studies from an organizational theory perspective.

A central issue with this study is the extensive literature it briefly covers, limiting the in-depth study of reviewed theories. Thus, the paper is conceptualized as an overview of theories suitable to approach the research question that is raised.

This paper unfolds in the following way: section one addresses the complex nature of construction through projects conceptualized as *temporary* and *socio-technical systems* (STSs). The second section elaborates on the complexity issue by discussing projects in the construction industry, assessing boundaries in the industry, and devoting particular attention to how boundaries affect a collaborative environment. The last part of the paper is dedicated to the discussion and conclusion of the study.

1. THE COMPLEX NATURE OF CONSTRUCTION

Research on the construction industry as a complex and dynamic system has become important to help understand the current problem of low productivity (Baccarini 1996; Bertelsen 2013; Dubois & Gadde 2002; Koskela 2000). Baccarini (1996) stated that the construction industry could be considered the most complex undertaking in any industry, and according to Gidado (1996), that complexity seems to evolve.

Complexity is a widely used but not well-defined term. Baccarini (1996) specified that complexity should not be confused with size and uncertainty. For Gidado (1996), the components that define the complex nature of construction are *"…the employed resources, the environment, the level of scientific and technological knowledge required and the number and interaction of different parts in the work flow."* This study embraces Gidado's (1996) two-part categorizations of complex components: (1) components that originate from the environment and resources employed and (2) components that stem from the interdependence of tasks. The two categories intersect, but the categorization helps to gain a deeper knowledge of each component. The first category can be studied to understand individual tasks in a production process. However, to elaborate on the consequences of projects being temporary and STSs in terms of a collaborative environment in the industry, this study is limited to the second category. Thus, this study focuses on two aspects of project complexity to elaborate on a collaborative environment in the construction industry: (1) projects as temporary organizations and (2) projects as STSs.

1.1 TEMPORALITY IN THE INDUSTRY NETWORK

One way that researchers have coped with complexity in the construction industry is to view the overall industry as comprising permanent and temporary networks (Dubois & Gadde 2002). This study adopts Biesenthal et al.'s (2015) use of the noun *temporality* when

describing the condition of being limited in time. Construction firms are permanent, whereas projects are defined as temporary organizations with a start and an end (Biesenthal et al. 2015). Projects are agengts of change in an organization, where the task is to transform an idea into a product in a given amount of time (Skyttermoen & Vaagaasar 2015).

This paper adopts a network perspective to study interacting units in the construction industry (Ruan et al. 2013). For example, network theory can be used to explore the flow of information, knowledge, and materials; it can also determine how trust and cooperation are established between permanent and temporary networks (Scott 2006). How both permanent and temporary organizational boundaries are structured (collaborative or hieratically) determines how resources flow and can be utilized in the overall network. In the second section, this paper focuses the network perspective to literature on organizational boundaries to explain how the connection between different network types affects a collaborative environment in the overall network.

Interaction in alliances has grown as its own subfield in the network approach (Scott 2006). The formation of alliances is an alternative to vertical integration when discussing organizational boundaries. Network analysis helps to understand why construction firms choose their partners, how time affects the relations, and what benefits specific relations create. This could potentially help to elaborate on the consequence of temporality for a collaborative environment in the construction industry.

1.2 A SOCIO-TECHNICAL ENVIRONMENT

Because Gidado (1996) stated that technological knowledge and interdependency in a workflow contributes to complexity in construction, this complexity can be explained with an STS approach grounded in system theory. The definition of an STS is that the interactions between people and technology introduces a social aspect (Coenen et al. 2009). Hence, one's understanding of project performance can only improve if social and technical aspects of a complex network are treated as interdependent parts.

The construction industry is transforming with the digital era (Macdonald et al. 2000). The most challenging problems the industry faces today are at the intersections of human behavior and engineering innovation. Baxter and Sommerville (2011) stated that a cultural shift among engineers in the industry must occur if STSs in projects are to succeed. Today, the connection between change in management in the industry and engineering in a project process is too weak. Technology requires collaborative work. Despite this, the literature has described the industry in terms of two distinct processes: one for workflows in a project, another for management change in the industry. The lack of a dynamic and jointly developed process could potentially hinder productivity.

