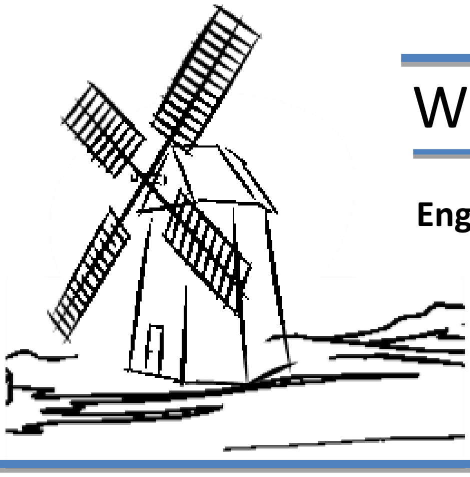

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Integration And The Hold-Up Problem In The Design Organization For Engineering Projects

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INTEGRATION AND THE HOLD-UP PROBLEM IN THE DESIGN ORGANIZATION FOR ENGINEERING PROJECTS

Vedran Zerjav[1], Timo Hartmann[2]

ABSTRACT

The paper presents a perspective of the design organization in engineering projects based on the economic concept of the hold-up problem. By integrating the economic theories on the boundaries of organizations into the existing knowledge on design in engineering projects, the paper hypothesizes a theoretical framework that represents the design organization in the context of the hold-up problem. The framework is illustrated with findings from an interpretive study of a large-scale engineering project that faced design integration issues that are well explained by the hold-up problem. The findings suggest the specific nature of the hold-up problem in design organizations which calls for a managerial mindset based on the concept of the social network and relational contracting instead of the typical project management reasoning based on static hierarchies of scope and controlling mechanisms.

KEYWORDS: Interdisciplinary design management, Hold-up problem, Design economics, Engineering project organizations.

INTRODUCTION

Due to the value that they provide to the society, an increasing number of large-scale construction projects is delivered through various integrated approaches, which is putting an increasing amount of attention on design of such projects. Although a body of research exists elaborating the topics of design and its management in the engineering project industries, the economic aspects of managing design at the project and firm level are still not adequately represented in scholarly literature on engineering projects.

One of the most persisting issues of design in complex projects is its integration. Because it is an iterative activity, it is reasonable to count on multiple sets of contributions from the participating designers and teams. This paper will address the scope of the design organization by focusing on the issue of design integration in large scale engineering design. By implementing economic theories on organizational boundaries, in this paper we will discuss how project-level design integration issues can be interpreted as a hold-up problem with implications for the organizational boundaries.

The structure of the paper begins with a summary of general design literature, which is then complemented with corresponding developments in the area of engineering project organizations. The subsequent part of the paper introduces the most relevant streams of theorizing economic boundaries of organizations. In the following part, we propose a conceptual framework the application of economic theories of organization to the engineering project design context. By using empirical data from a case study, the paper then discusses how the issue of design integration can be interpreted from the angle of economic theories of organizational boundaries. The paper concludes with an discussion section complemented with a list of recommendations for practitioners in the engineering project domain.

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DESIGN AND ITS MANAGEMENT IN ENGINEERING PROJECTS

In a very broad sense, design can be interpreted as the social construction of knowledge (Berger and Luckmann 2007/1966) about the project to be built. This collective knowledge then emerges from individual boundedly-rational cognitive frames (Simon 1996/1969). The two mentioned concepts have provided a stepping stone for researchers to focus on individual cognition (e.g. Rittel and Webber 1973; Schön 1983; Hubka and Eder 1987; Pahl et al. 1996) and social interaction (e.g. Bucciarelli 1984; Cross and Clayburn Cross 1995; Bucciarelli 2002) as the main aspects of the design process. While the cognition stream elaborates the rationality of each individual designer's perspective, the social stream of research in design attempts to integrate the different individual perspectives in a jointly negotiated meaning of the project and its underlying functions.

In practice, design occurs when teams of individual experts put their contributions into the design decision-making and consensus-building activities. Such experts come from either the core project team, or act as external experts who operate on the design market and whose services are bought for a fee. The main resource for designing is, therefore, expertise, coming either as individual or organizational domain-specific knowledge (Lawson and Dorst 2009).

