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• to support and develop the perception of the important role of the construction industry in the economy.

The Commission will study, evaluate, disseminate, exchange and discuss issues based on these objectives.

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• Applying Macroeconomic Theory: Use of input-output data for analysis of construction industry; Asset prices, monetary policy and building cycles; Stages of development and construction activity.
• Theoretical Issues: Methodology in construction economics; The property market and demand for new building; Measuring construction productivity.
• Cost Studies and Design Economics: Cost modeling; Life-cycle costing and sustainability; Value management
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Concept of a quantitative project selection model for PPP projects

Stefan Weissenböck¹, Gerhard Girmscheid²

Abstract

Project selection decision-making in construction companies that deal with life-cycle oriented and equity-intensive projects (e.g. Public Private Partnership (PPP) projects) is still dominated by intuition rather than structured rational processes. At the same time, companies from related business fields, like infrastructure investors, have been successfully using quantitative models to support their decision processes for years. Hence, there is room for improvement in the project selection process of construction companies.

This paper proposes the concept of a new quantitative model to guide the project selection process of construction companies, using PPP projects as an example. The introduced PPP project selection model (PPP-PS-model) combines Modern Portfolio Theory (MPT) with multi-objective optimization. The PPP-PS-model is divided into three modules. Each module represents a self-contained part of the overall model. In a first step, the company’s current PPP project portfolio is analyzed in order to determine the risk-return profile of every single project. To this end, quantitative parameters for the evaluation of both risks and return need to be identified in advance. Secondly, a target portfolio for the construction firm is calculated by applying MPT. Hence, this module quantitatively describes the future objective of the company’s PPP project portfolio. Its evaluation is based on the analysis of the current portfolio (step 1) as well as the corporate strategy and economic constraints. Finally, a multi-objective optimization algorithm is applied. As a result, this algorithm provides a hypothetical optimal PPP project, which reduces the difference between the evaluated current portfolio (step 1) and the calculated target portfolio (step 2) as far as possible. This hypothetical optimal project serves as a reference, in order to select a new PPP project.

The authors are convinced that rational decision-making and project selection processes based on quantitative analyses will improve the performance of PPP project portfolios. As a result, the PPP project portfolios of construction firms will contain a higher number of suitable projects. To this end, the new PPP-PS-model supports construction companies to better meet their commercial goals.

Keywords: decision-making, life-cycle orientation, Modern Portfolio Theory, operations research, project selection.

¹ Scientific Assistant and Doctoral Student; Institute of Construction and Infrastructure Management; ETH Zurich; Wolfgang-Pauli-Strasse 15, 8093 Zurich, Switzerland; weissenboeck@ibi.baug.ethz.ch.
² Professor; Institute of Construction and Infrastructure Management; ETH Zurich; Wolfgang-Pauli-Strasse 15, 8093 Zurich, Switzerland; girmscheid@ibi.baug.ethz.ch.
1. Introduction

Companies in demand-driven markets need to select the most appropriate projects out of all projects announced to be economically successful. The Public Private Partnership (PPP) market within the construction industry represents such a demand-driven market. Therefore, construction firms dealing with PPP projects rely on appropriate models which ideally support their project selection decisions.

Generally, project selection processes are predetermined by the corporate strategy, which defines e.g. business areas of interest for the company, and by the competitive strategy (Girmscheid (2010)). Nevertheless, decision-makers need to decide in their specific business unit (BU), for which project(s) they would like to apply. This project selection decision is particularly important, if the BU deals with PPP projects. This distinct type of project is characterized by immense bid costs in comparison to ordinary construction projects. In addition, PPP projects offer great potential regarding return on investments next to substantial risk exposure. Due to these facts, it is astonishing that PPP project selection processes in construction companies are still dominated by intuition rather than structured rational processes.

This paper proposes the concept of a new quantitative model to guide the ordinary project selection process of construction companies dealing with a PPP project portfolio.

2. PPP projects – Extended scope of service demands for an improved project selection process

2.1 Problem specification

The European Commission (2012) pointed out, that the “markets of the EU construction sector and the sector itself are highly fragmented…” (p4). Many different competitors with mostly small shares are determining the competitive market especially in traditional business segments (e.g. building construction). Furthermore, the composition of bidders, which are competing for the same contract, is commonly very heterogeneous. Companies of varying sizes and interests frequently applied and (still apply) for the same projects, which regularly leads to competitive disadvantages for bigger companies, as they need to cover higher overhead costs (Girmscheid (2000)). Consequently, many big construction companies both in Switzerland (e.g. Implenia, Marti, Priora) and abroad (e.g. Hochtief, Bilfinger Berger, Strabag, Vinci, Bouygues, Balfour Beatty, ACS, FCC) took actions against the ongoing price competition in the traditional business fields. These companies drift more and more towards becoming total service providers, trying to participate either in several project phases or the whole life-cycle of a building. According to the increasing life-cycle orientation, these companies offer a more comprehensive range of service. This range regularly includes construction, design, operation, maintenance and finance, having a positive impact for both the companies involved and the environment. These positive impacts are confirmed by a current study of the European Commission (2012), which points out that these distinct types of projects have „the potential to contribute to a competitive construction sector and to the development of a resource and energy efficient building stock…” (p12). On the other hand,
the extension of the range of service and the naturally longer contract duration of life-cycle oriented projects (e.g. PPP projects) lead to a significant increase in the magnitude of risks taken by the construction companies involved. As a consequence, construction companies that deal with these “high risk projects” increasingly emphasize considerations regarding risk management (Girmscheid (2007b), Girmscheid (2007c)), risk allocation (Girmscheid (2011a)) and risk diversification (Girmscheid and Busch (2008)) in their portfolio. However, there still is a lack of appropriate, quantitative instruments to support decision makers in selecting those PPP projects, which perfectly complement the risk and return profile of a company’s current portfolio. As a consequence, the actual process of decision-making in PPP project selection is mainly determined by the intuition of the company’s management rather than structured rational processes. Chapter 4 introduces a concept, which aims to improve the current project selection process of construction companies dealing with a PPP project portfolio.

2.2 The importance of an appropriate PPP project selection process

The reasons mentioned below have no claim to completeness, but stress the importance of an appropriate project selection process in construction companies dealing with PPP:

- **High bid costs:** Due to the fact that essential planning services are shifted from the tender authority to the bidders, notable costs arise for the private companies involved. These costs are further increased by the (mandatory) inclusion of several consultants. For instance, seven consultants were commonly mandatory due to specifications of the tender authority or specifications of lenders within the first stage of infrastructure PPP projects (A-models) in Germany. According to Stolze (2008), the average bid costs of all acquired PPP projects within the company Balfour Beatty added up to almost EUR 3,000,000 per project. This average amount can be largely exceeded in case of major infrastructure projects. Therefore, the success rate (i.e. the ratio between tender participations and acquired projects) is of considerable importance for construction companies dealing with a PPP project portfolio.

- **High equity investment:** The construction companies involved in PPP projects (usually) act as sponsors of the project and regularly invest a high amount of equity into a project. According to Weber and Alfen (2010), an “equity ratio (…) between 10 and 30% of the total financing volume of a project depending on its (perceived) risk profile…” (p199) is considered to be normal in this case. Thus, a lot of equity is tied up in one single project and is not available for other investments for a longer period of time.

- **Earnings depend on dividends provided by the SPC:** Usually, a special purpose company (SPC) takes the role of the private partner within a PPP contract. This SPC has to be financially equipped in order to fulfill its “special purpose”. Therefore, it receives debt capital from the lenders as well as equity capital from the sponsors, which are regularly the construction companies involved. If this is the case, the main earnings of these construction companies arise, according to Merna et al. (2010), from their “compensation for equity (which) is dividends (dividends are the amount of
profits paid to the shareholders)..." (p33). Dividends are only distributed, if the SPC makes profit. Furthermore, the debt claims of the lenders must be met, before the sponsors receive money from the SPC. Hence, construction companies that deal with PPP projects need to make carefully considered project selection (i.e. investment) decisions in order to be economically successful.

2.3 State of practice in arranging project portfolios in related business fields

When designing an applicable project selection model, it seems advantageous to make use of “best practice” solutions coming from comparable business areas by adjusting and enhancing the best suited methods to our specific problem. Furthermore, the participation of construction companies in PPP projects goes hand in hand with a broadening of the offered range of service. This offers the opportunity to learn from the experience of companies, which deal (or dealt) with comparable fields of action. Evaluations of related business fields have shown that the financial industry in particular successfully uses Modern Portfolio Theory (MPT) for quite a few years now to support their investment decisions. Furthermore, Wellner (2011) demonstrated that MPT can also be used for real estate investment decisions, which are highly comparable to PPP project investments. Wellner (2011) is convinced that “it is thus possible to implement the findings of the Portfolio Theory in practice and make investment decisions safer and more independent from subjective influences...” (p18). Viezer (2010) even goes one step further and proposes that private equity investors as well, such as construction companies that deal with PPP projects, “may someday find MPT as a useful engine of inquiry...” (p755). These recent findings demonstrate that MPT could contribute to an increase of rationality within the project selection process of construction companies dealing with a PPP project portfolio. Hence, the potential of MPT in construction has to be evaluated with further scrutiny, with special focus on its applicability to the PPP project selection process.

2.4 State of research regarding the applicability of MPT to the project selection in construction companies

The MPT was first developed by Harry Markowitz. Markowitz (1952) stated that the “hypothesis (or maxim) that the investor does (or should) maximize (…) return must be rejected...” (p77). He suggested instead considering both risks and return, where risks should be limited by optimal portfolio diversification. Markowitz’ research concerned the security management in share portfolios and had no ambition of being applicable to other types of investment. Subsequently, most of the research related to MPT focused on implementing the basic findings on various industries and fields. Vergara and Boyer (1977) tried to implement MPT to construction bidding practices and generally stated that “bid decisions can be rationalized...” (p33) by applying this method. Kangari and Boyer (1981) calculated the return of a project by using the net present value (NPV) and compared the portfolio approach with a market model approach. Kangari and Riggs (1988) conducted a “probabilistic approach (...) to show a more realistic approach to the evaluation of correlation” (p168) within the project portfolio. Archer and Ghasemzadeh (1998) introduced a decision support system (DSS) for project portfolio selection, which utilized a computerized project database. Han et al. (2004) focused on big, diversified international construction
companies and provided a practical method based on NPV, return on investment (ROI) and value at risk (VaR) for the selection of new international construction projects. Ravanshadnia et al. (2010) added a fuzzy model, in order to determine the optimal project portfolio of a construction company.

The literature research showed that MPT is applicable for the project selection of construction companies. Nevertheless, two main problems in applying MPT to the project selection in construction companies have been identified. Firstly, the high correlation and therefore the limited diversification in the project portfolio of traditional construction companies have been criticized in several publications. This problem has less influence, if MPT is applied to PPP project portfolios of larger construction firms. The various types of PPP projects (e.g. hospitals, schools, highways, airports) show completely different risk profiles. In addition, the particular risk profile of each project changes over the life cycle. Thus, a PPP project portfolio offers a much bigger potential for diversification than an ordinary portfolio of construction projects. Secondly, many researchers used MPT by adding specific announced projects to the current project portfolio and then compared the risk and return profiles of these various potential future portfolios. These researchers faced the problem of a limited knowledge of the announced projects. The PPP-PS-model presented in this paper uses a completely new approach for identifying an optimal future project. This approach covers the identified problem of limited knowledge and additionally provides a bid strategy.

2.5 Objectives of the new quantitative PPP-PS-model

The objective of this paper is to present a new concept to support the PPP project selection process in construction companies. The PPP-PS-model has to be developed on a quantitative basis, in order to increase the currently limited rationality within the PPP project selection process. Furthermore, the PPP-PS-model aims to achieve the targeted return, while minimizing the risks within the whole PPP project portfolio (and not just for maximizing the return and minimizing the risks of a single PPP project). Therefore, the PPP-PS-model needs to consider the current portfolio and has to determine the specific project that improves the risk-return ratio of this current portfolio as much as possible. To meet this objective, MPT is applied. The practical applicability of MPT is bounded by the limited knowledge of a potential future project. This problem has to be solved by using a new and different approach. Furthermore, the model should provide a bid strategy. In addition, the model needs to include the corporate strategy so to enable a target oriented long-term development of the construction firm.

3. Research methodology

Putting the PPP-PS-model into a broader setting, this specific type of model can be seen as a decision model. Decision models are characterized by evaluating alternatives of action for a specific problem. According to Girmscheid (2007a), the derivation of a decision model follows the constructivist-hermeneutic approach, which has been developed by von Glasersfeld (1996). The quality of decision models is guaranteed by applying the principle of triangulation (Yin (2009)). The application of this principle ensures the (1) viable, (2) valid
and (3) reliable model development. Firstly, the viability of the PPP-PS-model will be guaranteed by designing the model logically deductively. The underlying theory is provided by systems theory (von Bertalanffy (1968)) and cybernetics (Wiener (1992)). Secondly, the validity of the model is ensured by using proven and target oriented mathematical methods such as MPT. Finally, the reliability of the model will be evaluated by conducting both simulations and practical tests.

4. Conception of the new quantitative PPP-PS-model

This new quantitative PPP-PS-model aims for the identification of the specific new PPP project, which achieves the targeted return of a PPP project portfolio while minimizing the risks. To reach this objective, MPT will be applied. Moreover, the practical applicability of MPT in project selection processes will be improved by solving the problem of limited knowledge of new projects at the beginning of the tender stage.

Fig. 1 displays the basic concept of the new quantitative PPP-PS-model. As illustrated, the model consists of three major elements:

1. analysis of the current portfolio,
2. evaluation of the target portfolio and
3. determination of the optimal next project for which a company should apply.

![Figure 1: Basic idea of the new quantitative PPP-PS-model](image)

The “current portfolio” symbolizes the actual PPP project portfolio within a construction company. It is characterized by the total return ($R_{t0}$) and the total risk ($\sigma_{t0}$) of every single project. Furthermore, the average percentage of return $R_{t0,m} [%]$ and the average risk $\sigma_{t0,m} [%]$ of the currentPPP portfolio as a whole can be calculated.

The “target portfolio” symbolizes the optimal future PPP project portfolio within the same construction company. The target portfolio will be determined by the corporate strategy, taking into account the company’s specific constraints (e.g. risk bearing capacity and the availability of equity). It is characterized by the targeted return of the portfolio ($R_{tn} [%]$) and the corresponding minimal risk ($\sigma_{tn}$) of the PPP project portfolio. The target portfolio will naturally show a better risk-return ratio than the current portfolio:
The determination of an optimal next PPP project \( P_{\text{NEW, opt}} \), for which a company should apply in a tender procedure, represents the third major element of the model. \( P_{\text{NEW, opt}} \) is defined as the specific project, which minimizes the difference between the current portfolio and the target portfolio as far as possible. To meet this objective, the following formula needs to reach a minimum, where \( R_{t1,m} [%] \) represents the average return and \( \sigma_{t1,m} [%] \) the average risk of the PPP portfolio when adding one additional new project:

\[
\frac{R_{t1,m}}{\sigma_{t1,m}} < \frac{R_{\text{tn}}}{\sigma_{\text{tn}}}
\]

Each of the three major elements forms a separate module within the PPP-PS-model. Subsequently, these three modules are described in further detail.

4.1 Module 1: Analysis of the current PPP project portfolio

According to Busch and Girmscheid (2005), prior to “their acceptance, new risks to be assumed must be aggregated with the already accepted risks from, for example, other projects...” (p784). Consequently, a construction company needs to evaluate the accepted risks before applying for new PPP projects. As MPT constitutes the major instrument in the concept of the new quantitative PPP-PS-model, it is not just the risks that need to be identified but the composition of risks and return (Wellner (2003)). Therefore, every actual PPP project needs to be analyzed regarding its return (achieved + expected) and its associated risks. MPT defines the aggregated risks of every project as variance (\( \sigma \)) of the return. Referring to Girmscheid (2011b), the accumulated risks of a PPP project decrease over the contract period. Furthermore, the accumulated total return (achieved + expected) can be increasingly precisely determined with proceeding contract period because less parameters need to be forecasted (fig. 2). This time-related evaluation of both risks and return of every project allows for the comparison and aggregation of various projects at different stages. This makes MPT increasingly suitable for supporting PPP project selection.

\[ \text{Figure 2: Time-related evaluation of risks and return} \]
Supplementing the aggregated risks and the return (achieved + expected) allows for classifying each project by its current ($t_0$) risk-return ratio, as displayed in fig. 3.

Figure 3: Analysis of the current PPP project portfolio

4.2 Module 2: Determination of an optimal target PPP project portfolio

Module 2 aims to determine an optimal target PPP project portfolio. Therefore, several steps, which refer to the market and to the resource based approach of Girmscheid (2010), need to be conducted. Firstly, the market based view represents the corporate strategy, which is important, due to the "linkage of the company's strategy and its project selection activities..." (Ravanshadnia et al. (2010), p1083). Developing a target oriented strategy results in the determination of potential target countries and potential types of projects. Secondly, the resource based view leads to constraints, which limit the development of the company in the future. These constraints are, amongst others, the company's risk bearing capacity, the available equity capital and the company's technical and economic performance. The market based view, under consideration of the resource based view, allows for the identification of potential fictitious target PPP projects as shown in fig.4. Every identified fictitious project $T_n$ is described by the same characteristic parameters (respectively return and risks) as applied in module 1.

Subsequently, the application of MPT allows for the calculation of an optimal composition of various potential fictitious target PPP projects. To reach this target, an efficient frontier has to be calculated. This efficient frontier represents a curve of all possible compositions of projects that lead to the highest possible return at a specific level of risk (Elton et al. (2011)). The particular point of the curve, which represents the expected average return of the company, is named maximum sharpe ratio portfolio (MSRP). The MSRP represents the specific composition of potential fictitious PPP projects, whose combination bears the
smallest risks in reaching the return objectives. The obtained composition of PPP projects represents the optimal PPP project portfolio of the company.

Figure 4: Determination of an optimal target PPP project portfolio

4.3 Module 3: Determination of an optimal new PPP project

Module 3 aims to determine an optimal new PPP project ($P_{\text{NEW, opt}}$) and is displayed conceptually in fig. 5. Firstly, the difference between the MSRP and the current PPP project portfolio is calculated. Subsequently, an optimization process based on multi-objective optimization is conducted. This process searches for the fictitious PPP project that reduces the difference between the MSRP and the current portfolio as much as possible. The result obtained is $P_{\text{NEW, opt}}$, which signifies the hypothetical next PPP project a company should apply for. Thus, $P_{\text{NEW, opt}}$ serves as a reference, in order to select a new PPP project.

Figure 5: Determination of an optimal new PPP project ($P_{\text{NEW, opt}}$)

According to a holistic approach and in order to ensure the quality of the results, the parameters (return + risks), which determine $P_{\text{NEW, opt}}$ will be evaluated using qualitative parameters.
To solve the problem of limited knowledge of announced projects at tenders stage, the new PPP-PS-model distinguishes between two groups of parameters that describe $P_{NEW, opt}$:

- **Parameters that are known at call for tenders stage**: These parameters contain project information, which is commonly available when projects are put out for tender. Therefore, these parameters can be used to search for real projects that meet $P_{NEW, opt}$ as closely as possible.

- **Parameters that are unknown at call for tenders stage**: These parameters contain project information, which is commonly not available when projects are put out for tender. Notwithstanding this, these parameters are advantageous for designing and structuring the project in the bid phase. If applied, these parameters ensure that the bid strategy pertaining to the project is in line with the corporate strategy, which has been used to determine the optimal target PPP project portfolio.

### 5. Conclusion

The realization of this new PPP-PS-model will support construction firms in selecting and structuring highly suitable PPP projects for their specific strategy and their specific current PPP project portfolio. Furthermore, the problem of limited knowledge of projects at tender stage has been solved by following a new approach in applying MPT for project selection. This will allow for a more practicable application of MPT within the project selection process of construction companies dealing with a PPP project portfolio. Therefore, the authors are convinced that the realization of this concept will improve the performance of PPP project portfolios. As a result, the PPP project portfolios of construction firms will contain a higher number of suitable projects. To this end, the new PPP-PS-model supports construction companies to better meet their commercial goals.

The findings in this paper are restricted to large international construction companies that deal with a PPP project portfolio.

The current paper represents the first step of a research project at the Institute of Construction and Infrastructure Management, ETH Zurich. The next steps in the development of the new quantitative PPP-PS-model are the detailed determination of both an appropriate return measure and suitable risks as well as the mathematical formulation of the three modules. Finally, the model’s reliability will be evaluated by conducting several simulations and practical tests.

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Determining the magnitude of transaction costs in construction procurement systems: An exploratory study

Mohammed Rajeh¹, John Tookey², James Olabode Rotimi³

Abstract

Transaction cost economics (TCE) has traditionally examined customer-supplier relationships in the context of contractual arrangements. This enables the development of appropriate strategies, such as long-term agreements and alliances, to eliminate the risk associated with contracting uncertainty, limiting the number of instances of bargaining or opportunism and asset specificity. In the context of construction procurement decisions, TCE could generate a valuable understanding of the costs associated with coordination, inspection, translation, incentives, transactions, and other interactions. This paper therefore reports on an exploratory effort to capture the transaction costs (TCs) of different procurement systems used in construction projects. Specifically determining the relative values of TCs for Traditional and Design - Build systems for the purpose of comparison.

The paper involves a meta-study of construction procurement systems and TCE. It reviews the approach to the development of a conceptual framework that could enable the selection of appropriate procurement systems and/or make-or-buy decisions that could minimise TCs and therefore enhance the performance of the construction industry.

The study is an aspect of a doctoral research study on determining appropriate construction procurement systems based on rational evaluative tools (TCE being one such tool). An outline of the larger study programme that forms the basis of the current paper is presented to demonstrate the benefits of the research investigation to construction clients and the construction industry as a whole.

Keywords: Transaction costs, Procurement systems, Construction.

1. Introduction

Operational performance continues to generate interest in construction. For example the procurement process provides opportunities for cost reduction and value enhancement to project owners. The selection of appropriate procurement systems for a construction project may influence its success or failure. Merrow (2011) contends that procurement systems make a difference in project execution, while poorly managed project relationships

１Doctoral Scholar; Construction Management Programme; AUT University; mrajeh@aut.ac.nz.
２Associate Professor; Construction Management Programme; AUT University; jtookey@aut.ac.nz.
３Senior Lecturer; Construction Management Programme; AUT University; jrotimi@aut.ac.nz.
negatively impact project performance (Meng et al. 2012, Merrow 2011). In fact Meng et al. (2012) has shown that poor supply chain relationships significantly impact the occurrence of cost overruns than time delays.

Relationships in the form of buyer-supplier relationships have been the object of several investigations in construction (Al-Najjar 1995, Artz 1999, Bajari et al. 2009, Kajewski et al. 2010, Eriksson 2007, Hughes et al. 2006, Love et al. 2009). However for the purpose of this paper, the costs associated with customer-supplier relationship in the context of contractual arrangements is the primary focus. TCE focuses on economic actors’ behavioural assumptions (opportunism and bounded rationality) and transaction characteristics; i.e. asset specificity, uncertainty, frequency, complexity, and contestability (Williamson 1985, Williamson 2005, Williamson 2010b). Heide and John (1990) contend that TCE provides a useful framework for the selection of the most suitable procurement system for projects.

Eriksson (2007) argue that the procurement selection decisions are always judgmental, subject to bias, and heavily affected by individual experiences of a particular procurement system. Given that TCE is such a significant component of construction procurement, and that the procurement decision is highly cost sensitive, it seems apparent that there is a need to better evaluate TCs in construction. As early as 1985, Williamson (1985) suggested that the comparative costs of planning, adapting, and monitoring task completion under alternative procurement systems should be examined. Moreover, Turner (1997) expanded the notion to contemplate other important factors such as engineering, economic, environmental, and social factors, in the procurement selection process (Turner 1997). Therefore, theoretical elucidation is required to enhance the development of practical concepts and techniques, and to assess the circumstances under which they are suitable for a certain purpose (Cox et al. 1998). Theoretical concepts of TCE are supported by several empirical studies (Artz 1999, Heide and Stump 1995, Melese and Franck 2005) and will be discussed later in this paper. Researchers within the TCE field suggest the applicability of transaction costs theory (TCT) although some have employed imperfect proxies for key variables. TCT contends that there are costs to conducting transactions through the market, which can be reduced through certain mechanisms (Coase 1988, Williamson 1971). Specifically, these costs relate to drafting, negotiating, and safeguarding and exchange that could impede smooth transactions (Williamson 1985). Further, changes in design and information requirements for procurement are significant to TCs in construction (Wenan and Mengjun 2010).

This paper aims to investigate the linkage between procurement systems selection and TCs, using TCE methodologies. The paper presents a conceptual model that is developed, for the selection of the most economic procurement system that could achieve project success. The model of procurement selection so informed could help to reduce costs, enhance productivity, and increase quality performance and customer satisfaction.
2. Literature Review

2.1 Transaction cost

Ronald Coase first introduced the concept of TCs in 1937 (Jacobides 2008). He subsequently further investigated pricing mechanisms and concluded that there are costs related to searching for relevant prices, negotiating, and making a contract (Coase 1992, Coase 1988, Coase 1960). Williamson (1985) developed the theory of TCE by focusing on the economic actors’ behavioral assumptions (opportunism and bounded rationality) and transaction characteristics; i.e. asset specificity, uncertainty, frequency, complexity, and contestability (Williamson 2005, Williamson 2010a, Williamson 1985). Economic actors behaving opportunistically with bounded rationality and uncertainties dominate contracts, which partially accounts for contingencies. Importantly TCE has traditionally examined the customer-supplier relationship in the context of a contractual arrangement. This relationship is associated with TCs including; costs of information, negotiation, competitive advantage, contract administration and management, market structure, enforcement, and measuring/monitoring performance (Melese and Franck 2005, Artz 1999, Heide and Stump 1995).

TCs perspective has received considerable attention by researchers and academics and has been applied to a variety of construction topics. The rationale behind applying TCs in construction is to understand the cooperation and motivation among project stakeholders. Eccles (1981) conducted an investigation on the impact of asset specificity and uncertainty in the governance form of construction firms (Eccles 1981). Eccles adopted the hybrid contract (the quasi-firm) for examining the relationship between contractor and sub-contractor. Winch (1989, 2008) investigated the relationship of socio-technical systems, organization and environment, and project management in construction. Winch believes that the three perspectives do not fully elucidate the differentiation and integration of market governance. This means the transaction between firms in using the market governance model does not fully examine the relationships between firms (Winch 1989, 2008). Hence, Winch adopted the TCs perspective as an alternative approach in systematically handling the relationships within and between firms. The significance of his study was in specifying the sources of uncertainty, complexity, and number of these situations facing construction firms.

Reve and Levitt (1984) examined the effect of applying transaction cost framework in explaining contractual uncertainties in construction using the project as a unit of analysis in determining resource allocation uncertainties. However, construction project does not of itself allocate resources. Resources (land, labour, and capital) are allocated by individual firm involved in the delivery of the project. This in turn is dictated by the requirements of the client. Alsagoff and McDermott (1994) discussed applying TCE theory to explore the causes of disputes between clients, contractors, and subcontractors in the construction industry (Alsagoff and McDermott 1994). They concluded that contractual incompleteness and opportunism are the root causes of conflicts and disputes between firms. Therefore, they introduced the relational contracts as alternative contractual approach in resolving conflicts among contractual parties.
Walker and Wing (1999) developed a framework that explains the possibility of integrating project management theory (PMT) and TCE theory (Walker and Wing 1999). They tried to delineate the relationship between these approaches and the benefits of merging the two approaches in improving construction management theory. Therefore, they made a comparison of a traditional organization structure and a design-build structure to illustrate this relationship. By doing so they tried to answer why design and construction processes are separated in the traditional system. Walker believes TCE theory is providing an alternative theoretical basis, which can be integrated with the project management perspective and correlated models of organization. The strength of this study in underpinning the behavioural assumptions of TCE theory, such as opportunism, moral hazard, and shirking that the management theory could not cover.

Chang and Ive (2000, 2007) in their study proposed modifications to TCE methodology to make it applicable in dealing with construction (Chang and Ive 2000, 2007). They developed the direct measurement approach (DMA) and indirect measure approach (IMA) to predict theoretically the amount of TCs incurred. The DMA based on the identification and measurement of TCs elements, while, the IMA explained the relative effectiveness of governance structures in terms of TCs. Moreover, they tried to quantitatively analyze TCs elements to explore the link between these costs and procurement routes during construction. The weakness of this study is in dealing with theory for measuring TCs. Thus, the distinction between production costs and TCs became less clear.

Jin and Zhang (2011) developed a framework for risk allocation strategy for public private partnership (PPP) based on TCs characters. In this framework, the determinants of efficient risk allocation were identified based on TCE theory. As a result, the buy-or-make decision can be taken based on the risk response evaluation for adopting certain strategy. Using a proper risk allocation strategy can significantly reduce TCs. This is because risk allocation has been judged on a cost benefit basis. Therefore, improper risk allocated strategy might incurred costs such as; higher contingency costs, more resources to monitor risk, quality costs, safeguarding costs, enforcement costs, and legal costs.

In General studies applying TCs perspective in construction are not fully reliable with the suggestions of TCT; others employed imperfect proxies for key variables. Moreover some developed models have not directly tested the parameters of TCT. Nevertheless four key characteristics of transactions can make them more costly: complexity, uncertainty, frequency, and asset specificity (Williamson 2010a). Therefore, understanding the key characteristics of a transaction can help decision-makers improve the design of contracts, organizations, and other governance structures that could reduce TCs and improve the gains from an exchange between buyers and sellers (Williamson 2008). This research contemplates the gaps of these researches through developing a model that sets the mechanisms in selecting the most appropriate procurement system based on TCs. Further, a comparison of the results will be shown in a graph that illustrates the amount of different TCs for two procurement systems; the Traditional and Design – Build.
2.2 The linkage between Procurement system and TCs

The relationships between procurement strategies, contractual arrangements, and tendering procedures are not well articulated in the construction industry, whereas contractual arrangements are often dictated by the procurement strategy (Hackett et al. 2007, Hughes et al. 2006, Murdoch and Hughes 2008). Dudkin and Valila’s (2006) study in the UK construction industry shows that the private/public partnership projects (PPPs) in the UK are continually affected by significant costs related to the procurement phase of PPPs. Currently this amounts to an average 10% of the capital value of the projects that erodes the potential savings achieved within partnership projects (Dudkin and Valila 2005). There are other TCs that affect the performance of PPPs that are not easily assessed, for example the opportunity costs as a result of renegotiation and delays to the completion of the project (Ho and Tsui 2009), which may significantly undermine expected benefits. Frank et al. (2007) also found that outsourcing relationships could involve extra TCs such as negotiation, measuring, and monitoring costs that can quickly overwhelm a 10% production cost advantage (Frank et al. 2007). It would therefore seem that TCs are highly significant in the overall cost of construction on any project.

