

**THE DEVELOPMENT AND TESTING OF
A PURCHASING POWER PARITY METHOD
FOR COMPARING CONSTRUCTION
COSTS INTERNATIONALLY**

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for the award of Doctor of Philosophy of the
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CERTIFICATE

I certify that this thesis has not previously been submitted for any degree nor has it been submitted as part of the requirements for a degree.

I also certify that that the thesis was written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged.

I also certify that all information sources and literature used are indicated in the thesis.

Eric A. Best

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ABSTRACT

Over the past fifty to sixty years there have been numerous attempts to compare the performance of the construction industries of different countries. In almost all cases the cost of construction has been an important, sometimes the single parameter Cost performance has sometimes been equated to productivity, and productivity measurement and comparison is attempted by governments and their agencies on a regular basis.

Fundamental to these exercises has been the necessity to bring construction costs in different national currencies to a common base. This is imperative as amounts in different currencies cannot be directly compared.

Money market exchange rates do not provide suitable comparisons as they are too volatile and do not represent true comparisons of the volume or value of construction. Additionally there are real differences in price levels between economies that hamper valid comparisons. Purchasing power parity, however, provides a theoretical basis for cost comparisons without the distortions caused by moving exchange rates and differences in price levels between countries.

Using the option of purchasing power parity and its supporting theory, the Law of One Price, a mechanism for bringing construction costs to a common base currency has been devised. It is based on a basket of construction materials and labour referred to as a BLOC (i.e. Basket of Locally Obtained Commodities) and is applied to a hotel project.. The materials and their respective quantities were derived by the analysis of a completed hotel. Labour hours associated with those materials and quantities were derived using published materials/labour ratios for the various items. In this way the basket or BLOC represented a mix of the most cost significant materials in a typical hotel project.

Input costs for the BLOC were obtained from six cities, three in Australia plus Auckland, Singapore and Phoenix. BLOC costs were then used to derive a set of purchasing power parity factors specific to the construction industry in each location. These factors were then used to assess the relative cost of construction in each location.

The BLOC also provides a straightforward method for comparing productivity between locations. Lower building costs, when expressed in BLOC equivalents, signify higher productivity. While not an absolute measure of productivity this provides a clear indication of relative productivity between locations.

The study described provides some interesting results. For example, while construction costs in Sydney are clearly shown to be higher than those in Phoenix the industry in Sydney is shown to be considerably more productive. Higher costs in Sydney are related largely to higher pay for tradespersons and other resources, however, the higher pay is offset by the improved productivity.

The method devised satisfies many of the requirements for regional and international cost comparisons. It is theoretically correct and relatively inexpensive to administer and thus provides the opportunity for the gathering data from more respondents in each location and at more frequent intervals.

The thesis concludes with suggestions for a number of research projects that would extend this work considerably and greatly expand the body of work devoted to this fundamental construction economics problem.

CHAPTER 1

1.0 INTRODUCTION

This thesis is about designing a method for international comparisons of construction costs. The context and the rationale for the study as well as the detailed research questions are discussed below.

1.1 GENERAL CONTEXT

The construction sector in most nations makes a substantial contribution to both gross domestic product (GDP) and capital formation. Such is the importance of construction in the national economies that in the period 1945-1990, value added in construction in North America and Western Europe ranged between 5% and 8% of GDP. Consequently gross construction output was somewhere between 12% and 15% of GDP (Drewer, 1990:29).

The importance of construction has not diminished; the OECD (2001:66) suggests:

The contribution of the construction industry to GDP in OECD member countries ranges between 5%-8% and between 5%-9% of total employment. Of course, given that a significant proportion of construction activity is undertaken by units outside the construction industry, these percentages understate the importance of the construction industry.

Flanagan *et al.* (1986:1) note that, in the UK, construction output is exceeded only by that of agriculture, and point out that it is in everyone's interest that the sector operates with maximum efficiency. Meikle and Grilli (1999:1) suggest that if "construction is measured gross, in most countries it would be the single most important economic sector."

Many authors note the importance of construction in national economies not only in respect of its contribution to GDP (e.g. Croce *et al.*, 1999; Ward, 2003; McKinsey, 1995; DLC, 1999). Construction has an effect on the whole nation as it has direct effects on costs and prices, and influences international competitiveness both locally

and overseas (Business Round Table, 1983:1). It is also a key element in investment, and therefore to the future prosperity of nations (Croce *et al.*, 1999:13). Crosthwaite (2000: 619) points not only to the size of the sector but also to “its role in economic development”, and alludes to the importance of its products (buildings, facilities and infrastructure) that are so vital to modern society. The level of construction activity is often used as a measure of overall economic activity and an indicator of the general “health” of economies (Ward, 2003), and governments and others look for comparisons of construction investment costs between countries to inform their decision-making (DLC, 1999).

In 2005-6, in Australia, construction contributed strongly to both GDP and gross capital formation (Table 1.1). Commonly countries such as Australia, and others, are interested in assessing the performance of their respective construction sectors, and often look for ways to improve their performance (e.g. Ive, *et al.* 2004; Bernstein, 2003; DISR, 1999).

GDP (AUD x 10⁶) 2005-06 prices	All construction as % of GDP	Construction as % of gross capital formation	Residential: non-residential: engineering
965,969	6.4%	56%	37:22:41

Table 1.1 GDP, contribution of construction to GDP and capital formation, and ratio of industry sectors in Australia for 2005-6 (Source: ABS, 2006)

The importance that is attached to the industry in Australia is well illustrated by the following passage from a 1999 report to the Australian government, by the National Building and Construction Committee (NatBCC, 1999:1):

The building and construction industry is a vital element of the Australian economy and has a significant impact on the efficiency and productivity of other industries. Its outputs are critical for all of us whether it be via the provision of physical infrastructure that underpins the economy or through the built environment which more directly influences the quality of our lives.

Hampson and Brandon (2004:7) suggest that “....construction is the backbone of the Australian economy”. Given that the industry is such an important part of national economies it is only natural that there will be attempts to measure and compare

industry performance internationally. Any such assessment requires suitable methods for measuring and comparing performance. Such measurement is seldom easy, and in the construction sector it is a particularly demanding task due mostly to industry structure and the nature of construction output. Walsh *et al.* (2006:125) describe the construction sector as “comparison-resistant” due to the difficulties associated with data collection and the “complex and variable nature” of the sector itself.

1.2 FOUNDATION FOR THE RESEARCH

Any production that uses more resources and other inputs than required to achieve a predetermined outcome ties those resources to activities with lower productivity and thus reduces the overall efficiency of an economy (Pilat, 1996b:108). In the case of construction, given the amount that it contributes to GDP, even modest improvements in efficiency can translate into significant increases in growth, and growth is a common measure of the health of modern economies. Whether growth is the correct aim of governments is not to be debated here; suffice to say that those in government commonly present growth outcomes as evidence of good governance and for that reason, if for no other, they take a keen interest in any sector of the economy where it is perceived that efficiency or productivity can be improved, and growth increased.

Greater efficiency is a goal common to all industries; doing more with less has been the focus of a great many studies, schemes and programs since the Industrial Revolution. When Jethro Tull introduced the seed drill at the beginning of the 18th century (BBC, 2004) his aim was to make the performance of a simple agricultural task not only faster, but more accurate¹. By reducing the *time* it took to plant the seed, and by improving the *quality* of the operation, Tull was almost certainly also reducing the *cost* of carrying out the operation. In so doing he was pursuing the three goals so often mentioned in modern construction and project management literature.

¹ It should be noted that the first multi-tube seed drill appeared in China in the 2nd century BC, and the earliest known European seed drill was patented in Venice in 1566. It was Tull, however, who developed and promoted the first really sound implement in Europe (Temple, 1998).

Now, three centuries later, the same goals remain, and the success or otherwise of projects such as the construction of buildings is still measured, in many instances, in terms of time, cost and quality. The combination of these goals directly leads to the potential for value enhancement (value for money).

Assessing competitiveness in markets that have become increasingly global in recent years has led to analyses by firms and governments of the performance and productivity of major competitors, both in-country and across national borders (Pilat, 1996:121). Such analyses and comparisons can, by spreading knowledge, not only lead to the introduction of new and different methods of construction, both technically and from the viewpoint of organisation and management, but help establish international benchmarks that identify best practice, against which individual firms and even national industries can measure their performance (Xiao and Proverbs, 2002b:425). Ruddock (2002:32) describes the facilitation of comparative studies between countries as a major aim of researchers concerned with international construction. Fundamental to these studies is the concept of productivity and how it can be measured. Such studies demonstrate “possible scope for further gains in productivity and competitiveness and also place a country’s growth experience in the perspective of its current level of income and productivity.” (Schreyer and Koechlin, 2002a:8).

In recent years alternative approaches to the management of construction projects have emerged. A leading example is lean construction (Koskela *et al.*, 2002). This concept has its roots in lean production as applied in manufacturing (e.g. by Toyota) and has twin goals of value maximisation and waste minimisation. The perceived success or failure of these systems can only be assessed if outcomes can be measured and compared to historical performance records and/or those of competitors. The difficulty is always in devising readily applicable and reliable metrics to allow measurements and subsequent comparisons to be made. In construction the difficulties of formulating the required measuring tools are increased for a variety of reasons including the heterogeneous nature of construction output, which makes measuring and comparing output problematic, and the highly subjective nature of quality in construction, relating as it does not only to workmanship, finish and

incidence of defects, but also to quality of design (primarily in terms of functionality and aesthetics). Highly specialised metrics are required if useful comparisons are to be made possible.

Two points emerge from the foregoing: one is that there is interest in measuring how the construction industry in any place is performing with a view to improving that performance and thereby increase output and contribute more to economic growth; the other is that there is interest in comparing performance between countries, not only as a benchmarking exercise that can identify opportunities for performance improvement but also to gauge competitiveness.

1.3 PROBLEM DEFINITION

The balance between time, cost and quality has been discussed so often that it has become trite, but this has not necessarily reduced the validity of the model. In recent years, however, much thought and effort has been directed at increasing the range of measures by which construction outcomes are evaluated. At the level of individual buildings, studies such as the PROBE studies (Usable Buildings, 2007) assess buildings by interrogating the occupants and users of the buildings, addressing issues such as thermal comfort. While studies of this type assess the *products* of the industry, there are also many that assess the *processes* of the industry. Some (e.g. Xiao *et al.*, 2000) focus on client satisfaction; others (e.g. Proverbs *et al.*, 1999a) look at productivity rates for specific onsite tasks. Other variations include macroeconomic studies of labour productivity at a national level (e.g. Roy, 1982), comparative management studies (e.g. Nahapiet and Nahapiet, 1985) and comparisons based purely on construction costs (e.g. DLC, 1999). Love and Holt (2000:408) state very clearly that if construction firms are to compete and survive in the “shrinking global marketplace” they must have a thorough understanding of how they are performing in all aspects of their business, and how they will need to perform in the future in order to maintain or enhance their position.

To date there has been no method devised for making comparisons of construction activity and outcomes that is anything more than a reasonable compromise. Such

comparisons are acknowledged to be difficult by all who attempt them, and their results open to question. Published studies invariably carry many caveats and warnings of limitations relating to data collection and potentially unreliable results. Edkins and Winch (1999:47) note that it is “the challenge for those research individuals and organisations who are involved in this area of study to work at developing the methodologies that allow reliable findings to be generated.”

Comparative studies in construction are particularly complex for a number of reasons. Most importantly, the products of construction are almost never identical, thus truly comparing “like with like” is seldom possible. At a macroeconomic level total industry output may be aggregated but there is only one available unit of measure and that is money; it is impossible to aggregate output in any other way when the built facilities that comprise that output are of myriad types and sizes, each with its own set of unique characteristics relating to function, site, materials, climate, quality and so on.

Even at a micro level, when comparing onsite tasks such as the placement of ready-mixed concrete or the application of plaster or render, there are differences between projects. Factors such as climate affect building operations: concrete placement, for example, is a different task in an Australian summer to that in a Canadian winter. Similarly requirements and regulations pertaining to the safety of workers on building sites vary from place to place: the use of bamboo scaffolding, commonplace in Hong Kong, would be impossible in New York or London.

Yet, for all the difficulties, the search for reliable tests and procedures that will enable valid comparisons to be made continues. Ideally any such tools should be reliable, reasonably straightforward in use and utilise data that can be gathered without undue cost (in terms of both time and money). It is of paramount importance that data samples used are both representative of their country of origin and comparable with those of other countries so that comparisons can be made with confidence.

1.3.1 Time, cost and quality

Many of the comparative studies done over the past 50 to 60 years have focused on one or more of the three basic parameters of time, cost and quality. Others have attempted to measure industry productivity, typically in terms of output or value added per person employed or hour worked. Seldom have all aspects of performance been addressed in a single study, and many are based on a single parameter such as cost, or with a single input (typically labour) in single factor productivity studies (see Edkins and Winch, 1999 and Loosemore and McGeorge, 2002 for detailed reviews of a range of comparative studies).

Construction time has been the principal focus of some studies (e.g. Proverbs and Faniran, 2001), and it is the simplest of the performance factors to assess although it is important that data gathered on time has a consistent basis, i.e. that it is measured in the same way in all cases. If that is achieved then few measurement problems arise.

Quality is a much more difficult factor to assess as it has a number of facets (e.g. studies have been based on various parameters such as client satisfaction, compliance with specification and codes, and standards of workmanship). Quality has often been conveniently excluded from studies or handled by some adjustment factor, based on little more than an author's "best estimate". It remains an area that requires considerably more attention before any comprehensive and effective method of assessment or measurement emerges (see, for example, Sergueev, 2001 and Rittenau, 2002).

The third factor, construction cost, is generally included in comparative studies and a significant proportion of such studies have been based on cost alone (e.g. Page Kirkland, 1999). Inevitably any international comparison that includes cost, whether of labour, materials or construction in aggregate, or value (as value of output or value added) requires that amounts of money in various local currencies must be converted into some common currency before any valid comparisons can be made. At present this is generally done by converting monetary amounts to US dollars (USD), however, in some studies other currencies have been used, notably the euro for

European studies (e.g. BWA, 2006). Prior to the introduction of the euro the European Currency Unit (ECU) was used for such comparisons (e.g. Business Round Table, 1994). Whatever the chosen common currency the question arises of what system for currency conversion will be used.

The method adopted for such conversions is crucial as it can determine the ultimate usefulness of any comparative study, regardless of the overall comparison methodology that is used. The importance of currency conversion and the problems associated with making reliable conversions is the focus of this thesis, and it is discussed at length in subsequent chapters.

1.4 RESEARCH QUESTIONS

In this thesis the following research questions are explored:

Q1: How reliable and accurate are existing methods for international comparisons of construction costs?

Q2: Can these existing methods be improved?

Q3: Can an index with fixed weights provide more accurate and reliable outcomes than conversion factors currently in use?

Q4: Can this method provide a guide to comparative productivity in construction?

1.5 RESEARCH AIMS

The aims of the research are as follows:

1. To establish by means of a broadly based literature review, a detailed analysis of existing comparison methodologies with particular reference to the problems associated with conversion of construction costs to a common base.

2. To assess the reliability of those existing conversion mechanisms.
3. To develop and test a fixed weight index for computing cost conversion factors for different locations
4. To use these conversion factors for comparing relative costs of construction for these locations.
5. To explore the implications of the results.

The thesis starts from a foundation of existing work in the areas of comparative studies generally, and the conversion of international construction costs in particular. A number of previous studies are analysed in detail and their contributions to cost conversions are identified and discussed. Of special importance is the development of a specific set of conversion factors that are relative not to just several countries, but to specific cities or localities in those countries. Locality or regional cost indices are routinely produced in a number of countries (e.g. see Rawlinsons, 2004 for indices for all parts of Australia) and these can be used to adjust city specific conversion factors for other localities in each of the target countries.

1.6 RESEARCH METHODOLOGY

Different methodologies are, of necessity, applied to each of the research objectives.

The first objective is addressed through a conventional review and analysis of previously published work dealing with subject matter ranging from general economic theories of productivity definition and measurement to studies that deal quite specifically with various attempts at international construction comparisons, and in particular with the problems associated with cost conversion. This literature review summarises the problems and the various attempts that have been made, and are being made, to deal with them.

The second objective is addressed through detailed comparative analysis of previous studies.

