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# ARE CONTRACTORS' COST ACCOUNTING PRACTICES UP TO THE JOB OF ESTABLISHING IMPROVEMENT IN SITE OPERATIONS?

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Construction industry clients and regulators repeatedly call for the industry to reduce the cost of construction projects. Real cost reduction requires improvement in site operations. However, much of the industry expends effort in merely buying more cheaply. If a main contractor is looking to a subcontractor to undertake improvement for the sake of the supply chain, they need to be able to assess this and motivate it by a payment process that passes on the reward. Research is described that explores whether current costing methods could account for improvements in work processes. It considers cost as information and explores how contractors derive and use it. A case study of a major main contractor and two subcontractors is described that involved semi-structured interviews and document reviews. The results show that firms recognised that the costing practices they were using had unintended negative strategic and operational consequences. The research concludes that information about cost, that would be useful in a programme that seeks to improve site operations, is hidden in layers of commercial assumptions and lost when it does not cross the boundaries between organisations. A key finding is that automation of current cost management methods in BIM will not improve construction site operations. It will only produce more convoluted details that do not reflect what people actually do.

Keywords: building information modelling, contractor, cost accounting, improvement.

## INTRODUCTION

The role that cost information plays in a construction project is a central one. Construction is always being challenged on cost by government who, through its client and regulatory role, has continually pressed the industry to reduce the costs of projects (Department for Business, Innovation and Skills 2014; Egan 1998). The catalyst for cost reduction most recently proposed is the adoption of Building Information Modelling (BIM) (Department for Business, Innovation and Skills 2013). Through BIM the cost of collection, storage and manipulation of information is reducing dramatically and consequently it should be easy to access integrated information that can be used to change the industry.

It is BIM's ability to automate the creation of information and communicate it efficiently through a central hub that drives the construction industry's interest in developing cost information in BIM. Academic and industry research and software development in the area of cost BIM has, to date, focused on BIM's ability to automate current estimating and tendering practices. Montierio (2013) showed that the

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most well developed software uses knowledge-based systems to extract dimensions from Computer Aided Design (CAD) models. Meanwhile, current software for Computer Aided Estimating (CAE) uses library-based systems to manipulate historical cost data to create project related data. It is now timely to explore cost as information to establish its meaningfulness prior to the move to more integrated decision making via knowledge-based CAE decision support systems in BIM.

This paper therefore explores cost as information and asks what sorts of cost information contractors currently hold? To understand this, the research explored estimating and tendering practices and narratives in a national UK main contractor and two subcontractors from their supply chain. The study analysed the derivations and uses of cost information by different people. The exploration of contractor and subcontractor cost information in this pilot study is part of a wider project to make cost information more relevant to site operation decisions through the use of BIM. Results suggest that current approaches to contractor costing struggle to provide information that is meaningful for establishing how site operations influence construction costs and hence how site operations can be improved. It is suggested that further work is needed, to look at how different costing processes from manufacturing could be applied with benefit in construction.

## LITERATURE

The challenge of pricing one-off projects in construction has led to industry and country specific standard practices for project estimating and tendering (Kirkham, 2007). Regardless of the type of procurement route (such as competitive tendering, negotiation, two-stage tendering) or contract (such as lump sum, measure and value, or cost reimbursement) and regardless of the final format of the price information (formal bills of quantities, informal bills of quantities, schedules of rates, or lump sums), contractors and subcontractors all have the task of creating a project cost from three distinct types of information, namely, estimates of the cost of their own resources, quotations for work from subcontractors and the overarching strategic tendering decisions.

Greenhalgh, (2013) explains that cost estimates for work directly carried out by a contractor are often built up from 'first principles'; that is from the activities that consume internal resources of labour, materials and plant. The internal resource costs are allocated to either site overheads (preliminaries) or measured items. The estimator uses a combination of calculation and judgement to create the unit costs of measured items. For example, the 'measured item' of a brick wall has a quantity and a specification that both influence the resources required. The materials required are calculated by a simple mathematical relationship. The labour and plant required depends on judgements to optimise labour and plant productivity rates and minimise material waste. Greenhalgh (2013) argues that how a contractor makes best use of their internal resources is the main competitive differential between competing contractors. Ross and Williams (2013) identify that it is unlikely that this information on how a subcontractor makes best use of their internal resources will pass up the supply chain. Hence a contractor will not have a detailed understanding of their subcontractors' estimating processes and the decisions involved.

