Procurement and Contractual Choices for Engineer-to-order Supply Chains

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Abstract Complex projects are increasingly collaborative, involving ever greater numbers of multiple organisations, while also seeking to deliver high levels of innovation. To gain insight into how supply chain management might be developed to better support these developments, many have looked to high volume manufacturing to benchmark and seek best practice. Outcomes have often fallen short of expectation: in the construction sector, for instance, productivity and adversarial relationships are still a major cause of concern in many countries. While there have been some successes in transferring technologies and supply chain innovation from high volume manufacturing to engineering intensive sectors, such as construction, shipbuilding, machinery and capital goods, the more general narrative is of the difficulties that have arisen. We see these difficulties arising from underlying differences between the between supply chain types, and have developed a body of knowledge for 'engineer-to-order' situations to better support such sectors. The procurement process is crucial to establishing conditions for success and is typically a major source of concern for the supply chain. Hence, we summarise the findings of a research project that focused on developing the principles required for procurement excellence and to structure the possible contractual choices in engineer-to-order supply chains.

Keywords: procurement, contracts**,** supply chain management, construction, engineer-to-order

Introduction

Complex engineering projects are increasingly collaborative, involving multiple organizations, and involve innovative aspects. Many have typically looked to high volume manufacturing (e.g. automotive) to benchmark and seek best practice. However, we have found it useful to view projects as engineer-to-order (ETO) supply chains, where unique solutions requiring innovative engineering work are developed 'to order' [1]. Most discussion of operations and supply chain management ideas is underpinned with the assumption of stable, volume manufacturing, found for instance in retail and automotive. While some pioneering practices of relevance to ETO supply chains have emerged from these industries, it is possible to see difficulties in transferring practice directly to engineering intensive sectors, such as construction, shipbuilding, machinery and capital goods [2].

This observation led to the development a body of work that enabled a better definition of the underlying structures of ETO. This was defined by the extent of customer intimacy with the design and production processes, and led to guidance for design of supply chains operating in these structures, most recently in [3]. In our previous work, we have also noted the potential for a 'relational gain' in terms of hard performance improvements resulting from long-term relationships across the supply chain in engineering projects [4]. However, a critical barrier was found to be the procurement, commercial and contractual assumptions that underpin complex projects, which establish the conditions for effective incentives and relationships between different parts of the project delivery teams for engineering work. On the one hand the commercial arrangements did not incentivise relationships between different parts of the project delivery teams for engineering work, and on the other funding was purely for individual projects, so long term relationships were not supported.

Building on the fundamental research, we undertook funded projects with public procurement bodies, major contractors and their supply chains, working closely with experienced practitioner stakeholders to advance the field. We also worked in partnership with a UK organization that develops, and promotes internationally, a suite of contract forms to guide good practice. We selected case studies to cover a wide range of complex engineering project scenarios, and interviewed those who were involved in the ETO procurement environment (e.g. procurement directors, contract managers), technical experts to give insight into engineering designs (e.g. Chief Engineer), and more general managers or project managers.

Our research project was carried out against an interesting and changing backdrop. Engineering and construction related industries have traditionally found relationships and partnering challenging to adopt, since projects have been seen as one-time transactions, but there is evidence of change, and academics, governments and professional bodies have been pushing forward an agenda that embraces project partnering approaches, alliancing and collaborative procurement [5]; such partnerships involve complex risk ownership and resource issues. However, despite the desire for change, there is a general lack of guidance as to how to structure procurement approaches in accordance with project needs. Hence, we asked '*Which principles should guide the procurement of engineering work and how should engineering clients and contractors structure their contractual choices?'*

Achieving Excellence in Procurement

Building on the available evidence from academic studies and government reports, and from our observations during our research project, the following principles serve as a useful guide to position at the heart of the procurement process.