The third and fourth objectives are addressed by the introduction of a proposed mechanism for the production of city specific cost conversion factors for use in international comparative studies of construction industry performance. The mechanism, based on a basket of construction materials and labour, is described and developed in response to the problems identified in the literature review and comparative analyses outlined above. The proposed method is tested in a number of cities across four countries in collaboration with both quantity surveying firms and construction contractors in the various locations.

The final objective is considered through a theoretical analysis of the application of the mechanism and testing in the target locations.

Finally, the exploration of the research questions allows some conclusions regarding the proposed conversion mechanism to be drawn, and some suggestions for further research to be put forward. The method is shown to be practical in use and to produce robust conversion factors. It is also shown to provide a simple means for comparing relative productivity in construction between locations. Considerable scope for further research that builds on the work described here is identified. Overall the work makes a significant contribution to ongoing efforts to devise sound methods for converting construction costs to a common base. This is a fundamental aspect of international comparative studies not only in construction but across other industries and even whole economies.

1.7 RESEARCH OVERVIEW

This thesis comprises the following seven chapters, plus appendices.

Chapter 1 provides the general context of the research and the reasons why groups at various levels from national governments to individual contractors may be interested in industry comparisons and why the cost conversion problem is fundamental to the reliability of most if not all such comparative studies. The research problem is defined, research questions and aims are framed, and the methodologies for the study are outlined.

Chapter 2 contains a review of relevant literature pertaining to the study, and analyses of previous work. There are detailed analyses of some selected studies from recent years that identify common problems, particularly in relation to cost conversion.

Chapter 3 uses the information gained from the literature and previous studies to identify the desired characteristics of a comparison mechanism, compares a number of alternatives, and discusses the selection of an appropriate model.

Chapter 4 outlines the research plan undertaken in order to develop the proposed cost comparison mechanism, a basket of construction materials and labour, and includes a description and analysis of a pilot study carried out to test the basic concept.

Chapter 5 describes the pricing and validation process applied to the model basket of goods. It also includes some statistical analysis that assesses the reliability of the prices obtained and a detailed analysis of the component items of the basket.

Chapter 6 details the use of the comparison mechanism and demonstrates the usefulness of the mechanism in a number of comparisons. The robustness of the mechanism is tested through sensitivity analysis and is shown to provide consistent results under varying scenarios.

Chapter 7 revisits the research questions and provides answers to them in the form of conclusions drawn from the studies described in Chapters 2 to 6. A number of proposals for future research that would significantly extend the work described herein are suggested

The appendices include a comprehensive bibliography, the survey instrument, and supporting calculations and analyses that are only reported in part in the main body of the thesis.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 INTRODUCTION

This chapter comprises a comprehensive review of the literature relating to performance and productivity measurement, both generally and with specific reference to the construction industry. It focuses particularly on the conversion of financial data to a common base. The review revealed the complexities associated with making valid comparisons of industry performance between countries, and the specific problems of comparing costs that are reported in differing national currencies.

2.1.1 Comparative studies

Comparisons of performance are common in all forms of endeavour, whether in sport or business or any other sort of pursuit. In business the practice of benchmarking performance has become commonplace with “best practice” being identified and the performance of individual business units being compared regularly. The construction industry in the UK, for example, now works with an established set of key performance indicators (KPIs) that are intended to support programs of continuous improvement with an ultimate goal of improvements in industry performance across the board, in areas including reliability of cost and time estimates, adherence to budget and so on (Constructing Excellence, 2004; Martin, 2004).

2.1.2 Grouping comparative studies

Comparisons between industries and within and between industries are regularly carried out for a variety of reasons. Cross-industry studies (e.g. Roy, 1982; Ive *et al.*, 2004) provide governments, in particular, with some means of identifying under-achieving sectors in national economies. International comparisons between similar sectors such as construction (e.g. Vermande and van Mulligen, 1999; Loosemore and

McGeorge, 2002; BWA, 2006; BCIS, 2006) provide a basis for benchmarking the industries of one nation against their counterparts in other countries. Other studies are ongoing (e.g. RLB, 2008; Rawlinsons, 2008) and provide data on a commercial basis to prospective clients and contractors who may be planning to expand their operations to countries other than their own.

2.1.3 Cost comparisons

Cost performance, particularly in terms of the overall cost to construct, is an obvious comparator, and many studies have been done that compare construction costs in the hope of identifying areas of better (if not best) practice and to highlight projects that have been completed more cost effectively than others (e.g. Lynton, 1993; DLC 1999). Such comparisons are difficult even within a single national market due to the nature of the industry and its products. When international comparisons are attempted the problem of converting costs to a common currency base is added and the problem becomes a great deal more complex.

2.1.4 The importance of the cost parameter

However difficult it may be there are a variety of stakeholders interested in the construction industry who are interested in various sorts of comparisons that include cost in their parameters - indeed few comparative studies do not have cost as part of the equation, and many are based on cost alone (e.g. Page Kirkland, 1999; Danish Agency for Trade and Industry, 2000). Governments and their agencies, construction companies, and multinational businesses are some of those stakeholders and the fact that they routinely commission or carry out these comparisons means that there is a need for reliable methods. When international comparisons are attempted then the issue of cost conversion to allow direct comparisons becomes crucial more or less regardless of the method of comparison that is adopted (Best and Langston, 2006b).

2.2 PERFORMANCE, PRODUCTIVITY, EFFICIENCY OR SUCCESS?

Cost conversion is typically part of a method for comparing some aspect or aspects of the performance of industries, or even whole economies, in different countries. It is worthwhile at the outset to delineate the context in which the cost conversion

question is explored in this thesis. It is therefore appropriate to discuss, briefly, the aim of different types of comparative studies in which cost conversion may play a significant role. First it is important to consider what it is that various studies have tried to measure and compare; these include productivity (in many forms), and the broader concepts of performance, efficiency, effectiveness and success.

Sharpe (1995:221) suggests that “any analysis of productivity and efficiency issues must begin by defining the two concepts.” Bernstein (2003:53) concludes that major obstacles to productivity measurement in the construction context are the lack of agreement not only on how to measure success in construction but also the lack of a vision of exactly what an “efficient and productive” construction industry may be. Edkins and Winch (1999:11), in their review of a number of comparative construction studies, note that one report suggested that the definitions of productivity used were “not unequivocal and ...possibly not correct” – as a result the outcomes of that report were considered suspect. Already the variety of terms used is notable: productivity, success, and efficiency are all mentioned; some discussion of these terms, and some others, is warranted here.

2.2.1 Productivity

Productivity is a fundamental economic concept; it is seen as one of the keys to international competitiveness and is linked to rising living standards (Sharpe, 1995: 221). General definitions of productivity abound in the literature of economics as well as that of construction. Olomolaiye *et al.* (1998:3-4) review a number of definitions, beginning with Davis (1951) who suggested the following definition:

...the degree to which the power to make or provide goods or services having exchange value is utilised as measured by the output from the resources utilised.

Levitt (1982), perhaps seeking to provide a more measurable definition, offered the “ratio between the value of a unit of output and the cost of all the inputs.” English and Marchione (1983) attempted to broaden the concept of inputs and outputs to include intangible inputs such as management and ingenuity, and the concept of quality into output. Olomolaiye *et al.* (1998:3) make the point that managerial input, “while often invisible”, can greatly influence productivity.

Fenske (1985) included services in his definition and defined productivity as “the amount of goods and services produced by *a* productive factor in a unit of time”. Arguably “services” should also be included in inputs, but Fenske’s definition appears to be for a definition of single factor productivity. Olomolaiye *et al.* (1998:2) also offer their own general definition: “the effective and efficient conversion of resources into marketable products”, and in doing so add another term, “effective”, to this discussion.

2.2.2 Productivity in construction

In simple terms productivity is typically expressed as number of units of output produced per worker (unit of labour input) or per day (unit of time input), or most simply, “output over input”. The complexity and diversity of construction projects makes the quantification of outputs particularly challenging, and for any comparative exercise the problem of finding completed projects (i.e. “units of output”) that are comparable is an added problem. Construction outputs may be expressed in physical terms, such as m² of floor area or m³ of enclosed volume but most commonly it is measured in monetary terms, i.e. the “dollar value” of construction work completed.

In a very specific construction context Oglesby *et al.* (1989: 5) define productivity as

....the effectiveness with which management skills, workers, materials, equipment, tools, and working space are employed at or in support of work-face activities to produce a finished building, plant, structure or other fixed facility, at the lowest feasible cost.

This definition adds some further dimensions as it includes “working space” as an input. By so doing the authors acknowledge one of the major problems in measuring and comparing construction productivity, and that is that every building site is unique and imposes its own set of constraints on construction activity. The other addition is the specific inclusion of lowest cost as part of the definition; Oglesby and his colleagues (at 5) actually equate “productivity” with “cost effectiveness”. Efficiency or effectiveness of resource use may imply lowest cost but this definition makes it explicit. Cost is once again a fundamental concern with this method.

2.2.3 Efficiency and effectiveness

In the general economic literature efficiency is sometimes divided into two broad concepts: technical or productive efficiency and allocative efficiency (Caves, 1992:1). Baldwin (1992:274) differentiates the two: technical efficiency arises when a firm makes the best use of its inputs; allocative efficiency is the result of a firm employing its inputs in the correct proportion. He suggests (at 274) that efficiency can be expressed as “the ratio of actual output to potential output”. This may work for manufacturing but it is of doubtful use in a construction context as measuring “potential output” is largely impossible.

Caves (1992:1) talks of “efficiency in the popular sense”, saying it asks the question of whether a given task is completed with minimum effort or use of resources. In the context of construction the task may be the construction of a building, while resources are materials, equipment, labour, time and money (Task Committee, 1986:304)

Takim and Akintoye (2002:277) cite Pinto and Slevin (1994) and equate project success with measures of efficiency and effectiveness, and differentiate the two by linking efficiency to management and organisation (measured by factors such as adherence to schedule, budget and specification), and effectiveness to client/user satisfaction.

Olomolaiye *et al.* (1998:3) treat both as “performance measures”. They suggest that effectiveness is assessed in terms of whether meeting goals such as profit or market share is achieved, and whether the methods used in attempting to meet such goals are correct, while they see efficiency as simply a measure of productivity, where efficiency is measured as the ratio of input to output.

2.2.4 Project success

The notion of project success is yet another way of considering, and assessing, performance at the level of individual projects. Baccarini (1999:25) considers project success to have two distinct components: project management success, and product success. The first focuses on the meeting of time, cost and quality objectives (relating

to inputs and outputs to the project), while the second is related to the delivery of a product that satisfies the client/user. The cost aspect is related to meeting budgets rather than any measurement of actual cost, hence assessments of project success seldom require the measurement (and subsequent conversion) of cost data.

2.2.5 Performance

Performance is not the same as productivity (Olomolaiye *et al.*, 1998:3; Oglesby *et al.*, 1989:4) and may refer to factors that have no direct relation to conventional meanings of productivity, e.g. project success (Picard, 2002; Xiao and Proverbs, 2002b) involving metrics such as client satisfaction, and “construction business performance measurement” (Love and Holt, 2000) where the metrics are again different, focusing on factors such as relations between contractors and their clients, suppliers and employees.

Loosemore and McGeorge (2002:2) see productivity as just one part of performance, and suggest that any useful measure of performance should include time, cost and quality as well as productivity. Nahapiet and Nahapiet (1985) refer to the “vexed question of project performance” and describe project performance as an “assessment of project delivery”, based on time, cost and quality performance.

2.2.6 Measuring performance

Measurement of industry performance, whether at project level or at a whole-of-industry level, has been approached in a variety of ways, some including measurement of the traditional parameters of time, cost and quality, and some taking different approaches, similar to those mentioned earlier under “project success”. Xiao and Proverbs (2002a) attempt to measure construction contractor performance by a comprehensive set of measures of time, cost and quality performance, and relate performance in many instances to client perceptions of contractors’ performance. In the UK a set of key performance indicators (KPIs) (Constructing Excellence, 2004) that use a smaller set of measures (just ten in all) are used to measure performance both in numerical terms as well as qualitatively by assessing client satisfaction. Winch *et al.* (1998:193) relate performance to minimisation of “client surprise”, suggesting that “[a] surprised client is a dissatisfied client”. Surprise is linked to

predictability of outcomes (e.g. time and cost), and in effect this approach is just another way of looking at client satisfaction as a measure of project performance.

Takim and Akintoye (2002:276) adopt the position of Xiao *et al.* (2000), i.e. “a contractor’s performance should focus on client satisfaction”, but client satisfaction ultimately rests on meeting time, cost and quality criteria, so where possible, objective measures of these parameters are preferable to client perceptions. In any case, when attempting comparative studies, particularly in an international context, there are no common benchmarks: exemplary performance in Country A may equate to average performance in Country B, hence a completely satisfied client in one would be equally satisfied in the other but would actually be enjoying performance that may be considered as only just acceptable by local clients in the same country.

Brown and Adams (2000) take a very theoretical view of performance measurement in attempting to construct a model that can be used to assess the influence of project management on project success. They use a technique called path analysis in their model and combine time, cost and quality into a “joint product” in the model. This requires that all outputs be expressed in numerical terms to allow them to be aggregated into a single entity, known as the joint product. If this technique were to be applied in an international context cost conversion would be essential.

It is not necessary in this study to pursue these concepts further, but the preceding discussion illustrates the range of subjects that various authors have attempted to measure, and most importantly demonstrates how measures of cost are central to most if not all of them.

2.2.7 Concluding remarks on productivity

Governments and site supervisors, then, are interested in *productivity*; clients and their project managers focus on *success*, while firms like to gauge their *efficiency*, and may want to compare their efficiency to that of their competitors. Some combination of these parameters may be encapsulated in *performance*, and the term is often used in the literature, although not necessarily with any consistency.

Performance includes productivity (Loosemore and McGeorge, 2002; Oglesby *et al.*, 1989); efficiency is sometimes equated with productivity and can therefore be deemed to be a part of performance. Effectiveness is a part measure of success, at least at the project level; success, in turn, is largely measured by reference to the conventional parameters of time, cost and quality.

Regardless of the descriptor that is selected, in most cases cost is part of the comparative framework. The measurement of any attribute (such as performance or productivity) has its own problems, and time, cost and quality have their own measurement concerns, however, the focus here is on construction cost alone: how to measure it consistently, and how to compare costs in real terms between different localities.

2.3 HISTORICAL COST COMPARISONS

Scholars have long been interested in the assessing relative costs, incomes and wealth in different historical periods. In 1745 William Fleetwood, Bishop of Ely, published the *Chronicon Preciosum*¹, “one of the earliest works on changes in prices” (Davies, 2004). Such works provide, for example, a way of estimating comparative standards of living for various levels of society at different points of time. Even within a single country these temporal comparisons pose significant problems due to, *inter alia*, changes in patterns of consumption, methods of work, currency and technology.

Similar historical comparisons between countries require currency exchange rates; such rates can only be gathered, and often interpolated, from a variety of writings of the various periods (e.g. Nugent, 1756, cited in Gunther, 2002). Such comparisons are of historical interest and provide some insight into and understanding of how people lived and how society functioned, but they have little application beyond that.

¹ Or “An Account of English Gold and Silver Money, the Price of Corn and other Commodities; and of Stipends, Salaries, Wages, Jointures, Portions, Day-Labour, &c., in England, for the Six Hundred Years last past.” (See Davies, 2004).

Certainly any attempt to compare construction costs over long periods of time will be much affected by the enormous changes that have occurred, particularly during and since industrialisation.

2.4 COMPARATIVE CONSTRUCTION STUDIES

Comparisons between construction industries have been attempted many times since 1950, and have become quite common since the 1970s, although a variety of techniques and approaches have been adopted. Often cost has been part of some broader comparison of productivity or performance but at other times cost has been the primary focus, often intended to ascertain whether buildings in one country are actually constructed more or less cheaply than in another. This has often been prompted by perceptions that costs in one place are higher than those in others and that there are lessons to be learnt from other countries that could reduce cost levels at home (Lynton, 1993).

2.4.1 The Anglo-American Council on Productivity study

In 1949 a UK group, the Building Industry Productivity Team, visited the US to examine “the organisation, constructional techniques and industrial outlook of the American building industry” (Anglo-American Council on Productivity, 1950:3). The purpose of the visit was, *inter alia*, to identify ways that the British industry could “lower its costs and thus compete more effectively in the markets of the world.”