When someone is considered an expert in a field, this is normally an indication that the person possesses individual domain-specific knowledge that he or she acquired as a structured effort over the course of a number of years. Design firms, therefore, summon a pool of individual expert practitioners whose knowledge is idiosyncratic and specific to a design task. Since the design task by definition is not precisely defined, the expert designers will both frame the problem from the perceived situation and offer a solution for the problem by using their idiosyncratic design knowledge. This means that the expert's contribution will be as unique as the psychological frame, from which he/she approaches the problem (Schön 1983). This also means that the designers will attend to the problem by framing it from the perspective of their expertise educational background, and culture.

As Lawson and Dorst (2009) acknowledge, instead of looking at the design team as a group of independent individuals with domain-specific knowledge, a successful design team should be viewed as a group of people with shared beliefs and value systems. Throughout the design effort, the design team socially constructs information from a set of different cognitive frames. This knowledge construction, however, follows the shared values from within the design team. It is therefore a social process, characterized by collective domain-specific knowledge, created through strong cognitive and cultural framing. The designer's professional expertise is, therefore, not entirely subject to an explicit articulation, as it is largely tacit and implicit.

The engineering project sector has been facing an increasing demand for integration at the global level. This is mainly caused by global policy developments in line with increasing the productivity and sustainability of the construction sector. The result is that an increasing amount of attention is being paid to the performance of the buildings in terms of sustainability indicators, which, in turn, also motivated the need to integrate the design effort around teams of collaborative interdisciplinary contributions. In such a setting, design normally includes a large number of design professionals and other stakeholders who all jointly contribute to design decisions. Due to the scale of many of such projects, issues of design integration have a significant economic impact on not only the design itself, but also the entire downstream project and the lifecycle of the resulting building. As a result, research on design and engineering in the construction sector received a significant amount of explanatory and normative attention in literature at various levels of analysis. The aim of the following passages is by no means to provide an extensive review of the developments in the field of engineering design organizations, as this would be a very difficult task to perform.

Instead, our intent was to summarize some of the most evident research directions for the purpose of demonstrating the theoretical pluralism of the field.

At the micro-level of design, different theoretical angles were used to explicate insights spanning from individual design thinking (Lawson 2005) to team interaction, most notably, micro-sociological explanations of the role of digital visual infrastructure for design interactions (Whyte et al. 2007; Whyte 2011), micro-level ethnomethodological approaches to design interaction (Luck 2003, 2010), and sociological theories of diffusion of digital decision-support systems into the team organizational culture (Hartmann and Levitt 2010; Hartmann 2011). At the level of individual designers and design teams, most research, therefore conceptualizes design as the development of artifacts through social interaction mediated by boundary objects used to bridge the differences in designers' narratives.

The other stream of research of engineering projects acknowledged the importance of factors at the macro-organizational level of design. Some of the examples of such studies researched the interplay of institutional factors in construction projects (Mahalingam and Levitt 2007), and the management of the corresponding knowledge (Javernick-Will and Scott 2010; Javernick-Will 2011) in a multinational context. Although these issues barely scratch the surface of the vast and complex field of psychological, social, political, and cultural aspects influencing engineering projects (Henisz et al. 2012), they can be considered as valuable cornerstones in defining the range of issues that need to be taken into account in design.

The context of the engineering sector is such that the project can be considered the main subject of production, whereas the engineering structure can be considered the object of production. Since such structures need to meet an increasing volume of requirements, a stream of research developed that links the process level of design with the performance of the building according to these predefined requirements.

The most prominent pieces of research in this context come from the sustainability camp of the AEC sector and they study the achieved performance of the buildings in relation to project arrangements best meet the performance. This stream of research confirms that collaboration at the team level is the preferred way of achieving better sustainability performance indicators of buildings (Korkmaz et al. 2010; Swarup et al. 2011). To measure and improve the level of collaboration and interaction, different studies have researched collaboration aspects of engineering projects. In the conceptual phases, this refers to designing the governance arrangements in projects (i.e., DeWulf and Kadefors 2011). In downstream project phases, collaboration is approached differently. Chinowsky et al. (2011), for instance use social network analysis to introduce the idea of aligning the task-level knowledge exchanges with the knowledge requirements and suggest an appropriate modeling approach for the context of engineering projects.