There is a current and pressing need to examine the relationship between the procurement system and TCs in the New Zealand construction industry. Recent studies have shown generally that the New Zealand construction industry has poor productivity (Tran and Tookey 2011). More broadly, this recognition has led to extensive efforts to achieve a 20% increase in productivity by 2020 (see www.buildingvalue.co.nz). Since productivity is a function of cost versus revenues, developing and improved the understanding of the basis of costs offers significant potential to affect construction productivity.

With an appropriate TCE-based framework, acquisition management practices could be improved by evaluating the largely hidden costs of managing contractual relationships. TCE offers useful insights on appropriate contract types, provides useful predictions about how contracting relationships evolve over the project’s life, and highlights the crucial issue of resource ownership and the associated problem of asset specificity. The procurement selection process is associated with the degree of defined contract specifications and the value of transactions. With TC analysis, emphasis could be placed on developing formalized governance mechanisms (i.e. formal contracts, rules and regulations, reputation mechanisms, termination agreements, warranties, etc.) and suitable strategies, such as long-term agreements and alliances. This way it would be possible to eliminate the risk associated with procurement uncertainties, limiting the number of instances of bargaining or opportunism and any asset specificity issues. According to Angelis et al. (2008) the reasoning behind such strategies is the elimination of coordination and motivation cost which ultimately reduces TCs (Angelis et al. 2008). Thus a TCE perspective could improve the procurement phase through: firstly, developing a service strategy by improving risk profile; secondly, identifying the service goals, objectives, and priorities through better contractual agreements; thirdly, identifying the capacity development requirements through enhanced long-term strategies; fourthly, ensuring adequate funding through improved cost estimation, and finally, defining the most feasible contractual approach.
The larger study on which this paper is based determines the magnitude of TCs associated with procurement processes, for Traditional and Design - Build systems. Relative cost centers such as coordination, inspection, translation, incentives, transactions, and elimination of interactions are captured. In addition, the study attempts to define processes and identify the time and cost importance of procurement activities and processes. The study posits that any mechanism that can determine the magnitude of TCs will allow contractors to make more appropriate procurement decisions. Figure 1 illustrates the key cost elements within procurement systems that the TCE-based framework could focus on. Procurement systems implemented on any project have a significant impact on the TCs associated with the pre-contract and post-contract phases. Pre-contract costs relate to activities carried out during initiation, preliminary design, negotiation and contracting, and feasibility studies; while post-contract costs are commonly associated with monitoring and control, dispute resolution, and implementation activities for projects. These costs could be measured by evaluating the time- spent daily by professionals on these respective procurement activities relative to other project activities.

Common procurement systems are the Traditional, Design - Build (DB), Management, Alliance, Build Operate and Transfer (BOT), and PPP (Brook 2008, Murdoch and Hughes 2008). In the traditional procurement system the design is very often completed (or near completion) before construction begins, thus the certainty of a tender price is higher because the project scope is defined. In terms of TCs one could hypothesize that relative to other procurement systems its pre-contract costs are likely to be higher because of the time spent in defining the project scope before construction begins. With systems such as DB, BOT, and Management, it is more usual to commence construction before designs are completed. According to Brook (2008) such systems (DB, BOT, and Management) could benefit from speedy construction because the design and construction phases have been integrated,
although incomplete documentation is often a source of uncertainty and could pose difficulties to cost prediction and estimation, TCs for these integrated systems may be comparatively lower at the pre-contract phase but higher if and when implementation problems occur as a consequence of incomplete designs. Conversely with Alliance procurement systems, TCs at the pre-contract phase could comparatively be the highest because of the level of preparatory activities involved in setting up alliances.

2.3 Procurement selection: the model

Researchers have developed several theoretical models for the procurement selection process in construction (Skitmore and Marsden 1988, Chan et al. 2001, Kumaraswamy and Dissanayaka 1998, NEDO 1985, Singh 1990, Cheung et al. 2001, Alhazmi and McCaffer 2000, Franks 1990). However, these models generally do not address the environmental factors (internal and external) affecting firms in the procurement selection process. As mentioned previously, procurement system selection is very often subjective. This paper aims to address these weaknesses by adopting a more strategic approach that combines cost evaluation criteria with environmental (contextual) factors. Figure 2 depicts a comprehensive framework of criteria for procurement selection. The figure depicts a combination of project constraints, objectives, and environmental forces that could influence procurement system decisions. The framework is developed in line with Williamson (1991, 1998) wherein human and environmental forces were considered the most important contributory factors to TCs. In this case, environmental forces represent external forces (i.e. threats and opportunities) and internal forces (i.e. weaknesses and strengths) of the procuring party (project owner).

![Figure 2: The determinants of procurement systems](image)

Political, legal, and social factors play a crucial role in procurement selection decisions. For example Duncan (Duncan 2009) posits that lump-sum competitive tendering and cost reimbursement systems was the procurement trend in the era of post-war regeneration (1946-1969). During the 1970-1979 period of high inflation in much of the developed world, an increasing preponderance of clients started to use management contracting in the hope of saving some money by ‘smart’ letting of contracts. That said, it is well documented that the management form of contract should be kept in the preserve of ‘experienced clients’ (Masterman and Gameson 1994). Indeed the management route has been cited as a
significant contributor to the cost escalation of such projects as the Scottish Parliament building in the UK (Fraser 2004). Meanwhile the sub-prime mortgage market collapse in 2009 was reported to have caused a shift in procurement trend to design and build (Duncan 2009). Brochner (1990) suggested that procurement selection could be influenced by the level of information system (IT) usage and availability. IT improves coordination between team members, quality control/product inspection, and translation of client needs. Other determinants of procurement systems include: corporate culture (Wright and Race 2004), market competition (Duncan 2009), technology (Duncan 2009, Schermerhorn et al. 2002), project location (Hughes et al. 2006), finance situations and project ownership. These factors are depicted in Figure 2.

3. The research

As earlier alluded to, the current study is a part of a larger research (doctoral) programme that determines suitable construction procurement systems based on TCE tools. Key information in this larger study is outlined under the following subheadings.

3.1 The research questions

The research questions were developed based on the literature reviewed. Clearly there is a current need to investigate the linkage between procurement systems and TCs and to determine how this information could be useful in the procurement selection process. The study therefore will attempt to answer the following key questions:

1. What is the linkage between procurement systems adopted and the magnitude of TCs?
2. How could TCs evaluation help in the selection of appropriate procurement systems for construction projects?
3. How could client’s procurement selection procedures be improved?

Addressing these research questions could help to improve procurement selection practices in the construction industry, and subsequently reduce the costs associated with the project administration.

3.2 The research objectives

1. To identify and categorize TCs for two procurement systems, the Traditional and Design-Build in New Zealand construction projects during the pre-contract phase and post-contract phase.
2. To investigate the linkage between the procurement systems adopted and the TCs incurred with this adoption. This objective could be achieved by evaluating the cost of search and information, procurement, and monitoring and control cost.
3. To develop a model for the procurement selection process based on TCs.
4. To provide guidance for the client undertaking the construction and procurement selection process.

3.3 The research design

In pursuit of the goals and objectives of this research, a framework was developed and this is presented in figure 3. This framework contains four sequential phases. The first phase covers problem recognition and research scope. This will be achieved by an extensive review of relevant literature to articulate the research questions and objectives.

Figure 3: The research design

The second phase involves data collection and analysis. Two data collection tools will be developed to collect information from two key research participants. The first set of information will be obtained through the administration of a pilot questionnaire (using Delphi techniques) to an expert group, to validate the proposed survey questions. The second set of information will be procured through the administration of a semi-structured questionnaire to key construction professionals (at both managerial and operational levels). These professionals (project design consultants, contractors, suppliers) involved in project procurement activities would define processes and identify the time and cost importance of activities within respective processes. Data will be analyzed using structured data analysis techniques. It is envisaged that a verification exercise involving subject matter experts will be conducted to validate the results emerging from these analyses.

The third phase will involve the synthesis of the research findings. This will include a comparison among alternative procurement processes to evaluate the TCs associated with each one. Simple interpretive and descriptive methods of presentation will be adopted so that the findings will be communicative and understandable. This could be achieved using matrices that will indicate the variability of time, resource and technology sensitive costs across the range of activities involved in different procurement systems.

The final phase will conclude the research and proffer necessary recommendations based on the TCE of different procurement systems. It will provide decision makers with guidelines
for the selection of the most applicable procurement systems under a range of project circumstances.

At present the design of the study is largely evolved and the next step will be the collection of data. This is anticipated to be well advanced by mid-2013, with preliminary findings anticipated to be available from that time.

3.4 Potential benefits of the research

Generally, this research will benefit the wider construction industry through enhanced performance by eliminating non-adding value activities throughout project procurement processes. Some other direct benefits include:

1. Enhanced project performance - TCs are very often borne by the construction client as contractors (through submitted bids) and other project parties (through service invoices) pass this on. Eliminating TCs associated with non-value adding procurement activities would ultimately improve construction project performance.

2. Improved operational practice - In construction risks are generated at different levels of the supply-chain such as design and construction risk, financial risk, and market risk. The decision to outsource construction activity is made to reduce TCs through offsetting and/or mitigating risks and reducing capital employed in specialized sub-trades. Therefore improve operational practice, for example procurement practice will improve risk mitigation that inherently improves performance.

3. Reduced coordination and motivation costs - This could be achieved by applying proper strategies such as long-term agreements and alliances, which reduce TCs of writing formal contracts, termination agreements, warranties, etc. These strategies also reduce the risk associated with uncertainty, bargaining and opportunism, and asset specificity.

4. Conclusion

This paper introduced the potential for the use of TCE for determining the magnitude of TCs for different procurement systems in construction. It reviewed TCE, procurement systems and the linkages between them to show how procurement systems selection could benefit from this rational deterministic exercise. It is anticipated that these mechanisms may contribute to a reduction in TCs that may in turn reduce construction prices and/or increase profitability and productivity on construction projects. Further TCE could help to improve the procurement phase through: firstly, developing a service strategy by improving risk profile; secondly, identifying the service goals, objectives and priorities through better contractual agreements; thirdly, identifying capacity development requirements through enhanced long-term strategic procurement approaches; fourthly, ensuring adequate funding through improved cost estimation; and finally, defining the most feasible contractual approach under certain circumstances. This is achievable through discerning the costs associated with activities such as: coordination, inspection, translation, incentivising, and elimination of wasteful interactions.
References


Infrastructure construction in change – what is the sensible path forward?

Eero Nippala¹, Terttu Vainio²

Abstract

Infrastructure construction is changing. The formerly closed domestic markets have opened up and become international in Finland like in many other countries. The transformation of a closed public sector into an open market has proven a challenge both to the public sector and enterprises. Infrastructures themselves are also changing. They can be made to include technology that gives extra value to clients. Infrastructure is never complete, but despite its static nature must be modified along with changes in regional structure, society and structural changes of industry.

The importance of competitive intelligence has increased in market-based operation. It is needed by the clients of infrastructure construction and the service providers, both in short-term planning of operations and long-term strategic planning.

This paper focusses on research delving into the long-term changes and challenges of infrastructure construction. The research assessed the future changes in infrastructure construction and their impacts on the basis of LoNGPESTEL analysis. The research was done in co-operation between the state, local government and the university and research organisations.

Asset management, financing of infrastructure maintenance, structural changes in the public sector, labour availability and competence, EU directives and environmental legislation, soil materials and recycling of materials, as well as urbanisation have been put forward as the greatest challenges to infrastructure construction.

Keywords: civil engineering, local impacts of trends, future challenges

¹ Lecturer; Construction engineering; Tampere University of Applied Sciences (TAMK); Kuntokatu 3, FI-33520 Tampere, Finland; eero.nippala@tamk.fi.
² Senior Scientist; Eco efficient district solutions; VTT Technical Research Centre of Finland PO Box 1300, FI-33101 Tampere; terttu.vainio@vtt.fi.
1. Introduction

Enterprises and organisations are operating in a global, changing environment. Changes form into global giga-trends and mega-trends. Internationally and nationally significant sectoral trends can be derived from them.

One aim of the 'Infrastructure sector in change' project is to derive such sectoral trends to allow concretising global changes for sector organisations and companies. Public sector organisations and enterprises, which react slowly to changes, need long-term forecast data.

Usually forecasting of future development is done by scenario techniques. For example Kast (1985) present relationship of general and task environments to the organisation. These relationships help our project to find changes and challenges of business environment and each company’s activities to meet these changes (table 1).

Table 1: Relationship of general and task environments to the organisation (Kast, 1985)

<table>
<thead>
<tr>
<th></th>
<th>General environment</th>
<th>Task environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Economic</td>
<td>Customer</td>
</tr>
<tr>
<td>2</td>
<td>Sociological</td>
<td>Technological</td>
</tr>
<tr>
<td>3</td>
<td>Demographic</td>
<td>Legal</td>
</tr>
<tr>
<td>4</td>
<td>Natural resources</td>
<td>Sociopolitical</td>
</tr>
<tr>
<td>5</td>
<td>Legal</td>
<td>Educational</td>
</tr>
<tr>
<td>6</td>
<td>Political</td>
<td>Suppliers</td>
</tr>
<tr>
<td>7</td>
<td>Educational</td>
<td>Cultural</td>
</tr>
<tr>
<td>8</td>
<td>Technological</td>
<td></td>
</tr>
</tbody>
</table>

Planning for uncertainty increasingly poses the question: “What is most likely to happen?” (Drucker, 1995) A generic approach to describing a comprehensive foresight project has been suggested by Peter Bishop et.al 2007 as in the following table (table 2).

Table 2: Approach to a foresight project (Bishop, 2007)

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Framing</td>
<td>Project plan</td>
</tr>
<tr>
<td>2</td>
<td>Scanning</td>
<td>Information</td>
</tr>
<tr>
<td>3</td>
<td>Forecasting</td>
<td>Scenarios</td>
</tr>
<tr>
<td>4</td>
<td>Visioning</td>
<td>Prospective</td>
</tr>
<tr>
<td>5</td>
<td>Planning</td>
<td>Strategic plan</td>
</tr>
<tr>
<td>6</td>
<td>Acting</td>
<td>Action plan</td>
</tr>
</tbody>
</table>
Table 3: Scenario techniques have been categorized into eight basic types (Bishop et. Al., 2007)

<table>
<thead>
<tr>
<th></th>
<th>Judgement</th>
<th>Including genius forecasting, visualisation and role playing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Baseline</td>
<td>Producing only one scenario, the expected future, and conducted by trend extrapolation, system scenarios or trend impact analysis</td>
</tr>
<tr>
<td>3</td>
<td>Elaboration of fixed scenarios</td>
<td>In explicit consideration of multiple scenarios previous prepared using &quot;incasting&quot; or the popular SRI matrix method</td>
</tr>
<tr>
<td>4</td>
<td>Event sequences</td>
<td>Employing such approaches as probability trees, sociovision or divergence mapping</td>
</tr>
<tr>
<td>5</td>
<td>Backcasting</td>
<td>Adopting horizon mission methodology. Impact of Future Technologies or future mapping</td>
</tr>
<tr>
<td>6</td>
<td>Dimension of uncertainty</td>
<td>Using morphological analysis, field anomaly relaxation, GNB matrix or MORPHOL.</td>
</tr>
<tr>
<td>7</td>
<td>Cross-impact analyses</td>
<td>Calculating the relative probabilities of occurrence of future events and conditions in alternative scenarios employing a computer programme</td>
</tr>
<tr>
<td>8</td>
<td>Modelling</td>
<td>Having resource to trend impact analysis, sensitivity analysis or dynamic scenarios</td>
</tr>
</tbody>
</table>

Even there are several scenario techniques (table 3) project group chose for the first step the PESTEL analysis. The reasons for that were quite short focus period, 5-7 years and also the need to tie future development to business environment analysis. If the forecast period become longer it is possible to carry out study with scenario techniques described at introduction.

2. Subject of research and theory

2.1 Operating environment of enterprises and organisations

Civil engineering produces all structures of the built environment except buildings. Its end products can be divided roughly in two groups: communities and communications between communities.

Communities are built to serve the needs of people. Water supply and sewerage is the community structure that serves an extreme basic need according to Maslow’s hierarchy of needs. Other community structures are streets, energy supply networks and green areas. Communities are linked to each other – as well as to areas beyond national borders – by roads, rail lines, harbours, airports, telecommunications networks and electric power transmission networks.

2.2 Research theory and methods

LoNGPESTEL analysis was the applied research theory which examines simultaneously broad global, national and local factors. Changes in the operating environment and factors affecting the infrastructure sector were culled from among them (Gillespie, 2011).
The factors considered in PESTEL analysis are:

1. Political factors (impact of the public sector on the economy): public subsidies, procurements, education, maintenance strategy and development strategy of infrastructure (road and rail network).

2. Economic factors: economic growth, inflation, availability and cost (interest on) financing, exchange rates, tax rate, etc.

3. Social factors: Ageing of population, unemployment, etc.

4. Technological factors: Economic regeneration with the help of new technologies (new products and processes). E.g. BIM-based design combined with GPS control of earthmoving machinery enables a technology jump in earth construction. Technology can lower costs and improve considerably the quality of the end product.

5. Environmental factors: Preparing for and mitigating the impacts of changes in weather and climate conditions. The increasing role of environmental protection will cause changes e.g. in taxation of transport and transport technology (hybrid cars). Environment-friendly products are capturing market share.

6. Legal factors: Laws and decrees governing the operations of enterprises, accessibility, minimum wage, recycling requirements. Changes in these affect the operations of enterprises.

The version of PESTEL analysis that takes into account local, national and global factors is called LoNGPESTEL.

1. Local factors include protection of highly endangered animal species near construction sites.

2. National factors like the Euribor rate in Europe or Russia’s joining of the World Trade Organisation.

3. Global factors like crude oil price changes.

Changes and challenges have been examined and produced in a workshop of the project steering group (12 participants) and a seminar (INFRAEXPO 12 in FINBUILD exhibition) for sector professionals (120 participants). The next phase involves scrutinising emergent trends by sub-sectors at workshops and concretising them into infrastructure sector changes.
3. Forces of change

Mega-trends are global change processes at work everywhere. Giga-trends are the drivers behind mega-trends that change very slowly. Mega-trends, for their part, create national, regional and local trends that may be different, even opposite, to each other. Trends may also be studied from a sectoral viewpoint (Ahvenainen, 2009).

Giga-trends, mega-trends and trends indicate the direction in which the operating environment and a sector are moving. Giga- and mega-trends also change. New opportunities announced by weak signals are called meta-trends. Meta-trends can develop into new mega- and giga-trends (Ahvenainen, 2009).

This article seeks to find infrastructure meta-trends, i.e. possible new trends.

3.1 Giga-trends – drivers of mega-trends

Population growth: stable in industrialised countries, but large differences between countries. Population growth in Europe is slow while the populations of Asia and Africa are growing fast. European population is ageing and the birth rate is low. This giga-trend is not in line with natural resources and under pressure for change (Ahvenainen, 2009).

Economic growth: Though the financial crisis has caused economic turbulence in recent years, the long-term growth of the world economy has been quite steady. The slowing of economic growth due to an increase in the price of oil and certain key metals may have an impact on this giga-trend. (Ahvenainen, 2009)

Technological development: Technological development is a significant factor contributing to globalisation. Changes in sustainable development and global economy require new technology and a new type of infrastructure. The probability of a technology jump is increasing. (Ahvenainen, 2009)

3.2 Global mega-trends

Giga-trends cause mega-trends. The latter include scarcity, environmental problems, internationalisation and an increase in the number of disturbances and conflicts. (Ahvenainen, 2009)

Scarcity is the result of consumption growth in our finite world. Scarcity drives up prices of raw materials creating shortages of energy, food, water and land. Related environmental risks consist e.g. of pollution, depletion of natural resources, loss of biodiversity, environmental accidents and uncontrollable effects of genetic manipulation (Ahvenainen, 2009)

Internationalisation and globalisation will continue. The increasing number of crises and conflicts will require international co-operation. That has increased and complicated
interdependencies. International decision making is becoming harder, protectionism is arising. (Ahvenainen, 2009)

### 3.3 European trends

In the next few years Europe will focus on restoration of economic health and overcoming the cost crisis of public administration. The recession may lead to economic exile within the EU. At the same time, the EU is becoming bureaucratic and is functioning more slowly. It is difficult to agree on what is in the common interest due to complex economic interdependencies. (Stevens et al, 2006)

The pace of change in Europe is picking up. Enterprises, even entire sectors, are born and die at an ever increasing rate. So-called butterfly economies are emerging whose competitiveness is based on ability to change. The challenge is to make the existing linear operating model non-linear. (Stevens et al. 2006)

### 3.4 Meta-trends

Meta-trends are change factors and drivers that change giga-, mega- and trends, i.e. the direction of change. Meta-trends include increasing polarisation and inequality. Both poverty and wealth are increasing. More natural resources are being consumed. As a result, it is becoming more difficult to understand entity management and change. (Stevens et al, 2006)

Economic and population growth are giga-trends that can cancel each other out. They are also in contradiction with sustainable development and can lead to scarcity and environmental problems.

The so-called ‘slow life’ is raising its head. Remote work is increasing and populations are ageing. Slow and small systems are gaining ground also in the economy.

Values and feelings have become more marked in working life. Responsibilities are becoming a counterweight to profit responsibility, cost-effectiveness and the knowledge society. Value management has made inroads into working life. That has led companies to use hired labour and transfer ownership to tax havens.

### 4. Global and local impacts of trends

This paper concentrates on the future changes and challenges of this type of enterprises and organisations operating in the infrastructure sector. The most important working method has been joint seminars of the parties to civil engineering (two have been held by October 2012). The first seminar was attended by 12 project management team representatives from companies and the public sector. The seminar focussed on identifying changes and challenges of the sector. The results were presented for appraisal and completion at another seminar attended by 120 people (Table 4).
Table 4: PESTEL analysis of infrastructure sector, national and international factors (Nippala, Vainio, 2012)

<table>
<thead>
<tr>
<th>Local (Infrastructure sector)</th>
<th>National (Construction)</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networking of companies</td>
<td>Accrual of government debt</td>
<td>Globalisation</td>
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<tr>
<td>Securing financing of</td>
<td>Private financing of</td>
<td>Global financial crisis</td>
</tr>
<tr>
<td>companies</td>
<td>infrastructure projects</td>
<td>WTO</td>
</tr>
<tr>
<td>Tax planning</td>
<td>Cost of money (Euribor)</td>
<td>Economic growth of export countries</td>
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<td>Credit rating</td>
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<td>Economic</td>
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<tr>
<td>Political</td>
<td>Public financing of</td>
<td>European Stability Fund</td>
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<tr>
<td></td>
<td>investments</td>
<td>Global trade agreements, WTO</td>
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<td></td>
<td>Asset management and</td>
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<td></td>
<td>service level</td>
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<tr>
<td>Technological</td>
<td>Deployment of BIM</td>
<td>Standardisation</td>
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<tr>
<td></td>
<td>Machine automation</td>
<td>Patenting</td>
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<td></td>
<td>BIM</td>
<td>Innovations within intelligent</td>
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<td></td>
<td>Smart grid</td>
<td>transportation and infrastructure,</td>
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<td>carbon free energy</td>
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<td>Environmental</td>
<td>Extraction of soil</td>
<td>Climate change</td>
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<td></td>
<td>materials</td>
<td>Energy availability</td>
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<td></td>
<td>Replacement materials</td>
<td>Low-carbon economy</td>
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<td>Innovations in storm</td>
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<td>water treatment</td>
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Economic

Global: Development of the global economy has a big impact on infrastructure construction. The economy of many countries is dependent on exports. Public sector tax revenue and its ability to invest are tied to the success of export companies. This foundation is shaken by the tax planning of companies and the financial crisis. Global trade agreements are made to facilitate trade between countries.

On the national level, accrual of government debt reduces construction and maintenance of infrastructure for which the government is responsible. An effort has been made to complement the low level of funding by launching joint ventures between the private sector and local government. Life cycle projects have gained ground.

The financial crisis make it difficult for infrastructure construction companies to get financing which raises costs. Networking is carried out to improve the situation and competitiveness.

Political
The membership of the World Trade Organisation has widened. Russia was finally accepted as a member in 2012. The membership is expected to lower Russian import duties and ease trade when the complicated customs duties are eliminated.

On the national level, state and local governments finance a significant portion of infrastructure construction. Large infrastructure projects are built based on political decisions. Politicians decide whether state and local governments borrow when municipal tax revenue is not sufficient to cover investments. Asset management and maintenance of the service level of the existing infrastructure stock also depend on political decision making. Local government determines network user fees. They may be increased by a maintenance fee. However, the accruing funds are not automatically funnelled into maintenance.

Insufficient maintenance and neglected necessary repairs are leading to restrictions in the use of infrastructure. Life cycle-related repair of structures financed by tax revenue can be postponed, a case in point being the roads in outlying areas. Wear and damage that are a risk to personal safety, on the other hand, is repaired, a case in point being railways. Repairs are also done where related costs can be offset by user fees as in the case of the runways of airports.

The decision whether to charge rent for a lane occupied during the construction period is also a political one. Rent is conducive to a short construction period which cuts costs and disturbances to the environment during construction.

**Technological**

New technologies related to infrastructure construction include BIM models and global positioning systems (GPS). Wireless data as a tool in transmission in ground improvement or vibration measurement are examples of new infrastructure construction applications.

Intelligent transportation also saddles construction of new transport networks with new requirements and may reduce investment needs. For instance, traffic jams can be eased by controlling traffic lights instead of building new lanes or roads, telematics improve road safety, and sensors can monitor the maintenance need of crucial structures in real time. New materials and recycling of old ones can replace valuable natural resources.

On the national level there is need to increase the productivity of infrastructure construction by a technology jump. The building process involves too many unproductive delays. There, a technology jump can be taken e.g. by using the BIM model in production management.

When 3D designs are available for production, diggers and other earthmoving machinery using satellite positioning can be used.

Building of an eco-efficient, low-carbon society requires co-operation between planning, design and implementation.
Environmental

The disputed global warming has an impact on infrastructure construction which depends on geographic location. Rising sea levels threaten both small island nations and many large cities. No preparations have been made for rising water levels. Heavy rains are enough to show the vulnerability of communities.

The depletion of oil and exploitation of difficult deposits increase the price of oil thereby promoting a low-carbon economy.

National environmental issues include the Waste Act, which categorises an increasing share of waste as requiring extra handling, and protection of the eskers shaped by the Ice Age.

New recommendations and instructions concerning storm water treatment will be made to prepare for rainfall growth.

The environmental theme also includes the obligation to hear citizens at various stages of all construction projects. In addition to virgin nature, animals and plants, landscapes will also be protected.

Legal

The legal aspects of global factors are related to the safety and health of people during construction and use of infrastructure.

On the national level, laws and decrees have been enacted to conserve biodiversity. For example, conservation of endangered animal and plant species is governed by legislation. The National Esker Protection Programme is geared to the same goal.

Competencies dependent on the demandingness of the project are required locally of designers and builders of the infrastructure sector and companies. Personal competencies must be renewed at certain intervals (e.g. a blaster).

Social

People’s needs also as infrastructure users are changing globally. For instance, fixed phone lines have been replaced by fibre optic and wireless connections that enable mobile life. Work and study are no longer tied to a certain place or even country. Mobility has increased.

Ageing of the European population affects the need to make all services, infrastructure included, suitable for the elderly.

On the national level population growth and the dependency ratio affect the development of society. Though education is the result of political decision making, it is also a social factor. What share of each age group is to be left completely uneducated, and how many are to receive a university education?
The construction sector is suffering from too few people being trained at all skill levels. The skills shortage among those already working in the sector is also increasing as new IT is being introduced.

5. Conclusion

This study deals with the mega-trends affecting infrastructure construction around the world and derives from them concrete future challenges for local enterprises and organisations. Such concretisation is necessary since changes are usually treated on a much too general level to be of use for sector actors.

The speed of change has accelerated and future meta-trends quickly become concrete local mega-trends to overcome. Forecasting is needed since many organisations and enterprises react slowly to changes.

In future, the depletion of natural resources, population growth, environmental protection and changes in people’s needs will place strong pressure on infrastructure.

The supply of soil and rock materials is not unlimited and has to be replaced by something. Population growth creates pressure to develop transportation systems, energy supply and water services. Congestions in cities will increase, energy consumption will grow many-fold from the present level and availability of clean water is under threat.

Infrastructure construction trends are being derived from the mentioned trends. The work has been started but has not yet been finished. The greatest challenges indicated by the intermediate results are infrastructure asset management, infrastructure maintenance financing, structural changes in the sector, labour availability and competence, EU directives and environmental legislation, soil materials and their reuse, and urbanisation.

For the local companies technological challenges are for example use of machine automation and training of excavator drivers. Also staff must have all kinds of competence (rail, road, street) to do certain work. Environmental challenges are to get permission to use soil. Recycling of soil is also growing in the future because there are shortage of good quality soil or rock. Social point of view companies must devote to better breakrooms, safety equipments etc.

Acknowledgement

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References


Loss estimation methods utilised by stakeholders involved on residential post-canterbury earthquake reconstruction

Daniel Burrell\textsuperscript{1}, Linda Kestle\textsuperscript{2}

Abstract

The importance of natural disaster economic loss estimations is paramount, in terms of assisting policy makers in mitigation decisions, risk assessments and tracking losses as they occur. Historically the New Zealand construction industry and associated affiliate stakeholders has not employed a systematic method to estimate, or record the losses that have occurred as a result of natural disasters. Therefore records are lacking. The Canterbury earthquake of February 22\textsuperscript{nd} 2011 in particular, was the most significant natural disaster in New Zealand’s history, with economic loss occurring at all levels of the New Zealand economy. There have been numerous complexities around how to measure this loss, and what should be included or excluded in the estimates. Government’s direct intervention in respect of residents’ red zoned properties has added a further complication when trying to establish realistic loss estimation methods and data storage. Loss estimations have historically relied heavily on insurance data collected after large scale events. This exploratory research aimed to investigate the loss estimation methods / evaluative processes utilised by stakeholders involved in the post-disaster residential sector of Christchurch, and compare the findings to the reviewed literature. Semi-structured interviews were conducted with six selected participants from five insurance and project management companies in Christchurch. The findings suggested that there is a lack of regulation, no systematic framework, nor any consistency of process within the New Zealand construction industry, or their associated stakeholders.