As part of their investigation the team compared the cost of construction in the two countries by both comparing the cost of buildings of similar size used for similar purposes, and by comparing buildings built to the same design and specification constructed under similar circumstances. Costs (actual and estimated) were in local currency – GBP and USD – and these costs were equated by using the exchange rate current at the time of the visit in July 1949 (viz. USD4.00=GBP1.00). By the time the report was written and published in 1950 the exchange rate had changed considerably to USD2.80=GBP1.00.

The team reported that average building costs in the US, depending on building type, were 55-80% higher than UK costs, and that unit rates in the US for selected items of construction work were, on average, around 80% above comparative UK rates (Anglo-American Council on Productivity, 1950:16). Had the exchange rate current at the time the report was written been used, which represented an increase in the relative value of the USD against the GBP of around 43%, then US construction costs would have appeared to be considerably higher than was actually reported². This demonstrates two facets of the problem at hand: one is the problem of spatial comparisons where different currencies are involved; the other is the problem of fluctuations over time, even over fairly short periods, as was the case in this example.

2.4.2 Cost studies

High building costs flow on into higher production costs in other sectors and therefore contribute to reduced competitiveness in international markets, while improved productivity can not only reduce overall costs but increase economic growth. It is for these reasons that government agencies, such as the Productivity Commission in Australia, initiate studies into construction costs and take particular interest in the cost of construction in other countries. It is useful now to examine the aims of, and methods employed in, previous studies and to assess the outcomes of a number of them, particularly those in which cost is major factor. It is noteworthy that the body of literature relating specifically to international construction cost comparisons is not large (Stapel, 2002:3; Walsh and Sawhney, 2002:1) although several studies have appeared in recent years of which those by Walsh and Sawhney (2004 and 2005) and Meikle (2002, 2003a, 2003b, 2008) in conjunction with the Davis Langdon Consultancy (DLC, 1999) are particularly significant.

² At USD4=GBP1, and using the upper estimate of an 80% increase in comparative costs, £1 million worth of building in the UK would have been equivalent to (£1 million x 4.00) x 1.80 = \$7.2 million worth of building in the US. Given that UK and US costs (in local currencies) would not be expected to have changed much in the year or so between the team's visit and the writing of the report then the same equation would become (£1 million x 2.80) x 2.571 = \$7.2 million, where 2.571 is the derived factor that brings the two conversions to the same amount expressed in USD. This suggests that after just one year US costs were 157% higher rather than 80% higher than UK costs. Such a change is most unlikely in such a short time and illustrates the problems of using exchange rates in this context – this is explored further at 2.6.2.

2.4.3 Types of comparative studies

Edkins and Winch (1999:4) categorise comparative construction studies as:

- macroeconomic studies
- pricing studies
- case studies

A fourth category can be added, that of *hybrid*, as there are some studies (e.g. Xiao *et al.*, 2000; Langston and Best, 2000a) that display characteristics of more than one of the three original types. Each type has its strengths and weaknesses, and each can provide different views of the construction industry. Examples of all types are discussed in detail throughout this chapter.

2.4.4 Difficulties with comparisons

Comparative studies, regardless of type, present a range of problems, and those problems multiply when the subject is construction. They are exacerbated when international comparisons are attempted (Xiao *et al.*, 2000; Freeman, 1981; Meikle, 1990; DLC, 1999). While they may be difficult, such studies are done, and they can and do provide useful insights. Some results emerge consistently, regardless of the type of study done. For example, the US is generally acknowledged as building somewhat faster and more cheaply than other comparable countries (Xiao and Proverbs, 2002b, Nahapiet and Nahapiet, 1985; Flanagan *et al.*, 1986; Lynton, 1993 – but compare with Anglo-American Council on Productivity, 1950), while Japan has gained a reputation for taking longer to build but with an excellent record of completing on schedule and with higher than average quality (Xiao and Proverbs, 2002a, 2002c). Such broad conclusions are seldom questioned, but demonstrating the degree to which they are true is a more intransigent problem³.

2.4.5 Underlying problems

There are some fundamental issues that must be addressed when attempting comparative studies. One such problem is that of finding subjects (industry sectors, projects, activities) that are sufficiently similar for any direct comparison to be valid

³ For example, see the discussion of Lynton (1993) at 2.9.2.

(Walsh and Sawhney, 2004; Stapel, 2004). This is true from macro to micro level; the Lynton study (1993) discussed later falls somewhere between the two as it was based on just a single project, and as a result a compromise was necessary in order to compare actual data from the UK with estimated data from the USA. The use of estimated data has its own problems (Loosemore and McGeorge, 2002:6), and the use of actual cost data is always preferable (Dean, 2002:7).

2.4.6 Comparability and representativeness

Much of the literature dealing with comparative studies in construction, particularly international comparisons, mentions the problem of finding construction products⁴ that are both similar enough for comparison yet typical enough of products in use in the subject countries. These problems of comparability and representativeness are a subject of considerable debate (Meikle, 1990; Walsh and Sawhney, 2002 and 2004; Dubner and McKenzie, 2002; Stapel, 2002). A number of approaches have been tried as researchers have tackled this question. Those related to cost are discussed in more detail at 3.5.1.

Macroeconomic studies (discussed below at 2.5.4) appear to be less troubled by this problem, as the level of enquiry is such that underlying differences that affect comparability and representativeness are masked. This, though, is one of the shortcomings of those studies, and one reason why they are of limited value in helping to assess industry performance at anything below that of a broadly based whole-of-industry level.

2.4.7 Complicating factors

Factors that reduce both comparability and representativeness of construction output include:

- regional variations (in cost and design)
- market conditions
- taxation regimes
- climate

⁴ *Construction products* may range from complete projects down to individual on-site tasks or construction components.

- site conditions (related to general geographical location as well as with respect to foundations and footings)
- extent of site works
- differences in performance specifications
- safety regulations and other legal/statutory constraints (including environmental performance requirements)
- expected quality (in terms of both specified outcomes and local expectations)
- innovation
- conventional construction methods

Where any of these factors is deemed to have a significant impact on either the comparability or representativeness of products in a sample then data must be normalised to bring the products compared onto a more equal footing (de Valence and Langston, 1999; Langston and Best, 2000). This normalisation must be done with care, however, lest the data be comprised, or at least made no more reliable than it was at the start.

2.4.8 The impact of variable factors

The effects of most of these factors are discussed in detail below when specific problems associated with measurement and comparisons of cost are explored; others, however, are best dealt with in a more general discussion. Regional variations (within individual countries), for example, fall into two groups: those associated with *how* buildings are designed and constructed, and those to do with local conditions such as transportation (e.g. traffic congestion in downtown areas) and physical or geographical influences (e.g. potential for seismic activity or proximity to the ocean that places buildings in an aggressive physical environment).

Those in the first group have an impact on all aspects of performance, i.e. time, cost, quality and productivity, if the definition of Loosemore and McGeorge (2002:2) is accepted. Those in the second group are more likely to affect cost given that time and productivity can largely be controlled by increasing the amount of effort applied to the project. Quality should seldom be affected in this instance, beyond some changes in specification which will, in any case, emerge as increased cost.

2.4.9 Example

To illustrate these concerns consider two functionally similar buildings, located in the same large city, but with one in the central business district (CBD) and the other in a suburban location. Both have several levels of basement carparking. If the relative performance of the two projects is considered then the downtown project is likely to suffer cost penalties purely because of factors that are quite beyond the control of the contractor. The distance to landfill sites for disposal of excavated material plus typical CBD traffic will likely increase excavation costs, yet these increases occur regardless of how well managed or organised the project is and regardless of on-site productivity levels.

2.4.10 Innovation and building complexity

Innovation and complexity are also less easily defined influences – certainly buildings that are constructed using conventional methods and materials may reasonably be expected to be constructed more quickly and more cheaply than buildings that employ new materials or procedures. Thus data for buildings that do not include new or unusual components or methods may suggest that performance on those projects was better than that on buildings that are inherently more complex and therefore more time consuming in construction. The same is true for projects that feature new construction methods or that involve the use of new materials, components or assemblies⁵. Project selection during data gathering is important if data is to be consistent.

2.4.11 Balancing comparability and representativeness

In any case, some degree of both comparability and representativeness is needed if comparisons are to have any validity (Vermande and van Mulligen, 1999; Walsh and Sawhney, 2002). Studies that have moved too far towards either extreme must be questioned. Xiao and Proverbs (2000, 2002a, 2002b, 2002c) largely abandoned comparability for the sake of representativeness, although they claim otherwise (Xiao

⁵ Bernstein (2003) cites Flanagan (2003) and Young (2003) who suggest that buildings have become more complex and therefore there is an unfounded perception that productivity has decreased when in fact the apparent decrease is the result of increased complexity and quality of the product.

et al., 2000:121). The Eurostat/OECD purchasing power parity (PPP) program⁶ has been questioned repeatedly for its lack of representativeness (Stapel, 2002: 6), although in recent revisions some scope has been given for estimators to substitute more representative items into their pricing exercises (Stapel, 2002; Meikle, 2002).

2.5 MEASUREMENT ISSUES

The preceding discussion highlights the variety of terminology used to describe how well an industry or a project or even an individual firm or organisation may “perform”, or how “effective” or “efficient” they may be. Even if definitions can be clarified and a well-defined set of labels established, a whole new set of problems arise when any attempt is made to measure these characteristics in any objective (quantitative) or even subjective (qualitative) way.

2.5.1 Measuring productivity

Productivity measurement can be approached in many ways, from broad macroeconomic measures to onsite measurements of specific construction activities. Measurement below the level of individual projects is beyond the scope of this study and will not be explored further, however, some discussion of measurement methods at levels from projects to national industries is necessary.

2.5.2 Measuring construction productivity

The simple definition of productivity, output over input, is not particularly useful in the construction context. There are many reasons why making such a calculation is difficult and they include:

- the products of the construction industry are rarely exactly the same (OECD/Eurostat, 2001:24)
- inputs need to be expressed in a common unit, usually money, but factors such as management, organisation and ingenuity (English and Marchione, 1983:58) are difficult to express in dollars.

⁶ Purchasing power parities (PPPs) and the Eurostat method are discussed in detail later in this chapter.

- completed buildings (output) tend to be neither produced nor sold by a single contractor (OECD/Eurostat, 2001:10).

2.5.3 Methods for productivity measurement

Once again terminology and definitions are inconsistent in the literature. For example, Arditi and Mochtar (2000:15) cite three productivity measurements put forward by Oglesby (1989); they are total factor productivity (TFP), total productivity (TP) and what they term activity-oriented models. They define total factor productivity as the ratio between all outputs and all inputs, with both components expressed in dollars. Total productivity is described as “project-specific”; it is the ratio between the outputs (expressed in some physical measure such as m^2) and inputs (in dollars⁷). The inputs include labour, materials, equipment and management, with the last presumably including contractors’ profit and overheads. The activity-oriented model has labour as the only input, generally measured in hours worked, and outputs measured in units of physical product at a micro level, e.g. m^3 of concrete placed in columns, or m^2 of render to walls. The first two include cost, the third generally does not.

Zhi *et al.* (2003) also identify three types of productivity measure but describe them somewhat differently. They nominate total factor productivity (TFP), multi-factor productivity (MFP) and labour productivity (LP) as the three measures. They discount MFP and LP in the construction context, describing them (at 707) as being “misleading when applied to measure construction industry-level productivity performance”. Instead they suggest TFP as a more comprehensive indicator for evaluating “efficiency in the use of resources”, and select it as the most appropriate measure of productivity at the industry level. Their primary concern, however, is with examining trends in TFP growth over time rather than making any absolute measures of productivity. As their focus is on the industry in Singapore alone, the problems discussed later that characterise these macroeconomic studies are alleviated, as problems such as differences in national account keeping practices between countries do not arise.

⁷ Note that dollars is used throughout as a generic term for money. Specific currencies are identified as USD, AUD and so on in accordance with ISO4217:2001.

Croce *et al.* (1999) have a different view, equating TFP and MFP (at 81) and describe partial productivity (basically labour productivity) as “simple and robust”. Dean (2002) and Loosemore and McGeorge (2002:8) also equate TFP and MFP, and the latter restrict inputs in TFP calculations to labour and capital only. They note that productivity studies have generally concentrated on labour input, with output calculated as value added. They also point out, however, that this approach does not reflect changes in output based on technological change, changing capital ratios or new working practices (see also Pieper, 1990; de Valence, 2001).

Loosemore and McGeorge (2002:8) list a number of broad metrics that have been used in attempts to measure productivity:

- value added / employee or per hour worked;
- construction volume / employee or per hour worked;
- m² / employee or per hour worked;
- percentage of construction GDP/ percentage of construction employment.
- employment / thousand in workforce.

Only the first two involve cost but the authors identify a variety of problems with all these approaches. The first, however, has been used in several construction studies (e.g. Croce *et al.*, 1999; Access Economics, 1999) and the general method has been used in studies dealing with other industries, notably manufacturing (e.g. Pilat and Rao, 1996).

Loosemore and McGeorge discuss the use of the various measures at length and conclude, for a variety of reasons, that measuring productivity using such methods is problematic. This is discussed in more detail in the following section. Croce *et al.* (1999) share many of their concerns but use a value added approach to support their arguments regarding the productivity of the Australian construction industry. Their study is also discussed below.

2.5.4 Measuring productivity using macroeconomic data

Since 1980 a number of partial productivity studies have been reported in which the authors have used macroeconomic data, gathered by national statistics offices or international groups such as the OECD. Such studies have been criticised for a variety of reasons including:

- failure to provide data on quality (Kaglioglou *et al.*, 2001:86; Goodrum *et al.*, 2002:416)
- too simple to be an adequate measure of overall productivity in an economic sector as large and complex as construction (Bernstein, 2003:47)
- cost effective but with suspect reliability and comparability of data (Xiao *et al.*, 2000)
- too lacking in detail to be of use below the whole-of-industry level (Proverbs and Faniran, 2001:385)
- an unsatisfactory measure of efficiency of utilisation of resources (Chau and Walker, 1988:209)
- failure to reflect differences in capital intensity in measures such as output per hour worked or per person employed (de Valence, 2001:695)

Edkins and Winch (1999:19) suggest that they are a “crude” measure, particularly of output, and voice a number of concerns including the use of methodology that can be criticised as invalid as they use data from disparate sources. They add (at 44) that these measures often ignore the input from self-employed people in the industry, thus their calculations are skewed as inputs are under-measured. The US Bureau of Labor Statistics for many years chose not to publish figures on construction productivity, apparently due to concerns about defects in their measurement (Business Round Table, 1983:19; Goodrum *et al.*, 2002:418). Bernstein (2003:50) suggests that this is an indication that the Bureau recognises that accurate evaluation of the construction industry would require “many levels of sophisticated data.”

More recently BWA (2006:75) suggest that all methods for “international construction cost efficiency comparisons” that use macroeconomic statistics are invalid or at least unreliable.

2.5.5 The value-added approach

Studies based on value added in construction generally compare the total costs of inputs (labour, materials and so on) and the value of construction completed using those inputs. The difference between the two is the value added. When the value added is divided by the total input of labour hours value added per hour is derived; a higher figure indicates higher productivity. To compare these outcomes internationally requires the value added to be expressed in a common currency.

2.5.5.1 *The Access Economics study*

One such study (Access Economics, 1999) used OECD data for value added per hour worked to compare labour productivity in the Australian construction industry with that of five other countries⁸. Value added was defined as “gross revenue for construction work less purchases of materials etc [sic]”. The report highlights some of the problems associated with these studies, particularly when they lead to conclusions such as (at 5) “Australia’s labour productivity in construction is amongst the world’s highest”. The report gives minimal information regarding exactly what data was used, where it came from (apart from a note identifying one OECD source), or how it was used.

The calculation of value added is imprecise, and yet on the basis of this work the authors claim that Australia’s productivity was 10% better than the US and 40-60% better than Japan and Germany. The study also shows productivity in the UK industry to be the highest of the six countries studied, a result contradicted by Edkins and Winch (1999) in their analysis of 15 research studies that used a variety of methodologies. They concluded (at 46) that UK labour productivity tended to be low, and that this was demonstrated not only in macroeconomic studies but in most of the more detailed case studies.