From the above summary of the theoretical developments in the field of engineering design project organizations it is visible that economic aspects of the organizational scope and form are not captured in the analyses. The aim of this study is to suggest complementing the knowledge missing in this gap. To achieve this, the following section will introduce some of the most famous economic concepts that can be applied to study the economic organization of design in engineering projects. The subsequent part of the paper will introduce an conceptual explanatory framework for interpreting the economics of the design organization in engineering projects.

ECONOMIC THEORIES OF ORGANIZATIONAL BOUNDARIES

To fill the gap of missing economic interpretations of the design organization and its scope the present section will summarize some of the most prominent contributions in discussing the economic boundaries of organization and subsequently embed the economic theory of the firm into the engineering project organizations body of knowledge to develop a theoretical concept that captures both fields.

Organizational Boundaries and the Structure of the Industry

A specific stream of literature discusses the theoretical underpinnings of the economic organization. The focus of this theoretical stream is the scope and the boundaries of the economic organization, as opposed to an open market setting. The discussion on the organizational boundaries originated with the Coase's (1937) famous essay on the firm boundaries and has not seen much obvious development until the appearance of transaction cost theory that is concerned with discussing the existence of firms as integrated economic entities as opposed to a number of economic transactions in the open market (e.g., Williamson 1985, 1996). Apart from the field of transaction cost economics, the property rights theory has also made a major contribution to the discussion of the organizational boundaries (Holmström and Roberts 1998; Holmstrom 1999; Hart and Holmstrom 2010).

The summary of the most important contributions seems to be that economic boundaries of organizations define the allocation of asset ownership that enable control over the operations, which is important in a world of incomplete contracts and asymmetric information. The notion of the firm has, in turn, been the most widely used concept of the economic organization in literature. The currently accepted argument for the existence of firms seems to be that firms provide the solution to the so called "hold-up problem". The hold-up problem occurs when either of the two sides of the transaction makes an up-front investment in the transaction which causes the other side to behave opportunistically and induce ex-post bargaining. The hold-up situation allows the side that invested less in the transaction to impose its conditions opportunistically on the side who made the upfront investment. The result of this discussion is the dichotomy between the market and the hierarchy as the basic modes of governance, whereby the former is characterized by third-party contracting and the latter by in-house manufacturing of goods and services.

However, literature has also acknowledged hybrid forms of organization that do not belong entirely to either the firm or the market area. Such organizations are termed as subcontracting arrangements, networks of firms, alliances, and partnerships (Ménard 2004).

Such hybrid arrangements are particularly pronounced in the construction industry, as was first acknowledged by Stinchcombe (1959) who analyzed why the industry favors subcontracting over bureaucratic hierarchies much more than the manufacturing sector. Eccles (1981b, a) appears to have initiated the discussion of viewing the construction process as a stream of transactions in his seminal work on the quasi-firm in the construction industry. In essence, Eccles argued that project complexity, size, and the market extent result in extensive and recurring subcontracting in construction.

From these early studies there has been not much development in terms of economic theorizing of the construction industry structure until relatively recently. The structure of the industry has been identified as a "loosely coupled system" that defines the interaction of resources at the levels of both projects and firms (Dubois and Gadde 2002; Dorée and Holmen 2004). The interaction of resources at the project level is thus defined with "tight couplings", while the interaction within the organization across different projects with "loose couplings". The question of determining the firm boundaries persists throughout these studies.

The Economic Interplay between the Project and the Firm

line with literature that provides evidence that not only ownership provides incentive for the establishment of an organization (Holmström and Roberts 1998) we will summarize contributions relating to the project, as the most prominent organizational form found in engineering. The project is a hybrid between the firm and the market setting in that its management structure is a feature of the temporary project structure and asset ownership a feature of the permanent firm structure.

Reve and Levitt (1984) initiated the project-level economic discussion by using transaction cost analysis to discuss contracts as a mechanism to govern the client-consultant-contractor relationships in a construction project. Walker and Kwong Wing (1999), on the other hand, present project management activities as transaction costs in construction projects. They argue that the role of project management is minimizing the sum of production and transaction costs on behalf of the client.

These studies present analyses at the project level as the majority of economic activity in engineering projects, particularly construction, occurs in the form of discrete projects, as opposed to continuous production activity. Since the firm is the basic form of asset ownership in the construction and other engineering sectors, the project and firm levels of analysis should be linked theoretically.