- Establish and articulate governance frameworks, giving clear strategy, guidance and expectations for the supply chain. This forms a key part of procurement leadership.
- Focus on whole-life objectives, as far as possible, aligning the achievement of the client's whole-life objectives with the rewards and incentives of the supply chain.
- Continual supply chain engagement to optimize procurement strategies, plans and processes.
- Longer-term contractual arrangements to support the development of strategic supplier relationships, supplier investment, learning and continual improvement, as well as striving for collaborative relationships throughout contract delivery.
- Early appointment of an integrated delivery team to undertake design and construction planning in parallel, and to take full advantage of modern technology and methods.
- Simple contractual interfaces, avoiding multiple and complex contractual interfaces and ensuring that all necessary interfaces are well understood and managed empathically.
- Awarding contracts based on the supplier's ability to deliver best value solutions (not the lowest price).
- Facilitate the sharing of innovation, ideas and performance and cost benchmarking data across the supply chain to support learning and greater efficiency.
- Developing contracts with a fair and appropriate allocation of risk followed by a joint and active focus on risk and opportunity management during delivery.
- Committing to and implementing fair rewards and prompt payment for all suppliers.
- Minimize the complexity and cost of procurement exercises, such as pre-qualification and tendering.

Implementation of the themes and principles will likely raise some challenging questions. We had many discussions and workshops devoted to the achievement of these principles. We explain below in a 'questions and answer' style for issues that arose frequently.

How should work be packaged as contracts?

Work may be awarded as a large complete contract or broken down into smaller discrete packages. Multiple scope packaging has the advantage of flexibility so that different contract conditions can be used to suit the different work activities, but has the potential to create interfaces and fragmentation.

Larger all-inclusive packages have the potential to reduce interfacing issues, but the level of risk in bearing such a large contract must be carefully considered and/or whether a large contract would attract sufficient interest and competition to achieve best value. The capability of a package owner to manage the interfaces may also be unknown. The appropriate size and scope of the packages will depend on a number of factors, including client ability, capabilities of the supply chain, and project type.

To help make the choice, a recommendation is engaging with the supply chain to gather input into contracting strategy, as well as a structured approach to understand capabilities. Open dialogue and engagement with supply chain members is needed to evaluate their potential to support the contract package approach. A broader commitment to a collaborative climate will help soften any interfaces, and a structured process to control and manage interfaces will help to focus on the issues that arise.

How can long-term relationships be developed within the context of engineering projects?

Much has been written about partnering and alliance arrangements, which generally make the case that collaborative working across the supply chain maximizes the likelihood of the right outcomes. Strong collaborative links will likely arise from a combination of efforts, such as ongoing dialogue between organizations and putting in place the structures and incentives to make collaboration possible and attractive.

Collaboration approaches include formalizing relational structures across the supply base, for example through a classification system with a clear relationship focused lead, developing longer-term contractual frameworks and early contractor involvement mechanisms.

We recognize that long term relationships are not easy to sustain. It is likely that relationships will be characterized by upward and downward spirals. Hence, problem resolution processes should be incorporated into the relationship structure. A long-term relationship will also require robust performance to demonstrate efficiency and continuous improvement, which gives the client confidence that the contract is still delivering value for money over the long-term.

How can the interests of the parties be aligned?

The contractual framework adopted plays an important part in supporting collaborative behaviors. This raises the challenge of moving away from focusing on just one or two important contractual interfaces, and taking a broader consideration of crucial systems throughout the supply chain.

The procurement strategy, therefore, should establish common objectives and shared incentives, clear signposting of policy, strategy and expectations with regard to the supply chain.

A typical issue observed was the failure to consider the impact of contracts further along the supply chain. A possible approach to manage this is the use of ‘back to back’ contracts with consistent terms and conditions, which cascade along the supply chain. However, it may be possible to use different mechanisms throughout the supply chain to suit the situation.

How can I be an ‘intelligent’ client?

One of the principal roles of clients and large main contractors is to apply effective leadership and governance, linking with the ‘intelligent customer’ concept. This concept includes providing clear leadership in requirements and incentives to guide the supply chain, and ensuring governance frameworks are in place for the contract documentation and procedures.

The way in which organisations behave is largely driven by perceptions of what is in their own interests. To this end, incentivization needs to be designed at project level in a way that balances the interests of different parties and helps to align them to be both best for each and best for the project. It is difficult to appreciate all the potential impacts of contract conditions, or the behaviours that will be incentivised by contractual mechanisms. Therefore, it is suggested that clients must reflect intelligently on their approaches by conducting ‘What-if?’ scenario reviews to help understand potential impact and ‘future proof’ the contract.

Adopt appropriate assurance procedures, including independent reviews, to provide greater confidence that procedures and incentive mechanisms will work as expected. In addition, there is a need to establish a continuous improvement mechanism or review mechanisms to capture lessons learned for contracts.