In addition the Access Economics report suggests that Australia had the lowest real construction costs of any country in the sample, although it is interesting to note that UK costs are shown to be 5-6% below US costs, a finding quite at odds with a

⁸ Japan, US, UK, Sweden and Germany

number of other studies (e.g. Flanagan *et al.* 1986; Lynton, 1993; Xiao and Proverbs, 2002b). While the study shows Australia's "productivity performance" to be excellent (at 12) Langston and de Valence (1999) placed Australian productivity in the midrange of the countries studied in their report. Recent analysis of several of the earlier studies, carried out by Best and Langston (2006), suggests that the differences between UK and US costs are, in fact, even more marked than the original studies such as Flanagan *et al.* suggest (for example, see 2.9.1). The criticisms often levelled at macroeconomic studies seem well-founded in this instance.

2.5.5.2 *The Croce et al. study*

Another, more rigorous study, also from 1999, is that of Croce *et al.* It is a detailed investigation that tries to assess, in a number of ways, how the Australian construction industry compares with a number of other countries. They review previous studies as well as compiling and analysing their own datasets from public domain sources such as the Australian Bureau of Statistics (ABS). The authors point out many of the difficulties inherent in any attempt to measure productivity, particularly in construction.

They list (at 15) a series of reasons why labour productivity is an unreliable measure, including, amongst other things, distortions that emerge when construction times are shortened (and, as a result, costs decrease), thus appearing to decrease output when measured in dollars, as is typically done. They also mention changes in composition of activity (e.g. residential versus non-residential construction) that see increased activity in the residential sector, which they suggest typically has lower productivity than the non-residential sector, giving the appearance that overall productivity has levelled out or even declined.

In spite of questioning the reliability of macroeconomic studies (e.g. at 3, 14, 54 and 78) the authors use labour productivity figures (Table 16:78) to conclude that labour productivity in Australia "is above that for the US, Japan and all European nations". They rely on similar analyses of construction costs (Table 17:79) to conclude that "Australia is more than competitive with other western countries". Some of the figures in the table (at 79) were not quoted accurately from the source document

(Page Kirkland, 1999:2), and international costs in that study were converted to a common currency using exchange rates only, a method now generally recognised to be flawed (Meikle 1990; Pilat, 1996b; Vermande and van Mulligen, 1999; al-Adhath, 2002; ABS, 2002; Xiao and Proverbs, 2002b; Ong, 2002, citing Kravis, 1986; Schreyer and Koechlin, 2002a; Goodchild and Griffiths, 2004). In fact, in the Page Kirkland document (at 2) the authors of that study state “it would appear that Australia with its *currency exchange advantage* is more competitive” [emphasis added].

2.5.6 Pricing studies

Studies, such as the Page Kirkland (1999) study, that attempt to make comparisons based on construction cost and price only are the most common. Whether these studies, even if rigorously done, are valid measures of either competitiveness or performance is debatable. As a measure of competitiveness it is hard to see why lower costs in one country make the industry of that country more competitive in another. If a contractor from Country A (displaying lower costs) tries to compete in Country B (higher costs) surely they will be subject to local conditions (market conditions, taxation, specification, and safety and other regulations) and be reliant to some degree on local labour (at local rates). Local workers would also be expected to be more skilled in local methods and may require training if Country A methods are to be employed (Edkins and Winch, 1999:14). Unless it can be clearly shown that the lower costs in A are, to some appreciable degree, attributable to better organisation and management then any claims of A being “more competitive” than B are dubious. If cost is seen as just one part of performance then assessing performance on a cost only basis is as problematic as relying on labour productivity as a measure.

2.5.7 Standard projects

The typical approach employed in pricing studies is to use a “standard” project or projects, whether actual projects (e.g. Page Kirkland, 1999) or hypothetical ones (e.g. DLC, 1999) and collect price estimates for the projects from various countries. Estimated prices are converted to a common base currency and conclusions drawn about relative price levels between the countries concerned. There are several methodologies employed within this basic framework (Edkins and Winch, 1999:1):

- comparisons of identical standard projects (real or hypothetical) (OECD/Eurostat, 2001)
- comparisons of standard projects but with estimators given some flexibility to price “equivalent” local variants, either prescribed (Meikle, 2002) or at their own discretion (BCIS, 2006)
- comparisons of functionally similar buildings, with allowance for inclusion of materials and methods typical in each location, e.g. the alternative houses in the Eurostat method (Eurostat/OECD, 2006).

The first approach emphasises comparability at the expense of representativeness, the last reverses that emphasis, while the second falls somewhere in the middle. The Eurostat/OECD procedure⁹ for construction PPPs has moved towards the second model in recent years (Meikle, 2002).

The studies that are carried out regularly for determining purchasing power parities, the UN/World Bank’s International Comparison Program (ICP) and the Eurostat/OECD exercise, are major pricing studies covering the whole spectrum of economic activity¹⁰. They are discussed in detail at 2.7.2 as they are by far the most rigorous exercises of this type and the results are commonly used (sometimes inappropriately) in construction pricing studies.

2.5.8 Case studies

These studies (e.g. NEDO, 1990; Business Round Table, 1994) are usually very focused, concentrating on just a few projects (in the case of the NEDO study, just one pair of projects) and while they produce detailed outcomes the results cannot be treated as representative of a national industry nor even of a region or city (Pilat, 1996b: 114). They do, however, provide opportunities for identification of specific

⁹ It should be noted, however, that the Eurostat/OECD exercise is not aimed at assessing price competitiveness; the aim is to provide input to a far larger exercise to determine purchasing power parities at GDP level. – see further discussion below at 2.7.2.

¹⁰ Goodchild and Griffiths (2004) describe the Eurostat/OECD exercise as a “regional implementation” or “subset” of the ICP – while the two programs have much common ground they also pursue their own aims, and have their own management structures.

factors that may be responsible for apparent differences in productivity and overall performance, and some extrapolation is possible if done with caution. If not done carefully, exaggerated differences may be reported because of the difficulty in assessing how nationally representative the buildings studied actually are.

True case studies (e.g., Flanagan *et al.*, 1986) use only data from completed projects. This is the greatest strength of this approach (Meikle, 2004) as the use of “real” data immediately eliminates many of the problems associated with using estimates (Meikle, 1990:185; Business Round Table, 1994:2; Loosemore and McGeorge, 2002:6, Stapel, 2004:1). Unlike macroeconomic studies and pure pricing studies, the case study approach provides an opportunity for identification of the reasons for differences in outcomes such as cost and time performance (Edkins and Winch, 1999:45; Loosemore and McGeorge, 2002:6).

In spite of the potential dangers of extrapolation from an extremely small sample, perhaps the greatest value of these studies lies in their assessment of performance at a national level. If A can produce functionally similar buildings (or “equivalent” buildings) of comparable quality and amenity, while using less resources than B, then this may prompt B to examine its processes and look for ways to improve. Conversely such examinations may explain differences in results and whether changes or improvements are warranted or not. A number of studies in which the UK construction industry’s performance has been compared to others (e.g. Nahapiet and Nahapiet, 1985; Flanagan *et al.*, 1986; NEDO, 1990; Lynton, 1993) suggest that much of the perceived difference (which generally tends to disfavour the UK industry) can be attributed to factors such as the preference in the UK for bespoke building designs rather than the more standardised approach common in the US industry. Similarly the apparent French preference for prefabricated formwork (also possibly a corollary of a more standardised approach) over the UK norm of purpose-made, on-site timber formwork supporting in situ concrete (Proverbs *et al.*, 1999) may not be readily transferable to the different design culture in the UK. Edkins and Winch (1999:45) suggest that when these studies are well done they are “perhaps the most powerful tools for understanding differences in construction performance between nations.”

2.5.9 Hybrid studies

Some studies do not fit neatly into any of the three categories suggested by Edkins and Winch (1999) as they combine the characteristics of more than one of those categories. One such study is that of Langston and Best (2000a) that compared industry performance at the level of individual projects by comparing productivity (measured as m² constructed per month) and resource use (measured as the value/cost of building work completed per month). It has some of the characteristics of a pricing study but uses real data at the project level to assess performance at a national level.

Another set of studies, reported in a series of papers, was produced by a group of researchers headed by Proverbs. The papers basically report on two studies, the first, reported in a long series of papers from 1996 to 2001, deals with a hypothetical in situ concrete building frame (e.g. Proverbs *et al.*, 1999b), the second with a hypothetical six storey office building (Xiao *et al.*, 2000; Xiao *et al.*, 2001; Xiao and Proverbs, 2002a, 2002b, 2002c). While both studies are of interest the earlier series did not include cost data except for some estimates produced by the authors using published labour constants and unit rates. The later study is, however, of particular importance as in it the researchers tried to assess performance across a broad range of parameters relating to time, cost and quality, across three countries (UK, US and Japan).

The first two papers (Xiao *et al.*, 2000; Xiao *et al.*, 2001), relating to the second study describe the proposed methodology and a pilot study carried out in the UK to test the utility of their survey instrument. The three papers published in 2002 compare construction contractor performance, anticipated or estimated, in terms of time (Xiao and Proverbs, 2002a), cost (Xiao and Proverbs, 2002b), and quality (Xiao and Proverbs, 2002c). This study is of particular relevance to the discussion here as it is one of the most comprehensive attempts to date to combine the three cardinal factors of time, cost and quality into an assessment of contractor performance. A detailed analysis of the methodology, analysis and reported conclusions in respect of construction cost is therefore warranted here. The study and its resultant papers do,

however, have some serious shortcomings and show how the unwary may find many pitfalls concealed in the jungle of comparative studies¹¹.

2.5.10 The Xiao and Proverbs study

The methodology was survey based and used a hypothetical six storey concrete framed building project. No drawings were supplied with the survey; instead a written description of the project was provided, and respondents were expected to provide exact details of the project based on their experience. The authors make the bold claim that because of this “the best characteristics of pricing studies and case studies are utilised, while disadvantages of the two methods are eliminated” (Xiao *et al.*, 2000:121). They support their view by stating that this approach retains comparability of data but greatly improves representativeness. Another view could be that it simply compounds many of the problems associated with both pricing and case studies, as all the problems of pricing studies that arise from using estimates of cost are still present, and even exacerbated, while the “reality” of case studies is lost.

The authors themselves point out the unreliability of cost estimates: “...most construction projects meet the required quality specifications but seldom are completed within budget and time...” (Xiao and Proverbs, 2002b:427, citing Wright, 1997). They also cite Graves and Rowe (1999) who “reported that two thirds of the public projects investigated exceeded cost estimates” (Xiao and Proverbs, 2002b:427). Walsh and Sawhney (2002:19) cite research by the Construction Industry Institute in the US (CII, 1996, 1998) that shows estimates varying by as much as -50% to +100% (“compared to actual project cost on early estimates of industrial projects”) and even more detailed estimates showing discrepancies of up to 25% when compared to actual project costs.

Given the lack of drawings and minimal specification provided in the study it is hard to see how the cost estimates could be reliable – and a glance at the data presented (Xiao and Proverbs, 2002b: 428) shows a disturbing spread of estimates. For

¹¹ See Best and Langston (2006a) for a detailed analysis of the set of papers relating to this study, including those dealing with time and quality.

example, even before there is any question of the problem of converting costs to a common currency, the UK estimates of cost of construction range from £500 to £1400/m²¹². The data presented seem to contradict the generally accepted view of the relative performance of the three national industries, with Japan and the UK closely aligned and doing better than the US, at least in respect of time performance.

2.6 CURRENCY CONVERSIONS

The question of how to convert construction cost data from one national currency to another is arguably the single most important factor in any international comparison. The choice of a different conversion method can have quite pronounced effects on outcomes (Sharpe, 1995:226) and appear to invalidate conclusions based on other conversions (Best and Langston, 2006). This is true whether it is in the context of a simple conversion between two countries or where a data in a number of currencies must be brought to a common base. Clearly it is not feasible to compare sums of money unless they are in the same currency. Market exchange rates are of obvious interest to those who trade in currencies, to importers and exporters of goods and to travellers but as a mechanism for bringing costs to a common base for industry comparisons they are problematic (see 2.6.2 below).

2.6.1 Selecting an appropriate conversion tool

Before discussing the specific case of spatial construction cost conversion it is important to note that there is typically a variety of conversion factors that may be applied when comparing value or worth at different places or at different times, and these factors can and do produce different results. Hence it is important that the conversion mechanism chosen for a particular task is the most suitable in that situation. McManus (2005) illustrates this point well in his assessment of the relative wealth of distinguished doctors in the UK in the period between 1860 and 2001 – while this is a case of temporal rather spatial comparisons the range of outcomes provides a good example of just how much results can vary depending on the method selected for conversion.

¹² This is well beyond the usual range of variations between estimates and out-turn prices – for example, quantity surveyors routinely expect to produce pre-tender estimates within 5 to 10% of successful tenderers' prices (DLC, 1999:30).

In the study McManus compares the wealth (measured as the value of their estate recorded for probate at the time of their death) of 980 doctors who were eminent enough to be listed in the *Oxford Dictionary of National Biography*. In order to bring the various amounts of money (all in GBP but spread over 140 years) to 2002 equivalents he uses an index relative to average earnings, but gives the following example of one prominent doctor, Sir James Paget, who died at the end of 1899 leaving an estate of £74,861. This amount, adjusted to 2002 values becomes £4.9m (using a consumer or retail price index), £6.1m (using a GDP deflator), £25.9m (based on comparative average earnings), £28.9m (GDP per capita) or £41.6m (overall GDP). The last value is more than eight times the first, and yet all of the conversion methods appear, *a priori*, to be reasonable. The chosen method, based on average earnings, is recommended by Officer (undated) as this measure, he says, “makes good sense to obtain relative value for income or wealth” where a measure such as the retail price index is linked to average consumption across all levels of society (and an eminent doctor in 1899 was hardly a typical citizen) while overall GDP is related to economic activity at the level of the entire economy and similarly does not mirror the income and expenditure of the individual.

2.6.2 Exchange rates

As noted earlier exchange rates are generally acknowledged to be unsuitable for converting the cost or value of construction work in different countries to a common base. Vermande and van Mulligen (1999:20) suggest that “exchange rates do not indicate the comparative value of currencies in the production of goods and services”. They also point out that they often fluctuate significantly in the short term, and in any case they are only relevant to tradeable goods and services. Construction projects are very seldom tradeable in the usual sense, as they generally remain fixed in the location in which they are constructed (Koskela *et al.* 2002:217). The European Comparison Program Methodological Notes (NSI, 2004) advise against the use of exchange rates as they only reflect supply and demand on currency markets. As fluctuations in that supply and demand are driven by other forces (e.g. differences in interest rates) exchange rates are not set with regard to the value of goods and

services (see also Pilat, 1996a; Al-adhath, 2002; Goodchild and Griffiths, 2004; Blake *et al.*, 2004.)

Even using an artificial conversion method such as European Currency Units (ECUs) may be suspect. Edkins and Winch (1999: 41) say of some outcomes of one study in which costs were converted to ECUs -(Business Round Table, 1994):

It should also be noted that the price comparisons are based on a strong [UK] pound – little more than 12 months later the picture would have looked very different.

Best and Langston (2006b) revisited several earlier studies and compared the results reported in the original publications against the results that they obtained when using different methods to convert construction costs to a common currency. One of those (Page Kirkland, 1999) was a pure pricing study commissioned by the then Australian Department of Industry Science and Resources (DISR). In the first stage of the study costs were converted from national currencies to AUD using current exchange rates and Australia appeared to exhibit lower construction costs than comparable countries included in the study. Langston and de Valence (1999) and Best and Langston (2006b) converted costs using other methods which resulted in quite different conclusions about the Australian industry's performance thus highlighting the dangers of using exchange rates in this context.

2.6.3 Value, cost and price

Cost, value and price are terms that are often treated as synonyms, however, in this context they have different meanings and it is important to clarify those meanings. *Cost* generally refers to input costs, i.e. the cost to the contractor of performing construction work; this includes the net cost of labour and materials, hire or ownership costs related to plant and equipment, and job-specific overhead costs such as site sheds and hoardings, temporary services and insurance of the works (generally included as “preliminaries”).

Theoretically mark-ups for company or general overheads and profit make the difference between the *cost* to the contractor and the *price* paid by the client¹³. *Value* in construction has many meanings (Best and de Valence, 1999) but in the present context it is usually treated as the total of prices paid for completed construction work, e.g. in value-added studies such as the Access Economics (1999) study the total value of construction work is extracted from OECD data where value is the reported out-turn prices of all completed work in a given period.