The second type of information used in costing is quotations from subcontractors. Fryer *et al.*, (2004) explain that subcontractor quotes make up the majority of a main contractor's costs as a main contractor typically subcontracts over 80% of their work. Ross and Williams (2013) argue that this change in the industry means the

contractor's skill in managing the subcontractor input into estimates is now a significant competitive differential between competing contractors. The process of managing the subcontractor needs unpacking. For instance Ross and Williams (2013) throw light on the usually hidden practice of price discounting. They describe the discounting 'spiral' in which the originally benign practice of expecting 'trade' discounts from subcontractors escalates in a project to the dis-benefit of subcontractors. In contrast to Greenhalgh's (2013) assertion that contractors main competitive advantage lies in how they make best use of their internal resources, Zimina *et al.* (2012) contend that the skill in commercial purchasing is a primary contributor to project profit.

The third type of information used in costing is the overarching strategic tendering decisions that convert an estimate into a tender. Greenhalgh (2013) shows that contractors make judgments about allowances for design and other risk contingencies, and the required margin to recover company overheads and earn a profit. This type of information relies heavily on an understanding of project uncertainties and market conditions. Ross and Williams (2013) point out that many contractors are guarded when it comes to conversations about margins. Others have shown how discussions about margins are clouded by decisions made through self-interest and opportunism. For example, Cattell (2012) identifies that firms may adopt weighting strategies to manipulate cashflow in their favour and Rooke *et al.* (2004) show there is a culture of planning for claims.

Two alternative procurement methods seeking to reward cost savings have been recently applied in UK contracting. The first is 'supply chain cost management' (Constructing Excellence, 2004), which is used in conjunction with early involvement in design, and seeks design savings by rewarding contractors and key subcontractors with a guaranteed total margin upfront. It achieves this by decoupling margin from each unit item in the cost model so that design savings can be made without eroding margin. Another alternative method is 'target costing' (NEDO, 1982), used when building to budget. This again requires early involvement in design, and seeks efficiency savings by rewarding contractors and key subcontractors with a pain/gain share. It achieves this by using a 'cost plus incentive fee' method that uses open book accounting to establish cost and shares the difference between target cost and actual cost. These alternatives are re-presentations of current project costing practices for budgeting and control, not new, analytical costing practices.

Construction project costing practices exist alongside costing practices in other industries, within the broader field of management accounting. Management accounting emerged to facilitate financial budgeting and control and broadened over time to encompass analytical measurement and evaluation of financial performance (Chapman *et al.*, 2007)). The main approach in this shift has been the theoretically based model of transaction cost economics (TCE), which has sought to compensate for flaws in the market-orientated view of perfect competition by focusing on how organisations can avoid dependence and deal with opportunism (Williamson, 1985).

In manufacturing and retail sectors, new analytical tools for costing that reflect transactions in supply chains emerged alongside TCE during the 1990s. LaLonde and Pohlen (1996) compared the main four tools that account for the cost of transactions in supply chains. Activity based costing (ABC) (Kaplan and Cooper, 1988) as a method of assigning accurate costs to products or services based on the resources they consume. Total Cost of Ownership (TCO) (Carr and Christopher, 1992) that looks at

the total costs between two neighbouring firms in a supply chain. Direct Product Profitability (DPP) (Kurt Salmon Associates, 1993) that considers the logistics of moving items between supply chain firms. And Efficient Customer Response (ECR) (Weeks and Crawford, 1994) that focuses on reducing whole supply chain costs through a better transfer of information, automating administration processes and unifying replenishment cycles. LaLonde and Pohlen (1996) argue that a hybrid of these techniques offers a new costing system that reflects supply chain relationships.

Despite the shift in cost accounting in the manufacturing and retail sectors and the pressure to embrace learning from other sectors such as aerospace (Green *et al.*, 2005) and automotive (Egan, 1998), project cost accounting in construction has remained largely within the realm of budgeting and control with few exceptions. Staub-French *et al.* (2003) applied ABC to account more explicitly for the cost of design features in construction projects. They created a prototype tool using the methodology of activity based costing to help estimators customise early stage construction cost information based on design features. O'Brien and Fisher (2000) applied ABC to calculate the capacity costs in the construction supply chain.

The literature shows that construction is embedded in its own costing practice and that this is challenged for accuracy, but not for efficacy. It keeps on doing the job it has always done because the industry works around the inadequacies. What is needed is a closer study of the thinking behind these construction cost practices so that their success in developing efficacy in decision making can be evaluated. The potential for different approaches to costing needs also to be assessed on this basis.