2. PROJECTS WITHIN THE CONSTRUCTION NETWORK

2.1 BOUNDARIES BETWEEN PERMANENT AND TEMPORARY NETWORKS

Organizational theorists have defined organizational boundaries as an object-like frame used to manage the organization's relationship with its environment (Gohary & Karrbom Gustavsson 2012; Katz & Kahn 1978). When studying the construction network,

boundaries exist for teams, temporary organizations (projects), and permanent organizations (firms) (Scott 2006). Hence, in this paper the term *boundaries* must be understood in the context it is mentioned.

Organizational boundaries serve a variety of purposes in the construction industry: as buffers or bridges between permanent and temporary organizations (Gohary & Karrbom Gustavsson 2012). As complexity increases, one should not view boundaries as a by-product of the organization but as a frame that evolves through negotiation and interaction (Kerosuo 2006).

There are different approaches to the study of boundaries within and among organizations (Gohary & Karrbom Gustavsson 2012). Kerosuo (2006) has combined four perspectives when studying boundaries in action on a micro- and a meso-level. One perspective studies boundaries to explain institutional change (Scott et al. 2000), another through organizational learning (Wenger 1999). Wenger (1999) offered another approach, focusing on actors that establish boundaries through the establishment of mutual engagement, and Long (2001) explored how to chain an organization's micro- and macro-levels via actor theory.

To bridge the meso- and macro-levels of construction projects and the construction industry, respectively, this study uses the open system theory. This theory explains that the conditions of a system and its environment are closely connected (Scott 2006). For example, a construction project cannot be collaborative in a non-cooperative environment. Katz and Kahn (1978, p.242) suggested two approaches to the open system: (1) *"…the problems of organizations could be viewed as a function of the type of structuring in which they occur"* and (2) studying the interdependence of an organization and its environment.

In this study, open system theory is limited to the theory of loose and tight couplings in the construction industry. Loose couplings have been used to understand the productivity paradox within industries similar to construction—industries with significant investments in technology without consequential production growth (Scott 2006).

Dubois and Gadde (2002) used the theory of loosely coupled systems to study how the relationship between permanent and temporary networks implicates productivity and innovation in construction projects. In this study, the theory is used to explore collaboration. Dubois and Gadde (2010) stated that projects are the actions that connect construction firms. Within projects, teams are tightly coupled, whereas firms are loosely connected through project (organizational) boundaries. In their study, they also argued that mixed couplings negatively affect the industry overall, because interactions in projects do not provide long-term orientation or learning.

Orton and Weick (1990) have the best-known definition of loose and tight couplings when describing the degree of interdependence among organizations. They describe that tight coupling implies direct dependency between components. Behavior thus influences the network in an immediate, constant, and significant manner. However, a consequence of loose couplings, confirmed by Scott (2006), is that increased productivity from tight couplings does not necessarily equate to increased overall productivity in the industry.

2.2 INTEGRATED PROJECT DELIVERY

IPD is among the most common collaboration-based delivery models designed for construction projects (Lahdenperä 2012). With IPD, project success occurs with a contractual agreement between principal actors (e.g., owners, architects, builders, consultants, and contractors) who are involved early; who make collaborative decisions; who jointly offer innovation and control as well as respect, trust, and transparency; and who share risks and rewards (Cohen 2010). In this paper, project success is defined as increased project productivity, ref. the definition of the productivity paradox.

This study adopts El Asmar et al.'s (2013) definition of a project delivery model: a system that determines the relationships between stakeholders through the timing of their engagement in a project. Figure 1 presents two delivery models: the traditional design-build delivery and the IPD model. As illustrated in Figure 1, design-build models are designed with organizational boundaries working in favor of the firm (marked with a clear line), contributing to a hierarical relational structure. In contrast, stakeholders working in IPD has a joint organizational boundary where traditional boundaries of the firm gets less significant (stipled lines). Thus, according to Cohen (2010), relations in IPD is dynamic.