Price levels in general do vary between countries, however, with prices, particularly for non-traded goods, tending to be higher in countries where incomes are higher. This is generally attributed to the Balassa-Samuelson or Penn effect (e.g. Click, 1996). Ong (2002:94) notes that “high wages are usually accompanied by high productivity. The main concern in international comparisons is to eliminate, as far as possible, differences in prices between countries so that when costs are converted to a common currency they are then valued at the same price levels (Vachris and Thomas, 1999:3). This is commonly done using purchasing power parities (PPPs).

2.7 *Purchasing power parity and the Law of One Price*

The idea of purchasing power parity (PPP) can be traced as far back as the 16th century (Dornbusch, 1987). It is based on what Rogoff (1996:647) describes as “the disarmingly simple empirical proposition” that the cost of a good or service (or a basket of goods and services), once prices are converted to a common currency, should cost the same in different countries. This is the so-called Law of One Price (Pakko and Pollard, 1996; Lafrance and Schembri, 2002; UBS, 2003). The theory is that if an item can be bought more cheaply in country A than in country B then traders can profit by buying in country A and selling in country B. This is known as arbitrage. The theory suggests that over time international trade will see the price of the item in both countries level out.

¹³ Assuming that input costs are correctly estimated in the first place and therefore that the price paid by the client is greater than the cost to the contractor.

For some commodities that are traded often, such as gold, the Law of One Price holds well (Rogoff, 1996:650) but it seldom holds for non-traded items, such as housing and many services. The reason for this is that while it may be cheaper (based on current exchange rates) for a person to rent a house or visit a doctor in India than it is in Australia it is obviously not feasible for an Australian resident to live in Mumbai and work in Sydney. Because of this it has been suggested that the Law of One Price does not hold well for construction output (Vermande and van Mulligen, 1999:270) as built facilities are not tradeable¹⁴ (Schreyer and Koechlin, 2002a:11), and are produced and consumed locally. Vermande and van Mulligen go on to explain that a large proportion of the cost of a building is made up of labour costs and basic materials such as bricks, sand and concrete. These are mostly produced locally rather than imported and therefore their costs are little affected by exchange rates¹⁵.

This may be true of the majority of structural and envelope components of most buildings but the same is unlikely to be true for other building elements. For example, in recent years there has been a marked increase in the proportion of building costs represented by engineering services, and a significant part of services costs includes manufactured items such as fans, pumps, chillers, generators and mechanical transportation (lifts and escalators) (Nowak, 2007). Many countries do not produce these items locally and therefore have to import them (Nowak, 2007). Even some highly developed countries do not have local producers of some basic construction materials; Singapore, for example, imports most, perhaps all, of the cement and reinforcing steel that it uses (Tan, 2008). While such goods are obviously tradeable the built facilities into which they are incorporated should be considered as complex units of construction output and therefore such output represents a mixture of tradeable and non-tradeable goods.

¹⁴ In the sense of being traded between locations, which implies some sort of portability.

¹⁵ The example cited earlier (at 2.4.1) of the fluctuation in UK/US exchange rates between 1949 and 1950 illustrates this – while local construction costs would have varied little in the time described the apparent relative costs appear to have changed considerably, a proposition that appears untenable.

2.7.1 Purchasing power parity and exchange rates

Fundamental to the PPP doctrine is the notion that similar items (or baskets of similar items) are worth the same, i.e. they have the same value in any location. For example, the utility that an individual obtains from an item such as a loaf of bread or a service such as a haircut is the same regardless of where the item or service is consumed.

It follows then that the amount of local money necessary to buy such goods or services in one location is equivalent to, or has the same value as the amount of money in another local currency needed to buy the same items in another location. Therefore the amounts of the two local currencies are said to have the same purchasing power. The exchange rates, based on purchasing power, that link the currencies are referred to as “real exchange rates”, while those published daily in the media are termed “nominal exchange rates” (Rogoff, 1996). Nominal exchange rates determine the amount of one currency that is needed in order to buy a quantity of a second currency, but this is not related to the value of goods that could be purchased with that amount of the second currency in its home country.

There has been a lot of discussion and research related to the PPP concept since Cassel introduced it into modern economics in the 1920s (e.g. Cassel, 1921) and some aspects of PPP are not universally accepted. PPPs are, however, widely used by various agencies to compare national financial and economic data such as relative living standards and income levels. The European Commission, for example, uses PPPs to gauge GDP per capita (in real terms) among member countries and funding decisions are made based on these calculations (Dowrick, 2002; EC, 2006).

2.7.2 Calculation of purchasing power parities

A range of purchasing power parities (PPPs) are routinely produced. General PPPs are the result of extensive price gathering exercises carried out by Eurostat and the OECD, and by the ICP for the UN and World Bank (Walsh and Sawhney, 2002). The Centre for International Comparisons (CIC, 2006) at Penn State publishes the Penn World Tables that expand the range of PPPs to include 188 countries over more

than 50 years. The Union Bank of Switzerland (e.g. UBS, 2003) has also been producing PPP data since 1970.

2.7.2.1 The OECD/ICP method

The OECD's 1996 comparison used a list of around 4000 items including consumer goods and services, pharmaceutical products, capital goods, motor vehicles, government services, health and education services, and twenty construction projects (Walsh and Sawhney, 2002:2). Construction prices were gathered by having comprehensive bills of quantities (BQs) priced by estimators in participating countries. The system used for gathering construction cost data has been under review for some years as there are serious doubts about the reliability of results (Ive *et al.*, 2004; Meikle, 2004) and the level of effort and resources required to gather the data (Dubner and McKenzie, 2002:paras. 67 and 72; Stapel, 2002:1 and 11; Ward, 2003;2). For similar reasons the ICP method is also under review, with a new framework for collecting construction data being implemented in the current round (Walsh, 2008, pers. comm.)

2.7.2.2 The UBS method

The Union Bank of Switzerland (UBS) surveys prices and incomes in around 60 cities worldwide every three years. They use a basket of goods and services comprising 140 items based on 114 different products to measure price relativities (UBS, 2003:37) The basket is very similar in content and structure to that used in calculating a typical Consumer Price Index (ABS, 2005). The basket represents typical purchases of a western European household and is used in two forms: one includes three categories of rent expenditure and the other excludes rents. Consequently the costs of construction are included in the basket only indirectly inasmuch as education costs, for instance, reflect the costs of providing and maintaining classrooms, libraries and other associated built facilities. UBS uses the purchasing power concept in their comparisons and publishes PPP exchange rates for the cities that they survey (e.g. UBS, 2003:39). While Langston and Best (2005) suggested that the UBS PPPs were a preferred method for some cost comparisons¹⁶ the nature of the basket of goods and services on which these PPPs are based has

¹⁶ The method used and findings reported in Langston and Best (2005) are discussed further at 2.7.6.

little obvious relevance to construction, and the city based nature of the survey does not produce national PPPs. In fact the cities surveyed are often the more expensive cities, for example, in Australia only Sydney is included. In the US the four cities included are New York, Los Angeles, Chicago and Miami, and in the UK only London is surveyed. In none of these cases should the PPPs published by UBS be considered as representing purchasing power nationally.

2.7.3 The *Big Mac*TM Index

The Law of One Price, which provides the foundation for the doctrine of PPPs, has been applied in a very simple way since the 1980s in the formulation of the Big Mac Index. In 1986 *The Economist* magazine first published, somewhat light-heartedly, a comparative index based on a single, tightly-specified manufactured commodity, the Big Mac hamburger (Pakko and Pollard, 1996).

The idea is simple: the Big Mac is offered for sale, with virtually identical specifications, in around 120 countries (*The Economist*, March 27, 2004). By assuming that the value of this commodity must be equal in all countries, as it is an identical product, it was argued that the cost of a Big Mac in any country could provide a measure of the relative value of various currencies, and so reflected the purchasing power of a unit of currency in each country. For example, if a Big Mac cost, on average, AUD\$2.50 in Australia, and USD\$2.00 in the US, then the exchange rate should be AUD\$1.00 = USD\$0.80. If the exchange rate was below USD\$0.80 then the Australian currency was considered to be undervalued, and vice versa. It was further argued that an exchange rate based on the “hamburger standard” would be far less sensitive to the short term fluctuations that characterise open currency markets.

In essence the Big Mac approach assumes that a single commodity is as representative of domestic consumption as the extensive basket of goods and services used in sophisticated PPP exercises such as the ICP. In fact the Big Mac does incorporate a range of tradeable and non-tradeable inputs including the raw materials such as flour and meat as well as, for example, transport, rent of land and buildings, labour and cleaning. Pakko and Pollard (2003:72) suggest that the “simple collection

of items ... does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures”.

2.7.4 Testing the Big Mac Index

One researcher, Li Lian Ong from the IMF, has tested the index over a number of years. She concludes (Ong, 2002:23) that the notion of PPP “as a theory of exchange rate determination is probably the most useful and used of all exchange rate theories, despite its many detractors”, and (at 29) notes that empirical tests, utilising the Big Mac Index to track exchange rate movements have been “surprisingly successful”. She concurs with Pakko and Pollard (at 111), saying that, based on her research, the hamburger index is as reliable as “most other measures of purchasing power parity:”

Ong and Mitchell (2000) used the index to compare “real” academic salaries across eight English-speaking countries. Their study highlights just how misleading such a comparison can be when based on currency exchange rates rather than purchasing power. In effect the authors calculated how many Big Macs could be purchased with a year’s salary in each country, using average academic salaries (at various levels, lecturer, senior lecturer and so on) and Big Mac prices in local currencies. Comparisons of “real” salaries then involved a simple comparison of the number of hamburgers that could be bought in each country. For example, in the study year (1999) the average exchange rate between the AUD\$ and the USD\$ was around \$1.29. The average salary for an Australian lecturer was AUD\$49,432 – for the US equivalent (Assistant Professor) it was USD\$41,041. When compared using the exchange rate, the Australian salary was only USD\$38,319. In contrast, when Ong and Mitchell applied the Big Mac Index, the Australian salary had purchasing power equivalent to a salary of USD\$47,992, making the purchasing power of the Australian salary considerably greater than that of the comparable US salary.

2.7.5 Other commodity-based indices

The idea exemplified by the Big Mac Index has been expanded in various ways.

2.7.5.1 *The Braten Index and the “coffee standard”*

Gunther (2002) suggests a Braten¹⁷ index, based on a simple meal of meat with vegetables, as a means of assessing the purchasing power of people in Europe in the 18th century. *The Economist* (2004) compared the costs of a Big Mac in a number of countries with the cost of another standard food item, a “tall latte” as sold in over 30 countries by the Starbucks coffee company. While they concluded that for “most main currencies” the two indices gave broadly similar results, in Asia the two measures differed markedly. For example, the Japanese yen appears undervalued by around 12% using the hamburger index, but over-valued by 13% based on the “coffee standard”.

2.7.5.2 *The iPod™ Index*

In 2007 Commonwealth Securities (CommSec) introduced the iPod Index (CommSec, 2007) a similar index based on the price of a portable music player, the iPod Nano, in 26 countries. CommSec chose the iPod as virtually all iPods are produced in one place (China) unlike the Big Mac, which although it is made to the same specification in each place is made from local ingredients and does have some local variants. They also suggest that the Big Mac Index can be distorted by factors such as differences in taxation, labour laws and trade barriers. Also, unlike the Big Mac, the iPod is totally tradeable, and due to its compact size transport costs for iPods are not high. In CommSec’s view an iPod should cost much the same in all countries otherwise, in the age of Internet commerce, buyers would simply purchase their iPods from countries where they are cheaper than in their own.

At the time of the launch of the iPod Index the cost of the unit in the US was USD\$149 while in Australia it was AUD\$219. This implies an exchange rate of around 68 US cents to one AUD. In January 2007 the actual exchange rate was nearly 79 US cents to the AUD, hence it may have been possible to buy an iPod for around AUD\$189 and then ship it to Australia with a small net saving assuming that additional costs such as tariffs and transport are less than the basic cost differential.

¹⁷ German for “roast meat”

This illustrates the difference between a PPP approach and the use of nominal exchange rates when comparing costs between countries.

2.7.6 Applying “burgernomics” to construction

The Big Mac Index has been applied in a construction context in only two previous studies (Langston and de Valence, 1999; Langston and Best, 2000a). Croce *et al.* (1999) were scathing in their attack on the use of the Big Mac in the Langston and de Valence study, saying (at 21) that

... it should be obvious that countries where food production is not based on wheat, sesame seeds, beef, dairy products, dill pickles and potatoes¹⁸ and where a Big Mac is a luxury item, available only in major cities to urban elites mimicking Western tastes, rather than a fast food staple, is not any sort of a ‘standard commodity’.

As discussed above, there is some support for the index in the literature (e.g. Ong, 2002). It is possible, however, that Croce *et al.* were strong in their criticism of the Langston and de Valence report as it did not present a favourable picture of the Australian industry’s position, while their own study, commissioned by three trade unions¹⁹ with an obvious interest in a favourable result, concluded (see above at 2.5.5) that in the international context, productivity in the Australian construction sector was very high.

2.7.7 Comparing PPP outcomes for construction

Langston and Best (2005) tested the use of the Big Mac Index (BMI) as a basis for comparing construction costs. Primarily they sought to establish whether any of four conversion factors produced results that satisfied the Law. of One Price²⁰. They used published cost per m² rates in local currencies (Rawlinsons, 2004) for a single

¹⁸ The reference to potatoes is odd as the index is based only the hamburger – without fries

¹⁹ The Construction Forestry Mining and Energy Union (Construction), the Electrical and Plumbers Union and the Australian Manufacturing Workers Union.

²⁰ The Big Mac Index (The Economist, 2003), UBS PPPs (UBS, 2003), ICP PPPs (ICP, 2004) and annual average exchange rates (UBS, 2003).

building type (five star hotel) in ten major cities²¹ and converted those costs to a common base of USD using the four factors.

If it is assumed the Law of One Price holds for the commodity under consideration (i.e. five star hotels) in the chosen locations (i.e. the ten cities) and any of the conversion factors tested is reliable then, they suggested, the converted costs per m² should be equal or at least close to equal. Table 2.1 shows the results

Conversion factor	Mean \$	Standard Deviation \$	Coefficient of Variation
Big Mac adjusted hamburgers/m ²	2,388	1,069	44.78%
UBS PPP	2,051	628	30.61%
ICP PPP	2,096	497	23.71%
US\$ exchange rate	1,801	884	49.10%

Table 2.1 Statistical interpretations for international hotel costs per m² (Source: Langston and Best, 2005)

All four conversion factors gave results that showed considerable dispersion around the mean, with exchange rates and the BMI showing large variations and the ICP PPPs showing the smallest coefficient of variation. Further tests used the approach applied to six other building types and seven items of building work²² (e.g. placement of cubic metres of concrete, 100 x 50 timber rafters). In all cases exchange rates gave results with the greatest dispersion around the mean, and in no instance was the Law of One Price obviously satisfied.

Finally the authors tested the Law of One Price in relation to the Big Mac hamburger by converting the cost of a Big Mac (in local currency) in each city to USD using the ICP and UBS PPPs and exchange rates. Again the results were inconclusive with two cities (Kuala Lumpur and Bangkok) showing widely spread results (see Figure 2.1).

²¹ Sydney, Vancouver, Hong Kong, Tokyo, Kuala Lumpur, Auckland, Singapore, Bangkok, London, Los Angeles

²² Costs included materials, labour and minor items – costs used were in local currencies from Rawlinsons (2004).