Keywords: loss estimation, canterbury earthquake, residential sector

1. Introduction

This research topic resulted from sighting a number of publications following the 4th September 2010 earthquake in Christchurch, such as the $2 billion initial estimate (EQC 2011), and then subsequently after the 22nd February 2011 earthquake, reports of $10 billion, which was later increased to $20 billion (TVNZ, February 28, 2011). From the media

\begin{itemize}
\item \textsuperscript{1} Department Construction; Unitec Institute of Technology, PB 92025 Auckland 1142, New Zealand; Email. burreldani@gmail.com
\item \textsuperscript{2} Assoc Professor; Department Construction; Unitec Institute of Technology, PB 920125 Auckland 1142, New Zealand; Email. lkestle@unitec.ac.nz
\end{itemize}
reports it was unclear as to what the estimates included, excluded, or how the figures were even derived. The main source of data for economic loss estimates has been insurance information according to Walton (2004), and following the Canterbury Earthquake(s) there have been 302,000 claims lodged with the Earthquake Commission EQC as at April 2011 (Mathewson 2011). A complicating factor due to EQC involvement was that there are now multiple claims on individual properties, due to each major earthquake (Sept2010, Feb22, June13 2011) being treated as separate event, from an insurance perspective. Residential housing represents a substantial percentage of loss as a result of the Canterbury Earthquakes. The concept of economic loss estimation is broad and dependent on many factors such as time, geographic context, and the needs of the end user (Cochrane, 2004). For the purpose of this research the scope was limited to the residential sector only, due to insurance data being a main source of direct economic loss information. Research literature on the topic of loss estimation frameworks following natural disasters suggested that no consistent framework or relevant inclusions et al. were used in New Zealand. This, despite the issue being raised over 25 years ago by Ericksen (1985) and although this reference was in respect of flood losses, the principle remains relevant to any and all natural disasters. The research involved stakeholders engaged in Christchurch residential reconstruction work, where a sample of employees representing Insurance Companies and Project Management Companies were selected using a purposive non-random sampling technique. For the purposes of clarification, the following key terms are noted and explained in brief.

**Direct Loss:** “Direct losses as those that result from the physical destruction or damage to buildings, infrastructure, vehicles and crops” (Committee on Assessing the Costs of Natural Disasters 1999 p35).

**Indirect Loss:** “Indirect loss is any loss other than direct loss [which occurs as a result of a natural disaster]” (Cochrane 2004 p291).

**Intangible Loss:** “Intangible losses are those with no market value” (Bureau of Transport Economics 2001 p61).

**Natural Disaster:** “A natural disaster occurs when a natural hazard event causes damage to property or harms people” (Bureau of Transport Economics 2001 p5).

2. Literature Review

The selected literature on the topic of loss estimation included available and relevant New Zealand literature, most however were overseas publications.

2.1 Loss Estimation overview

From the literature reviewed there is no consistent approach to economic loss estimation in New Zealand, Australia or the US. This statement was supported by the findings from Walton (2004), The Bureau of Transport Economics (2001) and the Committee on Assessing the Cost of Natural Disasters (1999). The challenge is in defining a consistent dataset for
estimating disaster losses and identifying which data should be included in the estimates (Committee on Earthquake Engineering 1990). The literature had consistent themes but varied on how losses were calculated and what information was included and excluded. “Some measure only direct losses whereas others purport to include indirect losses”(Committee on Assessing the Costs of Natural Disasters: 1999 p8). Economic loss estimates are important in making informed mitigation decisions, for example, “it would be difficult to gauge the cost-effectiveness of public policy decisions such as relocating residents out of earthquake-prone areas without loss information” Despite this “little is known about the economic costs of natural disasters” (Bureau of Transport Economics 2001 p3).

Even though there was no agreed framework within the reviewed literature, losses were generally broken up into two broad categories being ‘direct loss’ and ‘indirect loss’, and then further broken into measurement subcategories of ‘intangible’ (non-market values) and ‘tangible’(market values). These same classifications were proposed by Handmer (1985), Smith et al.(1995) and supported by Walton (2004). There were, however, existing frameworks from overseas sources, namely the Economic Costs of Natural Disasters in Australia, and the Impacts of Natural Disasters: A Framework for Loss Estimation. This software based Loss framework followed a similar classification system of breaking the losses into two categories, direct loss and indirect loss. Natural disaster loss estimation software developed over the past two decades has provided an integrated framework and incorporated geographic information systems (GIS) to display spatially referenced data such as population, building types and infrastructure (Strasser et al. 2008 p1). The development of HAZUS (Hazards United States), provided an integrated framework for loss estimation. This framework used mathematical formulae and information on building stock, economic data and GIS to display shaking from an earthquake (Committee on Assessing the Costs of Natural Disasters 1999). The outputs of the model included direct and indirect economic losses displayed as dollar losses, and although the model was originally developed for earthquake assessment it has been expanded to include flood loss and storm loss. Examples of earthquake software have included HAZUS, KOERI-loss (Kandilli Observatory and Earthquake Research Institute), SELENA (Seismic Loss Estimation using a logic tree approach), and a relatively new ‘Riskscape’ programme which is a New Zealand application developed by the National Institute of Water and Atmospheric Research (NIWA) and Geological and Nuclear Science (GNS) to predict losses and early assessment of natural disasters (King & Bell, 2006). In New Zealand much is known about earthquakes due to past research by GNS and the Geonet system. Riskscape uses information from systems such as Geonet and formulates the impacts that may result from natural disasters much like HAZUS. Development of the Riskscape programme began in 2004 and currently this New Zealand application is limited in scope as it only has a direct loss output. Asset inventories are used as base data to the estimates; this includes bridges, buildings and pipeworks (Riskscape, 2010). Riskscape has two levels for estimation and uses synthetic data. Level 1 determines damage through the modified Mercalli (MM) intensity scale based on past earthquake data, to assess how buildings react based on the type of building and distance from the centre of the earthquake. The output is based on algorithms which model how assets perform in a natural disaster. There has been ongoing research in this field in New Zealand by Dowrick & Rhoades (2005, 2010) and a specific model is under development for the Canterbury region (Stirling et al.2008). Level 2 has more engineering input with the analysis of specific design spectra within a specific building class (King & Bell, 2006). Riskscape has “the potential to
become a nationally applied hazard and impact assessment tool enabling a standardised approach across the country” (Riskscape 2011).

2.2 Direct Loss Estimation and Measurement

There are different ways in which direct loss can be calculated, either based on imperial data (collected data), or synthetic data (based on likely impacts). Imperial data collection of direct losses can be divided into two groups, ‘Primary data’ collection which is most often surveys of businesses and households and the other is ‘Secondary data’, such as tabulated insurance claims, small business loans and various other sources (Brookshire et al. 1997) “There is little debate over the classification of direct economic loss which is the easiest to classify, they are losses that result from the physical destruction or damage to buildings, infrastructure, vehicles and crops” (Bureau of Transport Economics 2001 p15). The Edgecumbe Earthquake publication by Butcher et al. (1998), highlighted one of the potential problems with the data utilised, as a significant amount of money was involved in restoring chimneys, when in fact this may not have been earthquake related damage, and more likely general wear and tear; This would overstate the loss.

2.3 Indirect Economic Loss and Measurement

Indirect Economic Losses which are caused by natural disasters are losses resulting from the consequences of physical destruction. These have not been measured, studied, or modelled to the same extent as direct losses, despite the fact that indirect economic loss can have more of an impact than the direct economic loss in large events (Committee on Assessing the Costs of Natural Disasters 1999). New Zealand could incur significant indirect losses due to an open economy that is vulnerable to ‘capital flight’, with speculative investors withdrawing their investments from the New Zealand Economy (Cochrane1995 p68).

2.4 Intangible (non-market )losses

The importance of intangible loss is generally accepted, however they are often not measured, and are therefore discounted in the evaluation of natural disasters (Bureau of Transport Economics 2001 p88). Cochrane (2004 p291) supported this statement, stating that “Non-market losses are never estimated. Disaster losses are almost exclusively limited to impacts measured by market values”.

2.5 Timing and Measurement of Losses

There are a number of issues associated with measuring economic losses. Issues such as the use of replacement value vs. depreciated value (Ashley 2007 p197) also ignoring post-disaster liabilities, ignoring non-market losses, double counting, differentiation between gross and net values and confusing data as to whether post disaster economic trends are a product of the event or another unrelated factor (Cochrane 2004 p290). Often the effects are measured over a shorter period to reflect the full range of outcomes from the event “indirect flood loss estimation due to business interruption cannot be estimated over a single point in time but has to be regressed over the full recovery period” according to Ashley et al. 2007
This was further reiterated by the Committee on Assessing the Costs of Natural Disasters 1999 p18), when stating that, “Timing of the estimate also has an impact on the estimate. Measuring the losses of natural disasters takes time. In the case of earthquakes, the extent of the damage to houses or businesses have suffered may take weeks to establish. Initial loss estimates may understate actual losses, potentially by wide margins”

2.5.1 Ignoring Post Disaster Liabilities

Loss accounting often fails to account for the region’s liabilities or borrowings, and the cost of indebtedness could be missed if measured over a too short a period, as long-term these liabilities could have impacts on the region and economic growth (Cochrane 2004 p291).

2.5.2 Double Counting

Double counting is a common problem in loss estimation. Cochrane (2004 p290-291) suggested that double counting is endemic and that it is very easy to make the mistake of double counting disaster losses. “It is commonly asserted that total damage is the sum of direct damage (damage to building and contents) and lost value-added. Double counting exists here because value-added includes the services of capital, whereas direct damage should reflect the cost of replacing the depreciated portion of such capital.

2.6 Summary

The reviewed research was focused mainly on direct loss estimation, and the areas of most contention were those around the classification and measurement of indirect and intangible losses. Indirect loss data has proven difficult to collect, which has led to attempts to model the indirect losses using synthetic data. Intangible losses are rarely measured and are therefore excluded from most loss estimates. This is attributed to there being no market or agreed way of measuring them, such as health effects or loss of heritage buildings. The focus recently, has been around integrated frameworks with the development of software such as HAZUS and Riskscape a New Zealand application. This is still in development and does not have the capability to provide an indirect economic loss output. The development of a framework has been hindered due to the complexities and the debate over exactly what information should be included or excluded in a framework. Three measurements that can alter the result significantly are the timeframe in which the loss is measured; the unique nature of the event; and the geographic context of the loss estimate. Further to this there are measurement limitations which need to be addressed such as double counting, identifying the impacts on loss estimation by the uninsured, and replacement versus depreciated values. New Zealand has not measured the economic losses that result from natural disasters consistently in the past. Instead, the focus has been on understanding the event, and this is shown by the extensive works conducted by Dowrick & Rhoades (2005, 2010). The type of economic modelling used is dependent on the end user for example, insurance companies are only interested in insured loss, and not in the losses incurred by the ‘uninsured’.
3. Methodology

Following the 2010 and 2011 earthquakes in Christchurch, loss estimation occurred across several sectors, both locally within Canterbury and nationally on a scale never before witnessed in New Zealand. Although extensive research has been conducted in the field of loss estimation, there was only a limited amount of published knowledge related to the research question being explored, and little or no information about the specific loss estimation methods actually used in New Zealand. The scope of this particular research was deliberately restricted to residential housing and the insurance sector due to the level of remaining uncertainties in other post-disaster claim sectors. The research was exploratory, confirmatory and applied, exploring the methods stakeholders employed to estimate economic losses following natural disasters. The methodology was confirmatory in accord with the findings of Walton (2004) and the Bureau of Transport Economics (2001) which stated “there is no consistent approach to loss estimation and storage of that information.” The participant sample was non-random and purposive, as the participants were deliberately selected for their known attributes. Knowledge of the topic was seen as a key factor to the success of the qualitative data collected. The six selected participants from the five project management and insurance companies sampled, were in managerial roles, had an overview of the respective company’s processes and were involved in the loss estimation of residential housing following the Christchurch earthquakes. All were interviewed to compare and contrast the findings with the reviewed literature. Face-to-face semi-structured interviews were undertaken, and given the potential sensitivity of the information, the structure of the interviews focussed on methods and processes rather than on actual, and therefore commercially sensitive, statistics. The data collected data were then analysed and organised into categories. The findings were compared and contrasted across the various stakeholder participants’ responses, and with the findings from the reviewed literature.

4. Results/Findings

4.1 Initial Estimation Method

Of the five companies sampled, only the two Insurance Companies (A & B) and two Project Management companies (D&E), used a form of initial estimation to establish an indicative cost of the loss incurred on a residential property. Company A used their own historic insurance information using ‘a basic average of historical data over a period of time’ to establish a likely cost based on the insured’s description of the damage. Company C then set the estimation level which was based on factors such as the post-disaster property zoning (red, green, orange, blue-green). Similarly Company B used a computer based programme where the cost was calculated using their own empirical insurance data. Company D & E’s estimation methods used primary data collected from on-site inspections combined with secondary cost data from various market sources, and established an initial estimate of the loss. This was later used to evaluate residential repair options. This method was more intense than the method employed by the insurance companies as it was based on surveys from the actual damage and current market rates rather than historic data and costs. The insurance and project management companies considered that historic data bore little or no relevance to the (unique) earthquake events of 2010 and 2011. In effect then the
five companies sampled all used different methods to conduct loss estimates. This was in line with the main findings of the literature where there was an inconsistency in industry around loss estimation methods, due in the main to a lack of an agreed and common framework. Both Company A and B stated that the initial estimate was not particularly accurate when compared with the actual cost, and that “the initial estimate was essentially never right and often inaccurate”. An important distinction was that the scope of estimations conducted by the Insurance Companies was based on a per claim basis rather than on the overall loss. An overall loss estimation would occur later in the process, however this was not discussed in-depth in the interviews due to commercial sensitivity and because it tended to relate more to Insurance Company’s risk assessment rather than to loss estimation. Of note though is that all five companies utilized the actual, and therefore the replacement value of repairs, when finalizing their initial estimate assessment for every claim received, rather than the depreciated value.

4.2 Natural Disaster Loss Estimation and BAU

The selected six participants generally agreed that their methods for loss estimation following the Christchurch Earthquakes were essentially the same as BAU (business as usual) work as the end goal(s) remained the same. The notable differences though, was the necessary involvement of outside parties to assist in the process, and the fact that the companies’ loss estimation method(s) had to be simplified in order to respond to the scale of the damage being experienced, and the massive increase in the number and nature of claims received. From the findings it was difficult to compare the earthquake events with the companies BAU work. Despite the two Insurance Companies using the existing estimation method, all included some form of new process to deal with the earthquake events. However, one of the significant changes to BAU estimations by the Insurance Companies was to include a Project Manager on staff. The reason being that the insurers had never had to allow for earthquakes in Christchurch before, and therefore had no relevant /documented processes nor project management skills in-house. In the past, they ( the insurers) had managed the process ‘from go to whoa’. The Project Managers’ most significant changes involved the incorporation of increased and specialised Information Technology (IT) Systems being introduced to manage the claims process, and the development of a new overall claims management process.

4.3 Consistency within the Industry

All participants believed there was a definite lack of consistency within the process of claims assessments and that the different parties were handling the earthquake related claims completely differently from each other. This was due in the main to the competitive market in which the insurance companies work, and the policy response of the insurer’s, where some are focused on the bottom line while others are customer focused. Insurers do not share information about their estimation methods, as that forms an essential part of their competitive edge in the market. This was not highlighted as an issue within the literature, but would be a prohibitive factor to introducing a loss estimation framework into New Zealand, which has one of the least regulated insurance markets in the world” (Insurance Council of New Zealand, 2008). This market is largely self-governed, and there is no framework for
compulsory reporting which would be a major factor in having a consistent method of estimation. To implement a standard method when there is a lack of control or a governing body that can implement a scheme, would be difficult. Furthermore, the current situation is complicated by the uniqueness of the (earthquakes) event, where entire pockets of land have been retired from use (meaning that they are unbuildable now). Insurance policies have never been written to take this into account before now. In addition, the New Zealand government has taken on some of the private insurer’s risk where the property(s) were/are in the Red Zone, and offering packages to those red zone residents. The literature suggested the potential use of software in economic loss estimation such as HAZUS or Riskscape, but none of the companies interviewed have utilised software from New Zealand or overseas for loss estimation, as yet. This it seems was due to the perceived ‘lack of need or benefit of new technology’ in the residential insurance sector, as the companies have their own processes in place, and were confident regarding ‘estimate accuracy’. The participants considered the current and new software on offer as more suited to risk assessment and hazard response rather than loss estimation on this (Christchurch earthquakes) scale.

4.4 Lessons Learned

A number of lessons have been learned by the Insurance companies and the Project Management companies as a resultant of the Christchurch Earthquake events (s). Three participants (from Company B, C & D) noted that the information technology and processes utilised have had to be changed to assist in processing the large numbers and scope of claims. Company B had to adjust cost estimates for repair of foundations to allow for a range of differing repair strategies, and associated (labour) rate ranges. Company D & E has had to upskill their contractors’ abilities to prepare detailed post-natural disaster quotes, and what to include or exclude from those estimates. They also noted the need to find ways to ensure better consistency in pricing and communications in-house and with clients.

![Figure 2: Number and Type of Response for Lessons Learned](image)
4.5 Administration Costs

No literature was found in relation to how administration costs should be allowed for in an estimate or how it should be recorded. In the Christchurch earthquake event, a large amount of coordination and additional personnel was needed, adding to the administration cost, and this was shown by EQC paying out $138,000,000 in wage till September 2011 (Bennett 2011). This was an indirect cost which was a direct result of the event. The five companies sampled, identified significant administration costs relating to the Canterbury Earthquake, none had factored this cost on a claim by claim basis, instead it was treated separately.

5. Conclusion

The literature review established the current state of loss estimation and the limitations and problems associated with establishing a framework. The research findings identified that there was no consistent method of estimation loss, and this also agreed with the literature findings, as did the reasoning regarding why this occurred. To establish a consistent method between companies within the residential sector would be difficult, due to the competitive and sensitive nature of the private insurance market. In addition, the lack of regulation within the insurance industry does not aid the establishment of a consistent process. There would be value in having a consistent framework for natural disaster loss estimation in New Zealand to assist policy makers in the future, and aid in mitigation decisions by having comprehensive loss data stored and used in a consistent manner. Comparisons could then be made without fear of bias within the data. However, such a framework would be difficult to implement due to the issues identified and discussed as the research progressed. There is a possibility that in the future, and as the process evolves, uniformity may occur.

References


New Zealand new housing characteristics and costs

Ian Page¹

Abstract

New Zealand housing is mainly timber framed with a variety of wall and roof cladding types. Layouts and elevations are diverse and the amount of “standardisation” is quite small. The typical building firm is small scale and the top 50 builders account for only 25% of all new houses. This paper describes how the design characteristics of new housing and the structure of the industry affect the cost of housing. Comparisons with Australian housing costs are made. The analysis is based on two surveys, first a survey of the physical characteristics of new housing, second a survey of builders on factors affecting new housing costs. The New Zealand Productivity Commission has recently examined the affordability of housing and some of their findings and recommendations are discussed.

Keywords: Housing, costs, design, firms, standardisation

1. Introduction

New Zealand housing has traditionally been made from light timber framing, usually 100 x 50 mm nominal sizes, on timber piles but more recently on concrete slab foundations. In the early days of settlement the main cladding was timber weatherboard and corrugated steel roofing, continuing through to the early 1950’s. Now a wide variety of materials are used for claddings. Australian houses are similar in construction to NZ housing with timber framing in widespread use. Generally Australian builders produce a similar quality house more cheaply than in NZ. It is instructive to compare the similarities and differences in design and construction in order to better understand reasons for the cost differences between the two countries. Ownership rates are dropping from about 75% in the early 1990s to 65% now and falling. Affordability has always been a low income household issue but more recently middle income New Zealand households in some locations have found ownership unaffordable. The Productivity Commission (2012) said “it is not yet clear if this is a cyclical phenomenon or a structural trend.” This paper is about the supply side of housing rather than proposing measures to assist affordability, but it provides some reasons why new housing is increasingly unaffordable for many households.

2. Main results

This section examines a number of characteristics of New Zealand new housing with some comparisons with Australia. The characteristics examined are:

¹ Economics Section; Building Research Association of New Zealand
2.1 New house costs

The prices for a typical new house in New Zealand and Australia are shown in Table 1. This is taken from the NZ Productivity Commission report on housing affordability (NZ Productivity Commission 2012, Table 10.3). Prices were adjusted for purchasing power parity (PPP) and the Commission found Australian prices were 15% to 25% lower, depending on the cities compared. There are slight differences in specification, but generally the quality of houses is similar in all locations. Building code requirements differ (e.g. thermal insulation, double glazing, structural loading, termite protection, etc) but these do not amount to more than an extra 5% cost for NZ houses. So the conclusion is that new housing in New Zealand is at least 10% more expensive than the same house in Australia.

Part of the reason for the price difference appears to be material costs. A comparison of ten common materials (Kenly 2003) found a price premium in New Zealand of about 55% after exchange rate adjustments. The Productivity Commission (Table 10.2) identified an average price differential of about 24% for materials in place, (i.e. labour installation costs are included), see Table 2. Some items, e.g. framing hardware, have a large price difference which is believed to be due to specific building code requirements. Rawlinson (2012) has average tradesman rates at $A62/hour in Australia compared to New Zealand rates at $NZ38 per hour, including all overheads. In PPP terms the skilled labour cost in Australia is twice that of New Zealand. Hence the lower installed costs must be due to a combination of cheaper materials and more efficient use of labour. In fact Table 3 indicates less labour is used in Australia compared to New Zealand for most housing components.

<table>
<thead>
<tr>
<th>Location</th>
<th>Price (PPP adjusted to $NZ)</th>
<th>% of Auckland</th>
<th>% of Dunedin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auckland</td>
<td>$1.650/sqm</td>
<td>100%</td>
<td>108%</td>
</tr>
<tr>
<td>Dunedin</td>
<td>$1.525/sqm</td>
<td>92%</td>
<td>100%</td>
</tr>
<tr>
<td>Sydney</td>
<td>$1.175/sqm</td>
<td>71%</td>
<td>77%</td>
</tr>
<tr>
<td>Brisbane</td>
<td>$1.209/sqm</td>
<td>73%</td>
<td>79%</td>
</tr>
</tbody>
</table>

Source: Rawlinsons Australia and Rawlinsons New Zealand. Prices are for a moderate quality standard house using the mid-points of the price ranges given in the respective Rawlinsons Cost handbooks. Prices exclude GST and consent/ approval fees.

<table>
<thead>
<tr>
<th>Material</th>
<th>NZ price</th>
<th>Australian Price (PPP adjusted to NZ$)</th>
<th>Australian price as a %</th>
</tr>
</thead>
</table>

Table 1 New house building costs per sq meters

Table 2 Material prices for a typical house in New Zealand and Australia
<table>
<thead>
<tr>
<th>Component</th>
<th>Unit</th>
<th>New Zealand</th>
<th>Australia</th>
<th>Australia as % of NZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground floor joists 200 x50</td>
<td>hr/m</td>
<td>0.21</td>
<td>0.185</td>
<td>88%</td>
</tr>
<tr>
<td>Plates and studs 100 x50</td>
<td>hr/m</td>
<td>0.13</td>
<td>0.155</td>
<td>119%</td>
</tr>
<tr>
<td>Dwangs/ nogs 100 x50</td>
<td>hr/m</td>
<td>0.17</td>
<td>0.155</td>
<td>91%</td>
</tr>
<tr>
<td>Ceiling joists 150 x50</td>
<td>hr/m</td>
<td>0.20</td>
<td>0.17</td>
<td>85%</td>
</tr>
<tr>
<td>Erect trusses 6m span</td>
<td>hrs each</td>
<td>1.5</td>
<td>1.25</td>
<td>83%</td>
</tr>
<tr>
<td>Particleboard flooring 19mm</td>
<td>hrs/sqm</td>
<td>0.36</td>
<td>0.21</td>
<td>58%</td>
</tr>
<tr>
<td>Brickwork lay standard</td>
<td>hr/1000 bricks</td>
<td>16</td>
<td>13</td>
<td>81%</td>
</tr>
<tr>
<td>Brick clean/ point</td>
<td>Hr/sqm</td>
<td>0.20</td>
<td>0.15</td>
<td>75%</td>
</tr>
<tr>
<td>Weatherboard timber</td>
<td>hr/sqm</td>
<td>0.85</td>
<td>0.475</td>
<td>56%</td>
</tr>
<tr>
<td>Roofing concrete tiles</td>
<td>hr/sqm</td>
<td>0.30</td>
<td>0.17</td>
<td>57%</td>
</tr>
<tr>
<td>Roofing sheet steel</td>
<td>hr/sqm</td>
<td>0.15</td>
<td>0.20</td>
<td>133%</td>
</tr>
<tr>
<td>Painting Walls prep + 2 coats</td>
<td>hr/sqm</td>
<td>0.20</td>
<td>0.13</td>
<td>65%</td>
</tr>
<tr>
<td>Painting Ceiling prep + 2 coats</td>
<td>hr/sqm</td>
<td>0.25</td>
<td>0.15</td>
<td>60%</td>
</tr>
</tbody>
</table>


2.2 Building form and materials

The predominant structural material in new detached housing is framing timber, typically 100 x 50 mm nominal size. In recent years it has lost market share to concrete masonry, light steel framing and a variety of minor structural systems such as solid wood, mud brick and reconstituted timber panels. In the last 5 years steel framing has gained market share, see Figure 1. Similar data is not readily available for Australia but in the late 2000s (Australian Bureau of Statistics) the main systems were timber framing (approximately 65%), double brick (15%), light steel framing (15%), and Other (5%, concrete block and panels).
Wall claddings are shown in Figure 2. From the mid 1990s onward a “mediterranean” style with no eaves, flat roof and a flat wall finish became popular. Weather-tightness problems associated with these designs became apparent in the early 2000’s and by the mid 2000’s there was a shift back to traditional designs and materials represented by clay brick and weatherboard, and a reduction in the monolithic cladding represented by fibre cement sheet and EIFS. A feature of new NZ houses is the wide variety of cladding types as indicated on the chart. The “other” category includes plywood sheet, PVC weatherboard, and corrugated steel sheet. Furthermore many new houses have more than one cladding type, see Figure 3. Common combinations are brick and weatherboard. Owners appear to demand houses that look different to adjacent houses, both in cladding and in layout, the so-called “bespoke” housing. In contrast Australian detached houses are more limited in wall cladding types, with clay brick having well over 70% share and usually just one cladding type per house.

Roof cladding types show similar patterns with NZ housing having a variety of cladding types, with approximately equal shares in concrete tiles, pressed metal tiles and long run steel sheet, and small shares of flexible membranes and shakes. Australian new houses have mainly concrete or clay tiles. The BRANZ New Dwellings Survey referred to in the above charts is described in a report by Page and Curtis (2011).

The diversity of claddings is believed by the author to be one factor causing additional costs in New Zealand housing. Other cost factors relate to design characteristics and the size of the industry.
2.3 Detached versus attached new housing

The analysis in this paper is for detached housing because it is by far the majority of new housing in New Zealand. The proportion of multi-unit is quite low compared to Australia, see Figure 4, and most other Western countries. Average floor areas for detached houses are high by world standards, see Figure 5, with NZ houses third in size after Australia and the USA. Sizes have been rising in both countries for many years but now appear to have levelled out and may be declining.
Figure 5 Average floor areas for detached new housing

Most new detached new housing is single level, see Table 4, However this is likely to change as new starts are increasingly on small lot sizes.

Table 4 Number of storeys in New Zealand new detached houses

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
<th>Average floor area sqm</th>
</tr>
</thead>
<tbody>
<tr>
<td>One storey</td>
<td>78.2%</td>
<td>202</td>
</tr>
<tr>
<td>Two storey</td>
<td>20.3%</td>
<td>253</td>
</tr>
<tr>
<td>&gt;Two storey</td>
<td>1.5%</td>
<td>313</td>
</tr>
<tr>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: BRANZ New Dwellings Survey.

2.4 Firm size

The average size of house building firms in New Zealand is small, in common with many other countries, see Table 5. However for such a small country the NZ concentration percentage is unusually low, indicating it is very much a “cottage type” industry. This obviously affects firm market power in terms of material purchasing.

Table 5 House building firm concentration

<table>
<thead>
<tr>
<th></th>
<th>Australia</th>
<th>UK</th>
<th>USA</th>
<th>NZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 10 firms</td>
<td>15%</td>
<td>28%</td>
<td>15%</td>
<td>13%</td>
</tr>
<tr>
<td>Top 50 firms</td>
<td>33%</td>
<td>66%</td>
<td>23%</td>
<td>25%</td>
</tr>
</tbody>
</table>

2.5 Design factors affecting cost

A previous section mentioned the demand for “bespoke” housing in New Zealand which is manifest in varied layouts and different cladding materials for houses in the same housing development area. The large majority of new home owners have some input into the design (Curtis 2011); see Table 6. Almost half have a major input and even when standard plans are used over 40% have make some changes. This affects layout and other features such as windows, kitchens and bathrooms where common sizes of components are rare. For example, window sizes are not standardised and it is not uncommon for 6 to 8 difference sizes to be used per house. Bathroom vanities and showers are usually preformed but kitchen layouts are different in each house with custom made joinery quite common.

Builders were surveyed on design aspects and the effect on building costs (Page, Fung 2011), see Figure 6. The design features adding most to costs were an upper storey, complex roof lines, changing ceiling heights, sloping sites, and poor foundations. The latter two results from the varied NZ terrain causing issues with foundations in many locations. In the larger cities the better ground has already been claimed for housing and often new developments are forced onto more difficult sites.

Table 6 Owner input into NZ new house design

<table>
<thead>
<tr>
<th>What input do owners have into the new house design?</th>
<th>Percent of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select design from the builders standard plans with NO CHANGES</td>
<td>2%</td>
</tr>
<tr>
<td>Select design from the builder’s standard plans with SOME CHANGES BY OWNER</td>
<td>43%</td>
</tr>
<tr>
<td>One-off design by an architect with MAJOR OWNER INPUT</td>
<td>48%</td>
</tr>
<tr>
<td>One-off design by an architect with MINOR OWNER INPUT</td>
<td>6%</td>
</tr>
<tr>
<td>Source: BRANZ New Home Owners Satisfaction Survey 2011. Sample size 481.</td>
<td>100%</td>
</tr>
</tbody>
</table>

Figure 6 Factors affecting costs for new NZ detached houses
3. NZ Productivity Commission findings on housing costs

The Productivity Commission was tasked with the evaluation of the factors influencing the affordability of housing and to examine the opportunities to increase affordability. The main recommendations were:

- Increase land supply for new housing, including moderate-density development of brownfield sites and development of greenfield sites.
- Councils review regulatory processes with the aim of providing simplified, speedier and less costly consenting processes and inspections.
- Territorial authorities should develop strategies that promote competition between developers for the right to develop land.
- Treasury review the quality and robustness of the RIS process for changes to the Building Code.
- Building Consent Authorities (BCAs) adopt a customer-focused approach in their interaction with building practitioners.
- The Law Commission should consider a review of liability and the incentives faced by councils to minimise their liability.
- The Department of Building and Housing (DBH) should provide specific guidance for BCAs about what is required for an alternative solution to comply with the building code.
- The DBH should review the Multi-proof building consent process (where the same design is acceptable in all locations) to identify barriers to its application.
- Urgency should be given to Government efforts to improve BCA performance and promote greater consistency and efficiency in the building regulatory system.

Most of these relate to land zoning and other council processes. Making more land available and speeding up processes on the surface appear to be worthwhile solutions but the first conflicts with sustainability goals, and second, councils are wary of liability issues as they are often the “last man standing” in legal cases and have in the past incurred large repair costs. So while there can be improvements in land supply and council processes the right balance is needed.