How can uncertainty and risk be considered in procurement and contracts?

While uncertainty and risk ultimately begins and ends with a client, the contracting process is central to their management. The golden rule to follow during this contracting process is to place uncertainty and risk with those best placed to manage it [6].

Uncertainty must be managed in a coherent way, or else it will more likely than not result in negative outcomes. Hence, managing and allocating uncertainty is a key part of procurement strategy. Dealing with uncertainty is commonplace in complex engineering projects, and it requires clear allocation of contractual risk even if the parties are required to manage risk jointly to deliver outcomes that are best for the project.

The pathologies that lead to mismanagement of uncertainties are instantly recognizable, for instance through under/over estimating, hiding information and covering up failures [7]. However, a structured approach can help, and we return to this issue in the next section.

Forming and structuring a contracting strategy

Having reflected on the core principles at the heart of the procurement process, the next step is to develop a contracting approach that is 'fit for purpose'. Figure 1 shows the interplay of three key components of procurement and contract choice.

The model provides an intellectual structure and rationale to form a strategy, by considering the interplay between these aspects. It helps form a basis for facilitating discussions between clients and contractors. The figure shows relational forms, contract choices and engineering categories, along with observed performance indicators and collaborative mechanisms mapped onto it.

Along the 'slider bar' on the right-hand side of Figure 1 we show an indicator for the intended allocation of financial risk. Although in our wider study, we investigated cases across the spectrum, we only highlight here some typical interactions often experienced in industry. Hence, not all aspects of the framework are covered here – for more details see [3].