Given that exchange rate conversions can be disregarded in this context, several cities (Vancouver, Tokyo, London) showed ICP and UBS PPP prices to be very similar while the rest showed considerable differences. The authors concluded that while the use of the BMI to express construction costs in “hamburgers per m²” does not appear to be reliable for all locations (with a coefficient of variation of around 45% across the ten cities) it may be as good, for some cities, as any of the other methods that were tested. They suggest (Langston and Best, 2005: 5) that “it is difficult to compare nations that have quite different characteristics without introducing some form of bias.” They add that the bias in current attempts to create PPPs is generally “towards European and American spending habits”. These observations are reasonable when discussing general PPPs such as those published by the OECD and ICP, and also where a hamburger is the representative commodity,

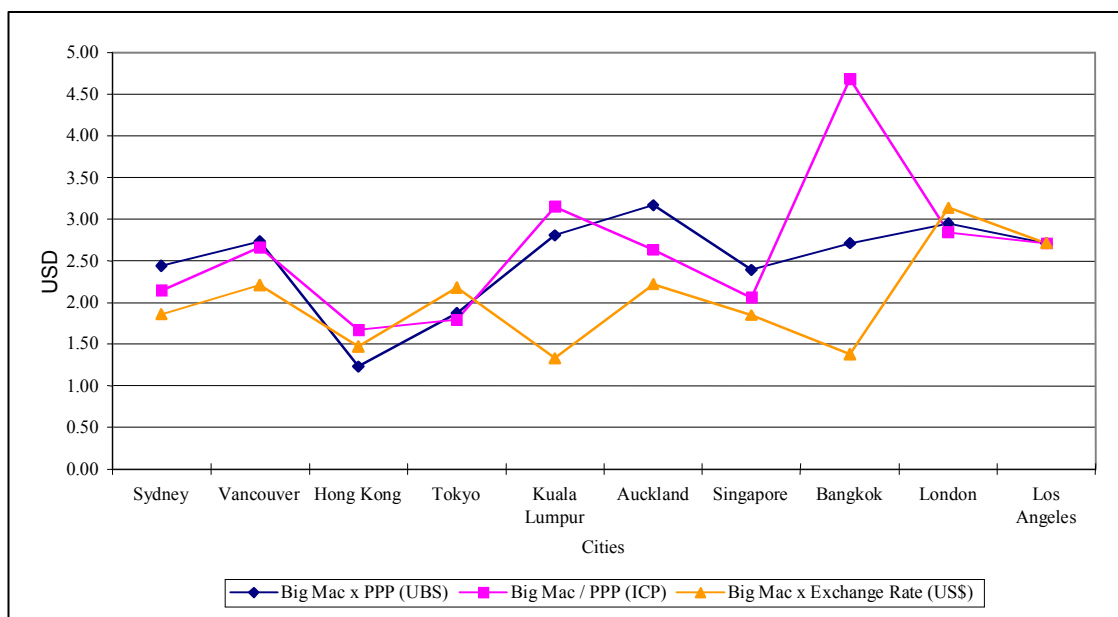


Figure 2.1 Price of Big Mac in comparable terms (Reproduced from Langston and Best, 2005)

but it should be less of a problem if construction-specific commodities are used as long as those commodities are suitably representative of local construction.²³

The spread of results and the inconsistencies in the results suggest strongly, however, that none of these conversion factors can be used with any confidence in the

²³ See 3.5.1 for further discussion of comparability and representativeness of commodities/output.

construction context. This adds further weight to the proposition that more robust and reliable construction-specific conversion factors are needed.

2.8 INDUSTRY SPECIFIC PPPS

Purchasing power parities (PPPs) at GDP level are routinely used for comparing output between countries (e.g. CIA, 2006). They may provide a method for converting construction costs from a number of countries to some common base, however, this method has limitations and they cannot be ignored.

Schreyer and Koechlin (2002a:8) advise against the use of general PPPs (i.e. PPPs at the GDP level) for use in industry-level productivity comparisons but point out that there are few industry-specific PPPs currently available. In Stapel's view (2004:20) PPPs have a limited number of legitimate uses, and should not be used for a variety of other purposes.

Recommended uses of PPP	• spatial volume comparisons of GDP, GDP per head, GDP per hour worked, size of economies • grouping of countries by volume index of GDP • spatial comparisons of relative price levels
Use of PPP with limitations	• time series analysis of relative GDP per capita or relative prices • analysis of price convergence • cost of living index across countries • use of PPP established for expenditure categories for the deflation of other values, e.g. household income
Non-recommended uses of PPP	• as a precision tool to establish rankings between countries • as a way of constructing national growth rates • as a measure to generate output and productivity comparisons by industry (unless there are industry-specific PPP) • as a measure to undertake price level index comparisons at detailed level • as an indicator for the over- or undervaluation of a currency • as equilibrium exchange rates

Table 2.2 Use of PPPs (Source: Stapel, 2004:20)

Stapel (2004:23) notes that in “the absence of industry specific PPP, users often use the overall PPP of GDP and apply it to output data of industries or use it for productivity comparisons of industries.” She advises strongly against this and

suggests that what is needed are “PPPs based on output prices for the products and services” of the relevant industries.

Over a decade ago Pilat (1996a:4) noted the lack of industry-specific conversion factors and the unsuitability of PPPs for total GDP (i.e. general PPPs) when comparing particular industry sectors between countries. Ive *et al.* (2004:22-23), however, recommended the use of general GDP PPPs “at least for the time being” in construction industry comparisons simply because they felt that reliable construction price level indicators were not yet available, and despite ongoing research aimed at improving such indicators, would not be available for “some time”.

It is also worth noting Stapel’s caution against using PPPs as a “precision tool” (See Table 2.2). The ABS (2002:1) suggests that there is a $\pm 5\%$ error margin in PPPs; Goodchild and Griffiths (2004) say that PPPs are useful but have “limited precision” and therefore small differences between countries should not be treated too seriously.

2.8.1 General PPPs and construction-specific PPPs

Langston and Best (2005) compared general PPPs and construction-specific PPPs (CPPP) published by the OECD/Eurostat for 2002 (OECD, 2005) and calculated percentage differences for 31 EU countries; the results are shown in Figure 2.2.

While a handful of countries showed little difference, 20 showed significant positive differences (11 of those being more than +20%) and 8 showed significant negative differences (6 being more than –10% different). The authors concluded (Langston and Best, 2005:10) that if CPPP were used (where available, and they do note that CPPP are not available for many countries) they would have a significant impact on the outcomes of previous studies, however, it is not clear whether the results would actually be any more accurate.

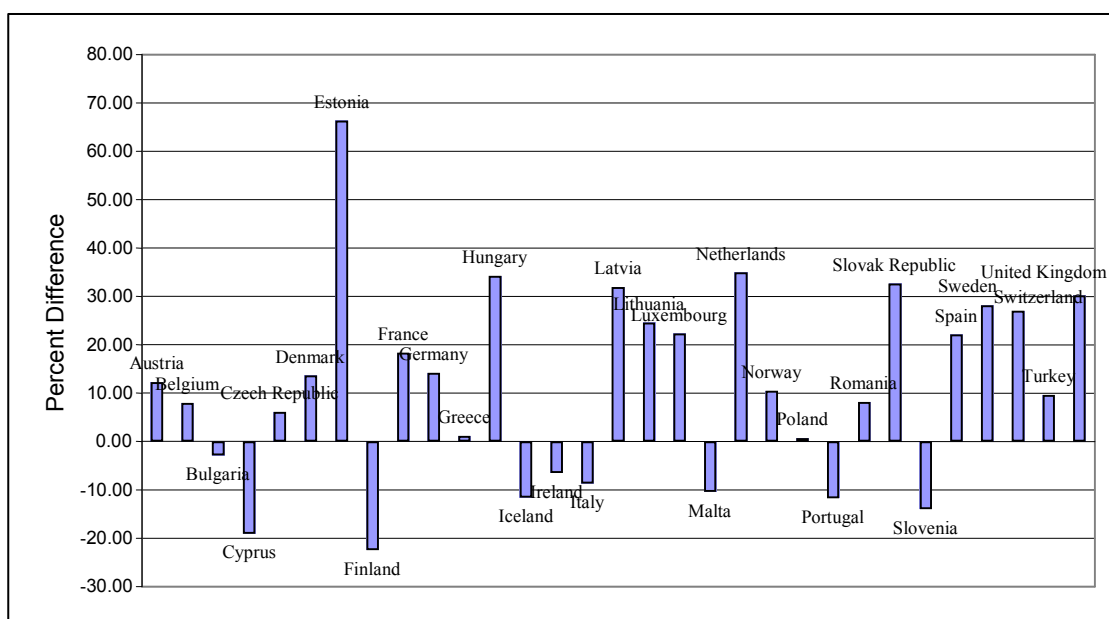


**Figure 2.2 Percentage difference between general and construction-specific PPPs
(Reproduced from Langston and Best, 2005:9)**

2.8.2 Construction data for PPPs – current method

Construction is just one of many parts of the price gathering exercises carried out under the ICP and Eurostat programs, however, the nature of construction and its outputs necessitates the use of a quite unique method for gathering construction cost data. Data relating to the cost of items such as motor vehicles (and other consumer goods) and medical services (and other services delivered by both public and private sector providers) can be obtained for reasonably standard products that are available in the markets of the various countries. Construction output (buildings, roads, sewers, airports and so on) however, may vary enormously even within a single country or within a single region.

In the ICP construction costs/prices have been gathered using comprehensive bills of quantities (BQs) for around 15 hypothetical construction projects. These include projects that fall into three groups: residential, non-residential and engineering construction. The proportions of total construction expenditure in respect of these three categories varies considerably (Meikle, 2002) between countries and can also vary from year to year within any country. Table 2.3 shows the differences in proportions across five European countries in 1996, while Table 2.4 shows variations in Australia over a five year period.

Category	France	Germany	UK	Poland	Hungary
Residential	41	52	25	15	39
Non-residential	31	29	49	55	32
Engineering	27	19	26	30	29

Table 2.3 Weightings of basic categories of construction in five European countries for 1996 (Source: Meikle, 2002)

Table 2.3 shows substantial variations in the relative weights of the three categories ; such variations are important if cost data from the different categories is aggregated to produce national indices or PPPs for “all construction”.

Table 2.4 shows some variation year by year over the five year period but the variations are generally very small. By comparison in 1990 the relative weights for Australia were residential 38%, non-residential 36% and engineering 26%. While the

Category	2001	2002	2003	2004	2005
Residential	43	46	45	44	39
Non-residential	24	22	22	22	22
Engineering	33	32	33	34	39

Table 2.4 Weightings of basic categories for Australia over the period 2001-2005 (Source: ABS, 2006)

relative weights in the period 2001-2005 are reasonably stable the 1990 figures show substantial differences in the relative weights compared to the 2001-2005 figures. This may be a result of the recession that was deepening in the early 1990s.

2.9 CURRENCY CONVERSION IN PREVIOUS STUDIES

It has been suggested earlier that the method adopted for converting costs can have a strong influence on the outcomes of comparative studies. The following examples, which cover a number of studies that were carried out over a period of 20 years, demonstrate clearly the importance of appropriate cost conversion and the effect that different approaches to the problem can produce.

2.9.1 Flanagan *et al.*(1986)²⁴

This study examined nine “matched pairs” of buildings from the US and UK, and compared cost and other aspects of construction performance. In comparing

²⁴ This analysis, and those in 2.9.2 and 2.9.3 first appeared in Best and Langston (2006a)

construction costs between pairs of buildings the authors did not convert to a common base currency but calculated a ratio of \$/m² to £/m²; these ratios were then compared to a notional exchange rate (or ratio) of USD\$1.25 = GBP£1.00. The costs for five of the pairs had ratios less than the exchange rate, the rest were above. The notional exchange rate was somewhat lower than either the mean rate (\$1.3009) or the median rate (\$1.3965) for 1985 (Federal Reserve, 2005). The volatility of exchange rates is clearly demonstrated by the fluctuations in the US:UK rate during 1985: in a period of just nine months the exchange rate moved between a low of USD\$1.052 = GBP£1.00 and a high of USD\$1.489 = GBP£1.00, a difference of over 40% (Federal Reserve, 2005).

On the basis of their calculations the authors concluded that their data lent “no support to the notion that UK construction costs are significantly higher than US costs for comparable construction” (Flanagan *et al.*, 1986:51). As the following figures show (Table 2.5), if cost conversions are done using PPPs²⁵ the outcomes become very different and their conclusion appears quite unreliable.

Several points should be noted from Table 2.5:

- Project pairs 2-6 and 8 are all office buildings; pair 1 comprises education facilities, 7 is light industrial and 9 is elderly/sheltered accommodation. Pair 7 is the only one that shows the UK cost lower than the US cost regardless of the conversion factor used – this raises some questions about the comparability of the industrial projects.
- All the office building pairs show higher UK costs except when the notional exchange rate of \$1.25 is used. When costs are converted using PPPs UK costs are consistently higher for office projects with the lowest result (pair 3) at +51% compared to the US, and the UK projects in pairs 2 and 4 both well over double the real cost of the matched US projects.

²⁵ As no construction specific PPPs are available for this year general PPPs were used.

Project pairs	Cost per unit area ^a	Cost \$/m2 ^b	% diff.	Cost \$/m2 ^c	% diff.	Cost \$/m2 ^d	% diff.	Cost \$/m2 ^e	% diff.	Cost: Big Macs/m2 ^f	% diff.
	\$/m2; £/m2	\$1.25 =£1	+/-	\$1.3965=£1	+/-	\$1.49=£1	+/-	\$1.9268=£1	+/-		+/-
US1	\$582.70	\$582.70		\$582.70		\$582.70		\$582.70		364	
UK1	£475.90	\$594.88	2%	\$664.00	14%	\$709.09	22%	\$916.82	57%	433	19%
US2	\$411.90	\$411.90		\$411.90		\$411.90		\$411.90		257	
UK2	£476.80	\$596.00	45%	\$665.85	62%	\$710.43	72%	\$918.70	123%	433	68%
US3	\$460.60	\$460.60		\$460.60		\$460.60		\$460.60		288	
UK3	£361.00	\$451.25	-2%	\$504.14	9%	\$537.89	17%	\$695.57	51%	328	14%
US4	\$658.60	\$658.60		\$658.60		\$658.60		\$658.60		412	
UK4	£766.50	\$958.13	45%	\$1,070.42	63%	\$1,142.09	73%	\$1,476.89	124%	697	69%
US5	\$765.00	\$765.00		\$765.00		\$765.00		\$765.00		478	
UK5	£754.20	\$942.75	23%	\$1,053.00	38%	\$1,139.85	49%	\$1,453.19	90%	686	43%
US6	\$520.70	\$520.70		\$520.70		\$520.70		\$520.70		325	
UK6	£511.10	\$638.88	23%	\$713.61	37%	\$761.54	46%	\$984.79	89%	465	43%
US7	\$442.40	\$442.40		\$442.40		\$442.40		\$442.40		277	
UK7	£173.80	\$217.25	-51%	\$242.71	-45%	\$258.96	-41%	\$334.88	-24%	158	-43%
US8	\$324.80	\$324.80		\$324.80		\$324.80		\$324.80		203	
UK8	£304.00	\$380.00	17%	\$424.54	31%	\$452.96	39%	\$585.75	80%	276	36%
US9	\$502.90	\$502.90		\$502.90		\$502.90		\$502.90		314	
UK9	£288.00	\$360.00	-28%	\$402.19	-20%	\$429.12	-15%	\$554.92	10%	262	-17%

Notes

All percentage differences are comparisons between UK costs and US costs after conversion of UK costs to US\$

^a Original data – (Flanagan *et al.*, 1986:52)

^b Cost converted using notional exchange rate from original paper

^c Ditto using median exchange rate for 1985 (Federal Reserve, 2005)

^d Ditto using 5 year median exchange rate (based on 4 end of quarter values for each year 1981-1985 inclusive) (Federal Reserve, 2005)

^e Ditto using general PPPs for 1985 (OECD, 2005)

^f Number of Big Mac hamburgers per m2 using 1986 prices (Pakko and Pollard, 2003) (Note: no figures available for 1985). Implied rate (1.6/1.1) \$1.45 = £1

Table 2.5 Project construction costs – based on data from Flanagan *et al.* (1986)

A couple of peculiarities in the method used by Flanagan *et al.* make it difficult to draw anything more than indicative conclusions from the data. Dates of completion for the selected projects are not given; the projects are just noted as being “of reasonably recent construction”. A footnote to the data table (Table 8J, at 52) states the prices per unit area “are not 1985 prices”, and on the previous page the authors say that prices have been indexed to bring each pair to a common date, although not necessarily the same base date for all nine project pairs. What is odd is that the prices between pairs were then compared to one notional 1985 exchange rate; what is clear is that when PPPs are used rather than exchange rate conversions the cost of construction (particularly for office buildings) in the UK appears to be considerably higher than that in the US, and the conclusions stated in the Flanagan paper are not supported by the data.