The report examined the structure of the building industry and material manufacturing in some detail, but did not have many specific recommendations. The main one related to the industry Productivity Partnership (2012) work which the commission said “should develop, in consultation with the sector, practical responses to supply chain issues”. The Commission did not list these issues but they are believed by the author to include:

- Need to increase the average firm size to achieve scale efficiencies.
- Promote more standardisation in housing design.
- Better integration between owners, designers, builders, material suppliers and sub-contractors in procurement, time management and in allocating costs fairly.
- Improved processes within regulatory authorities for monitoring compliance.
- Use more prefabrication, both from a quality and time-saving viewpoint.
- Improve skills both in firm management and the on-site trades.
4. Discussion

New housing in New Zealand is characterised by a variety of housing forms with little standardisation. There are a large number of cladding types compared to Australian houses and the floor plan layout varies with almost every detached house. Average sizes of new housing are large despite average household size declining in recent years (currently the average occupancy is 2.7 persons per occupied house, down from 3.5 persons in the mid 1970s.)

Why are new house floor areas in NZ among the largest in the world? Affordability could be significantly improved with smaller houses and although home ownership rates are quite high, at 65%, they are currently declining rapidly due to affordability constraints. The reason for the large sizes appears to be the role of housing as a financial asset. For most households it is their largest single asset and new owners build with re-sale in mind for what they perceive to be the main market, i.e. 4 bedrooms, double garage and as much floor area as their budget allows. These choices are influenced by the high cost of land. In Auckland the land cost represents over 50% of the house and land package (Productivity Commission Figure 2.8). Owners do not want to under-capitalise on the house given the high land price. The average new section size is now about 450 sqm in the major cities and quite often the new house needs to be 2-storey to fit on the section. This has addition construction costs, compared to single storey construction. Poor ground conditions and lack of flat sites in many New Zealand cities is also a factor contributing to cost particularly during housing booms when the best sites are developed first.

Local councils are now zoning for more intensive housing. The Auckland Council (2012) expects about 60% of new housing over the next 30 years to be within the current urban limits and most of that will be attached housing varying from semi-detached, terraced housing and medium to high rise apartments. So house sizes are likely to decrease on average and possibly reduce or stabilise new housing price rises. Prospective owners are now becoming more aware of choices affecting energy and water use, travel times and other design factors which impact on their on-going costs. Recently developed intensive housing in greenfield and brownfield locations has been quite well designed. So possibly there will be a trend to smaller but better designed houses which cost less to run and have lower sustainability impacts.

Material costs are on average more expensive than in Australia. This is probably due to scale effects. With an average demand of 20,000 new houses per year the size of most building material manufacturers is below world scale. Also builders find it difficult to efficiently use their labour and sub-contractors as work sites are often scattered rather than being concentrated in large developments. There are only two major manufacturers of building materials and so price competition is limited for some materials. The population is well distributed across New Zealand with Auckland having at most 30% of new building work, so transport of bulky materials over the quite mountainous terrain adds to costs.

The Productivity Partnership (2012) has a programme of work to improve productivity in the building and construction industry by 20% by 2020. It is currently addressing the topics
mentioned in the NZ Productivity Commission report and it has four streams of work; Procurement, Skills, Processes and Evidence. Procurement is mainly focused on large projects and big clients (i.e. central and local government) with attempts to co-ordinate work so that boom-bust cycles are lessened. The skills stream emphases trade training but has recognised a gap in management skills in the small builder sector. The Processes group is looking at the value stream and trying to identify what processes add value and which do not and hence should be eliminated. It is considering the greater use of technology and innovation (e.g. BIM, pre-fabrication, etc) to improve overall industry performance. The Evidence stream is looking at measurement of progress toward the goals including measures of quality. One of the biggest challenges for the Partnership is to improve the performance of the small firm housing sector and make housing more affordable. Some solutions have been discussed above, including smaller houses, more standardisation, and larger firm sizes. But issues outside the industry also need to be addressed such as land and material costs, and regulation and compliance costs.

5. Conclusions

New housing in New Zealand has specific local characteristics arising out of a tradition of ownership and a wish of owners to put their mark on the new house. Due to land and consent costs most owners feel they need to build as large as possible. All this has gradually made new housing unaffordable for many households and ownership levels are dropping rapidly. Councils are zoning to contain urban sprawl and the first new house for many owners will increasingly be a multi-unit on a redevelopment site within existing urban limits rather than a detached dwelling on a green field site. It is likely in the future we will see a trend to smaller dwellings, more intensification and more standardisation. The average firm size is likely to increase to undertake this more intensive construction. This will lead to a significant change in the characteristics of new housing, possibly leading to better quality, enhanced affordability and improved sustainability.

References

Auckland Plan (2012), Auckland Council, New Zealand.


Appendix

BRANZ New Dwellings Survey

This is a postal survey to builders. It asks questions on types of materials by selected components (frame, roof, walls, floor, etc) for a specific building identified from building consent lists obtained from local authorities. Approximately 1,200 returns are received per year. It was originally developed to provide specific product information on market size and share for manufacturers. It has been underway since 1999 and over the years additional questions have been added as requested including efficiency measures (insulation, glazing, lighting water conservation, solar panels, etc), and questions on structural design and weather-tightness. The latter are generally requested by officials and regulators. The survey’s value is that it provides data not available from official sources, and it now has wide use including time trend data. More details of the survey are available in a BRANZ Study Report (Page, Curtis, 2011).
Success or Failure: The NRAS

Xin Janet Ge¹, Connie Susilawati²

Abstract

Many Australian families are unable to access homeownership. This is because house prices are very high to the severely or seriously unaffordable level. Therefore, many low income families will need to rely on affordable rental housing supply. The Australian governments introduced National Rental Affordability Scheme (NRAS) in July 2008. The scheme aims to increase the supply of affordable rental housing by 50,000 dwellings across Australia by June 2014. It provides financial incentive for investors to purchase new affordable housing that must be rented at a minimum of 20% below the market rent. The scheme has been in place for four years to June 2012. There are debates on the success or failure of the scheme. One argues that the scheme is more successful in Queensland but it failed to meet its aims in NSW. This paper examines NRAS incentive designed to encourage affordable housing supply in Australia and demonstrates reasons for developing properties that are crowded in areas where the land prices are relatively lower in the NSW using a discounted cash flow analysis in a hypothetical case study. The findings suggest that the high land values and the increasing cost of development were the main constraints of implementing the scheme in the NSW and government should not provide a flat rate subsidy which is inadequate to ensure that affordable housing projects in high cost areas.

Keywords: Affordability, NRAS, Housing, Australia

1. Introduction

Many families in Australia aspire to have their own home but with house prices increasing and staying high, it is proving very difficult for the low- and moderate-income families to reach the goal of home ownership. These families have limited options but are forced into the rental market. However, the rental prices are ever increasing and have reach a point where they are very high to the severely unaffordable levels. The vacancy rates have fallen in all Australian capital cities to below the bench market level of 3 per cent (Schlesinger, 2012). Figure 1 shows the average weekly rents of the capital cities in Australia in January 2012. According to a report by the Australian Property Monitors, Darwin was the most expensive city with median rentals of $505 a week each, compared with the national average of $411 a week in January 2012 (Koremans, 2012). In Sydney, the average weekly rent for houses and units are $500 and $460 respectively. In Brisbane, the average weekly rent for houses and units are $480 and $350 respectively. The median personal income in

¹ School of the Built Environment, University of Technology Sydney
² School of Civil Engineering and Built Environment, Queensland University of Technology
the 2011 census was $577 a week and median household income was $1,234 per week (ABS, 2012). This implies that around 40 per cent of a household’s income go to their accommodation each week, which is termed ‘housing stress’, i.e., housing costs are more than 30 per cent of a household’s gross income defined by the Australian Government (National Housing Strategy, 1991). Due to the limited stock of public housing, many low income households will need to rely on affordable rental housing supply provided by the private rental market.

![Weekly Rents in the Australian Capital Cities](image)

**Figure 1: Weekly Rents in the Capital Cities of Australia (Koremans, 2012)**

This study uses the term affordable rental housing in the private sector as the housing which is rented below market rent. However, the investors of the affordable rental housing will receive a lower rental income than market rate. In order to attract investors into this sector, government incentives are crucial in providing tax incentives for them. The Australian government introduced the National Rental Affordability Scheme (NRAS) in July 2008 to increase the supply of affordable rental housing.

The NRAS provides financial incentive for investors to purchase new affordable housing that must be rented at a minimum of 20 per cent below the market rent for 10 years (FAHCSIA, 2011). The Secretary of the Department of Families, Housing, Community Services and Indigenous affairs (FaHCSIA) is responsible for the management of NRAS, in consultation with the Australian Taxation Office (ATO). The assessment of applications is undertaken jointly between the Australian Federal, State and Territory Governments (FaHCSIA, 2011). The scheme has been implemented through four funding rounds totaling up to 40,151 incentives allocated among a total 138 participants to September 2012 (Figure 2).
The actual delivery and realization of these incentives was only 10,112 to the end of September 2012 (Figure 3).

There are debates on the success or failure of the scheme. One argues that the scheme is successful in the Queensland (QLD) but it failed in the New South Wales (NSW). According to Table 1, there were 16.8 per cent (6,729 incentives) allocated to NSW and 28.1 per cent (11,281 incentives) to QLD of total incentive scheme (Australian Government, 2012). The QLD allocated 67 per cent more incentives than NSW. This paper investigates the reasons why many investors are attracted to invest in QLD rather than in NSW through the NRAS scheme. The research is important since it tests the factors that influence the implementing the NRAS scheme. The findings can be used as a reference for government when the incentive scheme is revised.

Table 1: Incentive Status by State/Territory

<table>
<thead>
<tr>
<th>State</th>
<th>Incentives Allocated</th>
<th>National %</th>
<th>Incentives Reserved</th>
<th>National %</th>
<th>Total Incentives</th>
<th>National %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>1,299</td>
<td>12.80%</td>
<td>1,396</td>
<td>4.60%</td>
<td>2,695</td>
<td>6.70%</td>
</tr>
<tr>
<td>NSW</td>
<td>1,462</td>
<td>14.50%</td>
<td>5,267</td>
<td>17.50%</td>
<td>6,729</td>
<td>16.80%</td>
</tr>
<tr>
<td>NT</td>
<td>105</td>
<td>1.00%</td>
<td>1,591</td>
<td>5.30%</td>
<td>1,696</td>
<td>4.20%</td>
</tr>
<tr>
<td>QLD</td>
<td>3,128</td>
<td>30.90%</td>
<td>8,153</td>
<td>27.10%</td>
<td>11,281</td>
<td>28.10%</td>
</tr>
<tr>
<td>SA</td>
<td>1,298</td>
<td>12.80%</td>
<td>2,493</td>
<td>8.30%</td>
<td>3,791</td>
<td>9.40%</td>
</tr>
<tr>
<td>TAS</td>
<td>477</td>
<td>4.70%</td>
<td>986</td>
<td>3.30%</td>
<td>1,463</td>
<td>3.60%</td>
</tr>
<tr>
<td>VIC</td>
<td>1,619</td>
<td>16.00%</td>
<td>5,203</td>
<td>17.30%</td>
<td>6,822</td>
<td>17.00%</td>
</tr>
<tr>
<td>WA</td>
<td>724</td>
<td>7.20%</td>
<td>4,950</td>
<td>16.50%</td>
<td>5,674</td>
<td>14.10%</td>
</tr>
<tr>
<td>Total</td>
<td>10,112</td>
<td>30.039</td>
<td>40,151</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The paper will begin with an introduction of the NRAS program, followed by comparison of how the NRAS were implemented in both Queensland and NSW. The main factor that influence the program implementation will be identified and analysed through a case study using DCF modelling and sensitivity analysis next and followed by a conclusion of the scheme’s success or failure.
2. The National Rental Affordability Scheme

2.1 The structure of the scheme

The NRAS was enacted by the National Rental Affordability Scheme Act 2008, the National Rental Affordability Scheme (Consequential Amendments) Act 2008, and the National Rental Affordability Scheme Regulations 2008 (FaHCSIA, 2011). The objectives of the scheme are to a) stimulate the supply of up to 50,000 new affordable rental dwellings; b) reduce rental costs for low and moderate income households by making these dwellings available for rent at a rate that is at least 20 per cent below the prevailing market rate; and c) encourage large-scale investment and innovative delivery of affordable housing (FaHCSIA, 2011). Establishment Phase (01 July 2008 – 30 June 2010) and Expansion Phase (01 July 2010 – 30 June 2014) were the two phases implemented by the Scheme.

Financial institutions, property developers and non-for-profit organisations are encouraged to apply for the incentives. Individual investors can be involved in the scheme through joint venture, purchasing NRAS dwellings from an Approved Participant, a superannuation fund or property trust (FAHCSIA, 2011). The tax incentive is provide by federal government as a refundable tax offset through the lodgment of investor’s income tax return. The amount of credit is $6,000 dollars per dwelling (in 2008/09) indexed in accordance with the rental component of the Consumer Price Index for ten years, subject to annual compliance of the rules of the scheme (Gilmour and Milligan, 2008). An annual cash payment is allocated for the non-for-profit organisations participating in the scheme that are registered charities with the Australian Tax Office (FaHCSIA, 2011). The State and Territory Governments have roles to provide in-kind incentives to the Approved Participants by ways of contributing land (gratis or discounted), reducing rates and fees, contributing infrastructure, or others. In addition, State and Territory Governments may provide their contributions to the NRAS scheme for future years in advance, and the Contributions may not be deferred (FaHCSIA, 2011).

Approved Participants must meet the mandatory conditions in order to receive the NRAS incentives. The mandatory conditions include dwellings will be rented to ‘eligible tenants’ for at least 20 per cent below the prevailing market rate. The eligible tenants of the NRAS are those in low- to moderate- income households. Household income and the number of people including children are taken into consideration for their eligibility. There is no asset test in determining tenants’ eligibility, except for tenants in Queensland. The dwellings must not be vacant for more than 13 weeks cumulatively or continuously and a statement of compliance for each approved rental dwelling must be lodged at the end of the NRAS year. The Secretary will issue a tax offset certificate to the Approved Participants, who are entitled to claim the NRAS incentive as a refundable tax offset under the NRAS. The Approved Participants must make sure the approved rental dwelling has complied with eligibility and reporting requirements of the Scheme for the NRAS year in order to receive a tax offset certificate (FaHCSIA, 2011).

The investors of the NRAS have no obligation to remain in the scheme. They may terminate from the scheme at any time during the 10-year period without penalty and merely foregoes the future benefits for the remaining balance of the 10-year term. The title of the NRAS
property remains with the investors and the government has no legal or equitable claim over the property (McAuliffe, 2011).

2.2 The NSW and the QLD

As explained in the previous section, the tenant eligibility requirements are the same for NSW and QLD. However, the housing costs (weekly rent) in NSW are higher than that in QLD. This conditions compounded by the increasing housing needs in NSW have forced the housing developments to the lower land cost areas and smaller size of dwellings. The sizes of dwellings approved in NSW and QLD under NRAS as at 30 April 2012 are listed in the Table 2. In QLD, larger dwellings dominate the approved NRAS incentives (3 and 4 bedrooms is 55%). On the other hand, 47% of NSW NRAS stock consists of 2 bedrooms and 42% of studio and 1 bedroom dwellings.

Table 2: Size of Dwellings approved as at 30 April 2012

<table>
<thead>
<tr>
<th>State</th>
<th>Studio</th>
<th>1 Bedroom</th>
<th>2 Bedrooms</th>
<th>3 Bedrooms</th>
<th>4 Bedrooms</th>
<th>Total Dwellings</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>1,143</td>
<td>1,726</td>
<td>3,163</td>
<td>624</td>
<td>116</td>
<td>6,772</td>
</tr>
<tr>
<td></td>
<td>17%</td>
<td>25%</td>
<td>47%</td>
<td>9%</td>
<td>2%</td>
<td>100%</td>
</tr>
<tr>
<td>QLD</td>
<td>290</td>
<td>1,827</td>
<td>3,060</td>
<td>4,364</td>
<td>1,743</td>
<td>11,284</td>
</tr>
<tr>
<td></td>
<td>3%</td>
<td>16%</td>
<td>27%</td>
<td>39%</td>
<td>15%</td>
<td>100%</td>
</tr>
</tbody>
</table>

(AMC, 2012)

The State and Territory governments are responsible in providing in-kind incentives to the NRAS program. According to the NSW government (2010), two forms of incentives are provided. The NSW NRAS A program is for not-for-profit registered community housing provides. There are $40 million is available for the State contributing upfront capital to the approved projects. The NSW government announced that it will limit the number of incentives available to for-profit applicants to 1,250 dwellings (NSW government, 2010), undermining the federal government’s more ambitious targets.

The NSW NRAS B is for all eligible organisations and $2,285 per year per unit, in addition to the Commonwealth Government incentive of $6,855, is contributed by the State for 10 years (NSW Government, 2010). The applicants must not only meet the mandatory conditions set by the federal government, but also demonstrate to meet the State/Territory priority needs.

In Queensland, the annual income-tax free incentive is currently $9,981 per dwelling and is indexed annually to the rental component of the CPI for 10 years. The incentive comprises a) the Australian Government contribution of $7,486 per year for 10 years as a refundable tax offset or payment, and b) the Queensland Government contribution of $2,495 per dwelling per year for 10 years as a cash payment for dwellings in Queensland (Queensland government, 2012a).

A one-off lump sum payment, e.g. a lottery and income earned from e.g. dividends or interest are considered as income (FaHCSIA, 2011). There is no asset test in determining tenant eligibility except for tenants in Queensland. Table 3 shows the difference in the
selection of eligible tenants for the NRAS program in NSW and QLD. It clearly shows that the QLD government is closely involved in monitoring and implementing the NRAS scheme.

**Table 3: Selecting Eligible Tenants**

<table>
<thead>
<tr>
<th></th>
<th>NSW</th>
<th>QLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenant Selection</td>
<td>Approved Participants are responsible to select eligible tenants</td>
<td>Queensland Department of Housing and Public Works (Housing Services)</td>
</tr>
<tr>
<td>Citizenship</td>
<td>No requirement</td>
<td>Citizen, Permanent Residence, Temporary or Bridging visa</td>
</tr>
<tr>
<td>Waiting lists</td>
<td>Tenancy management organisation keeps the waiting lists</td>
<td>Queensland One Social Housing Register</td>
</tr>
<tr>
<td>Decision Justification</td>
<td>Approved Participants are not required to justify their tenant selection decisions</td>
<td>Approved Participants are able to download lists of potential tenants</td>
</tr>
</tbody>
</table>


### 3. Analysis of the Costs and Benefits of the NRAS to Investors

Australian dwellings are considered as severely unaffordable according to the survey conducted by the 8th International Housing Affordability Survey (Bruegmann, 2012). The survey uses the ‘median multiple’, i.e. the median house price compared to median household income, to measure the housing affordability. The score under ‘3’ is considered affordable. Given the measurement, the Australia national median is 5.6, this falls in the severely unaffordable category (Refer to Table 4).

**Table 4: Median Multiple Survey 2012**

<table>
<thead>
<tr>
<th>Rank</th>
<th>Major Metro Market</th>
<th>Median Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sydney</td>
<td>9.2</td>
</tr>
<tr>
<td>2</td>
<td>Melbourne</td>
<td>8.4</td>
</tr>
<tr>
<td>3</td>
<td>Coff's Harbor</td>
<td>8.3</td>
</tr>
<tr>
<td>4</td>
<td>Gold Coast</td>
<td>7.6</td>
</tr>
<tr>
<td>5</td>
<td>Sunshine Coast</td>
<td>7.5</td>
</tr>
</tbody>
</table>

*(Source: Bruegmann, 2012)*

In particular, the multiple for Sydney is 9.2 and Melbourne is 8.4, among the highest in the world. This is because both cities are highly desired by most of people that creates pressure to house prices when house supply is inelastic. Table 5 presents the some of the survey data that shows demographic census results in 2011. The greater Sydney area is double the size of the greater Brisbane in term of the population, families and private dwellings. This indicates the demand for housing in NSW is higher than in QLD. The median weekly household income and weekly rent in the Sydney are relatively higher than the Brisbane. The information also implies that 35 per cent of median monthly income has been used for mortgage repayments in the Sydney while 32 per cent in Brisbane.

The supply of rental dwellings in the QLD performs better than that in NSW. The rate of rental stress in NSW was 47.6% and in QLD was 42.5%; both states are above the national average 41.7% in 2009-2010 (COAG Reform Council, 2012). According to the Shelter NSW
(2012), 40.8% of households or 155,357 households were in rental stress in 2011. There was a shortage of dwellings for rental in the private market for households with very low to moderate incomes in NSW. Only 10 per cent of rental stock was affordable for very low income households; 27 per cent was affordable for low-income households and 63 per cent was affordable for moderate-income households. The vacancy rate for all types of residential properties was around 1.7 per cent on September 2012 in Sydney, the lowest nationally (SQM Research, 2012). Comparing the same period with Brisbane, the vacancy rate was 1.5 per cent and 3 per cent in the Gold Coast. It is claimed that 184,031 households are at risk of financial hardship and poverty in Queensland (Queensland Shelter, 2012). Building more affordable housing in high needs locations to provide lower priced housing for key tenant groups are one of the objectives for the QLD government. The Queensland Government has important roles to allocate the NRAS project and direct the incentives to the area that most needed. However, Lawson, et al. (2009) pointed out that the flat rate subsidy is inadequate to ensure that affordable housing projects in high cost areas.

Table 5: Australian 2011 Census information for the Greater Sydney and Brisbane

<table>
<thead>
<tr>
<th></th>
<th>Greater Sydney</th>
<th>Greater Brisbane</th>
</tr>
</thead>
<tbody>
<tr>
<td>People</td>
<td>4,391,674</td>
<td>2,065,996</td>
</tr>
<tr>
<td>Families</td>
<td>1,152,548</td>
<td>548,496</td>
</tr>
<tr>
<td>Average people per household</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Median weekly household income</td>
<td>$1,447</td>
<td>$1,388</td>
</tr>
<tr>
<td>Median monthly mortgage repayments</td>
<td>$2,167</td>
<td>$1,950</td>
</tr>
<tr>
<td>Median weekly rent</td>
<td>$351</td>
<td>$325</td>
</tr>
</tbody>
</table>

(ABS, 2012)

The point was supported by the BVSC (2010) that most new properties have been built in middle and outer suburbs and in larger regional towns where land prices are lower due to limited funding through the scheme. These properties are crowded and developed in areas where the land cost are relatively lower in the NSW since low yield, high costs and risks (Berry, 2000) are claimed as being the main factors for the situation. As a result, the NRAS projects are a mismatch and might not be located in the area most needed affordable housing. To test whether developers are affected by the land costs for housing development and what benefits are there for the investors to invest in the affordable dwellings under the NRAS schemes, a discounted cash flow model is applied to test the effects of the policy based on the a hypothetical project. Profit maximization, i.e., minimising costs and maximising returns, is assumed as the aim for both developers and investors. Thus Net Present Value (NPV) and Internal Rate of Return (IRR) are used for measuring the benefits of the developments and investments. The calculation of NPV is denoted as follows:

\[
NPV = \sum_{t=1}^{n} \frac{C_t}{(1 + k)^t} - C_0
\]

\(C_t = \) net cash flow generated by the project at time \(t\)
\(C_0 = \) initial cash outlay
\(n = \) the life of the project
\(k = \) cost of capital
Development and investment decisions can be made when NPV is positive and IRR is greater than the required rate of return. The estimating procedure involves

a) investigating the costs and revenues of developments and investments that include the costs of land, selling prices, rental income, etc.

b) the government incentives for the development and investment.

c) building cash flow models and calculating NPV and IRR for developers and investors.

d) conducting sensitivity analysis and discussing the results

The hypothetical NRAS project is located 23 kilometres west of the Sydney central business district on the bank of Parramatta river Parramatta (postcode: 2150). The Parramatta has a population of 19,745 with the average age of 30, comparing to a national average of 37 according to the 2011 Census. The majority of dwellings in Parramatta were apartments (72%), compared to a national average of 14%, and 58% of all dwellings were rented compared to a national average of 27%. The median sale price is $379,400 and the median rent in Parramatta was $400 per week (indicates a rental yield of 5.5 per cent for 9 months Feb-Oct 2012) for all type of properties (Suburb View, 2012). The median weekly household income is $1,288 and median monthly mortgage repayments are $2,063 (ABS, 2012).

There were 175 NRAS dwellings allocated in the suburb of Parramatta includes North Parramatta. It is assumed that the average cost of $1,500 per square meter for land cost and an average of $2,000 per square meter for constructing the 175 dwellings in the area. Fifty per cent of the units can be sold off-the-plan prior to the commencement of construction. The completed units will be purchased by the investors and rented to the low- and moderate-income families for 10 years then the units will be sold at the end of 10-year term.

Other general assumptions include average interest rates and inflation rates (CPI) are assumed 7 per cent and 3 per cent respectively. Interest only loan is used. The investment properties are managed by a professional team who will ensure the eligibility of the NRAS tenants, process the tax credits and compliances. The fee charged is assumed to be $1,750 per year per dwelling including all management fees. Other fees such as strata and council rates are assumed to be $4,000 and insurance and maintenance costs are assumed to be $1,000 per unit. Market growth rate of 4 per cent is applied for the final sale. All expenses are adjusted by the CPI. No vacancy rate is assumed since there is a long waiting list of eligible tenants.

Assumptions also include

- Both the Federal and State government will contribute $9,981 tax free to the investor in 2012.
- The tax free contribution is indexed for the 10 year term of the agreement at CPI.
- Brand new properties are rented at 20 per cent lower than the market rent.

The Results

A discounted cash flow model is built and results of the modelling are in favour for both developers and investors given the assumptions. According to the sensitivity analysis, it shows that land cost is one of the crucial elements affecting development decisions. The higher the land cost, the lower the development profits. Figure 4 depicts land cost and development profits are inversed. When the land cost per square meter increases the NPV
and IRR decreases. The IRR decreases from 31% to 28% when the cost of land increases from $1,400 to $1,500 per square meter.

![The Effects of Land Costs](image)

**Figure 4: The effects of land costs to development returns**

Similarly, Figure 5 shows a negative relationship between investment values and returns under the NRAS scheme. The higher the value of investment, the less the return will be. When the investment value reaches $550,000 at the given assumptions, the investment will barely breakeven or a loss will be realised.

![The Effects of The NRAS](image)

**Figure 5: The effects of investing the NRAS affordable housing**

The hypothetical case study explains the reasons why some of the high priority areas identified by the NSW government such as Sydney, North Sydney, Willoughby etc. where there is less affordable housing developments and low investment participations due to the high price of land and investment costs in these areas. The findings also explain why QLD has attracted more investors participating in the NRAS scheme because of less expensive cost of land comparing to NSW. Investors are attracted to the less expensive projects which are normally located a long distance from the central business district. This can create a number of problems. The first problem is that the low- and moderate-income households
may have difficulty to access employment; Secondly, the higher transportation costs could offset the lower rental costs subsidised by the governments; Third, social issues can be created when numerous low- and moderate-income families are all crowded together in suburbs competing for limited available public resources and facilities.

The criticisms to the NRAS also include insufficient funds to build new properties for the current provided scheme and thus other contributions such as land donations, bank loans and use of the planning system are needed (BVSC, 2010). Institutional investors are not encouraged to participate with the scheme as low return and high risks under the current economic climate (Gilmour and Milligan, 2008). This is because the NRAS was introduced at a difficult time during the Global Financial Crisis (GFC). Many investors were overexposed to the property asset class as a result of the decline in list equity markets (Thornley, et al., 2011). The Australian bank deposits were guaranteed by the Australian government and the banking system was much more resilient, nevertheless, banks have tightened up their credit and lending policies to against the unforeseen risks. As a result, it was relatively difficult for institution and individual investors to access debts from the banks. On the other hand, many institutional investors reduced their risk exposures by adjusting their balance sheet to lower the level of debts to around 30 per cent.

In addition, the NRAS scheme was criticised that the supply of affordable rental housing is not sustainable because that a) the use of the dwellings produced after the expiry of the 10-year tax credit period are not restricted (Lawson, et al, 2009); b) no regulations apply for dwellings may be sold after the tax incentive period (Milligan and Pinnegar, 2010). The federal and states are both directly administering housing programs and having overlapping monitoring and regulatory processes (Plibersek, 2009). If the State and Territory governments do not perform or they disengage over time to match for all available incentives is of concern (Milligan and Pinnegar, 2010). There is also a risk that the federal government abandons or withdraws from their administrative roles and leaves the states to manage it alone. Evidences suggest that the NRAS scheme should set as long-term policy and provide tax credit formula in accordance with elements such as area priority, land value and costs of developments.

4. Conclusion

The NRAS scheme plays an important role in the supply affordable rental housing for the low- and moderate-income households. The NRAS scheme is successful in term that the scheme has offered a strong incentive for small scale investors to increase the affordable rental stocks. The scheme has performed better in QLD since the land cost and property values are relatively lower than that in NSW. The high land values and the increasing cost of development were the main constraints of implementing the scheme in the NSW. There are not enough incentives to attract Institutional investors to participate in the scheme. Most of the NRAS incentives were allocated to the areas located at long distance from CBD since the costs of these investments are relatively lower that can ensure positive returns on investments. The findings suggest that a) the relative more incentive should be provided to ensure that affordable housing projects in high cost areas; b) The government incentives provided in the scheme should work in partnership with other policies to ensure sufficient
funding security; and c) stable economic conditions and long-term policies can ensure the NRAS scheme run successfully. To develop analytical matrix to study the effectiveness and efficiency of the NRAS scheme and its implementations are considered for further research.

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The Effect of Construction Demand on Bidders’ Mark-up Decision

Alexander Soo¹, Bee Lan Oo²

Abstract

Construction demand is a core component of the construction market and affects the behavior and decision making of contractors in bid pricing. Much of the investigation performed to date, focus on the extremities of general market conditions such as the peak and trough of a boom or recession but provide little empirical support to describe the effects of the intermediary. That is, the effects of varying levels of construction demand on bidders’ mark-up decision. An experimental approach that allows active manipulation of variables for hypothesis testing is adopted for this study. A controlled laboratory environment was used to simulate construction bidding with participation from 55 inexperienced bidders with a construction project management background. Construction demand is modeled as the availability of projects in any instance of time. Over the 20 rounds of the experiment, the bidders were separated into two treatment groups, one with a continually increasing level of construction demand and the other case, a continually decreasing level of construction demand. The results suggest that the level of construction demand does have an effect on the bidders’ mark-up level and that periods of greater demand lead to a higher overall mark-up level, whilst lower mark-up levels are characterized by a lower level of construction demand. These findings provide empirical support for describing the effect of varying construction demand on the bid price level and allow for clients to better understand and incorporate this component that may affect their procurement strategy.