## **METHOD AND METHODOLOGY**

The research is grounded in the interpretivist tradition. It explores the narrative around actions and decisions in order to know what organisations and individuals do and why they act as they do (Walliam, 2006; Easterby-Smith *et al.*, 2008). The research adopts a position of 'cost as information' then sought to challenge the basis and practicalities of this by treating it as merely a representation of purchasing possibilities and resources. Cost information is made problematic when it is given wider meaning by people and becomes a fixed reference point in construction projects. This research did not therefore start from the hard propositional knowledge of current practices, but rather looked at where cost information is derived from and how it is used, seeking to better understand what cost information means to different people. The research did use some hard propositional knowledge from costing documents and reports but explored this from an experiential and performative perspective. The overall objective was to explain current approaches to costing and explore the potential for making better decisions.

The research involved collaboration with a UK national contractor. This allowed access to data in a case study approach to their costing practices with a view to establishing what was needed for them to apply BIM successfully. This also involved two subcontractors, a mechanical and electrical subcontractor and a suspended ceiling, partitions and dry-lining subcontractor, who entered into the research willingly, as they saw opportunities for better payment. The conflicts of interest and ethical decisions that the study involves have been managed with care so as to be sensitive to their position and gain full access to the reality of their situation. The study was undertaken using interrupted involvement to follow decisions and their consequences at intervals through projects. The research adopted an inductive approach to provide description, understanding and explanation of the sources and uses of cost information

in estimating and tendering. The study also used documentary evidence of cost processes and written cost reports as well as narratives from semi-structured interviews with key participants from pre-construction and site operation teams to establish how they source and use cost information. In the middle of the study a reflective group discussion took place with key participants from the main contractor. To maintain confidentiality, the study used a different project for each organisation. However each project involved a similarly large, complex, one-off construction in which the contractor did not control the design phase. Interviews established that the same project costing processes and written cost reports were used on all projects. In general what people do is similar on all projects.

## **COSTING PRACTICE DATA**

The empirical research aimed to establish whether the cost information collected by main and subcontractors during estimating and tendering was useful for promoting and accounting for improvements in site operations. The investigation sought to determine the reasoning behind the derivation and use of cost information and, importantly, what information was not created.

Based on the documents and narratives provided by the participants it was seen that, once a contractor or subcontractor had decided to submit a tender, their estimating, planning and buying functions face the task of building up project costs from a number of constituent parts while their commercial function faces the task of synthesising the information into a tender. It was seen that because subcontractors themselves subcontract work, there is no distinction between main contractor (MC) and subcontractor (SC1 and SC2) in terms of their costing process. In order to describe, understand and explain the costing processes and compare this with the literature, the investigation was structured around the same three distinct types of information categories as established in the literature review: estimates of the use of internal resources, quotations for work from subcontractors and overarching strategic tendering decisions.

### **Estimates of use of resources**

An estimator creates 'first principle cost information' to forecast the price to pass on for work that will be carried out using their company's internal resources. They check, and hence improve, information received on quantities and specifications for 'measured items' then customise these for work that is under or over measured, or under or over specified. They create good information on their company's costs for directly employed labour using annually updated company information on salaries that are based on national wage agreements and salary on-costs. They also create good information on their company's costs for materials and plant, using regularly updated schedules of negotiated prices from suppliers. They then forecast the activities, resources and resource productivity rates for measured items. Company standard calculations that are derived from previous project experience are created. However the study found that the 'accuracy' of this information in representing site operations is made opaque by commercial practices.

*"There are industry standard resource and productivity rates for activities but we create our own. We reviewed our labour productivity four years ago with our site operatives. We identified efficiencies, but then we didn't change our productivity rates because we were in a rising market and all costs were going up" SC1*

*“We have a standard productivity rate for our labour-only subcontractor who are required to work to a price. In a market upturn we have to use less productive labour but they take the hit” SC2*

### **Quotations for work from subcontractors**

For the main contractor, as much of 80% of the price passed on to the client comes from prices received from subcontractors. For a tier 1 subcontractor in one of the major trades, this can also be as much as 60% to 70%. The estimating and purchasing teams obtain and compare bids on the basis of price and technical issues and select a subcontract price to use in their tender. The selected subcontract price comes with a stipulated level of ‘standard trading discount’ that recognises trade business. The estimator creates a new figure by assuming a level of ‘additional trading discount’ on top of the standard. The risk is taken that the ‘additional trading discount’, or more, will be realised in further negotiations if and when the site operations team later place an order with subcontractor who’s price has been selected at this stage.