Winch (1989) seems to have been the first to introduce the theoretical project-firm dichotomy of the industry, whereby firms, not projects, make decisions about resource allocation transactions. Winch (2001) also subsequently proposed a conceptual framework for governing the construction process across both the participants in the project chain and the resources that each of the participant uses to deliver the work.

ECONOMIC GOVERNANCE OF DESIGN AND ENGINEERING

By drawing from both economic and design and engineering literature, a recent study by the authors of this paper focused on intra-firm governance of design and engineering in a multinational company as a stream of transactions between knowledge contributions from the company network of offices and the contracting office (Zerjav et al. 2012). In this representation, the transaction consists of applying design knowledge to a project-specific situation. The project creates the demand for domain-specific expert knowledge that needs to be complemented with expertise residing within the design team or outside of it. This means that sourcing the project with design expertise occurs in a knowledge market that needs to be managed through discrete transactions**.**

The study emphasized the existence of intra-firm organizational interfaces that define market relations internally to the multinational firm on the basis of different domains of knowledge. Different modes (i.e. local vs. distributed) of governing the design from the perspective of the contracting office are, therefore, on the basis of individual economic transactions conducted across different firm offices.

Although the existence of the firm presupposes integration based on asset ownership, the study showed that even within the stable firm structure, market conditions may apply. This is in line with the Holstrom's (1999) concept of the firm as a subeconomy, where the ownership assumes the role of a controlling mechanism similarly to the role of the state in regulating markets in macroeconomics literature. On the basis of the above firm-level study, we propose an economic concept for project-level design organization using economic concepts of organizational boundaries.

The main difference between the firm- and the project-level approaches is in the reversal of the dependent and independent variables of the study. In the previous analysis the dependent variable was the internal economic activity and the firm was regarded as a stable network of assets, thus an independent variable. The present study, by contrast, will regard the economic activity of design production as an independent variable, from which it will draw conclusions about the scope and form of the corresponding design organization, thereby considered as the dependent variable.

Framework for Project-level Economics of the Design Organization

The conceptual framework that we present considers the flow of knowledge exchange within the continuously shifting supply and demand sides of the design organization. This knowledge exchange is represented as a stream of economic transactions, defined in transaction cost economics theory. Because of the intertwining information interdependence between the design tasks, an efficient exchange of knowledge that occurs between any of the designers will need to be distributed across the entire design system. When this is interpreted through the lens of economic transactions, it follows that any one transaction will generally cause an undetermined amount of other transactions in the design system. This makes determining the boundaries of the project organization a complicated economic consideration. Figure 1 represents the notion of design coordination and integration in the light of economic transactions.