Keywords: construction bidding, construction demand, experiment, mark-up

1. Introduction

For the construction industry, descending sealed-bid auctions are the contractors’ main method of acquiring work. Part of this process involves formulating a bid that incorporates the cost of construction and a mark-up accounting for risk and profit (Dyer and Kagel, 1996). However, formulating an effective bid is complex and requires an accurate estimate of the cost of construction, in addition to a suitable mark-up with due consideration to the competitors’ prices (de Neufville et al., 1977). As de Neufville et al. (1977) summarize the outcome of the process; submitting an uncompetitive bid results in failure to attain the contract as well as forfeiting the time and cost of preparing the bid proposal, and submitting

¹ Ph.D Candidate; The School of Civil Engineering; The University of Sydney; NSW 2006; asoo9542@uni.sydney.edu.au.
² Senior Lecturer; Faculty of Built Environment; The University of New South Wales; NSW 2052; bee.oo@unsw.edu.au.
a highly competitive bid may result in unrealized profit. Part of this dilemma is due to price forecasting being an inexact science, based on historical data and limited information (Flanagan and Norman, 1983).

Amidst the main factors to be considered in bid price estimation, Runeson and Skitmore (1999) suggest that market conditions have a profound effect on bidder behavior and the price level. The difficulty associated with considering market conditions is due to there being no standardized measure of “market conditions”, rather it is necessary to identify a indicator variable that provides an indirect measure for “market conditions” (Flanagan and Norman, 1983). Such is the basis for many empirical works investigating the effects of market conditions on construction bidders, such as; Runeson (1988) in his development of a price-level forecasting model based on a Market Conditions Index reflecting the degree of competition and capacity utilization; Chan et al. (1996) in their analysis of changes in profits of construction firms, considering market conditions as a function of price indexes, GDP and inflation; and Oo et al. (2007, 2010) in their analysis of contractors’ mark-up behavior, with market conditions being reflected by the need for work.

When considering possible indicator variables representing market conditions, the neoclassical microeconomic forces of supply and demand have been investigated to be a suitable explanation for changes in the bid price level (Skitmore et al., 2006; Runeson and Skitmore, 1999). Skitmore (1987) defined supply as the availability of contractors and demand was defined by de Neufville et al. (1977) as the level of contractor activity. Much research has been performed to date describing the effect of the number of competitors on the bid price level and all have suggested that the number of competitors has a direct effect on the bid price level, for example; Carr (1983), Brannman et al. (1987); and Kagel et al. (1995). In terms of the effect of construction demand, the need for work and workload have also been shown to be correlated to the bid price level with a focus directly on “good years” and “bad years” or the peak and trough of a boom and recession (de Neufville et al., 1977 and Oo et al., 2007, 2010).

This study focuses on construction demand effects on bidders’ mark-up with the number of available projects (the need for construction work to be completed) being the indicator variable for market conditions. Following the work by Oo et al. (2007), an experimental approach is adopted to investigate the effect of varying levels of construction demand on bidders’ mark-up levels. Extending on the previous works, a complete observation is made from a boom period (good economic periods) to a recession and vice versa, thus incorporating the intermediate occurrences in the analysis. The paper begins with a literature review on mark-up decisions and construction demand, moving onto the research method adopted for the study and finally the results and conclusions.

2. Bidders’ Mark-up Decision

A typical bid mark-up consists of profit, general overheads and contingency (Kerzner, 2005). The decision to balance all three elements is complex, especially when uncertainty is involved (Li and Love, 1999). They suggest that mark-up decisions are based on past experience and unstructured problem solving activities. This is in agreement with Ahmad
and Minkarah (1988) whom also suggest that bid decisions are heuristic in nature and are made on the basis of “experience, judgement and perception”. They also investigated the important factors considered in mark-up decisions through questionnaire surveys received from the top 400 contractors in the United States and found that the top factors affecting such decisions included the degree of difficulty, uncertainty in estimate, historic profit, current workload and need for work. Similarly, in a study by Shash (1993), where the top 300 contractors in the UK were mailed a questionnaire survey, they found that the top five factors that affected the mark-up size decision included: 1) degree of difficulty; 2) risk involved in the work; 3) current workload; 4) need for work; 5) contract conditions. These survey findings are in agreement with the general studies that show mark-up decisions being dominated by a set of key factors related to uncertainty and risk for each unique construction project (McCaffer, 1976; Harris and McCaffer, 1983). These factors can be separated into two categories, i.e., internal and external, where internal factors incorporate design specific issues such as project complexity and external factors related to economic conditions and similar less controllable elements (Skitmore, 1989).

In terms of bidders’ mark-up strategies, Skitmore and Pemberton (1994) summarize that the purpose is to provide a balance between the probability of winning the bid and the potential profit gained if success is achieved. Male (1991) identified that construction bidders operated at three levels: the corporate strategy level; business strategy level; and operational strategy level. At the corporate strategy level, he suggested that contractors define the market domains for which the firm is to operate and compete within. At the business strategy level, contractors determine which contracts to aim and submit bids for (such as project type, size, location). Finally, at the operational strategy level, if the firm decides to bid for a project, a cost estimate is developed which is passed back to the business strategy level where executives apply a mark-up accounting for profit and contingencies. At the corporate and business strategy levels, decisions can be adopted such as random bidding during times of low demand, selective bidding and competitive bidding (characterized by fluctuations in the bid price level) (Fine, 1975) and submission of a cover bid (non-serious bid) (Skitmore, 1989). Three common bidding mark-up strategies were outlined by Boughton (1987) including the “adaptive approach”, “quantitative approach” and “strategic approach”. He describes the adaptive approach being similar to a learning theory model, where the primary goal is to win as many project as possible, with the mark-up percentage being based on the most recent bid and current market conditions. This has the advantage of a competitive bid price, however relies on winning many projects to be effective. The quantitative approach has the primary goal of profit maximization, with the mark-up percentage based on the size of the bid, number of competitors and past performance. The strategic approach has the primary goal of creating long run benefits for the contractor, with the mark-up percentage applied being based on milestones required to achieve the long-term goal. The factors considered in the strategic approach are similar to the adaptive approach and include assessments of competitors and the external environment. Best (1997) identified two pricing strategies similar to Boughton (1987), being cost-based and market based pricing, where cost based pricing is the total cost of service plus an additional mark-up (desired profit) and market based pricing based on competitors’ situation and the client. However, Phillips (2005) suggests that it is not uncommon for firms to use a combination of approaches with the addition of some improvisation.
3. Construction Demand

Construction demand is vital information for contractors as it provides indicators for their current and future workload and can be used to develop effective pricing strategies (Carr and Sandahl, 1978). This is made possible through industry reports and forecasts available (e.g. in Australia, Davis Langdon, 2011a; Davis Langdon 2011b; Australian Industry Group Report, 2011). Akintoye and Skitmore (1994) segregated construction demand into two sectors, public and private, with the construction demand varying differently between the two due to inherent differences in their physical environments and requirements. Runeson and Skitmore (1999) noted that for the industry as a whole, changes in effective demand for building and construction services could be ten percent of more per year, and up to fifty percent or more for individual markets. They suggested that a change in demand lead to a change in bidder behavior and strategy. Many empirical studies have suggested and shown similar relationships. Stone (1983) found a functional relationship suggesting that construction prices increased with increases in demand and prices decreased when demand declined (in line with the law of supply and demand). Runeson and Bennett (1983) considered demand as a function of capacity utilization and found that increases and decreases in the level of activity (demand) resulted in price changes due to the changing number of bidders. De Neufville et al. (1977) in their investigation of 167 building construction and 691 highway projects found that mark-up ratio differed between “good” years and “bad” years (with good years having more projects available for bidding and bad years having less). They concluded that in “good” years, bidders applied high mark-ups in their bidding attempts, whilst in “bad” years, they applied lower mark-ups. Oo et al. (2007) performed an experiment involving senior managers of Hong Kong and Singapore construction firms and found that during booming market condition, the lowest mark-up percentage applied by bidders was higher than that during a recession period. Flanagan and Norman (1985) performed mathematical models on the bid price level and concluded that the current and projected workload affected the bid price, with a higher current workload leading to higher bid prices.

It is interesting to note that that the questionnaire surveys performed by Ahmad and Minkarah (1988) and Shash (1993) both contained indicators of construction demand (such as workload and need for work) as the more important factors considered by contractors in formulating the bid mark-up. In terms of location specific questionnaire surveys performed, Fayek et al. (1999) investigated bidding practices of 58 Canadian civil engineering construction firms and also found that potential profit, need for work, familiarity with market and competitors were the top factors influencing the mark-up size. Shash and Abdul-Hadi (1992) surveyed 71 contractors in Saudi Arabia and found that strength in industry, need for work, competition and the economic situation to be important factors considered in the mark-up size decision. Dulaimi and Shan (2002) investigated 32 medium and large sized contractors in Singapore and discovered that the availability of work was the most important factor considered by the medium sized contractors followed by the need for work and client relations. For large sized contractors they found that the degree of difficulty was most important followed by the availability of work and the competitors in the market. In order to isolate the possible geographic bias from the questionnaire survey results, Ling (2005) performed a meta-analysis on similar surveys performed in Australia, Canada, Saudi Arabia,
Singapore, United Kingdom and the United States. She found that five global (restricted to aforementioned locations) factors included: i) risk; ii) current workload; iii) need for work; iv) reliability of company pricing; and v) competition.

When considering the factors affecting the level of construction demand, Akintoye and Skitmore (1994) suggested that these could be categorized as general and local factors. Local factors include the geographical location of the project, project type (e.g. infrastructure or building) and procurement types (Skitmore, 1987), whereas general factors cover the generic PESTL framework containing political, economic, social, technological and legal factors (Akintoye and Skitmore, 1994). Hillebrandt (2000) identified the key factors affecting construction demand to include: i) population; ii) interest rate; iii) health of the economy; iv) demand for goods; v) renovation demand; vi) government and tax policies; and vii) expectations of demand and profit.

From the literature review, it is clear that mark-up and construction demand work in tandem to directly affect the contractors’ profits and survivability. Whilst there have been many studies into the effects and causes of construction demand on bidders’ behavior, there are little empirical studies attempting to quantify and observe the specific effects. Although construction demand is often deemed as a factor that cannot be controlled (Skitmore, 1987), its effects on contractors are real and understanding how price levels change with the level of construction demand has clear managerial implications for both construction bidders and clients in formulating their bid pricing and procurement strategies, respectively.

4. Research Method

In order to test for the specific construction demand effects on bidder mark-up, an experimental approach was used. As de Vaus (2001) states, using an experimental approach allows us to focus on specific variables (i.e. the dependent and independent variables) that are likely to be the cause and effect of the study. This allows the filtering of external variables such that the effect(s) of the intervention can be clearly observed.

4.1 Experiment Design

There were a total of 55 participants for the experiment. These participants were final year undergraduate students with a construction project management background. The indicator variable representing construction demand is the number of available projects (or number of projects released in each bidding round). Two hypothetical demand curves were generated, one starting off from a recessionary point (low level of construction demand) and continually increasing towards a booming point (high level of construction demand). This curve was called the “booming” scenario. The other demand curve was a direct reflection of the booming scenario curve, starting off from a booming point and continually decreasing to a low point (see Figure 1). This curve was called the “recession scenario”. The 55 participants were randomly assigned to both scenarios, with 28 bidders experiencing the booming scenario and 27 bidders experiencing the recession scenario. Nested within these two groups were five subgroups consisting of five to six bidders each. The purpose of these subgroups were to simulate a realistic number of bidders competing for each project as it is...
unlikely for 27-28 bidders competing for a single project (see McAfee and McMillan, 1987 and Ngai et al., 2002). The experiment was conducted in a controlled laboratory environment and no communication was allowed between the groups.

Figure 1: Experimental Treatment Scenarios

The experiment duration was 20 rounds with each round representing a “quarter” of real time (total simulated time is 5 years). Each bidder was provided with a start-up capital of $800,000 and was required to bid for hypothetical building projects. These projects were based on past real projects obtained from the NSW e-tendering website (https://tenders.nsw.gov.au) and project types selected were restricted to general building projects. The construction cost estimate for these projects ranged from approximately AUD 4 - 14 million. Overheads were required to be paid every bidding round and each bidder had a capacity limit of five projects on hand in any one round. If the bidder chose to exceed their capacity, each additional project taken aboard was penalized with a percentage cost representing outsourcing and additional management costs.

In every bidding round, bidders were provided with one hour to decide which projects to bid for and the price to submit for each project. The bid price submitted was expected to include the construction cost in addition for an allowance for profit, overheads and contingency, with due respect for the competition. As the experiment simulates a first price sealed-bid auction, the lowest bidder wins the project, but how this was achieved was left up to them. The general guideline provided to all bidders was that their goal was to prosper and survive.

A market outlook indicator that provided a brief idea of the future construction demand expectation was provided to all bidders at the beginning of each round. From round two onwards, feedback information of preceding rounds was communicated privately to each bidder. These include the winners and the winning bid prices, an up to date statement on the
bidders’ current account balance, profit/loss from projects won and their current capacity utilization. An incentives scheme was also implemented in order to promote serious participation and to minimize dropouts, this was in the form of a “mystery prize” not revealed until the conclusion of the experiment.

5. Results and Discussion

The results and discussion begins with an exploratory analysis of the bid dataset obtained, followed by a more detailed statistical correlation test of bidders’ mark-up trend. Finally, a between treatments comparison is performed between the booming and recession groups.

5.1 Exploratory Analysis

The sample size for both the booming and recession scenarios is shown in Table 1. In total, 11,598 bid and no-bid observations were collected with 4106 and 3269 bids from the booming and recession groups, respectively. A possible explanation for the higher number of bids received from the booming group is because of the difference in the experiment design. As the recession scenario is a direct reflection of the booming demand curve, less number of projects was released to the recession group (184 vs. 216 projects). For the booming group there were 2156 no-bid decisions and 2067 for the recession group. Although the booming group has a higher number of bids, a simple ratio measure considering the experiment design and difference in the total number of projects released reveals that comparatively, there were more no-bid decisions in the recession group compared to the booming group (2067/2156 vs. 184/216, i.e. 0.96 > 0.85). This can be explained in terms of the need for work, where there was a large number of projects released to the recession group early in the experiment, bidders were likely to win jobs at the early stage of the 20-round experiment and remain occupied for a certain period of time (i.e. operate within their capacity) with more no-bids decisions recorded. A Kolmogorov-Smirnov test on the two sample groups revealed that both distributions were not normally distributed (booming: Z = 9.658, p = 0.000 & recession: Z = 7.102, p < 0.05), thus non-parametric were used for subsequent statistical analysis.

Table 1: Experiment Sample Size

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Bid N</th>
<th>Bid Percent</th>
<th>No-bid N</th>
<th>No-bid Percent</th>
<th>Total N</th>
<th>Total Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booming</td>
<td>4106</td>
<td>65.6%</td>
<td>2156</td>
<td>34.4%</td>
<td>6262</td>
<td>100.0%</td>
</tr>
<tr>
<td>Recession</td>
<td>3269</td>
<td>61.3%</td>
<td>2067</td>
<td>38.7%</td>
<td>5336</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Figure 2 shows the scatter plots for the bid dataset obtained from both the booming and recession scenarios. The x-axis represents the time scale and is a function of the bidding round number. The y-axis is the mark-up ratio and is calculated as the contractors’ bid divided by the unbiased project cost estimate of a project. A mark-up ratio greater than one represents a mark-up being applied by the bidder (on top of the cost estimate) and a mark-up ratio less than one indicates that the bidder is bidding below cost. A reference line at the
mark-up ratio of one is added on the scatter plots. Fitted to the data-points is a LOWESS curve (locally weighted scatter plot smoothing) and is based on a local polynomial least squares fit to set of data points. The fit is re-smoothed for several iterations to make it more resilient to the effects of noise and marginal outliers (Hardle, 1990).

![Figure 2: Scatter Plots for Booming (left) and Recession (right) Scenarios](image)

The LOWESS curve for the booming group shows an interesting trend. The mark-up ratio profile appears to be relatively static from rounds one to fourteen. This represents little change in the mark-up trend, most likely stemming from the continual need for work up until round fourteen. Considering that for the first four rounds of the booming scenario only two to three projects were released, the majority of the bidders would have been in high need of work to win job(s) in order to cover overhead costs. From round fourteen and onwards, there is a steady increase in the mark-up ratio being applied by bidders, most likely in response to the increased level of construction demand, and also less competition in the market. That is, at this time, many bidders’ would have had enough jobs on hand and less incentive in continuing to bid aggressively. In order to investigate the seemingly static trend from rounds one to fourteen, a Spearman’s correlation test was performed in this range in examining the correlation between the mark-up ratio and the number of available projects (see Table 2). Analyzing rounds 1-14 revealed a small overall change in this region ($r_s = -0.010$) with the correlation between the mark-up ratio and the number of available projects being insignificant ($p = 0.604$). This indicates an unvarying mark-up trend in this region and a “cut” was needed to explore the trend further. Closer inspection of the LOWESS curve shows a slight “kink” at round 10, indicating changes in the mark-up trend, thus this round was chosen as the cutting point. Performing the same test on rounds 1-10 revealed a positive correlation between the mark-up ratio and the number of available projects at a significant level ($r_s = 0.074$, $p = 0.005$). And testing rounds 11-14 reveals a slightly positive correlation between the two variables at a non-significant level ($r_s = 0.009$, $p = 0.762$). The results are
interesting in that between rounds 11 and 14 there is an adjustment in the bidders’ mark-up behavior before the steady increase in the mark-up ratio observed in Figure 2. A possible conjecture to explain this lies in the bidders’ current workload, whereby through learning and assessing their current position and the expected construction demand, they were able to optimize their mark-up in response to the flourishing market conditions.

Table 2: Spearman’s Correlation Test for Booming Scenario Rounds 1-14

<table>
<thead>
<tr>
<th>Mark-up Ratio vs. Number of Projects</th>
<th>Rounds 1-14</th>
<th>Rounds 1-10</th>
<th>Rounds 11-14</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>2484</td>
<td>1440</td>
<td>1044</td>
</tr>
<tr>
<td>Spearman’s rho</td>
<td>-0.010</td>
<td>0.074</td>
<td>0.009</td>
</tr>
<tr>
<td>p-value</td>
<td>0.604</td>
<td>0.005</td>
<td>0.762</td>
</tr>
</tbody>
</table>

As per theoretical expectation, the LOWESS curve for the recession group shows an overall opposite trend compared to the booming group. The trend line shows a steady increase initially from rounds 1 to 4 before steadily decreasing up to round 20. This may indicate a learning curve for the recession group, with the initial four rounds used to learn about the bidding environment and market conditions. With strong construction demand starting from round one for the recession group, there was likely to be enough work to go around thus keeping most bidders with a healthy workload. This is indicated by the initially high level of mark-up being applied in bidding attempts. As the construction demand decreased over the time, the need for work and competition in the market increased, thus bidders would have needed to adjust their bidding strategies accordingly in order to sustain or maximize the efficiency of their workload.

An overall comparison between the scatter plots of the booming and recession groups suggests that the overall mark-up ratio for the recession group is higher than the booming group. This again is the result of the treatment effect of the varying levels of construction demand, where for the booming group, the initial low demand would have likely “starved” many bidders at the early stage of the experiment. Since the need for work was high, the competition was high thus driving the bid prices at an aggressive level. Conversely, for the recession group, initial high demand is likely to have provided many bidders with a healthy workload, with an inherently less competitive market, mark-up levels are able to stay high, until changes in the level of construction demand that forced a change in mark-up strategy (i.e. lower mark-up), a product of learning and adaptation. These findings are consistent with the results from Oo et al. (2007, 2010) and de Neufville et al. (1977) in that during “good” years or booming times (strong market conditions/high demand) the level of mark-up percentage is higher in contrast with the times of poor market conditions or low demand.

5.2 Correlation Tests

To relate the observed mark-up trends from the scatter plots (Figure 2) to the experimental treatment scenarios (Figure 1), Spearman’s correlation test was performed on each dataset obtained from the booming and recession groups. The results show that, for the booming group, the correlation between the mark-up ratio and the number of available projects is
positive and significant ($r_s = 0.206$, $p=0.000$) and similarly for the recession group, the correlation coefficient is also positive and significant ($r_s = 0.118$, $p=0.000$). The findings show that mark-up applied to projects increases as the level of construction demand increases. The results also show that on average, the bidders were behaving in a rational manner. These findings are in line with the study performed by Ball et al. (2000) on the UK construction industry. They examined the performance of 32 medium size public construction firms and found that mark-ups were positively correlated with the construction cycle (in terms of the availability of new work).

5.3 Between Treatments Comparison

Table 3 shows the descriptive statistics for both the booming and recession groups. It can be seen that the mean mark-up ratio is higher overall for bidders subjected to the recession scenario compared to the booming scenario. The standard deviation shows that bidders were more consistent in their bidding attempts in the booming group compared to the recession group. The removal of outliers was based on a criterion set forth by the Hong Kong SAR government, which considers all bids that are 25% above the lowest bid to be non-serious bids (Skitmore, 2002). Due to the nesting of subgroups for this experiment, the criterion was modified such that bids with a mark-up of 25% above the cost estimate were considered as outliers, this explains the maximum mark-up ratio for both the booming and recession groups being identical at 1.250. The Mann-Whitney U test was utilized for comparing the difference in distributions of the mark-up ratio for both the booming and recession groups. The results support the descriptive statistics, and it was found that the mean mark-up ratio for the recession group was higher than the booming group at $p < 0.05$ ($U = 3522650 \ , \ Z = -35.107 , \ P = 0.000$). This provides strong evidence that that both groups come from different distributions (statistically), suggesting that the treatment effects (varying levels of construction demand) did have an effect on bidders’ mark-up behavior. In other words, bidders do consider the level of construction demand in their bidding attempts and have formulated their bidding strategies accordingly. This finding is similar to that of King and Mercer (1990) whom applied mathematical analysis to a bidding model and found that bidders adjusted their mark-up in response to changes in the current market and also cost estimate variability.

Table 3: Descriptive Statistics

<table>
<thead>
<tr>
<th>Scenario Type</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booming</td>
<td>4106</td>
<td>1.02603</td>
<td>0.04464</td>
<td>0.820</td>
<td>1.250</td>
</tr>
<tr>
<td>Recession</td>
<td>3269</td>
<td>1.06060</td>
<td>0.05952</td>
<td>0.854</td>
<td>1.250</td>
</tr>
</tbody>
</table>

6. Conclusion

This study investigated the effect of construction demand on bidders’ mark-up behavior. Utilizing an experimental approach, 55 inexperienced bidders were placed into two different construction demand scenarios and bid for projects in an environment simulating construction bidding in practice. It was found that bidders did consider the level of
construction demand in their bidding attempts and this was reflected by changes in their mark-up strategy. Correlation tests performed suggest that the mark-up increases as the number of available projects (level of demand) increases. The experiment design allows for intermediary observations between the peak and trough of a typical construction demand cycle. The findings provide empirical support on explaining how varying levels of construction demand affects the bid mark-up level. It is identified that a limitation of this study is the use of student subjects for the experiment, thus limiting the generalization from this study to inexperienced bidders. Suggestions for further studies include repeating the experiment with different demand curves, running the experiment for a longer period of time and use of experienced industry practitioners in similar experiments are all likely to produce useful insights that will further our empirical understanding on how construction demand affects bidder behavior. The results of this study are of importance to contractors and clients, particularly in formulating bidding or procurement strategies to take advantage of or to mitigate the effects of market demand.

References


The Euro Crisis and the German Construction Industry

Horst Brezinski¹, Katrin Brömer²

Abstract

The international financial crisis of 2007/2008 led to a drop of the key interest rate, set by the European Central Bank, from 4.25 % in 2008 to 1.0 % in 2009. Due to the Euro crisis, which followed the international financial crisis, the European key interest rate was lowered even further to 0.75 % in June 2012. These actions were taken to revive the European economy and to assist the struggling states and financial institutions. This led to an enormous increase in the liquidity of banks and a growth in the quantity of money, which ultimately led to increasing expectations about the future inflationary process. Following the traditional transmission mechanism of an increase in the quantity of money, the impact on the construction industry was not astonishing. Residential construction activities in Germany increased – a so-called “escape into concrete gold”.

This effect can be considered an indirectly financed stimulus program for the German construction industry. Whether it can only be observed in Germany or also in the other financially stable EU economies will be investigated in this paper. Moreover, the structural effects on the German construction industry will be examined. Finally, it will be analyzed, whether the construction industry can be considered a winner of the Euro crisis or not.

Keywords: construction industry, Germany, Euro crisis, residential construction, monetary policy

1. Introduction

Beyond others, two major factors caused the crisis of 2007: rising house prices due to an expansive monetary policy leading to low interest rates in the U.S. and a failure in the governance of banks worldwide causing a housing price bubble. There have been several price bubbles in the US housing market in the last decades (see Reinhart and Rogoff, 2009) yet this bubble with a dramatic increase in housing prices happened to be the largest in the history of the United States. The Case-Shiller Index pictures the changes in the price level of the U.S. Housing Market (see Figure 1).

¹ Professor; Chair of International Economics; TU Bergakademie Freiberg; Lessingstraße 45, 09596 Freiberg, Germany; horst.brezinski@vwl.tu-freiberg.de.
² Research Assistant; Chair of International Economics; TU Bergakademie Freiberg; Lessingstraße 45, 09596 Freiberg, Germany; katrin.broemer@gmx.de.
The so-called subprime-crisis has triggered the Euro crisis which is having large impacts on the European economies. The European Central Bank (ECB) reacted on the crisis by lowering the already low interest rates even further.
The European Key Interest rate has never been higher than 4.75 % (as for main refinancing operations). Between 2008 and 2009 it has been lowered from over 4 % to 1 %. The first signs of recovery triggered the ECB to slowly higher interest rates in order to prevent inflation. As it became apparent that the Euro crisis was significantly more serious, the interest rates were lowered again to nowadays a mere 0.75 %.

While many European countries struggle with the crisis, in some European countries the historically low interest rates were of interest for individuals especially when lending money. Combined with the fear of inflation a so-called “escape into concrete gold” or into other material assets such as gold began pushing the residential construction sector amongst others. The demand for private housing, especially condominiums in metropolitan areas, in economically stable countries like Germany rose (see Dorffmeister, 2012a, p.42).

Following the two governmental stimulus programs in the years 2008 and 2009 (see Brezinski and Brömer, 2012) the situation described above can be considered an indirectly financed stimulus program for the German construction industry. In contrast to Germany, not all European countries of the Euro-zone are benefitting from the crisis.

2. The effects of the Crisis on the German construction sectors

The subprime-crisis developed from a US-crisis into a world economic crisis followed by a Euro crisis which did not spare out the German construction sector. Yet, as the general construction business cycle is known as lagging behind by about one year compared to the
business cycle of the overall economy and due to the stimulus programs which the German government implemented, the downward effects were not as drastic as in other industries.

Split up into the three sectors - residential construction, commercial construction and public construction - Figure 3 shows the development of the construction investments in Germany from 2005 to 2011.

![Figure 3](image.png)

**Figure 3  Construction investments of the sectors residential, commercial and public construction in nominal prices (Statistisches Bundesamt, 2012)**

Residential construction investments are made mostly by private individuals. Public residential construction constitutes only an insignificant share in governmental expenditures. It becomes obvious that residential construction investments contribute the largest part to the total construction investments (see Figure 3). Generally rising from 2005 on, the sector showed a slight decrease of investments in 2009, followed by large increases in the years 2010 and 2011. Quarterly figures for the first half of 2012 show a further growth of residential construction investments.

Commercial construction had a negative growth in 2009 and recovered slowly in 2010. In 2011 the investments of companies in construction climbed up to the highest value of the last ten years.

Public investments include all areas of civil engineering and public housing. However, government investments for residential purposes have been very low compared to the public construction in total, hardly exceeding 2 % of the overall public construction investments in the last decade. Public construction investments in total have been rising during the crisis due to the large stimulus programs which still positively affect the 2011 numbers.
A more detailed picture can be drawn from the changes in the total order value (see Figure 4). The demand for residential construction has been fairly constant until 2009. Since then, the order value is booming. A boom can also be seen in commercial construction whereas public construction has been decreasing since that year.

![Figure 4](image_url) - changes in total order value (main construction industry, companies with 20 or more employees) of the sectors residential, commercial and public construction (Database ELVIRA)

Overall, the two sectors, residential and commercial construction, have been affected by the crisis, especially in 2009. Yet, looking at the investments, all three sectors show a rising trend from 2010 on whereas the order value of public construction is already decreasing from 2009 on due to the end of the stimulus programs. Particularly residential construction made a large saltus upwards whereas public construction is expected to fall in the future due to the phase-out of the stimulus programs. There may be a tendency in the future that construction companies allocate their resources to meet predominantly the increased private demand.

3. Residential Construction in Germany

After the German reunification the construction sector experienced a large increase in demand as the East German housing and infrastructure were poor and ailing. In 1995, saturation was reached and the residential construction investments stayed at a stable level until 1999. Since then (see Figure 5), investments decreased by more than 20% within 5 years. The short upswing in 2006 was then once more followed by a decrease causing a
backlog for housing in the country. From 2009 on, residential construction is developing very positively.

![Total residential construction investments in Germany (chained index, 2005 = 100) (Statistisches Bundesamt, 2012)](image)

Apart from the revival of demand for newly built houses and condominiums, the real estate market is also prosperous in Germany. As for construction work, the demand is not equally distributed over the country, but rather focussed on metropolitan areas (Bundesinstitut für Bau, Stadt- und Raumforschung, 2012). In Germany, a large private rental market exists apart from social housing provided by the state so that generally there is no urgent need in building own houses. Furthermore, the German tax system does not advantage private residential construction continuously, even though there have been temporary privileges in the past. In contrast, property taxes exist as well as high transaction costs. Even though the German house prices seem to be more stable than in other countries due to institutional differences (see Muellbauer, 1994, p. 246) and other factors (for more detail, see Kholodilin et al., 2008), house prices have been rising within the last months due to the large demand.

In general, the development of real estate prices depends on the rising of the real disposable per-capita income, the population growth, the long-term real interest rate, the degree of urbanization (Kholodilin et al., 2008) and real income expectations. In Germany, the population growth is negative, the average economic growth is slow compared to other nations and the real estate credit market is relatively non-elastic – all factors, that slow down the rise of real estate prices.
The increase in demand for newly built houses and existing property accompanied by rising real estate prices in metropolitan areas raises the question if a new housing bubble builds up in Germany. According to Kholodilin (2012) there is a threat of a speculative housing bubble looking at the real estate market e.g. in Berlin, but as of today, no housing bubble exists (similar options are shared by Bundesinstitut für Bau, Stadt-und Raumforschung, 2012 and others).

4. Residential construction in other European countries

Generally speaking, there are different factors influencing the residential construction sector: available and expected real income, financing conditions, the situation on the labour market, demographical effects, housing prices and others (see Dorffmeister, 2012a, p. 43).