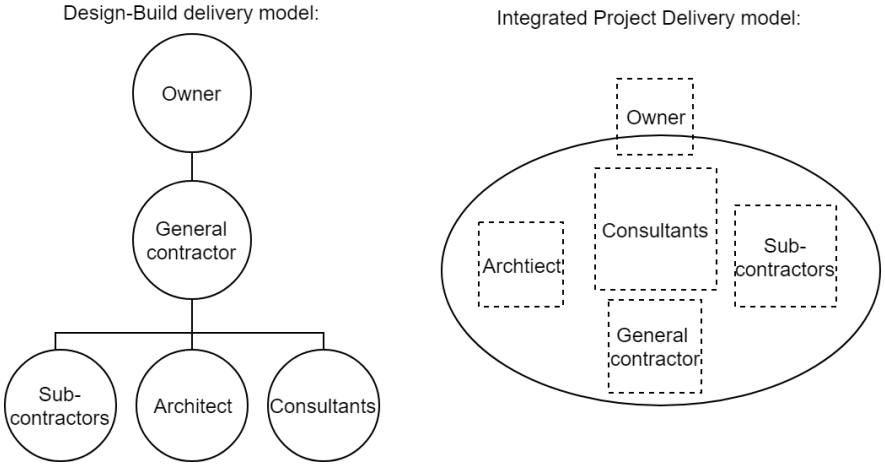

Figure 1: Differences in the structure of design-build and IPD models (free from El Asmar et al. 2013, p.2).

IPD has been described as an answer to the need for collaboration and the room for innovation in the construction industry (Lahdenperä 2012) because it deals with interdependence through alliances (Scott 2006). In addition, IPD is characterized with advanced communication technology. Thus, IPD requires actors to work outside the boundaries of their traditional roles as constructed in the design-build delivery model. However, the extent to which this collaboration-based organizational boundaries affects the overall construction industry remains unclear in the literature.

3. DISCUSSION

Rotman (2018) stated that the richest countries in the world are struggling with low productivity, and Koskala (2000) claimed that this is also a reality in the construction

industry. Hence, the industry must change to continually prosper. To face this challenge, Harris (1994) noted heavy investments in technology. However, based on insights from this paper, technological investments are not enough; the industry must stimulate work patterns that extend technological innovations from temporary projects to form permanent innovations for the entire industry

The aim of this theoretical exploration was (1) to assess the characteristics of temporality in the relationship between a project and the construction industry as a network and (2) to view IPD through the theory on loose and tight couplings. The main discussion is whether a collaborative environment can be created in the construction industry when the main operations are produced within temporary organizations and STSs.

3.1 THE LINK BETWEEN THE INDUSTRY AND TEMPORARY PROJECTS

The first question to be addressed in this discussion is why research has tended to separate the temporary project from the permanent network of the construction industry. When elaborating on the coupling between permanent and temporary components, the dominant research model that separates temporary projects from the permanent construction industry makes little sense. Previous attempts to increase the productivity of construction projects have been limited to the traditions of project management theory. Thus, researchers have understood projects without consideration of the projects' environment (Harris 1994). Skyttermoen and Vaagaasar (2015) discussed whether this contributes to a gap in knowledge. Nevertheless, the link between the permanent construction industry and temporary projects has received little attention from researchers. This may be due to the fact that project management theory is still new (Önday 2016), and thus nuanced understandings of tighter collaborations have yet to occur for that theory.

In addition, Dubois and Gadde (2002) argued that to cope with the complexities of the construction network, the industry has been divided into permanent and temporary networks. This approach compliments that of project management theory. Gidado (1996) explained the need to understand the construction industry as a complex system and to categorize the complexity in ways that are not overwhelming. However, the need for manageable pieces does not necessarily require the omission of a project's environment.

Gidado (1996) argued that because construction projects are agents of change, working within a limited timeframe, construction projects involve complex processes. Based on this logic, the structure of construction projects today may be too complex for a multilevel understanding. Nevertheless, Gidado's arguments about complexity contribute to the assumption that temporality itself is not the cause of a project's focus; but the organizational boundaries that are working in the construction industry as a network. Furthermore, despite Gidado's separation of complexities, he described the components as interacting. Hence, links between temporary and permanent networks must be studied. If complexity is to be handled in a collaborative environment, boundaries should be structured as bridges not barriers (Gohary & Karrbom Gustavsson 2012).

According to Kerosuo (2006), research on boundaries often differentiates between macro- and micro-levels. When addressing the productivity problem from an open system approach, an organizational problem can be explained through its environment. Katz and Khan (1978) argued that the relationship between an organization and its environment is

interdependent and must therefore be understood together. The fact that projects are temporary hinders the integration of permanent organizations among the project's production processes.