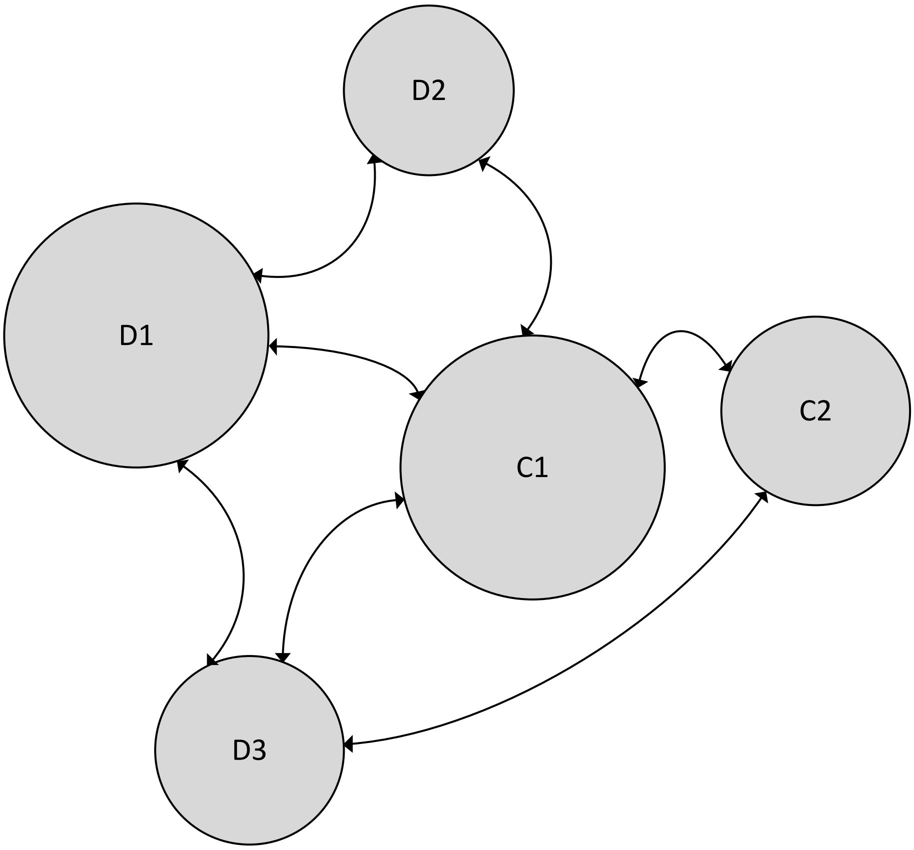

Figure 1: Design coordination and integration as a flow of transactions

The figure represents a hypothetical organizational setting on a project where interaction occurs between design offices D1, D2, and D3 and construction companies C1 and C2. In terms of design, the hold-up problem in this example manifests in integration problems as well as the number of design iterations needed to achieve the final solution. Once a design office has been appointed to contribute to the project with its knowledge, they will have the ability to manipulate the properties of their contribution in a way that will determine its integration with other design components. Thus, by behaving opportunistically, a design team might ensure further income from the project through a mechanism known in microeconomics as ex-post bargaining. In order to mitigate such hold-up problems, organizations form either long-term partnerships or alliances, or even engage in recurrent subcontracting as a form of the quasi-firm. As opposed to the hold-up problem within the design supply chain of the project, the same issue occurs at the interface between design and construction organizations. Because design and construction are complementary fields of expertise, the hold-up problem occurs when either of the sides takes advantage of the established relationship for opportunistic ex post bargaining. As a result, arrangements such as design and build are devised, to integrate the two sides under the same interest and, thus, mitigate the hold-up problem.

The above concept describes integrated organizational arrangements in engineering project sectors from the perspective of firm economics. The arrows between the circles in Figure 1 them represent multiple organizational couplings in the form of mutual interdependence. Following the analogy about transaction costs as organizational friction, design coordination efforts can be represented as transaction costs in the overall project.

To further corroborate that the above derived conceptual framework captures the economic considerations on boundaries of design organizations, we illustrate it with findings from a research study that gives phenomenological evidence for the hypothetical framework.

RESEARCH METHOD

The study supporting the conceptual framework from this paper is interpretive nature and consists of a major public-funded railway engineering design-build project. The reasoning for choosing a single case study is that, due to the size of the project, it is well aligned with the Yin’s (2003) concept of the critical case that emphasises the issues under investigation. The data collection included extensive interviews with project management, validated by comparison against the internal project database as well as against the publicly available material. The aim of the data collection in interviews was to reduce ambiguity through retrospective sensemaking by having all the relevant data after the project had finished (Weick et al. 2009; Winch and Maytorena 2009). The case study is retrospective because the decisions that affected the project events can, in such cases, only be evaluated ex post.

Instead of using the standardized protocols with a single interpretation of the data collected, this research collected data in a manner that supports the cognitive and interpretive nature of design. This is done through the open ended interviews that opened the possibility of different interpretations based on the informants’ sensemaking of the subject matter. When combined with secondary and tertiary sources of data, the overall data collection was immensely rich and requireed an iterative process of qualitative coding and complementing with theoretical concepts. The research method chosen, therefore, produces the iterative loop of qualitative theory building and hypothesis testing, very similar to the process of design itself (Eisenhardt 1989; Friedman 2003).

The case project involved extending a section of a rapid transit urban railway system and incorporating it into the suburban rail system of a congested European metropolitan area. The scope of works comprised partial extension of tracks, replacement of track and signaling equipment, construction of four new stations and refurbishment of five old stations. The project was particularly demanding in civil works as long sections of the track were on viaducts and in tunnels.

The core project organization included the public agency owner and the contractor. Because the owner organization did not have substantial experience in railway construction, they appointed a project management organization to manage the project on their behalf. Concurrently, the contractor’s organization mobilized an engineering department for the project with the aim of coordinating design and construction. The project also had three major external stakeholders, being representatives of the urban and the suburban rail systems as well as the operating company. The former two had the role of ensuring that the newly built section complied with the existing standards of both networks and the latter had the role to ensure that the delivered facility complied with their train operating procedures.