The Euro crisis had large negative effects on the European construction sector, especially residential construction. Amongst others, many South European countries, especially Spain, suffered from the dramatic drops in residential construction sector, due to a bursting housing bubble which had its peak during the residential construction boom in 2007. Private households in these financially strongly hit countries refuse to make large property investments due to uncertain economic developments or simply because of lacking financial possibilities. Vacancies and decrease of prices for real estate burden the situation even further.

In contrast, some North and Central European countries find themselves in a totally different situation. Economically stable and financially solid countries such as Norway, Finland, Poland, Switzerland and Germany might be seen as winners of the crisis (Dorffmeister, 2012a). Not just private households invest their money within their home countries, e.g. in “concrete gold”. Moreover, foreign capital investors transfer their money from South Europe to stable Central and North European countries. Due to the fear of inflation, investments in material assets like construction and real estate are favored.
Figure 6 Development of residential construction volume in selected European Countries (Index 2011 = 100, prices of 2011) (Euroconstruct, June 2012)

Figure 6 shows the development of the residential construction volume for selected European countries until 2010 and the estimates by Euroconstruct for the next years. Ahead of the crisis, Spain and Ireland had high construction volumes in the residential construction sector, resulting in housing bubbles which busted in 2007/8. As for the future, Spain and Ireland are expected to need another couple of years to reach a steady, yet much lower level in the residential construction sector.

The residential construction sector of Germany, Norway and Poland only had minor decreases during the crisis. From 2010 on, this sector in all three nations increased in prosperity and is expected to keep rising or stabilizing respectively within the next years. The initial situation of these countries was different from those in Spain or Ireland. The European residential construction boom (see Dorffmeister and Gluch, 2011a, p. 37) which ended in 2007 was stimulated by a prosperous economy, high inflation rates, low interest rates, rising housing prices and easy credit initiation. It did not spread equally over Europe – south European countries were particularly affected whereas the situation in e.g. Germany was much more retained. The German residential construction sector was not overheated compared to e.g. Spain: more than one third of the 1.5 million newly build condominiums in 2007 were built in Spain (see Gluch and Dorffmeister, 2011, p. 28). Instead, a backlog in housing construction exists in Germany due to the long recession in the sector after the German reunification.

How long the period of recovery of the European construction sector will be, cannot be predicted as it is dependent on the development of the public debt crisis. According to
estimations of the Euroconstruct summer conference, it might take another couple of years until the European economy returns to growth (see Dorffmeister, 2012b, p. 35). In times of austerity measures resulting in cuts of wages, subsidies and investments, only particular branches might recover.

5. Conclusion

The Euro crisis which followed the global financial and economic crisis had large effects on the construction industries in many European countries. The different impacts on the German construction sector, in particular the residential construction sector, were investigated in this paper. Furthermore, the situation in other European countries was considered as well.

The overall German construction industry has been affected by the crisis, especially in 2009 except for the public construction sector, which profited from the government’s stimulus programs. However, the declines of investments and order values were not as drastic as in other countries and recovery began in 2009 already. Although public construction investments are expected to decrease in the future, particularly residential construction has made a large saltus upwards and is expected to rise even further. The positive development in Germany might be due to the long recession, which the residential construction sector went through in the last decade. So far, a new housing price bubble in Germany has not been predicted.

Even though the basic conditions such as interest rates in Europe were the same at the beginning of the crisis, the initial situation in each country was different. The starting point of the international financial crisis was also the end of a European residential construction boom which on the contrary did not capture all countries. The residential construction sector developed very differently in the various European countries. In some North and Central European nations with economic and financial stability e.g. Germany, Poland or Norway, the sector had the possibility to profit from the crisis. In these countries, the fear of inflation is worse than the expectation of lower incomes whereas negative income expectations are the main reason for the downward development in many south European countries, but also Ireland for example, which have experienced a deep recession in the residential construction sector.

The scope of this paper only allows a short insight to the development of the German construction industry, particularly residential construction. Further research should be done in order to econometrically demonstrate the relations between the different factors relating the Euro crisis and the construction sectors.
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The highs and lows of unbalanced bidding models

David Cattell

Abstract

The unbalanced bidding models developed in the first 50 years, since Marvin Gates first invented them in 1956, have suffered from a significant common flaw. Typically designed as linear programming models, with the objective being to maximise the contractor’s profits from a project, they have incorporated constraints on the prices for each of the items such that they are each bound by lower and upper limits. The intent of this was to find optimum prices falling somewhere within these limits. Instead, the effect of these models has been that all optimal prices (barring only one) are found to lie exactly on the extreme edge of these limits. In effect then, these models serve only to decide which items should be assigned their lowest acceptable price, and which items should be assigned their highest acceptable price. Tests done on a series of simulated hypothetical projects, created randomly by way of an automated process, illustrate this effect, which has previously not being observed. This effect is suggested as being undesirable – these pricing boundaries are vague and heuristically difficult to determine and hence relatively ‘soft’ in nature, rather than being inelastic and hard-and-fast. The risks - that these limits are designed to avoid – are not of the nature that they are incurred (fully) marginally beyond these limits and yet not incurred at all within the limits. Nevertheless, even though these boundaries are only vaguely definable by nature, these models do somehow need to acknowledge that extreme prices are unacceptable and normal (‘central’) prices are fine. This problem has been solved with the use of component unit pricing (CUP) theory.

Keywords: pricing, optimisation, unbalanced bidding, risk analysis

1. Background

Unbalanced bidding describes the process of contractors deciding unit prices for each of a project’s component items, such that these can then form the basis of their contractual agreement with the client. Prior to this, it is typical that the client and the contractor will have provisionally agreed to the overall tender price for the project as a whole (possibly on the basis of a competitive tender) but then the detailed level of the individually priced items become necessary. These are required in order to provide the basis for determining the interim monthly progress payments, the value of variations and of any escalation adjustments. The item prices form an essential basis of the contract and yet they are difficult for clients to properly assess (Skitmore and Cattell, 2012).

1 Associate Professor / Associate Dean; Institute of Sustainable Development & Architecture; Bond University; University Drive, Robina; Gold Coast, 4227 Queensland, Australia; dcattell@bond.edu.au.
Contractors can benefit greatly from optimised item prices. Tests done on a hypothetical project showed a contractor enjoying an increase of 150% in profit by way of optimised unbalanced prices, by comparison to the equivalent balanced prices (the latter describing those produced by way of simply applying the same mark-up to the estimated costs of all of a project’s items) (Cattell, 2011).

Gates (1956) was the first to identify unbalanced bidding as a strategy. This led to various efforts (Stark, 1968; Ashley and Teicholz, 1977; Teicholz and Ashley, 1978; Green, 1986; Tong & Lu, 1992) to determine a mathematical basis for optimising this, all of which entailed linear programming (LP), except for one that involved quadratic programming (Diekmann, et al., 1982). All of these efforts sought to maximise profits and yet recognised that unbalanced bidding is a ‘risky’ strategy. Cattell et al. (2010) identified these risks. The principal mechanism by which to moderate these risks was the universal use of LP constraints on each of the prices, restricting them within defined lower and upper limits. The intent was seemingly that optimum prices would be found that would fall somewhere within these limits.

2. What identifies these limits?

None of this research suggested a basis for deciding these limits. It appears that it was intended that subjective human judgement would be sufficient. Presumably, contractors were intended to be adequately able to identify the points at which any single price crossover point would differentiate acceptable pricing from that which is unacceptable. These models do not cater for the combined effect of multiple item prices being at or near these limits and yet, presumably, the risk of many or all prices being ‘on the edge’ is greater than a scenario where only one price is at or near its limit (at times when the other items are priced more moderately).

3. Unintended consequences

Numerous tests have been made using this LP modelling technique and in all instances, all of the items (barring only one), in each experiment, get priced at their very limit. The models, in effect, only serve to decide which items get priced at their highest extreme limit and which ones get priced at the lowest limit. Furthermore, they serve to consistently identify the one item in each project that gets needed to be priced somewhere within its limits, in order that the summation of the extension of all the item prices exactly equates to that project’s overall tender price, which is input into these models as another constraint.

4. Alternative algorithm

The exact same results can be accomplished without the use of linear programming, using a conceptually simpler method that is mathematically less abstract. The objective is to maximise a project’s overall expected profit and this comprises contributions from each of the project’s constituent items. These contributions have been found (Cattell et al., 2007) to have a linear relationship with the prices of these items, with various slope coefficients (referred to as being their Beta coefficient in Cattell et al., 2007). Different items will contribute various proportions towards profits, for every dollar added to their prices. In other
words, given a choice of where to allocate or distribute the overall tender price, amongst all of a project’s constituent items, some items will deliver more profit when assigned a dollar, than other items. Clearly then, the objective of maximising profit can be translated to identifying those items that will deliver the most profit / dollar of price and these are then assigned their highest possible prices. This can be accomplished by way of assigning the least prices to those items that will contribute the least profit for every dollar of price. This “unbalancing” of the bid will deliver the maximum profit to the exact same extent as by way of using LP, assigning each item with the exact same price as the technique of LP will also identify.

The algorithm to implement this strategy is as follows:

- sort the items in descending order of their Beta coefficient
- assign all the items their lowest acceptable price
- calculate the summation of the extension of all these prices
- calculate the difference (‘Delta’) between the tender price and this summation
- if Delta is less than 0, then report an error (flagging the need to make these minimum prices even lower) and terminate
- as long as Delta is more than 0, then starting at the top and looping down through all the items in their sorted sequence, price each item with its highest acceptable price, adjusting Delta by way of…

\[ \text{Delta} = Q_n \ast (P^\text{max}_n - P^\text{min}_n) \]

where \( Q_n \) = BQ quantity for item \( n \)

\( P^\text{max}_n \) = maximum acceptable price for item \( n \)

\( P^\text{min}_n \) = minimum acceptable price for item \( n \)

- if this loop has reached the last item, then report an error (flagging the need to make these maximum prices even higher) and terminate
- else, \( P_{n-1} = \text{Delta} / Q_n \) which will serve to finish off from identifying all of the optimum prices (as defined for the purposes of the LP models that have previously been advocated).

This algorithm should be computationally more efficient than using LP but more importantly (because LP will be very fast, anyway) it is an easier algorithm to understand and to implement. This algorithm bears a strong resemblance to that advocated by Teicholz and Ashley (1978).
For the purposes of this research, this alternative algorithm is important because it provides proof of the cause of the outcome that all of the ‘optimum’ item prices (barring only one) will be prices that sit at the very edge of their acceptable pricing limits. In effect, all that the LP approach is shown to accomplish is to split the items into two sets: those to be allocated their maximum prices and those to be given their minimum prices, with one item remaining to serve to satisfy the finer details of the tender price constraint.

The problems are, principally, two-fold, as follows:

(1) that the risks from pricing have been found (Cattell et al., 2010) to not transcend from being non-existent within some range to suddenly being excessive outside of some sharp boundary; and

(2) that contractors are, furthermore, believed to be incapable of being precise with being able to recognise and thus set any such boundaries.

However, the precision of these limits is proven to be highly significant to the outcome of the use of these models. There is a 50% chance that any adjustment to any single limit will lead to a different solution (as regards offering a list of optimal prices): with each item adopting exactly either its lower or upper limit in each case.

Nevertheless, there is little basis for contractors to decide these limits and at best they can only do this with a fairly considerable degree of vagueness, rather than with any confidence of absolute sharpness.

5. Solution

Inuiguchi and Ramik (2000) suggest that Fuzzy Mathematical Programming and, more particularly, that Fuzzy LP is better suited to this nature of problem. Fuzzy LP provides a basis to recognise that, depending on the degree of confidence being sought in the outcome, the solution varies, taking account of the inherent imperfections in the precision to which each aspect of the input can be expressed, whether this is ambiguous in nature (being of either one value or another), or is vague (being, to some degree, fuzzy / blurred or not ‘sharp’ by nature).

The alternative, more typical approach to such challenges lies with stochastic modelling, such as by way of making use of Monte Carlo simulation. Stochastic models recognise the inherent uncertainty and inconsistency of financial data (amongst other areas of application).

Besides the inherent indefinite nature of the data involved, the other issue lies with recognising that risks increase gradually as prices become more extreme. They typically do not transcend from a state where the risks are non-existent to becoming entirely unacceptable, at any price point that is only marginally different. In mathematical terms, this is referred to as the transition from membership to non-membership of the feasible region. Furthermore, CUP Theory (Cattell, 2011) has shown that this rate of transition (from low-risk prices to high-risk prices) is different for different items and should be capable of being
determined. Thus, if a contractor is wishing to reduce their risk, they will find that changing to more moderate pricing for some items will yield more of a change to their risk than with other items. With this in mind, clearly any optimisation of this domain should seek to recognise these differences between items and not treat them all as having the same nature of risk profile. Changes to more moderate pricing with some items can be more effective as regards lowering risk whilst preserving profitability, relative to other items.

CUP Theory is, therefore, based on recognition that the problem with item pricing has not one, but two objectives. The one objective (that has been catered for by way of the abovementioned traditional approach using LP) is to seek the maximisation of the contractor’s profit. However, this approach fails to recognise the significance of a second objective: to also minimise the contractor’s risk. LP models are limited by catering for only one objective. However, Pareto optimisation facilitates that LP models can be manipulated so as to satisfy two or more objectives – even though the underlying mathematical mechanism (for instance, solved by way of the Simplex Algorithm) is restricted to having only one expressed objective function. Pareto optimisation caters for situations where the multi-objective aspect of a problem is nontrivial, i.e. where satisfying one objective distracts from - or competes with - satisfying another of the objectives. When objectives conflict, there are potentially an infinite number of optimal solutions and the chosen solution will depend on some degree of preference being given to one of the objectives at the expense of the others. This implies some degree of weighting having to be applied to each of the objectives.

In the case of item pricing, a model can be structured so as to have the single objective of maximising the contractor’s utility (as with CUP Theory), with utility being expressed as a function of both profit and risk.

6. Conclusion

This paper has provided proof that the popular structure of unbalanced bidding models, in which LP is used to maximise the profit and in which the problem of risk is catered for solely by way of item price limit constraints, delivers an unexpected and unwelcome solution. Rather than avoiding extreme pricing, these models instead serve to induce such pricing: pricing every item at the extreme edge of what is considered acceptable, even when the extent of these edges is difficult to determine.

Whilst almost all unbalanced bidding models have had this form, future models will benefit from a different approach – one that caters for the inherent uncertainties and also that caters for recognition that the risks climb as prices become more extreme and don’t simply switch over to becoming simply unacceptable at some magical single point of transition.

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Toward a Typology: cost overrun causes framework in infrastructure projects

Fahad Saud Allahaim\textsuperscript{1}, Dr. Li Liu\textsuperscript{2}

Abstract

The cost overrun of infrastructure projects potentially poses significant financial risks to the investment parties involved. Substantial cost overrun has been identified in infrastructure-project data from across 20 nations in five continents. Studies, in fact, show that the average cost overrun of infrastructure projects presents substantial fiscal risk (Flyvbjerg & COWI, 2004; Odeck, 2004; Flyvbjerg et. al., 2009). Yet, over the last several decades, the magnitude of cost overrun of infrastructure projects has failed to improve, suggesting that no significant learning has occurred in mitigating its detrimental effects.

The possible causes of cost overruns are numerous. They are dependent upon the unique characteristics and context of individual projects. According to Flyvbjerg et al. (2004), the two main causes of cost overruns are: optimism bias and strategic misrepresentations. Other studies have identified a spectrum of various causes for cost overruns. These include: technical factors such as lack of experience; the project size, design error, overall price fluctuations, inaccurate estimations, and scope changes (Love et al., 2011; Memon et al., 2011). The spectrum of possible causes makes the planning and management of projects especially challenging.

The objective of this research is to propose a conceptual framework to classify the causes and corresponding approaches to the management of cost overruns along pre-defined dimensions. The typology is developed according to the following steps: firstly, the empirical literature on infrastructure project cost overrun causes is reviewed and catalogued; secondly, based on the review a typology of cost overrun causes has been developed to provide a theoretical framework which organises and describes, parsimoniously, the pattern of relationships between types of causes, overrun and corresponding management approaches - thus simplifying the seemingly complex pattern of relationships. The typology study organises the main causes in four types (financial uncertainty, novelty, complexity, and time pressure) and develops a conceptual framework that identifies and explains patterns of relationships among causes, overrun and the corresponding management approaches within each category. Such a typology can be used to aid the assessment of

\textsuperscript{1} Ph.D. candidate, School of Civil Engineering, Faculty of Engineering and IT, The University of Sydney; Demonstrator, College of Architecture and Planning, King Saud University, [fall5762@uni.sydney.edu.au]

\textsuperscript{2} Senior lecturer, School of Civil Engineering, Faculty of Engineering and IT, The University of Sydney, [li.liu@sydney.edu.au]
cost overrun causes for large infrastructure projects and to effectively mitigate risks of significant overruns. Finally, we propose a plan to validate the typology empirically.

**Keywords:** Causes of Cost Overrun, Cost Overrun, Infrastructure Project, and Typology.

1. Introduction

Cost overruns in infrastructure projects are common around the world. High profile examples include: the Big Dig project in Boston which had a cost overrun of 500%; the Wembley Stadium that experienced a 50% cost overrun; and the Scottish Parliament Building that was over three years late and experienced more than 900% cost overrun (Love et al., 2011). In Australia, the Western Australian Perth Arena had an original contract value of AUD 168 million, but a cost overrun of more than three times this amount (Love et al., 2011).

According to Flyvbjerg et al. (2005; 2009) the average cost overrun for infrastructure large-scale projects could range from 20.4% to 44.7%; and nine out of 10 projects have cost overruns worldwide. Cost overrun is found across 20 nations and five continents covered by this study. Over the past 70 years, there have been no systematic improvements in cost overrun of infrastructure projects (Bruzelius et al., 2002).

Various causes of cost overruns have been identified. Studies have shown that technical factors lead to cost overruns, including lack of experience, project size, mistakes in design, overall price fluctuations, inaccurate estimations, etc. (Memon et al., 2011). Love et al., (2011) conducted a study on the causes of cost overruns via case studies on a hospital and a school. They found that technical factors (such as design errors) are the major causes leading to cost overruns.

According to Flyvbjerg et al. (2004), however, there are two basic reasons why projects experience cost overruns. Firstly, optimism bias encapsulates the systematic propensity of decision makers to be over-optimistic about outcomes of planned actions. Secondly, strategic misrepresentations are the misleading actions used in politicisations and economics, and by planners, to ensure projects proceed (Flyvbjerg, 2006). Traditional estimation practices have been shown to be particularly vulnerable to these detrimental effects, resulting in poor estimation accuracy in previous studies (Flyvbjerg et al., 2002).

It is apparent that there are a large number of causes of overruns and many share similar patterns of impact on overrun costs. Therefore, it will be functionally useful and conceptually meaningful to develop a typology of causes based on their impact on the overruns of infrastructure projects. Based on the review of empirical literature on the cost overrun of infrastructure projects, a typology of causes has been developed to aid the assessment of cost overrun causes for large infrastructure projects.

Below, background literature is reviewed and the research method is described. Then, based on the causes identified in the literature review, a typology of causes of cost overrun has been empirically developed. The proposed plan of validating the framework is explained. Finally, conclusions are drawn.
2. Theoretical Background

Cost is one of the main considerations throughout a project’s lifecycle and can be regarded as a significant parameter of a project and the driving force of project achievement. Despite its proven significance, it is not rare to observe a construction project failing to achieve its objectives within the specified, or even the approximate, estimated cost. Cost overruns vary significantly in scale from project to project. Yet, cost overrun is common to infrastructure projects (Azhar et al., 2008). Understanding the causes of cost overruns is critical to the success of infrastructure projects. Past studies have found significant, yet common cost overrun of infrastructure projects.

Pickrell (1990) carried out a study for the US Department of Transportation covering US rail transit projects with a total value of US$24.5 billion. The total capital cost overrun for eight of the projects was calculated to be 61% ranging from -10 to +106%. Another study by the Auditor General of Sweden (1994), covering 15 road and rail projects, revealed that the average cost overrun of eight road projects was 86%. The range for road projects was from -2 to +182%, while the average cost overrun for the seven rail projects was 17%, ranging from -14 to +74%. Another study by Fouracre et al. (1990), carried out for the UK Transport and Road Research Laboratory (TRRL), covered 21 metro systems in developing countries. The outcomes of the study showed that six metro projects had cost overruns above 50%. Two of these projects range up to 500%. Three had cost overruns in the range of up to 100%, and the remaining four ranged up to 50%.

Skamris and Flyvbjerg (1996, 1997) conducted a study in Denmark, in which they compared the accuracy of cost estimates on large-scale infrastructure projects. The study considered cost estimates of seven tunnels and bridges before the decision was made to build. The major conclusion from this study is that cost overrun of 50–100% is common for larger transportation infrastructures, and that overruns above 100% are not unusual.

Studies on causes of overrun have identified a wide spectrum of causes. Frimpong et al. (2003) identified 26 factors that cause cost overruns in the construction of groundwater projects. They found that, according to the contractors and consultants, monthly payment difficulties were the most important cost-overrun factor. Owners, however, ranked poor contractor-management as the most important factor. Although there were some differences in viewpoints among the three groups surveyed, there was a high degree of agreement among them with respect to their ranking of the factors. The overall ranking results indicated that the three groups felt the major issues which can cause extreme groundwater project-cost overruns in developing countries are: monthly payment difficulties; poor contractor management; poor technical performances; material procurement; and escalation of material prices.

In Kuwait, a study was done by Kouski et al. (2005) in which cost increases in the construction project was examined. The study found the three most important causes of cost overruns are contractor elide, material related problems and owners’ financial constraints. Other studies have identified four of the most important factors that cause cost overruns as:
design changes; inadequate planning; unpredictable weather conditions; and fluctuations in the cost of building materials (Kaming et al., 1997; Chimwaso, 2000).

Flyvbjerg et al. (2002) carried out a study on the cost overrun of road projects. Based on a sample of 258 infrastructure transportation projects valued at US$90 billion, they found that cost estimates used to justify the go-ahead of these projects are systematically misleading. They concluded that the underestimations observed cannot be explained by error, but are best explained by strategic interpretation - which is tantamount to deceitfulness (Flyvbjerg et al., 2002). They thus warn legislators, administrators and those who value honest numbers not to trust cost estimates and benefit-cost analysis produced by project promoters (Flyvbjerg et al., 2002).

Around the globe, many other researchers have been attracted to cost overrun. Asian and African countries have attracted particular attention. In Southeast Asia these researchers are: Kaming et al. (1997) in Indonesia; Ogunlana et al. (1996) in Thailand, Sambasivan; and in Malaysia, Soon (2007). Chan and Kumaraswamy (1995), Chan and Kumaraswamy (1997) and Lo et al. (2006) studied cost overrun in Hong Kong, and Acharya et al. (2006) studied it from a Korean perspective. Chang (2002) conducted surveys in the US. In Middle Eastern countries where petroleum and natural gas exports have played an important role in the economy, researchers are: Faridi and El-Sayegh (2006) in UAE, Koushki et al. (2005) in Kuwait.

In Africa, Frimpong et al. (2003) conducted studies in Ghana, as did Mansfield et al. (1994), and Abinu and Odeyinka (2006) in Nigeria. In Vietnam, large-scale projects were studied by Long et al. (2004a) to identify project success factors, and by Long et al. (2004b) to identify ordinary and general issues. Regarding these issues, the Vietnamese government declared the infrastructure project cost-overrun issues as the biggest “headache” (Le-Hoai et al., 2008, p.368) in recent times, especially with government-related funded-projects (Ministry of Planning and Investment in Vietnam, 2003, as cited in Le-Hoai et al., 2008).

Skamris et al. (1996) concluded that in most previous studies, technical factors such as changes in design and technological innovation can be explained as causes of cost overruns. However, there remains a considerable portion of divergence that cannot be clarified by technological causes alone (Odeck, 2004). In fact, Wachs (1990) pointed out that the probable cause of cost overruns in infrastructure projects is due to the inaccuracy of cost forecasts.

On the other hand, Flyvbjerg et al. (2004) argues about the main causes of the cost overruns. They postulate that these causes affect projects throughout their life cycle, and are due to misinformation in policy and the management of the project. Why projects experience cost overruns is firstly due to optimism bias that encapsulates the systematic propensity of decision makers to be overoptimistic about outcomes of planned action. Secondly, they relate to the strategic misrepresentation (deceitfulness) that misleads actions used in politicisations and economics, and by planners to ensure the projects proceed (Flyvbjerg 2006).
Doty and Glick (1994) typologies could constitute theory. Shenhar and Davir (1996) claimed that typologies are complex theories that can be subjected to rigorous empirical testing if typologies are properly developed and fully specified. According to Doty and Glick, “typologies do not provide decision rules for classifying organisations. Instead, typologies identify multiple ideal types, each of which represents a unique combination of the organizational attributes that are believed to determine the relevant outcome(s)” (1994, p. 232). Construction of a conceptual framework through a typology approach, as outlined by Doty and Glick, are required to meet the following criteria: “(a) constructs must be identified, (b) relationships among these constructs must be specified, and (c) these relationships must be testable” (1994, p. 233).

In this paper a new typology for cost overrun causes is proposed. First, causes of cost overrun in infrastructure projects have been identified from the literature review. Then, the causes have been grouped into types based on how they impact overrun. The limitation of understanding cost overrun causes creates differences in mitigating the causes effectively. Therefore, it is important to develop a conceptual framework to reduce the complexity of causes, and to facilitate effective understanding in management of such causes. By mapping studies to identify frequent causes of cost overrun through the literature review of data, we have identified a set of “ideal types”. Furthermore, the typology will be useful in predicting the dependent variables, when fully developed.

### 3. Conceptual framework of cost overrun

Through a comprehensive literature review, most of the causes that have frequently occurred are listed in the table below and measured, based on frequency. This has resulted in the identification of more than 90 causes of cost overrun, which are presented in table 1A in the appendix. Then, we developed a rough-cut typology by grouping factors sharing similar patterns of how it impacts on cost overrun (by identifying relationships between cause and overruns), fitting the factors identified to the rough-cut typology for further refinement. The causes have then been grouped into four types based on how the causes impact on overrun.

**Table 1: A typology of cost overrun causes**

<table>
<thead>
<tr>
<th>Causes of cost overrun</th>
<th>Frequency</th>
<th>Relationship to overrun</th>
<th>Ideal types</th>
<th>Description of each ideal type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in material prices, Inflation, Difficulties in obtaining construction materials at official current prices, Increase in wages, Labour cost increased due to environment restriction, Monthly payment difficulties from agencies, Cash flow during construction, Financial difficulties of owner, Financial difficulties of contractor, Slow payment of completed works, Fluctuation in money exchange rate, High interest rate charged by bankers on loans, Cash flow and financial difficulties faced by contractors, Shortage of materials, Deficiencies in cost estimates prepared by</td>
<td>32%</td>
<td>Increases the volatility of input costs and thus the chances of overrun.</td>
<td>Financial Uncertainty</td>
<td>This type represents factors impacting on the volatility of input costs for the project (Odeck, 2004).</td>
</tr>
<tr>
<td>Causes of cost overrun</td>
<td>Frequency</td>
<td>Relationship to overrun</td>
<td>Ideal types</td>
<td>Description of each ideal type</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------</td>
<td>-----------</td>
<td>-------------------------</td>
<td>-------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Lack of experience of project location, Lack of experience of project type, Inadequate contractor experience, Unexpected subsoil conditions, Poor technical performance, Impractical and complicated design, Inadequate modern equipment (Technology), Unpredictable weather conditions, Unexpected geological conditions, Unforeseen site conditions, Site constraint, Rock and soil suitability, Earth conditions, Deficiencies in the social structure, Social and culture impact, Problem with neighbours, Heritage material discovering experience in contract, and Inaccurate quantity take-off.</td>
<td>20%</td>
<td>Increases the uncertainty of tasks and outcome, thus making planning and estimating difficult.</td>
<td>Novelty</td>
<td>How new the project and the project solution is to the industry (Shenhar &amp; Dvir, 2007)</td>
</tr>
<tr>
<td>Deficiencies in the infrastructure, Labour problems, Insurance problems, Problems related to work security, Problems related to workers’ health, Additional works, Contractor’s poor site management and supervision, Shortage of site workers, Lack of communication among parties, Mistakes during construction, Relationship between management and labour, Slow information flow between parties, Inaccurate site investigation, Rework, Changes in material specification and type, Design error, Project size, Incomplete drawings, Inadequate specifications, Lack of skilled labour, Equipment availability and failure, Number of works being done at same time, Lack of constructability, Scope Change of the project, Insufficient equipment, Labour disputes and strikes, Owner interference, Obstacles from government, Laws and regulatory framework, and Delay of preparation and approval of drawings. Disputes on site, Political complexities.</td>
<td>38%</td>
<td>Increases the complexity of coordination of parties and tasks, thus making it harder to meet preset targets.</td>
<td>Complexity</td>
<td>Project complexity can be defined as consisting of many varied interrelated parts' and can be operationalized in terms of differentiation (the number of varied elements, e.g. tasks, specialists, components) and interdependency (the degree of interrelatedness between these elements) (Baccarini, 1996)</td>
</tr>
<tr>
<td>Unrealistic contract duration and requirements imposed, Incorrect planning and scheduling by contractors, Delay in material procurement, Poor design and delays in design, Late delivery of materials and equipment, Delay in decision making, Reasons that yield construction delays, Inadequate planning and scheduling, Delay in payment to supplier/subcontractors and Insufficient time for estimate.</td>
<td>10%</td>
<td>Forcing project team to take short-cuts, crashing, concurrent tasks/projects which are known to cause delays and overrun</td>
<td>Time pressure</td>
<td>This represents the urgency of the project, namely how much time there is to complete the job (Shenhar &amp; Dvir, 2007)</td>
</tr>
</tbody>
</table>

The four types identified in Table 1 are the ideal types of each group, which are; ‘financial uncertainty’, ‘complexity’, ‘novelty’, and ‘time pressure’. Each type will be ranked based on each variable. Figure 1 shows the framework of cost overrun and the scale of each type.
4. Research design

The research design of this paper is divided into three stages: empirical literature review, construction of a theoretical framework by using typology, and empirical validation. The typology has been developed via the following steps:

First, the empirical literature on infrastructure project cost overrun causes has been reviewed and catalogued. 26 studies on infrastructure projects have been selected (transportation, health, education, power and water). The selection is based on countries and citation of the publications. The literature covers developing and developed countries. The period of the literature reviewed is between 1990 and 2011.

Second, based on the review, a typology of cost overrun causes has been developed to provide a theoretical framework that organises and describes the relationships between types of causes, overrun and corresponding management approaches. Thus, the seemingly complex pattern of relationships has been simplified. The typology study organises the main causes in four types: financial uncertainty, novelty, complexity, and time pressure. It develops a conceptual framework that identifies and explains patterns of relationship among causes, overrun and the corresponding management approaches within each category. Such a typology can be used to aid the assessment of causes of cost overrun for large infrastructure projects and to effectively mitigate risks of significant overruns.