From a short-term perspective, it remains unclear if conceptualizing the construction industry as a collaborative environment is possible. Harris (1994) exposed the assumption among researchers that increased productivity at one level will contribute to the overall productivity at the level of the environment. This assumption could contribute to the marginalization of research needed to understand multilevel networks.

Undoubtedly, multilevel networks contribute to the construction industry's complexity. According to Baccarini (1996), the industry will become even more complex. Thus, one must approach the productivity paradox from a multilevel perspective. Furthermore, the complexity of multilevel networks in the construction industry must not be confused with the complexity of a single project. Otherwise, Baccarini's warnings not to confuse size and uncertainties in a network will go unheeded.

3.2 DOES IPD TIGHTEN THE COUPLING IN PERMANENT NETWORKS?

Dubois and Gadde (2002) stated that a combination of loose and tight couplings are problematic for the construction industry because that mixture benefits a temporary project more than it benefits a permanent industry that needs to learn from its projects. Moreover, Scott (2006) elaborated that network theorists have taken greater interest in the interactions between alliances. Instead of using vertically integrated change, alliances can tighten couplings when behavior influences the network immediately, constantly, and significantly. Based on these statements, there is a need to address the general interaction structures established in the industry today.

Based on the literature review in this paper, IPD has emerged as a result of the need to tighten the industry's couplings due to socio-technical developments. Instead of accepting a fixed model of complexity in the construction industry, IPD researchers have stressed that early and dynamic boundary definitions can increase productivity (Cohen 2010). Cohen also characterized IPD-structured projects as joint developments with boundaries negotiated through interactions, as Kerosuo (2006) recommended.

Boundaries for collaboration-based delivery can be more dynamic than general contracting, as evident in Figure 2. This figure combines Figure 1 with boundary theory and Gadde and Dubois's (2010) theory on loose and tight couplings, illustrating, first, how boundaries develop as a product of collaboration in IPD and not as the static frame of a project owner, as in general contracting. Second, Figure 2 illustrates the different evolutions of strength in relations. Much attention has been paid to the separation of design and construction in the field of construction delivery models (Cohen 2010; Lahdenperä 2012). As Figure 2 shows, IPD can create a more stable connection among the primary actors in a project (the cooperative relations get ticker with time).

In addition, STSs introduce a need for greater collaboration in the industry. Coenen et al. (2009) argued that digital transformations add a social aspect to a project's processes. Sommerville (2011) extended this discussion to a macro-level and stated that the industry must change to harness the potential of technology. Thus, relationships in the industry must be tighter to better correlate technological change and workflows. The tighter couplings

are provided in IPD, as evident in Figure 2. The project boundary is a joint development, which opens up for a flow of information and technological change.