2.9.2 Lynton (1993)

In 1992-93 Lynton plc acted as joint developers and project managers for the construction of a 240,000 ft² (22,300 m²) office complex at Heathrow Airport. They compared the cost and specification of the project to a hypothetical project of identical design and specification “constructed” in Charlotte, North Carolina. Charlotte was selected as the location for the hypothetical project as, based on a chosen exchange rate, this location had similar input costs to the UK for labour, supervision and basic materials, and this therefore provided a “level playing field” for the comparison of costs. Costs were converted to a common base using a 10 year money market average rate of USD\$1.60 = GBP£1.00. On that basis the estimated cost of the project in the US was practically identical to the actual costs of the completed project in the UK (Category 1 in the Lynton report). However, when the US estimators were allowed to amend the design so that it more closely reflected US codes and standard practices, while maintaining the UK aesthetic intent and performance criteria (Category 2), the US price dropped to around 8% below that of normal estimating error or tolerance (Edkins and Winch, 1999; Meikle, 2002) and is therefore not of much significance. A more significant difference emerged when the design was adjusted so that it reflected expectations and requirements typical of US clients (Category 3): in this case the estimated US price was 32% lower than the actual UK figure.

What this study suggests is that while the US reputation for building more cheaply may be well-founded, the reasons may have less to do with greater onsite productivity (or better contractor performance) and more to do with differences in building performance specifications, design intent and market expectations.

In this study the average exchange rate used (USD\$1.60 = GBP£1.00) is actually very close to the general PPP for 1993: USD\$1.57 = GBP£1.00 (OECD, 1995). Using the general PPP for 1993 the estimated US cost for the identical project is around 2% higher than the actual UK cost. In 1995 the OECD also published construction specific PPPs (for 1993) including separate figures for residential, non-residential and engineering construction, and a composite construction PPP. Using the composite construction PPP the US cost of the identical project is around 6% lower than the UK cost, while the non-residential construction PPP puts the US cost 5% above the UK cost.

Similar results emerge when PPPs are applied to the other scenarios in the study, e.g. applying the non-residential construction PPP to the Category 3 case (i.e. where the design was amended to reflect local practice and expectations) shows the US cost dropping by around 28% compared to the UK cost (cf. 32% in the original report). As noted previously these results suggest that the apparently lower costs in the US are caused by differences in design rather than construction methods or management.

2.9.2.1 Comparing conversion factors

In this case the use of an average exchange rate produced similar results to those that emerge when PPPs are used, and even the construction PPPs do not vary markedly from either the general PPPs or the average exchange rate at the time of the Lynton study. The following graph (Figure 2.3) shows the relative levels of general PPPs against a rolling 10 year average money market exchange rate as used in the Lynton study. As Fig. 2.3 shows, in the period 1992-3 general PPPs were very close to the 10 year average rate but in 1999, for example, the PPP fell somewhat below the average rate. Construction specific PPPs in later years show a very different result

though with the 1999 and 2002 figures falling well below both general PPPs and the 10 year average rate.

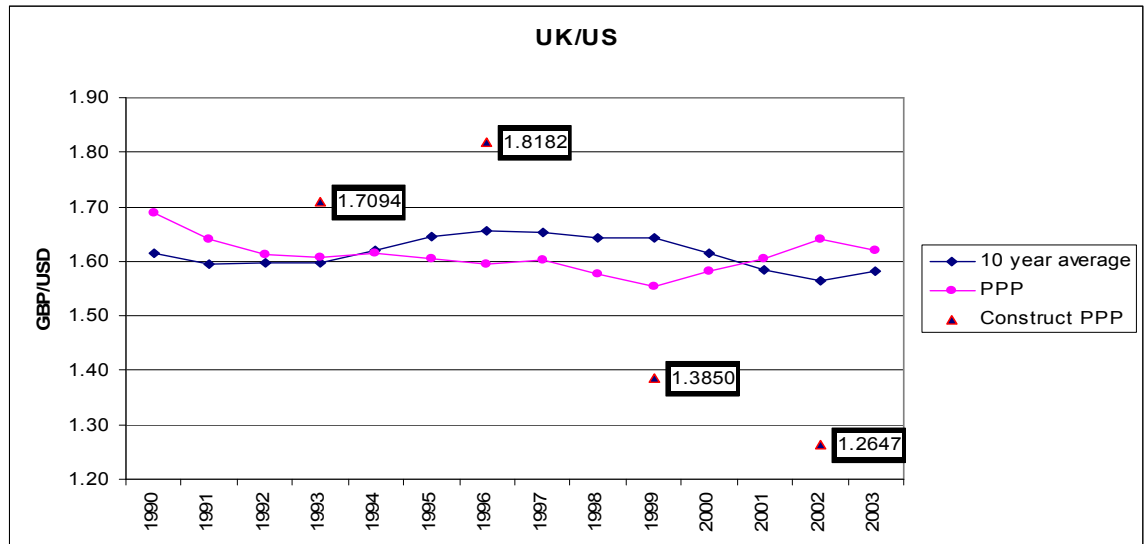


Figure 2.3 General PPPs (OECD, 2002) and 10 year average money market exchange rates (Federal Reserve, 2005) – construction specific PPPs shown are for 1993 (OECD, 1995), 1996 (OECD, 1999), 1999 (OECD, 2002) and 2002 (OECD, 2005)

When the estimated US cost for the identical project (Category 1) is indexed to 1999 (Reed Construction Data/RS Means, 2006) and converted into GBP using 1999 factors²⁶ the results differ considerably. If the 10 year average exchange rate (USD\$1.6422=1GBP) is used the US cost to build the project appears to be 17% lower. Using the general PPP (USD\$1.5529=1GBP) it is 13% lower and using the composite construction PPP (USD\$1.385=1GBP) the cost of US construction appears to be just 2% lower than the UK cost.

In this case the use of a construction specific PPP puts the US costs quite close to UK costs, while the average exchange rate puts US costs well below the UK, reflecting a rise in the UK Tender Price Index of over 36% in the period 1992-99 (Thomas, 2006) compared with a rise of just under 16% in the US (Reed Construction Data/RS Means, 2006). This illustrates the effects that emerge when the countries being compared are at different points on the building cycle – in 1992 the UK industry was

²⁶ Separate PPPs for non-residential construction do not appear to have been published for 1999

at a very low point but was much more buoyant by 1999 and the Tender Price Index reflects that.

In the Category 3 case the differences become -44%, -41% and -33% (10 year average, general PPP and construction PPP respectively). These results, when compared to the 32% difference suggested in the Lynton report, still support the general observations made about differences in cost between the US and UK mentioned above. There are, however, other methodological issues in the Lynton study that are open to question, particularly in the treatment of differences in taxation between North Carolina and the UK and how they were handled. These concerns are beyond the scope of this discussion – what is important here is that once again, as shown in the preceding example (the Flanagan study), the use of different conversion methods can produce conflicting results.

The Lynton study does, however, by its nature, avoid some of the concerns that characterise similar studies. The issue of project time was eliminated inasmuch as it is only included by being embedded in the US cost estimates. Quality is not an issue as it is assumed that quality is equal in both halves of the study (in terms of meeting specification), and changes in specification are acknowledged in the other scenarios. No mention is made of perceived or anticipated variations in other aspects of quality such as standards of workmanship, number of defects or amount of rework required.

2.9.3 Page Kirkland (1999)

This was the first stage of this two part study, published in 1999, carried out for the Australian government by consultant quantity surveyors (Page Kirkland). The study was a pure cost comparison based on seven hypothetical projects (hotel, office, factory, stadium, highway, railway and petrochemical plant) priced in Australia and six other countries. The projects were priced in local currencies and costs converted to Australian dollars using current exchange rates. For the purposes of this analysis the costs for offices only are presented; further analysis of the data carried out by Langston and de Valence (1999) showed that the type of project had little effect on relative costs in the study.

Based on these costs converted to AUD using 1999 exchange rates(see first row in Table 2.6) the authors of the first stage report suggested that “it would appear that Australia with its currency exchange advantage is more than competitive with the other Western countries and on a par with Singapore” (Page Kirkland, 1999:2).

Conversion method	Australia AUD millions	UK AUD millions	USA AUD millions	Germany AUD millions
Exchange rates	156.12	185.40	173.53	191.31
General PPPs	156.12	144.81	141.92	265.87
Construction PPPs	156.12	123.27	137.59	226.44
Big Macs (equivalent number of hamburgers in local currencies)	57 million	37 million	42 million	41 million

Table 2.6 Office project costs - based on data from Page Kirkland (1999)

2.9.4 Langston and de Valence (1999)

In their subsequent analysis of the data (Stage Two of the study), Langston and de Valence (1999) acknowledged the problems of using exchange rates to convert costs. They noted, for example, the effects of fluctuations in exchange rates in Indonesia around the time of the study which appeared to make construction projects in that country look efficient when just a year earlier Indonesian projects appeared to be the most expensive.

In an effort to eliminate the problem they utilised the Big Mac Index (Langston and de Valence, 1999:73) and translated costs in local currencies into the number of hamburgers that (at local prices) equated to building cost. On that basis, as shown in Table 2.6, Australia appeared to be more expensive than all but one of the other six countries (China) included in the study and the most expensive of the four Western countries. Using PPPs (both general and construction-specific) changes the outcome inasmuch as Germany then appears to be more expensive than Australia but both the UK and US costs remain substantially lower. These results are quite at odds with the preliminary conclusions presented in the original Page Kirkland report which put both the UK costs and the US costs higher than Australia by +19% and +11% respectively.

As noted at 2.7.6 Croce *et al.* (1999) attacked the use of the Big Mac Index in the Langston and de Valence study, saying that the hamburger was not “any sort of a standard commodity”. They concluded that in the international context, productivity in the Australian construction sector was very high. This conclusion was largely based on the results (cited extensively in Croce *et al.*) of the Page Kirkland study, which are shown here to be highly questionable due to the inappropriate use of exchange rates for cost conversion.

2.9.5 Xiao and Proverbs (2002b)

This paper is one of a set of three²⁷ that report the outcomes of a study intended to assess the relative performance of construction contractors in the UK, US and Japan. Each of the three papers addressed one parameter of the time-cost-quality triangle although all three were based on a single survey of project managers in the three target countries. Various aspects of the methodology used are described above at 2.5.10, however, here the focus is on the conversion, to a common currency base (in this instance GBP), of the cost data that was gathered.

The cost data comprised estimates by the survey respondents of the cost per m² for a hypothetical six storey building, based on a written description of the project (no drawings were supplied). It has been suggested that some of the data are of dubious value²⁸ and it could be argued that median values rather than mean values may have been more appropriate in the analysis. For the purposes of this exercise, however, the data is assumed to be valid and reliable and it is just the question of conversion of the USD and JPY average costs per m² to GBP that is discussed.

2.9.5.1 *Converting the cost data to a common base*

Initially costs were converted using current exchange rates; Table 2.7 is reproduced from the original paper and shows Japanese costs to be nearly double those of the UK and more than double those from the US. It also shows the very large spread of

²⁷ Best and Langston (2006a) is an extensive critique of the entire study - only the parts relevant to cost conversions are discussed here.

²⁸ See 2.5.10

cost estimates from all three countries, with the ratios of maximum estimate to minimum estimate ranging from 2.8:1 (UK) up to 3.67:1 (Japan).

The authors quite rightly note (at 428) that exchange rates are not a suitable method for conversion in this context and then convert the costs to GBP using PPPs “at the rate of UK:USA:Japan = 100:103:70”. Table 2.8 shows the results.

Country	No. of respondents	Unit price (£/m2)			Standard deviation	Rank
		Mean	Minimum	Maximum		
Japan	22	1443.72	855.93	3138.20	123.29	3
UK	30	882.98	550.00	1400.00	187.89	2
USA	32	710.10	352.82	1230.90	43.55	1

Table 2.7 Unit price for the hypothetical project (Xiao and Proverbs, 2002b:428)

Country	No. of respondents	Unit price (£/m2)			Standard deviation	Rank
		Mean	Minimum	Maximum		
Japan	22	843.38	500.01	1833.28	337.81	2
UK	30	882.98	550.00	1400.00	187.89	3
USA	32	738.60	365.94	1280.28	256.25	1

Table 2.8 Unit price for the hypothetical project converted by PPPs (Xiao and Proverbs, 2002b:428)

Two observations should be noted: the estimated mean costs are now much more closely grouped across the three countries, and the UK now appears to be a little more expensive than Japan (+4.7%) whereas in the previous table Japan appears to be considerably more expensive than the UK (+63.5%).

There is, however, an important discrepancy to be considered. The stated ratio of purchasing power does not appear to agree with any PPPs published by the OECD in 2001²⁹. PPPs are revised retrospectively from time to time but the ratios given bear little resemblance to the PPPs for 2000 that appear on the OECD website (OECD, 2007a).

²⁹ Xiao and Proverbs give the following reference as the source of the PPPs used: www.oecd.org/std/ppp/pps.htm – this URL is no longer active so it has not been possible to check exactly what PPPs were used.

Those PPPs are presented relative to one USD – the PPPs for UK and Japan are 0.633 and 155 respectively, i.e. one USD buys the same as 0.633 GBP or 155 JPY. If these are recalculated to a base of one GBP then the PPPs relative to the GBP become 1.58 USD and 245 JPY, These could possibly be expressed as a ratio of 100:158:245 but this is an unusual way of expressing the currencies (100 pence rather than £1, and 158 cents rather than \$1.58) and it is very different to the stated ratio of 100:103:70.

The OECD PPPs are of the same order of magnitude as the exchange rates that the authors used (Xiao and Proverbs, 2002b:428) to produce the figures in Table 2.7, viz. £1 = \$1.47 = ¥164.90, and it is difficult to see how the ratio given can relate to these rates.

If the exchange rates given by the authors are used with the costs in Table 2.7 average costs in national currencies (i.e. the original data from each country) can be calculated – these are shown in Table 2.9. If these figures are compared to those in Table 2.8 (calculated using PPPs) then the conversion factors that emerge are £1 = \$1.41 = ¥282. These PPPs do not match in any way the 100:103:70 ratio stated in the paper so it is quite unclear as to how the final figures, on which the authors based their conclusions about relative costs between the three countries, were derived. It does appear, however, that those final figures are reasonable when the notional PPPs are calculated and the 100:103:70 rate is ignored.

2.9.5.2 Comparing the use of different conversion factors

The authors do suggest (at 428) that “there might be a need for a special PPP index for construction” – in fact CPPPs for 1999 were published in 2002 (OECD, 2002). Figure 2.4 shows the original data converted to GBP using those CPPPs and a number of other factors such as the Big Mac Index and UBS PPPs.

Country	Unit price (local currency/m ²)		
	Mean	Minimum	Maximum
Japan (JPY)	238069	141143	517489
UK (GBP)	883	550	1400
USA (USD)	1044	517	1809

Table 2.9 Original cost data in national currencies calculated from GBP equivalents (Source: Xiao and Proverbs, 2002b)

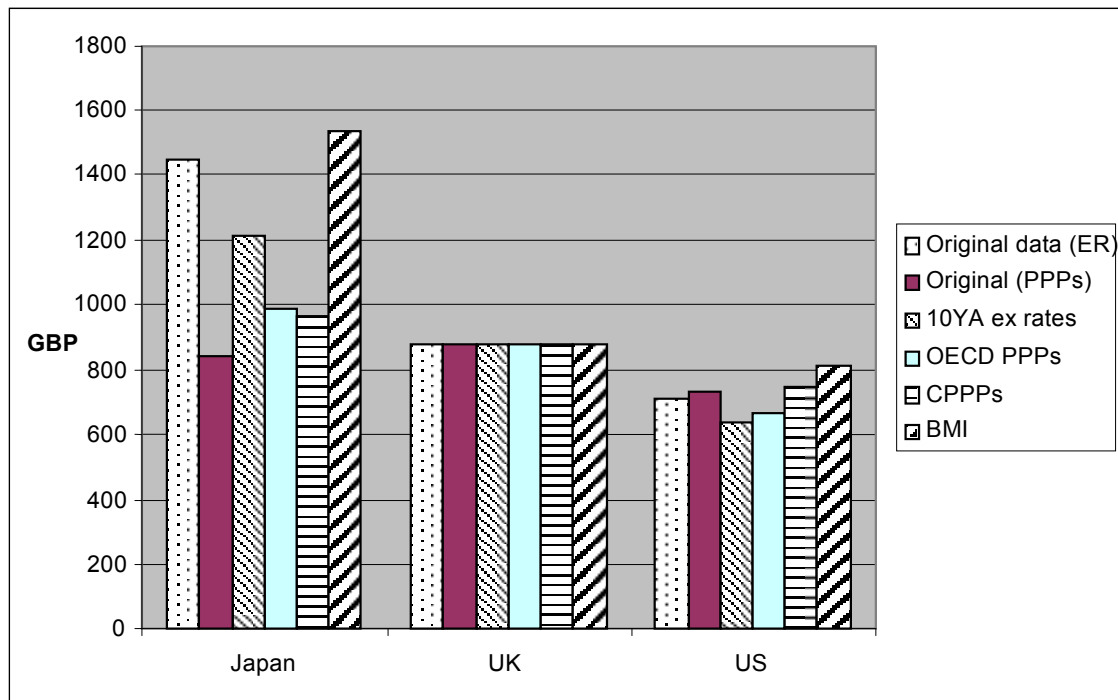


Figure 2.4 Cost data from Xiao and Proverbs (2002b) converted to GBP using six different conversion factors Sources: Original data (ER: exchange rates and PPPs) from original paper and as shown in Tables 2.7 and 2.8; 10 year average exchange rates calculated from Federal Reserve (2005); OECD PPPs and C PPPs from OECD (2002); Big Mac Index from Pakko and Pollard (2004).