Finally, we have proposed a plan to validate the typology empirically. A survey has been used to validate the conceptual framework of cost overrun. The reason to conduct the survey in Saudi Arabia is twofold. First, the construction boom which started in 2005 is expected to go through a period of accelerated growth over the next few years, with a value of projects estimated at US $629 billion (Al-alrabia, 2012). The other reason is due to the lack of research on cost overrun in infrastructure projects in Saudi Arabia.
The survey questionnaire has been designed and distributed to experienced project managers and executive managers. The questionnaire poses specific questions to the respondents' that have most recently completed infrastructure projects (e.g. education, health, transportation, water, power and IT) with a contract value over 50 million Saudi Riyals (US $14 million), excluding operation and maintenance variables. The questionnaire consists of three sections: general information about the participant's experience; causes of cost overrun; and the frequency and severity of each of these causes, including the extent of cost overrun, respectively.

The first section contains questions about participants and their organisation, work experience, academic qualifications, the number of projects constructed within 20 years. In the second section, the participants are asked to scale the frequency of 40 cost overrun causes using this scale: (Never (N)=1, Occasionally (OC)=2, Sometime (S)= 3, Often (O), =4, Always (A)= 5). Furthermore, they are asked to scale the severity of the same causes within the following scale: (No significant (NS)=1, Some effect (SE)=2, Moderate (M)=3, Significant (S)=4, Extremely significant (ES)=5). They are also asked about their most recent involvement in a project regarding the overall major causes of cost overrun. The last section of the questionnaire elicits general comment in reference to the study.

Currently, we have received approximately 85 responses to the online questionnaire. The average experience of participants is 15 years with the average age of respondents being 45 years old. Water and transportation projects overall experienced cost overrun of 40%-60%. The overall causes were reported to be poor design, unclear project scope (owner), lack of experience of the contractor and consultants, poor planning and programming, and corruption between the contractor and subcontractor.

Subsequent to these findings, we will empirically examine a data set from the survey being conducted in Saudi Arabia to validate our framework. We will use factor analysis for the validation, due to the fact that we have developed a measure of cost overrun causes for the survey (explained above in this section). According to Thompson (2004) there are two discrete classes of factor analysis: exploratory factor analysis (EFA); and confirmatory factor analysis (CFA) to empirically validate the typology framework.

EFA is a statistical method used to uncover the underlying structure of a relatively large set of variables. EFA is a technique within factor analysis whose overarching goal is to identify the underlying relationships between measured variables (Finch and West, 1997). It is commonly used when developing a scale and serves to identify a set of latent constructs underlying a set of measured variables (Kline, 2010). It is not required to have any specific hypotheses about how many factors will emerge, and what items or variables these factors will comprise (Suhr, 2006).

CFA, on the other hand, is a special form of factor analysis. It is used to test whether measures of a construct are consistent with the understanding of the nature of that construct. As such, the objective of CFA is to test whether the data fits a hypothesized measurement framework. This hypothesized framework is based on analytic research
(Thompson, 2004; Schmitt, 2011). When developing a scale, it should use EFA before moving on to CFA (Thompson, 2004).

As a result, first, we will use EFA technique to inductively generate an alternative conceptual framework of the level grouping of cost overrun framework causes. Subsequently, we will test the ability of each of the competing frameworks to account for the underlying structure of the data, using CFA technique.

5. Conclusion

The purpose of this paper was to develop a conceptual framework to aid the assessment of cost overrun causes for large infrastructure projects, to identify the major types and to measure the relationship between causes and overrun. We were also interested in seeing how various causes would impact on cost overrun. Since there are many studies identifying various causes, we synthesized the empirical literature on infrastructure project cost overrun causes and analysed the frequency of cost overrun causes. The potential contribution of this study is in identifying an empirically derived typology of cost overrun causes, comprising financial uncertainty, novelty, complexity, and time pressure. Within each type, there exist similar patterns of relationships between causes and overrun, whilst the patterns between types are different.

Based on developing a conceptual framework from the literature review, the design seeks to empirically validate the typology framework. Therefore, this paper proposes a plan to validate the typology empirically via a survey that has been conducted in Saudi Arabia. We have used the questionnaire data for the analysis. The design is comprised of three steps. The first step is to construct the conceptual framework through typology theory. The next step is to validate the framework using two techniques of factor analysis which are: exploratory factor analysis (EFA); and confirmatory factor analysis (CFA).

References


### Table 1A: Mapping previous study

| Causes of cost overruns                                                                 | Z | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | D | F |
| Increase in material prices                                                            | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Inflation                                                                              |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 7 |
| Difficulties in obtaining construction materials at official current prices.          | 1 | 1 |   |   |   | 1 | 1 | 1 | 1 | 1 | 1 | 3 |   |   |   |   |   |   |   |   | 3 |
| Increase in wages.                                                                     |   |   |   |   |   |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   |   | 3 |
| Price fluctuations.                                                                    | 1 | 1 | 1 |   |   |   |   |   |   |   | 5 |   |   |   |   |   |   |   |   |   | 5 |
| Materials cost increased by inflation.                                                 | 1 | 1 |   |   | 1 | 1 | 1 |   |   |   |   | 1 |   |   |   |   |   |   |   |   | 2 |
| Labour cost increased due to environment restriction.                                   |   |   |   |   |   | 1 |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   | 2 |
| Monthly payment difficulties form agencies.                                            | 1 | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Cash flow during construction                                                          |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Financial difficulties of owner.                                                       |   |   |   |   |   |   |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   | 2 |
| Financial difficulties of contractor.                                                  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Slow payment of completed works.                                                       | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Market Conditions.                                                                     | 1 | 1 |   |   |   | 1 |   |   |   | 1 |   |   | 1 |   |   |   |   |   |   |   | 5 |
| Fluctuation in money exchange rate.                                                    | 1 | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Delay payment to suppliers/subcontractors.                                             | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Deficiencies in cost estimates prepared by public agencies.                           |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Deficiencies in the infrastructure.                                                    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Labour problems.                                                                       | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Insurance problems.                                                                    | 1 | 1 |   |   |   |   |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   | 4 |
| Problems related to work security.                                                     | 1 | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Problems related to workers’ health.                                                   | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Additional works.                                                                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Inaccurate quantity take-off.                                                          | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Lack of experience of project location.                                                | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Lack of experience of project type.                                                    | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Contractor’s poor site management and supervision.                                     | 1 | 1 |   |   |   | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Inadequate contractor experience.                                                      |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 1 |
| Shortage of site workers.                                                              | 1 | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Lack of communication among parties.                                                   |   | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Unrealistic contract duration and requirements imposed.                                |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Mistakes during construction.                                                          |   | 1 |   |   |   |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   |   | 4 |
| Relationship between management and labour.                                            |   | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Slow information flow between parties.                                                |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Inaccurate site investigation.                                                         |   | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Lack of coordination between parties.                                                  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 1 |
| Rework                                                                                 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Unexpected subsoil conditions.                                                         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 1 |
| Deficiencies in cost estimates prepared.                                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Poor technical performance.                                                            | 1 |   |   |   |   |   |   |   |   |   |   |   | 1 |   |   |   |   |   |   |   | 4 |
| Design changes.                                                                        | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |
| Incorrect planning and scheduling by contractors.                                      | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Delay in material procurement.                                                         |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 2 |
| Poor design and delays in design.                                                      | 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 3 |
| Late delivery of materials and equipment.                                              |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | 4 |

Appendix A
## Causes of cost overruns

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Using Pareto Principle plus statistic methodology in establishing a cost estimating model

Ivy Blackman¹, Eric Chan²

Abstract

Previous experience and research indicated that the Pareto Principle (80/20 Principle) has been widely used in many industries to achieve more with less. The study described in this paper concurs that this principle can be applied to improve the estimating accuracy and efficiency, especially in design development stage of projects. In fact, establishing an effective cost estimating model to improve accuracy and efficiency in design development stage has been a subject, which has attracted many research attentions over several decades. For over almost 40 years, research studies indicate that using the 80/20 Principle is one of the approaches. However, most of these studies were built by assumption, theoretical analysis or questionnaire survey. The objective of this research is to explore a logical and systematic method to establish a cost estimating model based on the Pareto Principle. This paper includes extensive literatures review on cost estimating accuracy and efficiency in the construction industry that points out the current gap of knowledge area and understanding of the topical. These reviews assist in developing the direction for the research and explore the potential methodology of using the Pareto Principle in the new cost estimating model. The findings of this paper suggest that combining the Pareto Principle with statistical analysis could be used as the technique to improve the accuracy and efficiency of current estimating methods in design development stage.

Keywords: Pareto Principle, Cost Estimating Model, Cost Estimating Testing

1. Background

The study described in this paper is intended to explore a logical and systematic method to establish a cost estimating model using the Pareto Principle (80/20 Principle), which was proposed, by many academics (Yu, Lai and Lee, 2006), to be used in the early cost estimating stages of projects to improve the cost estimating accuracy and efficiency.

Previous experience and research indicated that the 80/20 Principle has been widely used in many industries to achieve more with less (Korch, 1998). The research described in this paper considers that the Pareto Principle can also be applied to the Quantity Surveying field.
to establish cost estimating models through a logical and systematic method. This study has faith in the established cost estimating model in assisting the quantity surveyor to improve the understanding and skills of conducting the cost estimating in the early budgeting and cost planning stages of projects, such as the concept and sketch design stages. Most importantly, it is also believed that the proposed cost model will enhance the efficiency and accuracy of the cost estimate. The possible future study is listed in the conclusion. The objective of the research described in this paper is to prove that the Pareto Principle could be used to set up a logical and systematic method in establishing and testing an elemental cost estimating model in the early pre-tender stages.

2. Literature Review

In the mid 1960s, Stone (1966) suggested the building industry is one of the most important activities in any economy. It can account for 8% to 10% of national employment. The importance of the construction industry in a national economy has been established by scholarly work in the field of economics. Smith (1998) concluded that the construction industry consistently contributes 7% to 10% to the GNP (Gross National Product). Ashworth (2004) agreed with this, and he suggested that the construction industry is an important industry worldwide, even in poor countries. He described how governments regard the construction industry as an economic regulator, an important tool in government’s management of the economy. In Australia, according to ABS (2012), during 2010-2011, construction is the 3rd GDP contributor with 7.7% share after Finance and Insurance Services with 9.7% and Manufacturing in 8.1%. At August 2012, there was nearly one million people employed, representing 8.5% of the total workforce (ABS, 2012a). Therefore, it is essential to continuously investigate and regulate the building economy.

2.1 Building Economics

Before going into the specific field of the cost estimate accuracy, it is worth introducing the more general areas, such as “building economy”, “cost planning of buildings”, “building economy” and “estimating and cost control”. In the 1950s and 1960s, a booming population caused a dramatic increase in demand for construction work in the world; especially an increased demand for housing. Building projects became larger and more complex. Therefore, there was a need to officially establish “building economics” as a research subject. Many researchers have studied building economics since then. Ashworth (2004) listed the building economics texts from 1950s to 2000s, which includes more than thirteen studies. Nisbet (1961) concluded that cost plays its part throughout every stage of the whole design and building process. Cartlidge (1973) agreed with this assertion and advised that throughout the design development, cost had a continuous influence on a building project. Cost planning plays a very important role in decision-making in the building industry. For a small building owner, building investment might be once in a lifetime decision. For a larger building owner, cost planning would affect their future investment policy. Ferry, Brandon and Ferry (1999) suggested that the developer or investor is likely to be affected most by cost planning. They analysed the impact of cost from the developer’s viewpoint and identified cost planning has a role in profit development, social or public sector user development, private user development and mixed development.
2.2 Cost Estimating Accuracy in the Building Economics

Due to the important role highlighted above that cost planning plays in the construction industry, many research studies suggested that cost estimating accuracy has always been one of the important topics in the building economic and the cost planning. Ferry Brandon and Ferry (1999) described how the government recognised that unrealistic cost rules can lead to bad design. Therefore, the government would put enormous efforts to allow money saved in one direction, which could be spent in another. Most importantly, tantamount efforts were also put in to work out complex cost criteria to achieve accuracy. In 1973, Trimble and Jupp developed cost models using regression techniques for various facets of building work. In 1981, Bennett stated that the key activity in the quantity surveying profession’s cost planning service is cost estimating. The main task is to improve the estimating accuracy. Morrison (1984) examined the accuracy of cost estimates prepared by quantity surveyors in the design stage of construction projects. He suggested that the most likely area for improvement lies in developing methods of using large cost databases. Skitmore (1985) strongly agreed the importance of the availability and adequacy of the essential cost information in the accuracy of cost estimation.

2.3 Using Pareto Principle in the Construction Industry

Therefore, it is viable to adopt a logical and systematic method based on the Pareto Principle and establishes a cost estimating model to improve the cost estimating accuracy and efficiency. This 80/20 Principle was identified by an Italian economist – Vilfredo Pareto in 1906. He found that a minority of the people held most income and wealth. He also discovered that a consistent mathematical relationship exists between the proportion of people and the amount of income or wealth that this group has (Koch, 1998). Today, this Principle has become a golden rule in the management field to help millions of managers separate the “vital few” from the “useful many” in their activities (Reh, 2002). The reason that the 80/20 Principle is so valuable is, because this principle asserts the pattern of imbalance exists everywhere, in everything. The imbalance relationship may be 65/35, 75/25, 80/20, 95/5 or any set of numbers in between.

From 1980s, the 80/20 Principle was widely adopted in the construction industry. Ashworth and Skitmore (1982) and Thompson (1981) suggested that 20% of the items of a bill or quantity contained 80% of the value. Shereef (1981) developed an alliterative estimating, which predicted an accuracy of +/- 5% without pricing more than 30% of items in the bill of quantity. Bennett (1981), POH and Harner (1995) and Morrison (1984) agreed that the majority of the cost lies in a small number of ‘cost significant’ items. Shaket et. al. (1986) established a cost significant model, which can be used both to estimate and control construction projects. This model contains only 10% to 20% of the items in a conventional bill of quantities.

2.4 Improving Cost Estimating Accuracy by the Pareto Principle

Further to the various research studies described above, there also have been many studies investigating the possibility of using the Pareto Principle to improve the cost estimating
Curran (1989) studied to link the Pareto Principle with cost estimating accuracy and efficiency together. He found that in almost all project estimates the uncertainty is concentrated in a select number of critical items. Curran further suggested that relatively small items are often critical while very large ones may not be critical at all. Further to his study above, Curran (1989) developed the Range Cost Estimating, which can significantly reduce the risk of overestimating or underestimating associated with cost estimation. Range estimating is a risk analysis technology that combines Monte Carlo sampling, a focus on the few critical items, and heuristics (rules of thumb) to rank critical risks and opportunities. This approach is often used to establish the range of the total project estimate (Humphreys, 2008). Furthermore, Humphreys (2008) use Curran’s research and Monte Carlo analysis techniques to determine probabilities and contingency in a reliable manner.

Later on, Raftery (1994) suggested that 80% of the project cost might be accounted for by measuring the largest 20% of the units of finished work. However, he indicated that this ratio is just a rule of thumb. Whether 80% of the project cost is covered by 20% of the items measured in the bill of quantities depends on which method of measurement was used. Horner and Zakieh (1996) agreed and indicated that it is possible to aggregate cost significant items into cost significant work packages, which represent a consistent and high (close to 80%) proportion of the total value of any project in the same category. Therefore, the total value of a project can be determined by pricing the relevant cost-significant work packages (Asif and Horner, 1989). In 1998, Koch simply stated that the Pareto Optimum Criterion suggests 80% of the overall project cost determined by 20% of the cost items. Therefore, instead of estimating the quantities of all cost items, only the top 20% most significant cost items’ quantities were estimated and their related unit prices were sought. With the Pareto Optimum Criterion, almost 80% of estimation cost and time can be saved; not only does it reduce the cost but also expedites the estimation process.

Yu, Lai and Lee (2006) used the 80/20 Principle to create a web-based intelligent cost estimate (WICE) system, which fulfils the need for real-time response to construction cost estimating and to increase the estimate accuracy. The author recognised there are two construction cost elements - quantity of the cost item and unit price of the cost item. They used the 80/20 Principle to accommodate the changes of unit price and indicated that 80% of the overall project cost is determined by 20% of the cost items. Therefore, WICE only estimates the top 20% most important cost items and their related unit prices. This does not only reduce the cost, but also expedites the process of estimation.

As shown, over some 40 years, the 80/20 Principle has been used to develop the cost estimate models in order to improve the cost accuracy and efficiency in the construction industry. Academics suggested that the cost estimating accuracy topic has attracted more and more attention from the construction industry participants and academics. However, comparisons with other research topics of the construction industry, the number of study carried out to test, examine and review the reliability and effectiveness of the cost estimating model is still limited. Therefore, in one aspect, the study described in this paper proposed to use the 80/20 Principle to set up a logical and systematic method in establishing an elemental cost estimating model to improve the accuracy and efficiency of cost estimating. In
another aspect, this study also tests and validates the reliability and effectiveness of the established cost estimating model including the theory.

3. Methodology

The literature review above revealed the history and development of cost estimating modelling and the cost estimating accuracy. The Pareto Principle has been identified as one of the most constructive theories, which could be used to establish cost estimate models. The application should include two phases. Phase 1 is about the establishment of the cost estimating model based on the Pareto Principle. This includes applying 80/20 Principle and using statistical methodology to analyse cost data and test the statistical analysis results. This follows by Phase 2 which is interpreting and validating the statistical analysis methodology in order to test and validate the theory and cost estimating model established in precedent phase.

3.1 Phase 1: Proposed Analytical Method

This study mainly uses the statistical methodology as the analytical method. Statistics is widely used by individuals and organizations to analyse and understand data in order to make judgments and decisions throughout the natural and social sciences, medicine, business, economics and other areas (Corty, 2007). The main perspective of this study involving the analysis the correlation study examining the extent to which differences in one variable were related to differences in another variable (Leedy and Ormrod, 2005). Therefore, the statistical technique of regression analysis would be a suitable method of deriving a cost model (Buchanan, 1972). The analysis was carried out using multiple regression to examine the data and the SPSS (Statistical Package for the Social Sciences) was used in this study to assist in the statistical analysis, because it is one of the most used computer programs for statistical analysis in the social science (Argyrous, 2011). Two types of regression analysis were applied in this study.

- Stage 1 (Multiple Regression Analysis) – the establishment of the cost estimating model
- Stage 2 (Bivariate Regression Analysis, also named as Linear Regression Analysis) – the testing of the cost estimating model

3.1.1 Stage 1: Multiple Regression

In Stage 1, the multiple regression is used to establish the cost estimating model. Multiple regression is an extension of the linear regression analysis, in which several independent variables (IVs) are combined to predict a value on a dependent variable (DV) for each subject. The equation 3.1 below represents the best prediction of a DV from several continuous IVs:

\[ Y' = A + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + ... + B_kX_k \]  
(Eq. 3.1)
Where Y’ is the predicted value on the DV, A is the Y intercept (the value of Y when all the X values are zero), the Xs represent the various IVs (of which there are k), and the Bs are the coefficients assigned to each of the IVs during regression (Pallant, 2007). Pallant (2007) concluded that each independent variable is evaluated in terms of its predictive power, over and above that offered by all the other independent variables. The multiple regression analysis could also indicate how much unique variance in the dependent variable each of the independent variables explained. The elemental costs studied in this research were defined as the independent variables. The total cost analysed in this study was defined as the dependent variable. The standard multiple regression of SPSS categorised by Pallant (2007) was used to carry out the establishment of the cost estimating model in Stage 1. The primary goal of the regression analysis in this study is to investigate the relationship between the total cost and the elemental costs. Through the analysis, this study could identify what are the essential elemental costs to predict the total cost. The multiple regression analysis is also used to find the best prediction equation. There are 3 questions asked in the correlation study which are listed as below:

- How well do the independent variables (elemental costs) predict the dependent variable (the total cost)?
- How much variance in the total cost can be explained by those elemental costs?
- Which elemental costs have the strongest correlation relationships with the total cost? Which elemental costs have the weakest correlation relationships?

3.1.2 Stage 2: Bivariate Regression (known as Linear Regression)

Stage 2 is to test the reliability and effectiveness of the cost estimating model established in Stage 1 including the supporting theory. There are two variables included in Stage 2:

- Total cost of the project – calculated using the equation composed by the major cost contribution elements investigated using Equation 3.1
- The winning tender price – the successful contractor tendering price at the tender stage of each project

Bivariate regression has the ability to predict scores on one variable from scores on another variable. This is also called the simple regression, which is to discover the correlation relationship between two continuous interval variables. Therefore, Bivariate Regression was adopted in this stage.

Overall, in both multiple regression and bivariate regression analysis, this research carried out the process in using the Pareto Principle as a logical and systematic method to establish and test the cost estimating model based on the elemental costs excluding the preliminaries, overheads and profits. One of the purposes to analyse the elemental costs excluding preliminaries, overheads and profits is to eliminate the differentiation between each data. This can ensure the validation of the statistical analysis.
3.2 Phase 2: Interpretation of output from the statistical analysis

Following the above description regarding Phase 1 of this study, the interpretation of output from the statistical analysis can be defined into two parts:

- Part 1 – the establishment of the cost estimating model, this research used the Multiple Regression Analysis.
- Part 2 – the testing of the cost estimating model, this research used the Bivariate Regression Analysis (linear regression analysis).

3.2.1 Establishment of the cost estimating model

This part is to combine the multiple regression analysis and the Pareto Principle to establish a cost estimating model, which uses the major cost elements to predict the total construction cost of projects, especially in the early stages of the projects. In this part, five steps are taken to illustrate the details of the findings.

- Step 1: Analysing multi co-linearity

Multi co-linearity is designed to assist the researcher to analyse whether there is at least some relationship between the elemental costs and the total cost. This step also checked that the correlation between each elemental cost was not too high. If there are strong relationships between elements, these relationships will distort the final results of the multiple regression analysis regarding the relationships between the element costs and the total construction cost. The study referred the Pearson’s correlation coefficient between two independent variables shown on the Correlations table to assess whether there were any concerns in terms of multi co-linearity. A correlation of 0.7 or more is the warning sign (Tabachnick and Fidell, 2007). In this study, if two of the elemental costs were highly correlated, one of these costs would be omitted.

- Step 2: Checking outliers, normality, linearity, homoscedasticity and independence of residuals

The second step is to check the outliers, normality, linearity, homoscedasticity and independence of residuals. These critical values could be tested by a number of methods — Normal Probability Plot of the Regression Standardised Residual and Scatterplot.

- Normal Probability Plot – a reasonably straight diagonal line from bottom left to top right suggests no major deviations from normality, which means there is no presence of outliers.
- Scatterplot – If the Scatterplot of the standardised residuals does not achieve a roughly rectangular distribution (with most of the scores concentrated in the centre), this suggests that deviations and violations exist. Tabachnick and Fidell (2007) define outliers as cases that have a standardised residual of more than 3.3 or less than -3.3.
Tabachnick and Fidell’s (2007) concluded that with large samples, it is not uncommon to find a number of outlying residuals. If only a few residuals are found, it may not be necessary to take any action. In a normally distributed sample, only 1 per cent of cases would be expected to fall outside this range.

- **Step 3: Evaluating the model**—Identifying how much of the variance in the dependent variable can be explained by the model including all independent variables.

This step looks in the Model Summary box and check the value given under the heading R Square. The R Square can indicate how much of the variance in the dependent variable (total cost) is explained by the model, which includes all the independent variables (elemental costs). For a small sample, the Adjusted R Square value provides a better estimate of the true population value than the normal R Square value (Tabachnick and Fidell’s, 2007).

- **Step 4: Evaluating each of the independent variables**

This step is to answer the third question listed above, which of the variables included in the model contribute to the prediction of the dependent variable? This information is labelled as “Coefficients”. The Beta value under Standardised Coefficients can be used to compare the different variables. 'Standardised' means that these values for each of the different variables have been converted to the same values so that the comparison is feasible. The larger the Beta coefficient value is, the stronger the unique contribution the particular elemental cost makes towards explaining the total cost, and vice versa. The value of “Sig” indicates whether a variable is making a statistically significant unique contribution to the equation. If the Sig. value is less than 0.05, the variable is making a significant unique contribution to the prediction of the dependent variable. If the Sig value is greater than 0.05, then that variable is not making a significant unique contribution to the prediction of the dependent variable Tabachnick and Fidell (2007).

- **Step 5: Determining the cost estimating equation**

This step is to use the results from Step 1 to Step 4 to establish the cost estimating model. This study used the cost per square metre as the measurement unit. Cost per square metre is the cost predictor most used by quantity surveyors, as it provides a measure of cost that is essentially independent of building size (Emsley, Lowe, Duff, Harding and Hickson, 2002). This was also applied to price/m2 and price/ft2, which could be calculated as (cost/m2 = total construction cost divided by gross floor area (GFA). GFA equals to FECA (Fully Enclosed Area) plus UCA (Unenclosed Area). In this study, further to Equation 3.1 listed in Section 3.1.1, when all the X value are zero, the value of Y is zero as well. Therefore, the above equation is rewritten as the below Equation 3.2:

\[ Y' = B_{X_1} + B_{X_2} + B_{X_3} + B_{X_4} + \ldots + B_{X_k} X_k \]  

(Eq. 3.2)
3.2.2 Testing the cost estimating model

As described in the introduction paragraph of Section 3.1, the second stage is to test the cost estimating model using Bivariate Regression. The relationship analysed is the total construction cost predicted using major elemental costs excluding preliminaries, overheads and profits and the winning tender prices. According to the statistical theory of Bivariate Regression (Corty, 2007), three assumptions have been made.

1) Two variables were considered.

   Independent Variable X – The predicted construction cost, calculated by the equation with the major elemental costs ($/m2)

   Dependent Variable Y – The winning tender price ($/m2).

2) Hypothesis.

   The null hypothesis, \( H_0 \) is \( \rho_{xy} = 0 \)

   States that there is no linear relationship between the predicted construction cost and the winning tender price.

   Thus, the alternative hypothesis, \( H_1 \) is \( \rho_{xy} \neq 0 \)

   States that there is a linear relationship between the predicted construction cost and the winning tender price, and the observed correlation in the sample will reflect this.

3) The hypothesis is non-directional, therefore, a two tailed test is applied.

The statistical test used in this study was the Pearson product moment correlation coefficient, since the relationship between two interval level variables were examined (Corty, 2007). Three steps were set up for the statistical study of the testing.

- Step 1: Pearson product moment correlation coefficient 'r'

The Pearson product moment correlation coefficient \( r \) is used to verify the hypothesis. The \( r \) is value obtained from the linear regression analysis is described as follows:

1) According to the basic statistical rule, firstly, set up the Type I error as \( \alpha = 0.05 \) means that there is 5% chance making a Type I error. A Type I error is that we reject the null hypothesis when it is true. The intention of the test is to find there is a linear relationship between the two variables. Secondly, find the critical values of \( r \) — \( r_{cv} \) (Critical Values of \( r \) for Pearson Product Moment Correlation Coefficients When \( \rho = 0 \) (Corty, 2007), which is the cut-off point for rejecting the null hypothesis.), based on the sample size.
2) Use the $r^2$ obtained by using SPSS software to calculate the absolute value of the observed value of $r$. If $r > r_{cv}$, then the null hypothesis is rejected. This indicates that there is a linear relationship existing between the predicted construction cost and the winning tender price.

- Step 2: Examining the strength and the meaningfulness of the correlation

As labelled above, this step is to examine whether the linear relationship between the predicted construction cost and the winning tender price is strong. In other words, examining the strength is to validate whether the predicted construction cost based on the major elemental costs is capable of forecasting the winning tender price. From the statistical principle, if the hypothesis is statistically different from zero, the next focus is to prove the statistical significance. Statistical significance means that the observed difference between samples is large enough to reflect a difference between populations, and the possibility of obtaining such a difference by chance is low. Practical significance means having a meaningful effect, and having relevance in practice (Corty, 2007). Three tests are applied to quantify the predictive capacity of a correlation coefficient, which could prove whether statistical significance represents practical significance.

1) Test I – Testing the strength of correlation, by creating a confidence interval of $r$ at the 95% level (the most commonly calculated interval). The narrower the confidence intervals for a Pearson $r$, the smaller range within which the “real” correlation value, the population parameter, falls.

2) Test II – Testing the strength of association, by calculating a coefficient of determination with $r^2$. Cohen (1988) offered the ‘effect size’ theory about correlation in the social and behavioural sciences. He suggested that a variable that predicts $\approx 1\%$ of variance has a small effect; one that predicts $\approx 10\%$ of the variance has a medium effect; and one that predicts $\approx 25\%$ has a large effect.

3) Test III – Testing the statistical power with $r$. The statistical power is the probability of correctly rejecting the null hypothesis. Power is defined as $1 - \beta$. $\beta$ is a Type II error, which is incorrectly failing to reject the null hypothesis. The accepted convention is to set $\beta$ at 0.20, and make power at 80%. This test is used to compare the calculated power from samples with conventional power in order to determine whether the power is significant enough and to find the minimum case number of samples.

In conclusion, the methodology can be displayed as the following flowchart Figure 1.

4. Conclusion

This paper has set out the literatures and methodology framework to set up a logical and systematic method in the establishment of the cost estimating model by using the Pareto Principle in order to improve the cost estimating accuracy and efficiency. This study described in this paper has also demonstrated the method of testing the reliability and
effectiveness of the cost estimating model with the provisional theory. In the last four decades, the improvement of the cost estimating accuracy and efficiency has been a recurring subject in building economics. However, literature reviews suggested that the number of research studies directly investigating the methodology of testing and validating the reliability and effectiveness of the cost estimating model including the provisional theory is limited. Therefore, the need of carrying out this study is identified.

The methodology described in this study represents the outset of a series of investigation regarding using the Pareto Principle to discover a logical and systematic method in establishing and testing a cost estimating model in order to improve the cost estimating accuracy and efficiency. Further research could be:

- Conduct further analysis using the low-rise residential projects to test the theory described in this study
- Conduct further analysis using other types of projects, such as the high-rise residential projects and the office buildings.
- Conduct further analysis applying the same method on the trade format

These possible future works are to further prove the reliability of the methodology described in this paper. This also enables the finding of the logical and systematic method described in this study can be widely used in the building industry throughout different types of projects. However, there are some possible underlined issues, which the researchers would have to face. First of all, it is difficult to obtain a sufficient sample due to the poor data keeping habit and the sensitivity issue of the cost data in the construction industry. Second is the limitations regarding the assumptions of multiple regression used in the scientific and commercial fields – Theoretical Issues and Practical Issues (Green, 1990), which would could be further investigated and discussed in the future studies.
**Figure 1: Methodology Flowchart**

**References**


Variable Productivity in Earthwork Services of Roadwork’s in Brazil: the Divergence between the Opinions of Different Budgeting Manuals

Dornelas Ricardo Cruvinel\textsuperscript{1}, Souza Ubiraci Espinelli Lemes\textsuperscript{2}

Abstract

\textbf{Introduction:} The participant agents in the chain of Civil Construction have increasingly been charged as its efficiency increases, as a result of a series of changes in the market, such as intensification of the competition among the active companies, the larger consumer awareness and more effective control by the Government. Therefore, the agents of Civil Construction have been working in order to seek such increase of competence, which can lead to changes in the indicators used in the unitary compositions available to assist the prediction of costs. Thereby, it is considered necessary the continual improvement of systems of productivity indicators to mark the analysis of costs in Civil Construction. \textbf{Study objectives:} This work studies the productivity variation in the highway earthwork and discusses the differences among the opinions of Brazilian budget manuals. \textbf{Methods:} Based on the Model of Factors (this approach entails the prediction based on aspects observation related to a greater or lower expectation of efficiency of equipment in a certain service), the selection of research methods covers the objectives outlined, including literature review, exploratory studies and field surveys. \textbf{Conclusions:} Regarding services of highway earthwork, there are many manuals, however each one deals with the execution steps differently and the productivity indicators presented are extremely variable. Furthermore, it is not possible to know (reading the manual) which factors were considered when the manual indicates a specific value for a certain service. Accordingly, its usage (the manuals) as a tool for budgeting and management is inefficient. The result of budget manuals study is presented and new methodology is proposed.