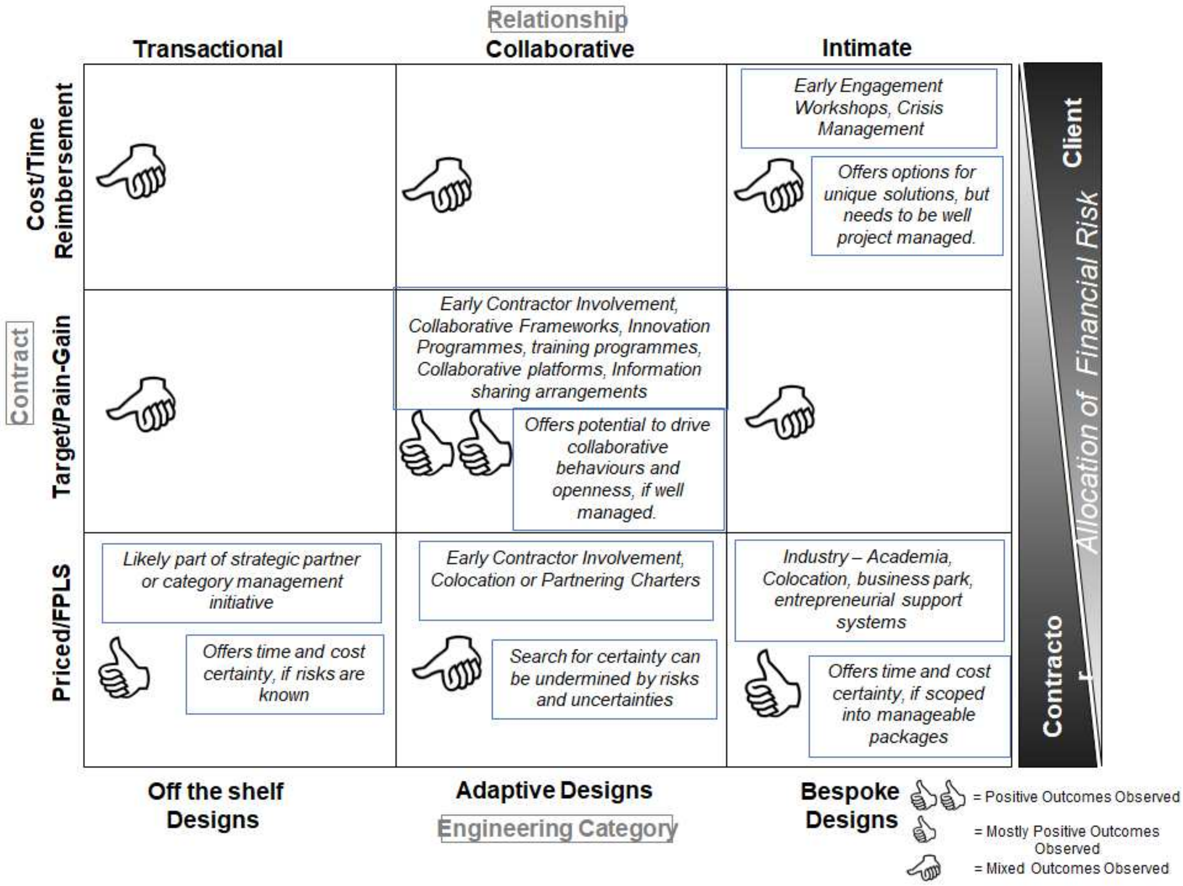

Figure 1: A proposed structure for contract choices.

It shows the contractual dimension, which includes the three different financial mechanisms: fixed price, target cost and cost reimbursable, which are commonly found across contract forms [8]. These are crucial mechanisms for the allocation of risk, directing incentives and establishing the conditions for desired behaviors in engineering work.

The *Fixed Price* mechanism offers stipulated work in exchange for a fixed sum of money, often paid as a lump sum or instalments. The risks of carrying out the work are largely borne by the contractor, since the work must be carried out exactly as specified, and any issues that arise are, in principle, 'owned' by the contractor. It is perhaps counter-intuitive that such an approach works in the domain of bespoke designs; our finding here is that it does when the work is in small 'bites' and the contractor is committed to a scope of activity—for instance a number of hours spent experimenting—not an outcome.

The *Target cost* mechanism is characterized by the development of a target, as well as the sharing of 'pain-gain' between employer and contractor. The approach requires a move towards more transparent and open book cost calculations in the development of a target cost. Risks are, therefore, shared between the employer and the contractor.

Cost reimbursable mechanisms refer to a situation where the contractor is reimbursed its costs plus a fee as the contract progresses. In a pure form of reimbursement, there would be no target or limit, but a common practice in this mechanism is to limit the liability or commitment of the contract, and approval processes for the employer to review. The employer largely owns the risks, as any changes to plan will be borne by the employer in terms of time or cost.

Figure 1 also shows a range of engineering design categories as a key consideration. A key idea advanced in this work is that the client or customer can engage with engineering design activities at different points in the process, resulting in different customization and risk profiles [9]. The categories we developed represent the extent of customer engagement, and offer insight into the extent of risk and likelihood of unique or customer specific innovation in the engineering design.

'Off-the-shelf' designs take existing designs, drawings and subsystems as the starting point for the completion of engineering designs. Here we may find innovative reconfiguration of mainstream products, parts of established designs—such as CAD (Computer Aided Design) drawings or product libraries—being exploited to produce new customer driven adaptations. The primary risks in this category is of unsuitable customisation of existing designs, or an unexpected context.

Adaptive designs require either the creation or modification of codes and standards for a particular customer order, as well as those that develop novel designs which take such codes and standards as the starting point. The risk here is that adapting codes and standards will be very resource intensive and complex, if there are many interacting standards. Designs are developed on an individual basis from a 'blank sheet', or more precisely a set of codes and standards. Hence, the nature of innovation is in developing solutions that do not take existing designs as the starting point.

Bespoke designs involve research and development activities that are conducted 'to order' for the client in the development of engineering designs. Examples include customer specific scientific equipment development based on non-established principles, material science testing or engineering testing. There is a risk in this category that the proposed solution may not perform as intended, as the innovation is unique and unproven.

Finally, there is a relational dimension. As service provision and complexity increases, intimacy between the parties should increase and hence the relationship become stronger. In a supply chain context, the relationship type, from close to loose, depends on the degree of alignment required for joint innovation. Hence, three mechanisms are articulated for the relational dimension. *Transactional mechanisms*, where relational activities are tactical in nature. *Collaborative mechanisms* include more strategic partnering and close inter-organizational working. *Intimate mechanisms*, is where firms become very interlinked in the pursuit of innovation.

It is interesting to understand collaborative and behavioral mechanisms at the interaction points of these different considerations. Some examples of this are shown in Figure 1. Such mechanisms observed, for example, are partnering charters, Early Contactor Involvement, shared IT (Information Technology) systems, co-location, and early engagement workshops. The combination used, we argue, depends on the situation. We have found it useful to begin with the engineering design type as a basis for discussing strategy and choices, and also taking into account possible performance outcomes.