The design scope was organized in disciplinary work packages and geographic design areas. The disciplinary work packages comprised civil design, structures, buildings and services, mechanical and electrical systems in buildings, and design of accompanying rail systems. Each work package was further broken down into design areas defined as "geographical groups of neighboring work packages or a logical system comprising a number of subsystem work packages". Because of its fragmentation, the project developed an Interface Management Plan to identify and manage issues that would occur between work packages, design areas and organizations in the design supply chain. As the design evolved, the identified project interfaces were planned to be translated into requirements for each of the design contributors.

At the peak of the design, a total of around 600 of design staff were contributing to the project off site, which exploded the number of requirements to be handled. There were around 6000 requirements and about two thirds of them were changed or modified as the project unfolded. These changing requirements were the key source of design fragmentation issues that this study presents in the light of the corresponding design organization.

FINDINGS AND DISCUSSION

The present section will provide illustrative empirical evidence for the above-derived notion of transaction cost issues and boundaries of the project design organization. In general, the informants involved in the management of design were emphasizing issues with poor design integration that caused substantial rework and other related problems downstream in the design and construction process.

To illustrate the fluent notion of the project design organization, we will mention that the resource allocation for the design organization was not following the initially-defined work packages, in that many parts of design work were distributed to different units, some of which had no relation with the original project whatsoever. As an informant in an executive position of the program management organization explained:

At that time, the demand for specialist skills was so high in the [local] area that [the main designer] needed to get capacity elsewhere. For their part, they were using about ten offices scattered around the country and some abroad.

This situation caused an additional level of fragmentation within the design supply chain with a new kind of project interface that had to be taken into account. This significantly augmented the number of different designers contributing to the project and further exacerbated design fragmentation as opposed to the initial plan. As a result, the burden on the management became more pronounced as the coordination meetings were now including up to 60 design managers who were responsible for different parts of the design.

Coordinating large numbers of remote design teams was challenging, especially within boundaries of a single organization whose contributions were mutually incompatible due to inconsistent management practices across different offices. The director of the engineering organization summarized the issue:

People had to travel long distances to meet up for meetings and communication was a problem in general. They were, for instance, using different expansion joints in different offices. We also found that they used different procedures in different offices. Standardization was a problem even within a single organization.

Each of the remote offices within would create its own requirements for the rest of the offices and synchronizing them by a common standard was time consuming and created tensions amongst the contracting designer's team members. The tensions could only be resolved by using the organizational hierarchy as the engineering director put it:

We had to say: You've got to do it the same as this bloke, if you know what I mean.

The result of this intra-disciplinary synchronization was significant iterative rework, depending on the complexity of a particular interface where parts of the design would meet. This rework and problems at the design interfaces can be considered transaction cost problems at the project level. A quote from the engineering organization director further elaborates the managerial sensemaking of this issue.

With people working remotely, you will never get everybody fitting together at the first shot, in design. Sometimes it takes two or three shots.

All these examples from the case study suggest that boundaries of the design organization are difficult to determine when only using the formal documents such as contracts and schedules. Our interpretation of the data analyzed suggests that the occurrence of transaction costs in the project took the form of schedule delays, travel costs, design iteration loops, and additional management time, another form of transaction costs, needed to be put into the project to alleviate all these issues. The boundaries of the design organization should have, therefore, been designed by using a more theoretically-grounded economic rationale instead of opportunistic subcontracting causing significant hold-up problems. The cause of the hold-up problem was the interdependency of the contributions that needed to integrate in the design of a project that is by its nature, an integrated and continuous structure. By subcontracting merely on the basis of man-hours demand, the management team of the project omitted the fact that poorly integrated design has the potential to cause so many hold-up problems that the actual project organization will need to shift its focus on additional investment into organizational relationships that might not even provide any added value for the project. If the hold-up problem was not resolved at the level of the relationship causing it, the fragmentation problem dissipated into the entire design which caused a significant loss of managerial control over the design effort.

As the final piece of empirical evidence of the existence of the hold-up problem in the design organization, we include a quote that the engineering director uttered when asked about the best way to mitigate design fragmentation issues in future projects:

A lesson for the future would be that if you could somehow limit the number of people involved in the parallel design process and if you could have them sitting in the same building and actually working together, that would be very helpful.