\textbf{Keywords:} productivity, earthwork, highway infrastructure.

1. Introduction

Providing infrastructure represents major public investments and a long-term planning. It is essential that the functionality is in line with the useful life of the enterprise. Its usage spans several generations during which the society will pass for dramatic changes. This long period of time means that the development in transportation of people and goods should be

\textsuperscript{1} PHD student and Professor; Department of Civil Engineering; University of Sao Paulo and Federal University of Goias; Rua Antonio Horacio Pereira, 1830, Catalao, GO, Brazil, 75705-150; ricardo.cruvinel@catalao.ufg.br.
\textsuperscript{2} Professor; Department of Civil Engineering; University of Sao Paulo; Av. Prof. Almeida Prado, trav. 2 n\textsuperscript{o}. 83, Cid. Universitaria, Sao Paulo, SP, Brazil, 05508-900; ubiraci.souza@poli.usp.br.
assessed and planned quite in advance in order to make the right choices not only for today but also for tomorrow (Fehrl, 2008).

Aware of this reality and the social importance and needs of the sector, between 2007 and 2010 several works were completed in Brazil: 1.306 kilometers of roads were doubled, 1.789 kilometers were paved and 3.282 kilometers were granted to private companies, which manage 15.000 kilometers - less than 1% of the paved mesh. There are duplication works on 1.592 kilometers and 3.524 kilometers of pavement in execution, besides signposting and maintenance services hired for more than 50.000 kilometers of network. For the private sector, there is immediate potential to grant, at least, over 12.000 kilometers (Abdib, 2011).

1.1 Available pointers of productivity

In general, the execution of a highway is through the hiring of private companies by public organs, preceded by public bidding. The highway budgets are the result of the combination of quantitative services extracted from projects and the compositions of unitary prices of services (Pedrozo, 2001).

In Brazil, for the forecast of the productivity the cost data manual use is common. However, it is perceived in practice, that the productivity pointers can have a great variability requiring knowledge of the factors that make them vary.

In the revision / perfection work developed for the Polytechnic School of São Paulo, USP (EPUSP, 2008) of the prognostic costs effected by the Brazilian Federal Government for the airport construction it was found a great variability of relative efficiencies to the pavement service (according to study in construction and consults to specialists, manuals and technical documents). Examples of variability are presented in Figure 1.

![Figure 1 – Change (%) among the yields for the excavation service (number of equipment hours to launch a cubic meter of soil)](image)

This example, which varies from 771% to 1874%, is a warning about not being able to make reliable decisions based on imprecise indicators.

1.2 Study objectives

This paper proposes studies of productivity variation in the highway earthwork in Brazil and discusses the differences among the instructions from Brazilian budget manuals. Built on the concept of productivity variable (unprecedented in the subsector of heavy construction) and it uses the approach of Model Factor. This approach entails a prediction based on careful
observation of various aspects related to a greater or lesser expectation of labor productivity and the efficiency of equipment in a particular service.

2. Material and methods

The improvement of understanding the productivity of highway earthwork started from the finding that many available methods assume postures that prevent them from making different decisions: those related to budgeting to those associated with production management.

Thus, the following steps were developed: a) expert opinion survey; b) use of theoretical and empirical methods; c) review the different executive phases of each type of service; d) present the indicators of these services through ranges of values (representing the variable productivity), e) and allies to the tracks are the guiding factors for the decision on what value to adopt. Therefore, based on ranges of values (productivity variable), and abnormalities of the factors that affect the productivity of earthwork, data obtained from eight sources studied (five books and two case constructions), and grounded in bibliographical studies, presents the following is the proposal to improve the understanding of productivity. This proposal aims to apply the concepts of variable productivity in Earthwork Services of Roadwork’s.

The following criteria were used to choose the Brazilians manuals adopted in this work: technical recognition; degree of detail as the description of the cases examined, avoided use of manuals with the same sources of information.

The manuals used in this study are derived from the following sources:

a) National Department of Transport Infrastructure – DNIT (Brasil, 2007);

b) Company of Public Works of the State of Rio de Janeiro – EMOP (EMOP, 1999);

c) Municipal and Urban Infrastructure Works – SIURB (Sao Paulo, 2010);

d) Composition Table Prices Budgets – TCPO (TCPO, 2008);

e) Department of Civil Engineering at the Polytechnic School of the University of São Paulo (EPUSP, 2008).

The results of data collection processing and the posterior analysis are originated from the system presented in Figure 2.
3. Divergence between the Brazilian budget manuals

Amongst the services related to the highway asphalt pavement construction, aiming at illustrating the application of the productivity improvement, the service of the earthwork will be presented as follows.

In the study effected in some cost data manuals the variety of equipment teams met a great difference and the same enters the productivity adopted for service. The variations found were: a) Harrow to Farm Tractor was 313%; b) Motor Graders was 270%; c) Soil Compactor was 123%; d) Water Truck was 278%; e) and Farm Tractor was 303%. Table 1 illustrates this situation.

<table>
<thead>
<tr>
<th>Discrimination</th>
<th>DNIT</th>
<th>EMOP</th>
<th>SIURB</th>
<th>EPUSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harrow to Farm Tractor</td>
<td>313.2</td>
<td>175</td>
<td>100</td>
<td>138.9</td>
</tr>
<tr>
<td>Motor Graders</td>
<td>539.4</td>
<td>350</td>
<td>200</td>
<td>285.7</td>
</tr>
<tr>
<td>Soil Compactor</td>
<td>215.7</td>
<td>175</td>
<td>200</td>
<td>208.3</td>
</tr>
<tr>
<td>Water Truck</td>
<td>156.6</td>
<td>175</td>
<td>100</td>
<td>277.8</td>
</tr>
<tr>
<td>Farm Tractor</td>
<td>303.4</td>
<td>175</td>
<td>100</td>
<td>277.8</td>
</tr>
</tbody>
</table>

4. New approach for productivity prediction

The method of prediction of productivity of asphalt paving services, proposed here, is divided into five parts, as the matters described below:

a) Unitary Production Ratio;

b) Unitary Production;

c) Model of factors;

d) Use of Quartile;

e) Details of equipment hours.
According to Souza (1996), productivity could be defined (Figure 3) as the efficiency (and, to the extent possible, the effectiveness) in the transformation effort by workers or equipment on construction products (the work or its parts).

![Figure 3 – Definition of productivity](image)

### 4.1 Unitary Production Ratio

The accepted definition of productivity shown in Figure 3, Souza (2006) suggests adopting the indicator called unitary production ratio (RUP) as a measure of productivity by linking the human effort, measured in hours x men (Hh) or equipment x time (Eqh), with the amount of work performed, *Equation* (1). It is emphasized that, according to the setting made, a high value indicates productivity worse than a low value.

\[
RUP = \frac{Hh}{\text{Amount of service}}
\]  

(1)

### 4.2 Unitary Production

The unitary production (PU) translates the amount of service produced for the equipment (or workers) at the moment available for the service. He is the inverse one of the RUP, *Equation* (2).

\[
\text{Unitary Production} = \frac{1}{RUP} = \frac{\text{Amount of Service}}{H \text{ available to the service}}
\]  

(2)

### 4.3 Model of factors

According to Souza (2006), the unitary production (PU) of equipment and labor may vary according to age rather large amplitude. Figure 4 justifies the assertion that demonstrates that the production unit for the compression landfill ranges from 884 m²/h to 2746 m²/h. The wide variation in the unitary production for the construction work force leads to the following conclusion: we cannot make good decisions without the knowledge of such ranges and the reasons why they change.

![Figure 4 – Range of variation of the production unit: compression landfill (m² / h)](image)
It has arrived, then, to another important question: why does the unitary production of the equipment and the labor vary?

Conceptually, the model of factors would have an answer to the question. In an attempt to classify the factors potentially altering the unitary production presented in the various parts of the production process, it is said that the unitary production can be influenced in the presence of the normal manner by factors linked to the content and related to factors having the service context under consideration. In addition, the unitary production can be changed when anomalies occur. They are usually factors related to the content on the characteristics of the "product" running and "processed resources" such as materials and components. The context factors normally associated with "processing resources" such as labor and equipment and the "boundary conditions", such as temperature and usual attitude of the unions. Abnormalities would be "offsets" exacerbated by the regular features of the content and context cited.

4.4 Use of quartiles

The maximum and minimum values represent the extremities of the range, representing, obviously, situations have limited the available database; the medium value represents the central region of the data set, that is, it represents the central value of the data set.

Completing this reasoning, for the determination of the high and low values, the concept of Quartile will be used. The Quartiles allow the division of a data set into four equal parts (Figure 5).

![Figure 5 – Quartiles](image)

Alternatively to the presentation of the maximum and minimum raised values, the processing of the data will be concentrated in the First and the Third Quartile as the extreme of the variation range to be argued.

Ramos (2003) recommends this methodology (the application of quartiles) as a tool of statistical control. In the civil construction it is indicated by some authors such as: Souza (1998); Albuquerque, Costa and Pereira (2007); Duarte, Lamounier (2007).

4.5 Details of equipment hours

It is a common situation having a product and during some periods of time not having work to allocate it, becoming idle in the company. Within the period in which the equipment is available for service is the time it is effectively working, in other words, the power is on. This leads to the definition of "working hours". To develop this work it will be used these two moments of the incidence of equipment hours, the hours available for service ($H_{service}$) and hours in operation ($H_{operation}$). Deducting from the “available hours for the service” the “hours
in operation" one has the “unproductive hours” \( (H_{\text{improd}}) \). Figure 7 presents an example of application of these definitions.

![Figure 7](image)

**Figure 7 – Different moments in the highway earthwork compressing service**

5. Application example of the methodology proposal

Studied the subject (literature, five manuals and two case studies). It is how services were handled / broken by hand. It was proposed a breach of these new services. A proposed approach to the compositions was performed. The indicators of the manuals were adequate according to this proposal. Tracks contemplating productivity variable (1st quartile, median, 3rd quartile), referring to the manuals and case studies were developed. Based on all the learning acquired abnormalities were identified and the factors that make the productivity of these bands vary. This study was presented to the experts, who judged and scored on indicators of abnormalities and factors. The result of this research led to the improvement of understanding the productivity variation in the highway earthwork.

In terms of the different parts of the earthwork service, part of the scope, the values shown below: scattering, leveling, aeration or homogenization, wetting, compacting the layer.

The ranges of unit output of the equipment shown below were made with the following considerations:

- to show ranges of values for the production unit including the equipment and his operator (Table 2).

- those bands are related to the factors which lead to an expectation better or worse than the value of the output indicator unit, in another word, a greater closeness of the extreme right or left, respectively, of the band (Table 3).
Table 2 – Compaction embankment service in layers of 30 cm.

<table>
<thead>
<tr>
<th>Step: scattering of the soil (after unloading by trucks)</th>
<th>Equipment</th>
<th>Unitary Production (m²/H&lt;sub&gt;service&lt;/sub&gt;)</th>
<th>H&lt;sub&gt;operation&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quartile</td>
<td>Median</td>
</tr>
<tr>
<td>Dozer</td>
<td></td>
<td>250</td>
<td>550</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step: leveling layer (the motor grader levels the soil layer)</th>
<th>Equipment</th>
<th>Unitary Production (m²/H&lt;sub&gt;service&lt;/sub&gt;)</th>
<th>H&lt;sub&gt;operation&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quartile</td>
<td>Median</td>
</tr>
<tr>
<td>Motor Grader</td>
<td></td>
<td>1000</td>
<td>1200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step: aeration and / or homogenization of the layer (if you need the tractor to make the grid aeration or mixing of soil)</th>
<th>Equipment</th>
<th>Unitary Production (m²/H&lt;sub&gt;service&lt;/sub&gt;)</th>
<th>H&lt;sub&gt;operation&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quartile</td>
<td>Median</td>
</tr>
<tr>
<td>Farm Tractor with harrow</td>
<td></td>
<td>1000</td>
<td>1200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step: wetting layer (if you need to moisten the soil by water truck)</th>
<th>Equipment</th>
<th>Unitary Production (m²/H&lt;sub&gt;service&lt;/sub&gt;)</th>
<th>H&lt;sub&gt;operation&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quartile</td>
<td>Median</td>
</tr>
<tr>
<td>Water truck</td>
<td></td>
<td>1075</td>
<td>1322,5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step: compacting the layer</th>
<th>Equipment</th>
<th>Unitary Production (m²/H&lt;sub&gt;service&lt;/sub&gt;)</th>
<th>H&lt;sub&gt;operation&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Quartile</td>
<td>Median</td>
</tr>
<tr>
<td>Soil Compactor</td>
<td></td>
<td>300</td>
<td>450</td>
</tr>
</tbody>
</table>

Table 3 – Factors and abnormalities: Compaction embankment service

<table>
<thead>
<tr>
<th>Approaches the 1st Quartile</th>
<th>Approaches the 3rd Quartile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstable weather conditions</td>
<td>Stable weather conditions</td>
</tr>
<tr>
<td>Equipment with high maintenance during operation</td>
<td>Equipment with low maintenance during operation</td>
</tr>
<tr>
<td>Operator untrained</td>
<td>Trained operator</td>
</tr>
<tr>
<td>Poor continuity and sequence of operations</td>
<td>Good continuity and sequence of operations</td>
</tr>
<tr>
<td>Preliminary tasks to be performed (e.g. drains)</td>
<td>Preliminary ready tasks (e.g. drains)</td>
</tr>
<tr>
<td>Improvisation prevails</td>
<td>Plan activities in advance</td>
</tr>
<tr>
<td>Team equipment less compatible (different equipment, different weights, quantity incompatible with the degree of compaction)</td>
<td>Team equipment compatible (similar equipment, like weights, quantity compatible with the degree of compaction)</td>
</tr>
<tr>
<td>Less trained laboratory staff</td>
<td>Trained laboratory staff</td>
</tr>
</tbody>
</table>
6. CONCLUSIONS

Studies in the economic area indicate that the development of infrastructure is essential in determining the level of income "per capita" of a country. Providing this infrastructure represents a major public investment and long-term planning.

In Brazil, in recent decades, investment in highway infrastructure is far below the needs of the country. It is, therefore, that the highway pavement is a technology area with development potential and needs sorted investments in various sectors.

This paper proposes studies of productivity variation in the highway earthwork in Brazil and discusses the differences among budget manuals. In the first moment, the Compaction Embankment Service was presented as an example of service, and variations between 123% and 313% were found.

Concluding, for the services of highway earthwork there are, in Brazil, many budgeting manuals, but the indicators are sometimes presented as the theoretical basis without empirical proof, extremely variable and, the factors that do vary are not perceived. This imprecision makes it difficult to trust decisions, affecting the budget processes and production management.

To solve this problem the prediction method of highway earthwork productivity was propose. The model was developed based on the concept of variable productivity (productivity indicators presented through ranges of values) that in addition to unprecedented heavy construction subsector in Brazil, the approach uses the Model Factor (demonstrates the guiding factors for the decision on which embrace value).

The improvement of understanding about productivity in highway earthwork construction projects proposed here can mitigate the failures presented in the Brazilian budgeting manuals and thus help to bring the technological area of highway pavement to a new level of productivity and efficiency.

REFERENCES


Why do costs of civil engineering grow faster than prices in general?

Terttu Vainio¹, Eero Nippala²

Abstract

In recent years infrastructure ownership has been privatised. New public infrastructure is being built according to different public-private cooperation models. Despite the privatisation, the public sector – local and central government – finances a major share of new infrastructure. The international financial crisis and its impacts on the public economy make infrastructure maintenance considerably more difficult and cut investment in civil engineering. Along with scarce financial resources, the problem is exacerbated by the rising costs of civil engineering. Several input prices of civil engineering have increased clearly more than prices in general.

The issue is examined on two levels: the international and national levels. The used material consists of statistics compiled by Eurostat and the national statistical office as well as material acquired from clients. The aim of the two-level examination is to first determine whether the increased cost level of civil engineering is a global, a national or a cyclical phenomenon. Another aim is to discover the reasons for the runaway costs of civil engineering and whether their rise can be brought under control. The study will use primarily statistical methods.

The main reasons for the rise in the cost level are the increase in the prices of fuels and taxation. Changes in the content of infrastructure projects also tend to raise the cost level. Whatever the reasons, the situation forces the public sector to try and choose the most beneficial projects. The rapid rise of costs increases the pressure to improve productivity.

Keywords: cost, price, civil engineering, time series

1. Background

Civil engineering projects typically have a long lead time from planning to completion. The majority are financed by the public sector. Decisions are made at several stages in all civil engineering projects, especially in public ones. The costs of a project must be estimated at

¹ Senior Scientist; Eco efficient district solutions; VTT Technical Research Centre of Finland
PO Box 1300, FI-33101 Tampere; terttu.vainio@vtt.fi.
² Lecturer; Construction engineering; Tampere University of Applied Sciences (TAMK);
Kuntokatu 3, FI-33520 Tampere, Finland; eero.nippala@tamk.fi.
the same time. The first cost estimates are prepared already at a very early stage based on rough plans by comparing alternative solutions.

As planning proceeds, the content of projects becomes more precise and their scope tends to widen. In projects of long duration, even amendments to laws, e.g. on safety requirements or tax solutions, manage to increase costs. It has been noted that used cost calculation methods do not work on pricing of risks, pricing of projects implemented in difficult conditions (e.g. in a dense urban structure), or pricing of demanding types of work like tunnels. (Haapamäki, 2007)

Cost overruns are also caused by the failure to take a rise in cost level into account. That is more pronounced when the input costs of civil engineering increase significantly more than costs in general. If allowance for an increase in cost level is not made in comprehensive contracts, the profitability of contractors suffers. Clients, on the other hand, must know how to prepare for higher input costs both in traditional procurement models with an index clause and new procurements based on an alliance contract. (Hurskainen, 2009)

There are deficiencies in the cost management of civil engineering projects. It has been suggested that better understanding of the operating environment and monitoring of business cycles and markets can also improve cost management. Scheduling of projects so that unintended over-demand is not created by projects involving the same types of work or selection of the appropriate procurement model and contract form for each economic situation are suggested as means of managing costs. (Hurskainen, 2009)

This paper delves into the cost formation and cost level changes of civil engineering. The goal is to determine the factors influencing the sector’s cost level, which would allow looking for ways to forecast cost developments. The target is member states of the European Union, one of which is examined in more detail.

2. Material and methods

The study consists of two parts. The first part identifies the factors influencing the cost developments in one country (Finland) and compares the results with changes in the levels of civil engineering costs in other European countries.

The second phase of the project involved searching for variables that would allow forecasting cost changes. For that, the correlations between variables describing civil engineering and its operating environment and cost developments were analysed.

Used research material consisted of public official statistics on civil engineering and its operating environment. The source of national data is Statistics Finland and that of European data Eurostat.
3. Civil engineering cost development in Finland

In Finland, the development of civil engineering costs is measured by an input cost-type cost index of civil engineering works as in most European and OECD countries. The input price index or input factor price index measures the weighted, combined price development of factors of production consumed in construction (labour, construction materials and components, services, machine work, etc.). The impact of each factor of production on the index corresponds to its share of the construction budget. The input price index describes the change in the construction costs of a construction lot, unchanged in terms of production technology and input cost breakdown, from the base year to the period under review. A construction lot or input structure is a combination of 40 different type contracts. Input price developments are based on market prices compiled either specifically for the cost index of civil engineering works or its parallel indices. (Official Statistics of Finland, 2005)

Based on this cost index of civil engineering works, sector costs have increased twice as much as the general price level since 2000 (figure 1). The inputs in civil engineering with the biggest impact on the development indicated by the index are fossil (fuel point figure 195 and bitumen point figure 385). The general price level increase is based on the cost-of-living index (2000=100). Costs of civil engineering works have also developed differently from those of building construction.

![Graph showing cost development](image)

**Figure 1: Costs of civil engineering works have increased twice as much as consumer prices in Finland. Index 2000=100. Source: Statistic Finland.**

The cost level of Finnish civil engineering works measured by the national index and adjusted to the European cost level (EU=27) rose at the same rate from 2002 to 2005. In 2006–2007 the Finnish cost level rose at an accelerated rate compared to the general European cost level. National statistics indicate that the Finnish cost level has continued to rise at an alarming rate since 2007. Yet, the Finnish price level has fallen compared to the
European price level (figure 2). This allows drawing the conclusion that European costs have increased even more.

*Figure 2: Costs of civil engineering works (Finland) have increased but price level has depreciated against EU27 price level. Sources: Statistic Finland and Eurostat.*

Since 1993 construction clients have been asked to give their views on the level of civil engineering tender prices. According to them (figure 3), the tender prices of contractors, which had been considered high, collapsed back to normal in 2008. Clients find that tender prices have remained normal until autumn 2012.
The cost index of civil engineering works reflects the development of input prices. Tender prices consist of items such as risk provisions and a margin in addition to them. Analysis of the financial statements of civil engineering companies explains the steep increase in input prices while tender prices have remained normal (figure 4). Companies have compromised their margins. The traditional theory of supply and demand assumes that prices should fall when demand decreases, but that did not happen.

3. Development of civil engineering cost level in European Union member states

Statistics on EU member states' civil engineering cost levels have been compiled since 2002. A common reference level (EU27=100) is calculated annually for the EU area as well as an index adjusted to the reference level for the member states and three other EU countries (Eurostat database, referred 29.10.2012). This analysis sought out those among the 27 countries when this index had been the highest or the lowest. These values were compared to the countries' civil engineering volume, economic development and fluctuations in the world market price of oil.

In 2007 the relative cost level of civil engineering works rose in 18 of the 27 monitored European countries. At the time, the economic situation in Europe was good. It was also good in all major economic regions on different continents (World Bank database, referred 29.10.2012). The U.S. economy was growing at 2 per cent, and though there were indications of losses suffered by banks there, the Federal Reserve was expected to be able to manage the situation. Economic growth was about the same in Europe and Japan. Russian growth (7%) was accelerated by oil. In the developing Asian markets economic
growth was many-fold compared to the old economies. China was growing at 11 per cent and India at 8–9 per cent.

In 2007 the world market price of oil shot up as production could not keep up with demand. Problems with production in Nigeria (The New York Times 17.9.2008) and a reduction in Russian production occurred at a time when China’s demand for oil surged (OPEC press release 24.10.2008). At the time, it was assumed that the economic downturn would cut consumption of energy and lower the price of oil.

Economic growth generated tax revenue for the public sector. Its solid financial situation allowed increasing investment in civil engineering works in many EU countries. Typically, investments exceeding the normal level for civil engineering lag behind economic growth (Graf, 2000). Statistics show that the volume of civil engineering works remained high until 2009. In 2010 it collapsed. Despite the collapse, the cost level of European (EU27=100) civil engineering has increased.

4. Anticipation of cost changes – results of correlation analysis

Based on earlier analyses, the variables chosen for more in-depth study against the cost of civil engineering works were gross national product (GDP), inflation, wage development, oil price, bitumen price, metal price, soil and rock material prices, transport service price, building construction volume and civil engineering volume.

The reviewed material consists monthly observations from 2000-2011 (144 observations). The relations of the variables were examined by methods typically used with time series. Because the material consists of annual data, trend removal, proportioning (logarithmic conversion) or differentiation are used to filter the material, as necessary.

Time-series which have constant mean and variance over time are said to be stationary. Stationarity is assumed for achieving reliable conclusions: non-stationary time-series may yield random results. As most of used variables are not stationary but time-dependent they are dealt with trend-removal. (Kendall, Ord 1990)

For yearly data the existence of a trend is dealt with filtering the observed trend. The direction of change may also be other than linear, for example, quadratic and time-dependent, which is why filtering is performed case by case. The quarterly data is processed with differencing to remove seasonal trend and thereby introduce stationarity. (Kendall, Ord 1990) In the analysis of civil engineering or the economy, trend removal refers, for example, to converting current prices to flat rates. The purpose of trend removal is to eliminate the change that takes place in the series in any case, such as recurrent economic fluctuations, to be able to examine their deeper nuances.

Logarithmic conversion is used to normalise the variables, that is, to observe relative changes in the variables. Logarithmic values were used in the comparisons when possible. Because a logarithm can only be taken of a positive number, some variables were defined
as a percentage of GDP if they contained also negative values and had originally given in that form in the material. The percentages also indicate relative values.

The variables are compared one at a time against civil engineering. The relation is first examined using graphic descriptors to assess their joint integration. Graphs are also made for trend-filtered variables to get a more accurate result for the dependencies of the directions of variables.

Change balances, i.e., sums of the numbers of changes in the same direction, are calculated for the pairs. This figure may support the correlation, which makes it possible to conclude whether the variables affect directly or inversely each other’s changes. If the balance figure were close to half of the number of common events, it could be interpreted to imply that changes between the variables are not closely interconnected. By contrast, if the balance figure is close to the extreme ends (0 or maximum number of observations), it can be assumed that the variables are interrelated directly or through a third variable. For example, if 80% of the changes in variables a and b are in the same direction, they can be considered to be strongly directly proportional. Should the variables have only 20% changes in the same direction, they would have 80% changes in a different direction, indicating strong inverse proportionality.

Correlations indicate linear dependencies. In the case of time series variables, the correlations calculated for the initial values are rather high for unlimited variables, since time series often have a trend, a direction of development. Thus variables that increase or decrease over time may have significant correlations, as the scatter plots generated from them follow a trend. Filtered variables, again, have had their trend removed, so it is possible to observe similarities previously masked by apparent dependencies. Significant correlations between stationary series are a more reliable indicator of dependence than correlations between the original values.

Time-dimension is important feature in this study. Since correlations are calculated with time-series compared each other, they are placed in comparison with time too. Normally correlations are taken from values that occur simultaneously. This will yield only the dependency of concurrent events. By moving the compared value pairs we are able to observe the correlations between lagging and delaying variables. The method is called cross-correlation and it is instrumental in estimating the degree to which two series are correlated. From these correlations it is possible to gain findings from the causality between two series. Are changes taking place at the same time? (Kendall, Ord 1990)

While moving the series in time dimension the amount of compared pairs reduces. This is particular fall for those variables with small observation amount. This is particularly the case for those variables with a small number of observations.

The examined variables were divided in four groups based on the correlation analysis: leading, lagging, coincident and acyclical variables. Leading variables are those that in the light of the results of this analysis forecast changes in civil engineering costs. They included
GDP, building construction volume and oil price. These three test results for the cross-correlations are explained and visualised as 3D graphs (figures 5–7).

Figure 5: GDP reflects changes in the cost level of civil engineering works throughout the time series. The lead time has been halved in a short while (NB delay in months). Earlier, GDP development could forecast changes in costs of civil engineering works up to 18 months in advance. Presently, the lead time has shrunk to five months.

Figure 6: Changes in building construction volumes forecast cost changes. The delay between the changes has become shorter and stabilised at 5–6 months.

Figure 7: Changes in the price of oil unavoidably mean changes in costs of civil engineering. Earlier, the delay between an oil price change and cost changes was 6–12 months. Presently, it is only 2–4 months.
Correlating factors also affect the index either directly or through a common so-called third factor that affects both simultaneously. Changes in the prices of transport services and the volume of civil engineering works also occur concurrently with cost changes. Coincident reaction of transport services became established only in the 2000’s. Earlier, transport service prices forecast changes in costs of civil engineering works.

Changes in the volume of civil engineering works also used to precede changes in the cost level, but today they change simultaneously (see figure 8). Thus change in civil engineering work volume is not significant from the viewpoint of cost forecasting.

![Graph showing the demand does not come before but simultaneously with increase in prices.](image)

**Figure 8: The demand does not come before but simultaneously with increase in prices.**

Analysis of the lagging variables showed that their role can change. The results indicate that part of them have had a coincident or even leading relationship to the index. Yet, over time, the nature of the relationship has regressed and they have become lagging variables. An interesting fact is that sector wage development has lagged behind cost development, initially by 10 months, and now by as much as two years. Changes in the price of an important input of civil engineering works, soil and rock materials, are no longer a coincident variable, but lag behind changes in the cost index by 6 months.

The prices of fabricated metal products used to move quite inconsistently in relation to costs of civil engineering works, but have started to behave more consistently over time. The delay is about 9 months. The price of bitumen reacts similarly with a delay of 10 months.

The impact of inflation has varied during the review period. For long, it followed the costs of civil engineering works, but in the last few years the delay has shrunk so that changes occur almost simultaneously. It is no longer possible to determine whether inflation is a lagging or coincident variable to civil engineering costs (figure 9). Inflation is on the way of becoming a leading variable.
Figure 9: An interrelationship between civil engineering costs and inflation has been turbulent.

5. Summary

Civil engineering involves many types of work that require petroleum products. These products are needed to transport soil materials, to operate earthmoving machinery and to pave roads and streets. The aim of EU climate policy is to reduce the use of petroleum products. The means to achieve that goal include emission fees and taxes on fossil fuels. The increase in the world market price of oil and taxes together have increased petroleum products’ share of the cost of civil engineering works to 20 per cent.

Globalisation and data communication have integrated the world’s economies. This is evidenced e.g. by the fact that the delay between an increase in the price of oil and one in the input costs of civil engineering works has shrunk to a few months.

World market prices of raw materials also influence domestic inputs. According to the traditional theory of supply and demand, only growing demand increases prices until equilibrium is produced by increasing supply. The theory posits that a cost increase should follow from an increase in the volume of civil engineering works. Yet, according to the analysis of this study, that is not the case. Instead, volume and cost level increase simultaneously with each other and economic growth.

Civil engineering is local activity, but yet highly susceptible to changes in global economy. One indication of that is that the costs of civil engineering works have continued to grow even though demand has collapsed. Cost development is governed by international economic development instead of local supply and demand.
Thus, not only development of the national economy, but also development of the global economy and the world market price of oil must be considered in forecasting costs of civil engineering works. In the case of special work types, local supply may become the key factor in determining the cost level.

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