*“Quite often it's pre-discounted so already the client has had the benefit. The person carrying the risk [that the additional discount will be realised when an order is placed for the subcontract] is us.” MC*

*“Sub-contractors never give the best price first. We pre-discount our price when we put our price in. So we take a discount off their prices so you add all these subbie costs. We'll pre-discount ours before we sell it.” SC1*

### **Overarching strategic tendering decisions**

An analysis of estimated direct costs and subcontract prices is passed from the estimating and purchasing teams to an adjudicating group, who review the information and establish the project mark up. The ‘mark up’ is made up of judgements on (i) anticipated cost of ‘design contingencies’ for uncertainty and level of risk and (ii) a ‘margin’ to recover general, non project specific, overheads and a level of profit expected to be earned from the project.

*“We've had some vigorous debates about what the correct level of risk contingency should be on those jobs. We've had similar debates on every single job and it's the most subjective point that you could take.” MC*

This establishes information on the total cost and is passed on as the going rate. The going rate is used as a target to budget and control costs within cost envelopes.

*“We apply risk costs, OH&P as agreed in settlement meeting with directors and this form becomes the financial record of our tender. If successful this passes to the project delivery team and particularly procurement as a record of decisions made at tender stage to come to our offer” SC1*

When the price is presented in a standardised format, such as a bill of quantities or schedule of rates, the contractor decides a gross price to put against each cost item in the model. The gross price is made up from the net price of measured items plus a share of the ‘mark up’. Both the net and gross prices can be manipulated across cost items in the model.

*“We like to have overvalue in our orders. So we get paid more than we pay out every month and that generates a surplus for our business.” MC*

Interviews established that participants recognised that the cost information that is created and the price information that is passed on throughout the supply chain has

many forces acting on it from operational and strategic decisions made throughout the supply chain. Participants saw project costing as a process that results in firms in the supply chain winning and losing on projects at each other's expense.

*"There's two layers. Some people might take a few bob off to win a job but the figure they take that from is a figure which people have already made assumptions on."* MC

*"Some contractors will make double the margin they expected to make and other contractors that'll make half the margin they expect to make. You can guarantee only one of them is going to bang your door."* MC

Participants understood that the project cost information created is obscured by layers of commercial decisions that remove cost information from a good representation of work processes, site activities and the resources that are consumed by those activities. They also recognised that as a buyer, their line of visibility into their subcontractors' cost information is shallow.

## DISCUSSION

This research sought to understand the problem of costing in a way that allows the industry to move on and account for improvements in work processes rather than rely on gains obtained through commercial buying practices and opportunism. Discussion on costing in the UK construction industry focuses a lot on reaffirming established methods currently used by practitioners and so, (with exception of Zimina *et al.* (2012) and Ross and Williams (2013)), does not ask important questions of efficacy for assessing work processes across the supply chain. This questioning needs to go beyond the concept of improving productivity (e.g. Sezer and Bröchner, 2013). As participants in this case study revealed, in their explanation of 'working to a price', the concept of productivity has the connotation of how much labour you can get out of someone. This privileges self-interest over improving wider processes.

If a contractor is looking to a subcontractor to undertake improvement for the sake of the supply chain, they need to be able to assess this and reflect it in their payment process (i.e. pass on the reward). Zimina *et al.* (2012) looked at target costing and concluded that UK commercial and cost management practices are a major barrier to rewarding efficiencies through a pain/gain sharing payment process. Ross and Williams (2013) look at supply chain cost management and conclude that lack of transparency is a major barrier to rewarding cost and waste reduction through a payment process that protects each company's margin. This study supports the conclusions of Zimina *et al.* (2012) and Ross and Williams (2013) that it is very difficult for the construction industry to get good cost information that reflects the different work processes across the supply chain. Without such cost information, the industry can only enter into buying decisions on the assumption that what is being brought is already fixed. This does not achieve improvement. In a wider critique of improvement in the construction industry, Green (2011) demonstrates the fallacy of the argument that in a market where costs are driven down, subcontractors will be forced to innovate to survive.

The problem of costing needs to be understood in a different way as current practice does not contain the information needed for achieving improvements. What is required then is for the construction industry to look more carefully at alternative accounting practices. Accounting practices that reflect transactions in supply chains may be useful as these were adopted by other industries through the 1990s in response to increased competition and alongside the emergence of TCE. The most developed of



the four main tools that account for the cost of transactions in supply chains, as compared by LaLonde and Pohlen (1996), was Activity Based Costing (ABC), which assigns accurate costs to products or services based on the resources they consume (Kaplan and Cooper, 1988). Tsai (1998) gave a framework for measuring costs under ABC in a two dimensional model adapted from Tsai (1998) as shown in figure 1.