The emphasis on “people actually working together” seems to be an indication to reconsider the notion of organization boundaries in designing large-scale engineering projects in an attempt to reduce the likelihood and impact for the hold-up problem within the project boundaries.

THEORETICAL PROPOSITIONS AND PRACTICAL RECOMMENDATIONS

On the basis of the theory derived and empirical data present, we extract several theoretical propositions accompanied with several implications for the practice of managing engineering design project organizations. We, thus, deduce the following theoretical propositions from the above theory:

1. Design concerns a flow of knowledge exchange transactions in the market of expertise. As the most distinct difference from the classical production systems, the breakdown of scope and temporal sequencing of tasks in design should be taken very flexibly as the project structure can be much more fluid than what is normally the case in construction.
2. Because design concerns the production of information on the basis of individual interdependent contributions, the hold-up problem is a significant issue in design organizations.
3. The social structure and information processing in the design organization is more similar to a network than the traditional hierarchical structure of organizations. As a

consequence, relational contracting seems a much more meaningful approach for establishing and maintaining the relationships than relying on classical contracting forms and procurement routes.

From these theoretical propositions, we propose a relatively wide area of practical implications of the project-level framework:

1. Because of the fluid structure of the design organization, tools from traditional project management should not be used so much for controlling purposes as much as means for discussion and ensuring a common understanding of the design scope and content.
2. Instead of thinking about design as a hierarchical structure, managers should think of it as a decentralized social network. The allocation of tasks should also take into account the network context of the design organization. The relationships between the members of the network should be based on trust validated through previous collaboration.
3. Design & Build contractual arrangements for project delivery do not necessarily accomplish integration of the design project structure, as construction managers can overlook the nature of the hold-up problem in design when appointing the design team of the project.
4. The relatively independent design tasks can be compiled without the risk of the hold-up problem, thus, they do not need to be a part of the design organization.

Although the theoretical propositions and practical implications of this study should be further validated by future studies, we believe that, even in this stage, they can provide a valuable tool for managerial thinking in the design project organization context.

CONCLUSIONS

This study contributes to theory with an economic representation of the design organization based on the notion of avoiding the hold-up problem in a stream of knowledge transactions in the market of expertise. We believe it is a novel and promising approach for analyzing both project- and firm-level issues in design management. This approach argues for identifying the tight couplings in projects (Dubois and Gadde 2002; Dorée and Holmen 2004) in the light of the hold-up problem. The tight couplings and the hold-up problem will become visible as the design integration issue in the situation when the design organization needs to address a requirement. This complements Winch’s (2001) recommendation of governing the design process internally. In other cases, the design organization may choose a more flexible market-based approach which will determine the boundaries of the core design organization for the engineering project.

This study further extends the previous author’s study on internal governance in multinational design organizations (Zerjav et al. 2012) with a project perspective on the hold-up problem and the corresponding organization boundaries. While the former study took the basis of the transaction-based theory to look at the implications of a relatively stable organization structure for its governance modes, the present study used the economic concept of the hold-up problem as an argument to identify boundaries of the temporary design organization encountered in engineering projects.

The conclusions at the project-level of analysis advocate the integrated structure of the design organization in engineering projects to reduce transaction costs that occur whenever mutually interdependent organizational entities engage in a joint effort. Similarly to recent discussions that advocate the use of centralized information to facilitate decentralized organizational decision making in engineering project organizations (Levitt 2011; Whyte and Levitt 2011), this study advocates the centralization at the information-level of design rather than at the formal and hierarchical level of the organization. This also contributes to the notion of determining the boundaries of project organizations as networks as recently suggested by Chinowsky and Taylor (2012).

The nature of theory presented in this paper is mostly descriptive with the main aim to provide a basis for discussing aspects of the design organization for engineering projects using a simple explanatory economic rationale. Future studies should bring the argument further and continue relating it to the already existing literature that applies economic theory to various levels of analyzing engineering project organizations. Since theory presented is explanatory, further research should be directed towards the development of normative and predictive theories. All this will ultimately lead to a more profound understanding of the alignment between the design process in the context of engineering projects, engineering industries, and the wider society.

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Parts of the literature review as well as the interpretive case study have already been presented in different forms in other papers by the authors, however, from entirely different perspectives.

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