Figure 1 also provides performance outcome indications. In the bottom left cell of the framework, where there are existing designs and a Fixed Price payment mechanism, the contractor is allocated most of the risk. Relationships here are transactional.

Our analysis indicates that this approach leads to as-planned performance outcomes, but only if there is certainty across all key domains, which are, primarily: certainty of client's needs, certainty of what the solution is, and certainty of the delivery context. Hence, if a contractor can provide a project solution from existing designs to meet client requirements that are clearly stated, and there are no complication arising from the location or other matters of 'context', then a Fixed Price payment mechanism and transactional relationship will lead to as planned performance outcomes.

In the middle cell of the framework adaptive designs interact with a target cost and relationships are collaborative, the risks are shared between the parties. This approach, in the various case studies selected, led to positive performance outcomes. If a contractor must apply or integrate codes and standards as a basis for an original design to arrive at the project solution, then a target cost payment mechanism and collaborative relationship will lead to positive performance outcomes.

The lower middle cell, where adaptive designs interact with a Fixed Price payment mechanism, showed a greater tendency to negative performance outcomes. It is possible that a collaborative relationship can mitigate some of this tension, but the contractor assumes most of the risk in conditions where there is a lot of engineering uncertainty. If a contractor must apply or integrate codes and standards as a basis for an original design in order to arrive at the project solution, then, unless mitigated by close collaboration, a Fixed Price payment mechanism will lead to negative performance outcomes.

At the bottom right position of the framework, where relationships need to be intimate, research work is undertaken on a Fixed Price basis. In these cases the performance outcomes are positive. Cases we observed in this space were more aligned with consortia of companies addressing an innovative solution, but were also packaged into a clearly scoped and manageable chunk of work moving the area of endeavour towards its eventual endpoint.

If a contractor is to undertake bespoke designs, then a Fixed Price payment mechanism and intimate relationship will lead to positive performance outcomes, provided the research is undertaken in a series of small steps. At the top right, bespoke designs are undertaken on a reimbursement basis, and we observed mixed outcomes in this space.

Lessons Learned

Lesson Learned 1 – Pick your weapons accordingly: There are a wide range of procurement approaches available, but the approach taken on any particular project needs to be proactively designed and there is a need to pick your weapons according to the situation.

We suggest, however, that the project management industry needs a better set of principles and structures to inform decision-making when setting the project procurement and contracting strategy. These principles and structures will need to be considered on an ongoing basis, and then specifically revisited for each procurement decision, but with reference to the principles and intellectual structure guiding the decisions. The spectrum of engineering types outlined in this article are a good starting point and have trade-offs which need to be understood and managed.

Lesson Learned 2 – Lead as an intelligent client: Clients need to lead the way by being an ‘intelligent client’, but contractors can help them. For implementation, clients will need to consider how current practices are anchored in the principles and mechanisms described in this article.

To become more effective, there will likely be an initial need to revisit and integrate internal teams, such as technical, commercial, procurement and delivery teams. The models and principles in this article can then be used as a basis for discussion between client and contractor, considering early engagement of relevant parties, including internal teams and relevant external parties. Contractors may also put themselves in an informed position so that they may help to guide clients.

Lesson Learned 3 – Configure and develop a spectrum of relationship types: Collaborative relationships need investment, but your ability and resources to invest are limited. At the outset of this article, we posited the idea that long term relationships can lead to positive performance outcomes. However, these often require trust building, subtle and sophisticated forms of relationships building, and frameworks with which to develop relational forms. We refer to ‘relational investments’ to characterize this, which may take the form of specialized investments between firms, which act as the basis for relational ties. These may take the form of, for example, physical, people-based, process or technology-based investments that are specific to a project or relationship. It is possible to consider these viz-a-viz Figure 1 in this article.

Conclusions

The procurement of engineering work has too often been guided by intuition, rather than robust evidenced based rationale, and there is little guidance for clients as to how to establish the right approach. While many contextual factors, such as planning, financial, environmental factors, and health and safety concerns, may shape the final approach, we have presented a set of principles to achieve procurement excellence. We explained how three key considerations can form the basis and structure for a rationale for contract choice.

If done well, good procurement establishes the conditions and climate to ensure benefits are realized for the public good, and that the right behaviors across the supply chain.

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