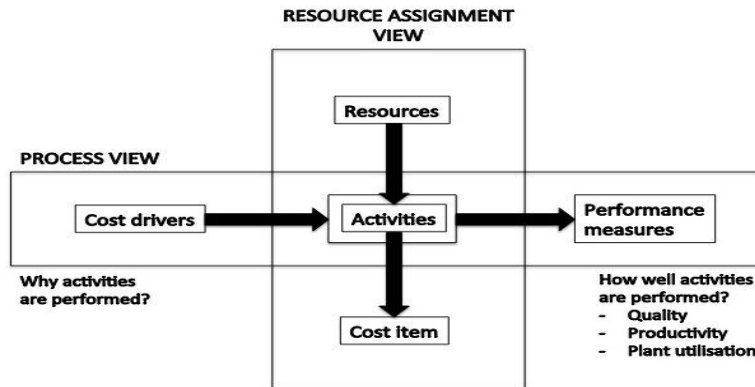


Figure 1: Two-dimensional model of ABC. Source: adapted from Tsai (1998)

The first dimension, the resource assignment view, includes information on labour, plant and materials but does not contain information on work processes (other than in labour which only assumes a measure of productivity). Without information on work processes the resource assignment view does not represent improvement well. However the second dimension, the process view, adds information on method in the form of ‘cost drivers’ that explain why activities are performed and ‘performance measures’ that explain how well activities are performed. Information on cost drivers can quantify improvements in work processes and information on performance measures can be used to fairly reward those improvements.

One barrier to accessing information on cost drivers and performance measures is the shift to larger supply chains in which both main contractors and subcontractors predominantly undertake to buying rather than making. Thus information is lost from the supply chain whenever information created about use of resources is missing as it is passed on as quotations for work. This is illustrated in figure 2.

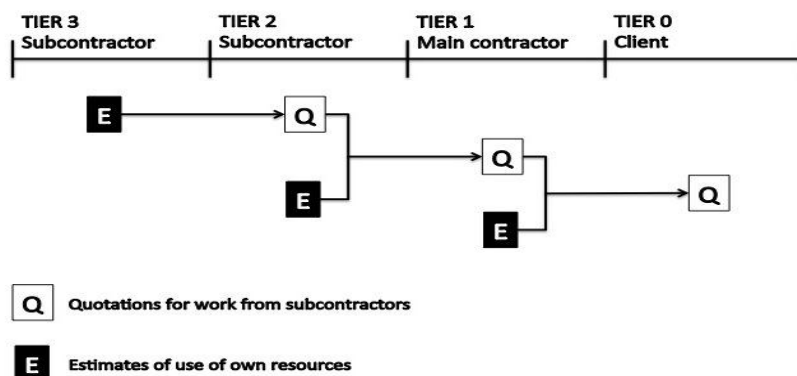


Figure 2: The flow of cost information through the supply chain.

The problem of information loss is exacerbated by different people interpreting the cost information that flows through the supply chain differently. Each of these people

has a different use for the information and this dictates how the costs are interpreted. Most of the cost information in construction has been created for buying, payment and accounting purposes. So when it is used for other purposes it is inadequate. Because of this, getting even more of the current cost information, in no way improves the industry's ability to arrive at decisions that improve processes, or reward better site practice. Even worse, current cost information actually discriminates against improvement by driving perverse incentives and creating unintended consequences following cost information being wrongly used or underused.

BIM offers an immense amount of information that can be extracted from digital models into BIM based costing applications. Currently, digital costing applications are based on either simplistic object quantity take offs or the complexities of current approaches to quantity surveying. This sort of cost information does not adequately represent the reality of site operations; thus, automating this further or exploiting the greater level of detail of information offered by BIM cannot improve site operations as the cost information is at best constrained and at worst provides misleading information. To advance this situation, the construction industry needs to understand its costing processes better and to tie these more clearly to the purpose for which the costs are being used. In particular, the connection between site operations, the purpose for which costs are used, and the method of producing costs needs to be explored in much more detail to devise an alternative to current costing techniques.