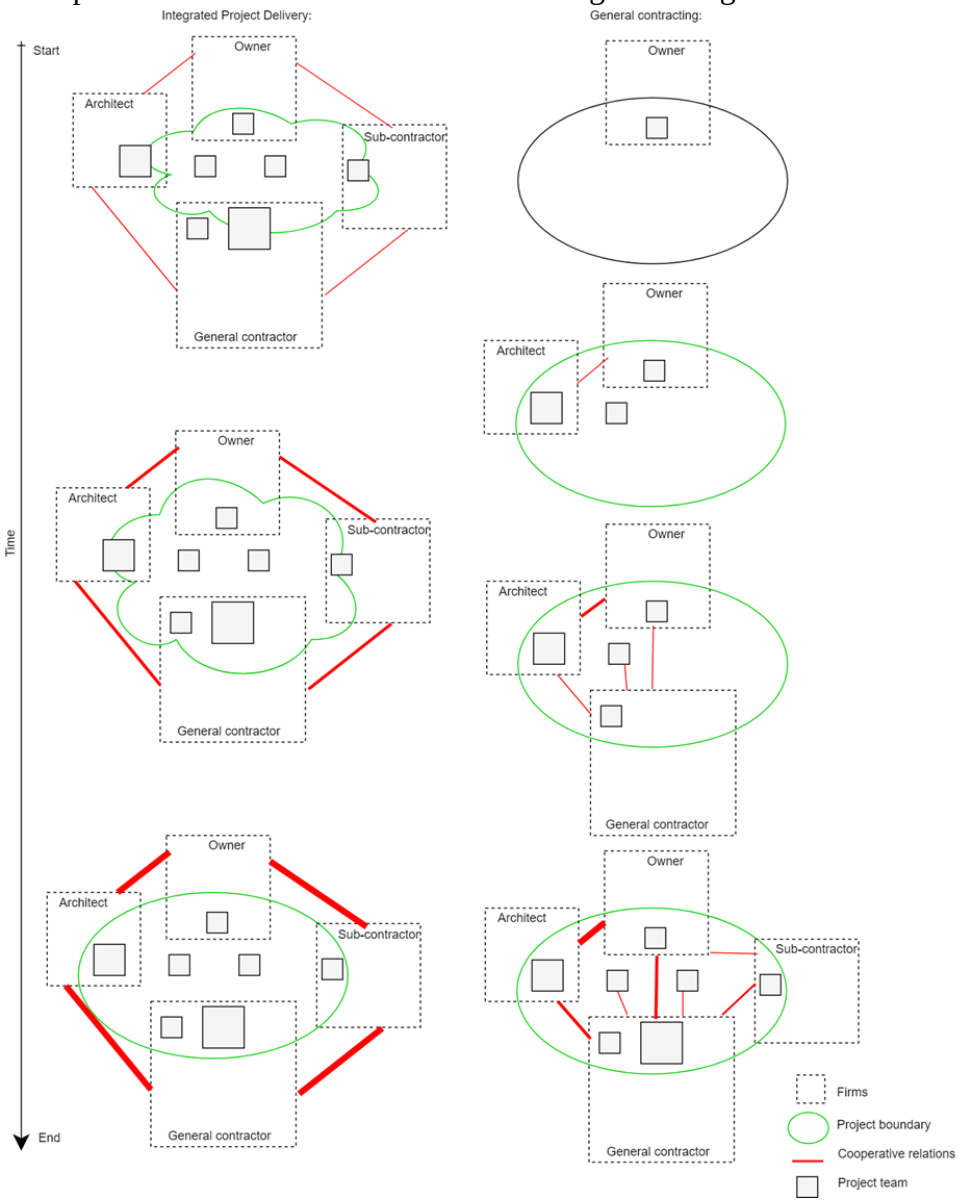

Figure 2: Strength of relationships and boundaries in IPD and general contracting.

An unanswered question in the theory of networks is whether collaboration is more important than structure when discussing multilevel interactions. This question must be answered. Because boundaries play an important role in the construction industry (Gohary & Karrbom Gustavsson 2012), researchers have argued that collaborative delivery models blur boundaries in ways that induce engagement (Cohen 2010). But what happens to these relations when the projects end? Few studies have addressed the impact collaborative projects have had on the construction industry's permanent network. If tight couplings lead to more interdependence, coordination, and hopefully more information flows, then tight

couplings might extend into the larger network when a temporary project ends. One possible effect could be static collaborative patterns among firms in the industry. This effect can create hinders for new firms to establish in the industry.

CONCLUSION

This exploratory paper elaborated on new ideas about the challenge and the importance of collaboration as a result of project temporality and projects as STSs. Theories on boundaries were discussed to demonstrate the possibility for collaboration in the construction industry.

This article raised the following question*: Can we talk about a collaborative environment in the construction industry when working with temporary socio-technical processes?* Theories indicate that the combination of loose and tight couplings favor short-term projects but not necessarily the construction industry's overall network. Because projects are STSs, a closer connection must occur between a project and its environment to better link change to the workflow. Couplings are tightened in projects that use IPD, even though temporality still makes it difficult to establish long-term relationships in a collaboration-based construction industry.

Theoretical implications: The contribution to knowledge lies in the deepening of understanding if collaboration-based delivery models (e.g. IPD) could provide tighter couplings in the construction industry.

Further research: This study was a literature review and was thus not the full answer to the question that it raised. Future research must address how negative effects of temporality can be handled, so that the industry gain from increased productivity as a result of the tightened couplings of IPD. In addition, the theoretical framework created in this paper needs to be brought down to the level of actual practice, interviews and observations. This is where new theories can be applied. If the ideas in this paper were to be strengthened through empirical studies, they would have significant managerial implications.

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