## CONCLUSIONS

This research has produced unique knowledge about costing by a main contractor and subcontractors. It has established how current costing practices lose information about site operations and methods, as it is transferred during a tendering situation. At each transfer, participants want different information from the costs; however, the ability to do this is limited by the original purpose of the cost. Current cost information is produced for buying, payment and accounting purposes. Thus, using the current costing methods in BIM is not helpful for use for a different purpose, such as evaluating and rewarding improved site practices and supply chain operation. It could, in fact, make things worse by producing more convoluted details that appear accurate but are not linked to what people do. If the industry needs BIM to deliver information that is useful for improving site operations, then this requires understanding cost information better and using costing methods that are tied to that aim. It is only this that will provide real benefits from BIM in relation to cost and improvement.

## REFERENCES

- Cattell, D W (2012) An overview of component unit pricing theory. "*Construction Management and Economics*", **30**(1), 81-92.
- Chapman, C S, Hopwood, A G, and Shields, M D (2007) "*Handbook of management accounting research*". Oxford: Elsevier.
- Constructing Excellence (2004) "*Supply chain management*". London: Constructing Excellence.
- Department for Business, Innovation and Skills (2014) "*Construction 2025: Industrial Strategy: government and industry in partnership*", Department for Business Innovation and Skills, London.
- Easterby-Smith, M, Thorpe, R and Lowe, A (2008). "*Management research: an introduction*". 3ed. London: Sage.

- Egan, J (1998) *"Rethinking construction"*. London: Task Force Report for Department of the Environment.
- Fryer, B, Egbu, C, Ellis, R and Gorse, C (2004) *"The practice of construction management"*. 4ed. Oxford: Blackwell Publishing.
- Green, S D, Fernie, S and Weller, S (2005) Making sense of supply chain management: a comparative study of aerospace and construction. *"Construction Management and Economics"*, **23**(6), 579-93.
- Green, S.D. (2011), *"Making Sense of Construction Improvement: A Critical Review"*, Oxford, Wiley-Blackwell
- Greenhalgh, B (2013) *"Introduction to estimating for construction"*. London: Routledge.
- Kaplan, R and Cooper, R (1988) *"Cost and effect"*. Boston, MA: Harvard Business School.
- Kirkham, R J (2007) *"Ferry and Brandon's cost planning of buildings"* 8ed. Oxford: Blackwell
- Kurt Salmon Associates (1993) *"Efficient customer response: enhancing customer value in the grocery industry"*. Washington DC: Food Marketing Institute.
- LaLonde, B J and Pohlen, T L (1996) Issues in supply chain costing. *"The International Journal of Logistics Management"*, **7**(1), 1-12.
- Monteiro, A and Poças Martins, J (2013) A survey on modelling guidelines for quantity take off-oriented BIM-based design. *"Automation in Construction"*, **35**, 238-53.
- NEDO (National Economic Development Office) (1992) *"Target cost contracts - a worthwhile alternative"*. Engineering Economic Development Committee, London: National Economic Development Office.
- O'Brien, W J and Fischer, M A (2000) Importance of capacity constraints to construction cost and schedule. *"Journal of Construction Engineering and Management"*, ASCE. **126**, 366-73.
- Rooke, J, Seymour, D and Fellows, R (2004) Planning for claims: an ethnography of industry culture. *"Construction Management and Economics"*, **22**, 655-63.
- Ross, A and Williams, P (2013) *"Financial management in construction contracting"*. Chichester: Wiley-Blackwell.
- Sezer, A A and Bröchner, J (2013) The construction productivity debate and the measurement of service qualities. *"Construction Management and Economics"*, **32**(6), 565-74.
- Staub-French, S, Fischer, M A, Kunz, J, Ishii, K and Paulson, B (2003) A feature ontology to support construction cost estimating. *"Artificial Intelligence for Engineering Design, Analysis and Manufacturing"*, **17**, 133-54.
- Tsai, W-H (1998) Quality cost measurement under activity based costing. *"International Journal of Quality and Reliability Management"*, **15**(7), 719-52.
- Walliman, N S R (2006) *"Social Research Methods"*. London: Sage.
- Weeks, D and Crawford, F A (1994) Efficient customer response: a mandate for food manufacturers? *"Food Processing"*, **55**(2), 34.
- Williamson, O E (1981) The economics of organisation; the transaction economics approach. *"American Journal of Sociology"*, **87**, 548-77.
- Zimina, D, Ballard, G and Pasquire, C (2012) Target value design: using collaboration and a lean approach to reduce construction cost. *"Construction Journal of Management and Economics"*, **30**(5), 383-98.