The US shows a fairly small range of variations depending on the conversion approach used while Japan shows much more marked fluctuations. In spite of those fluctuations it is, however, reasonable to conclude that Japan is the most expensive place to build while the US is the least expensive, as it is only when the unexplained PPPs discussed above were used by the authors of the paper that Japanese costs appear to be below UK costs. All other instances show the Japanese costs to be higher than those in both the UK and the US. In all instances construction in the US appears cheaper than in the UK so on balance it can be concluded, with some confidence³⁰, that the ranking Japan–UK–US in descending order of cost is sound while the Xiao and Proverbs ranking of UK–Japan–US is not.

³⁰ Any conclusions drawn do, however, depend on the validity of the original data, and the robustness of that data has already been questioned.

2.9.6 BWA (2006)

This study explored various comparative methods with the aim of benchmarking the efficiency of resource use in construction in a number of EU countries. Cost conversion is discussed in several contexts within the report, however, the authors suggest that the scope of the study and the major comparative method that was developed made cost conversion less of a concern. As the study was confined to EU states most of the cost information was expressed in euros, however, several countries in the study do not use the euro (Sweden, UK, Denmark and Norway) hence some form of conversion was necessary to bring data from those countries to a common base. More importantly the report used a unique index to rank efficiency based on labour input. Basically it is a ratio between building cost per m² and the average hourly labour rate - as both terms are expressed in the same currency there is no need to bring costs to a common base.

2.9.7 BCIS (2006)

In August 2006 the Building Cost Information Service (BCIS) published the first issue of the *Asia Building Construction Survey* (BCIS, 2006). The authors carried out a number of comparative exercises within the study which compares construction costs for ten different building types (based on cost per square metre of gross internal floor area) as well as comparing input prices for a range of labour and materials items. It should be noted at the outset that this document is produced as a commercial commodity that is offered for sale, and not as a theoretical academic work. That is not to say that it has not been prepared carefully and with appropriate rigour but that it is intended to inform businesses that may seek to build in countries outside their own as to the cost that they may incur, e.g. a Singapore company may be considering building a facility in Malaysia – their concern, quite naturally, will be how much they need to spend in SGD in order to finance construction that will be paid for in MYR, and that is the sort of information that this document attempts to provide. Some aspects of the methods used are relevant to the discussion here and again some differences in outcomes are evident when different conversion factors are used.

2.9.7.1 The study

The BCIS report addressed a number of issues; some, such as labour shortages and trends in input costs over time, are not relevant here while others such as

comparisons of building costs are. The report was survey based and amongst the data gathered were average costs per m² for ten building types³¹ as assessed by the respondents in the various countries. Surveys were distributed in twelve Asian countries; only partial responses were obtained from the Philippines and South Korea while five other countries returned quite small samples³². Five countries³³, however, had a better response rate and these countries were reported separately. Due to the small samples in the other countries only the five with larger response rates are discussed hereinafter.

In the sections of the report that deal with each country, average building costs per m² of gross internal floor area for the ten building types are reported in local currency, and in USD, EUR and GBP, with these three costs converted from local currencies using current exchange rates. Figure 2.5 (BCIS, 2006:51) shows fairly consistently, on the basis of the method used, that Hong Kong is the most expensive country of the five in which to build (regardless of building type) followed by Singapore, Thailand, China and Malaysia. The same order emerges from Table 2.10 which shows the data that underlies Figure 2.5 and also gives USD/m² for a “notional average building”. It is important to note that these figures are not suggested as “average building costs” as the notional average building cost is nothing more than the mean of the costs gathered for the ten benchmark building types, with no weighting of any sort applied to account for the relevant expenditure shares of the various types.

2.9.7.2 Cost conversions

When other methods of cost conversion are used the rankings change considerably, at least in some instances. Figure 2.6 shows the original results and the results that emerge when other conversion factors are applied, viz. Penn World Table PPPs

³¹ Hi-tech factory/office, warehouse, business park offices, city centre office (8-20 storeys), iconic city centre offices, hospitals, schools, universities, private apartments, budget hotel.

³² Brunei, Sri Lanka, Taiwan, Japan, Indonesia

³³ China, Malaysia, Hong Kong, Singapore, Thailand

(CIC, 2006), the Big Mac Index (Oanda, 2007), World Bank PPPs (World Bank, 2007) and UBS PPPs (UBS, 2003)³⁴

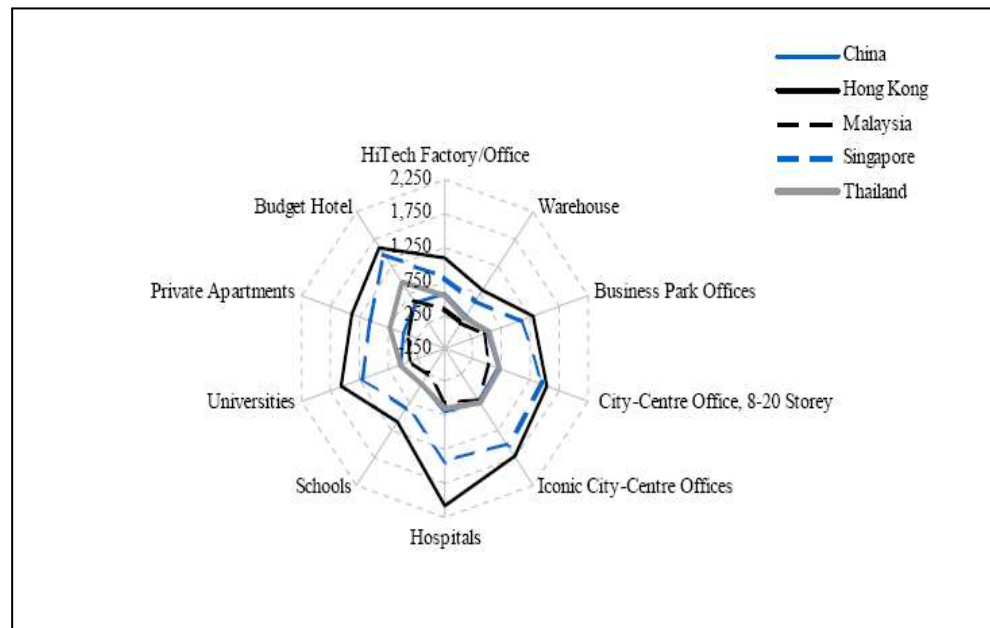


Fig. 2.5 Comparison benchmark building costs in five countries: USD/m² of gross internal floor area (Reproduced from BCIS, 2006: 51)

While some consistent results are observed, e.g. Malaysia generally appears as the cheapest place to build while Hong Kong is generally the most (or nearly the most) expensive. China, however, shows great variations and appears as most expensive in one instance and least expensive in another; Singapore similarly ranges from most expensive to second cheapest depending on the conversion method applied. If the results based on exchange rates are excluded then Malaysia and Singapore show some consistency regardless of the method used but the remaining three countries show almost random results, with China for instance showing costs spread over a range of approximately USD\$2000 per m².

³⁴ The following PPPs used are the latest available sets: PWT PPPs for 2003; BMI for March 2006; World Bank PPPs for 2004; UBS PPPs for 2003. The BCIS exchange rates are assumed to have been current at the time the report was released (August 2006).

Building benchmark type	Building Costs in USD/m ²				
	China	Hong Kong	Malaysia	Singapore	Thailand
Hi-tech factory/office	552	1089	345	812	526
Warehouse	364	808	215	611	299
Business park offices	475	1296	429	1101	532
City-centre office, 8-20 storeys	682	1511	524	1446	717
Iconic city-centre offices	719	1730	679	1503	746
Hospitals	694	2066	562	1405	623
Schools	409	1085	214	836	402
Universities	542	1572	348	1195	545
Private apartments	456	1356	374	1047	701
Budget hotel	591	1605	610	1469	950
Notional average building	548	1412	430	1142	604

Table 2.10 Comparison benchmark building costs in five countries (BCIS, 2006:51). Note: costs have been converted from local currencies using exchange rates

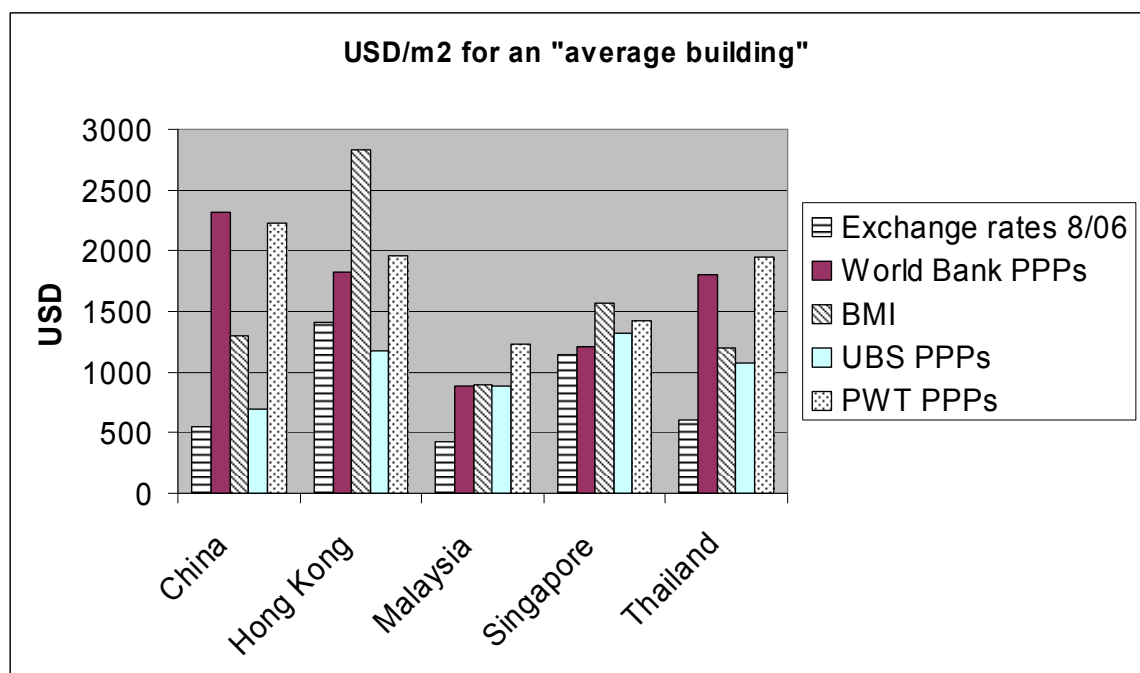


Figure 2.6 Comparison of BCIS results using different conversion factors.
Sources: Penn World Table PPPs (CIC, 2006), the Big Mac Index (Oanda, 2007), World Bank PPPs (World Bank, 2007) and UBS PPPs (UBS, 2003)

No construction PPPs could be found for these countries so no CPPP comparison against the results shown above could be done. Once again, however, the application of different PPPs has been shown to make substantial differences in outcomes with

little consistency evident, and this again highlights the need for a method that can be relied on for such construction cost conversions.

2.10 CONCLUDING REMARKS

In this chapter basic frameworks for international comparisons of construction industry performance have been discussed and the role of construction cost in such comparisons has been highlighted. It has been acknowledged that such comparisons are not easy but they can be made and they can provide at the very least some useful insights into the relative performance of the construction industries in various countries. It has been demonstrated, however, that there is little consensus as to how the basic problem of comparing costs between different countries is to be done, and the effect that the use of different conversion methods can have on the outcomes reported from such studies has been clearly shown.

Performance can be assessed with reference to four parameters; productivity, time, cost and quality. It is acknowledged that while time and cost can (at a project level at least) be readily measured when international comparisons are attempted the choice of method used for converting construction costs to a base currency is crucial.

In the following chapter the question of cost conversion is examined in greater detail and methods for establishing construction specific conversion factors, based on purchasing power parity, are discussed.

CHAPTER 3

3.0 CONVERSION FACTOR METHODS

3.1 INTRODUCTION

In the previous chapter the role of construction cost measurements in comparative studies was identified and the importance of using appropriate cost conversion methods emphasised. The concept of purchasing power parity (PPP) was examined and the use of PPPs nominated, at least on a conceptual level, as a suitable mechanism for bringing costs to a common currency base. The lack of reliable construction specific purchasing power parities (CPPPs) was confirmed and thus the development of such CPPPs was affirmed as an appropriate focus for this thesis.

The literature review also exposed the general lack of both theoretical and empirical research devoted to the problem of construction cost comparisons. The bulk of the published work in this area is restricted to a handful of authors, notably Meikle, Stapel and Sergueev (working with Eurostat) and Walsh and Sawhney (working with the UN/World Bank). It is therefore appropriate to pursue this topic in greater depth by both the development of more robust theoretical underpinning and the execution of an empirical research exercise that tests the theory.

3.2 INDUSTRY COMPARISONS

The perceived importance of construction industry comparisons, particularly international comparisons, and the central role of construction costs in such comparisons have both been established earlier in this thesis. The following discussion focuses on the fundamental question of making valid comparisons of construction costs in different locations.

3.2.1 Cost v. price

While the basic difference between construction *costs* and construction *prices* was addressed in the preceding chapter¹ in practice the terms cost and price tend to be used interchangeably. While the term cost is often used there is wide agreement that data that represent the prices actually paid by the consumer (client) for building work (out-turn costs) is preferred to input cost data when construction costs are compiled (DLC, 1999; Dean, 2002:2; Meikle, 2002:6; Stapel, 2004:16).

This is true for several reasons:

- Out-turn costs include contractors' profit and overheads
- Estimates are only approximate predictions of out-turn costs, and estimated and final costs are seldom if ever the same (BWA, 1993).

In practice, however, obtaining out-turn prices, i.e. final prices paid by clients, is very difficult. The BCIS² in the UK, for example, gathers comprehensive details of building costs from cost plans and estimates but not final contract figures that reflect prices that include variations, extensions of time and so on (Martin, 2006). Meikle (2002:6) notes that the difference between the tender price and the eventual price paid by the client can vary considerably between projects within the same country, and from country to country. It is not uncommon in some countries for tenderers to price low, hoping for variations, while in others prices are fixed; obviously this makes tender price comparisons problematic (Edkins and Winch, 1999:43; Meikle, 2002:6).

Even if out-turn prices for completed projects are obtainable a host of other problems arise when any attempt is made to compare these prices due to the difficulties associated with finding projects that are similar enough to allow valid comparisons (Stapel, 2002). Out-turn costs may only be reliable at the level of whole projects as trade, element or work item rates/prices may be distorted due to front-end loading

¹ See 2.6.3

² Building Cost Information Service

and abnormally high or low pricing as described by Walsh and Sawhney (2004). The question of estimates and actual prices is discussed further at 3.5.4.

3.2.2 What is being compared?

At this point it is important to recognise that the choice of a method for comparing construction costs will depend on the situation in which such a comparison is to be made. Currently there are two main areas of study that involve these comparisons: performance studies (such as the pricing studies defined by Edkins and Winch) and wider comparisons studies such as the ICP, where construction is just one part of economic output. The mechanisms used may be similar or they may be quite different.

In the wider context construction cost data has generally been gathered at the level of individual work items in comprehensive bills of quantities for a number of hypothetical projects or prototype models (Ward, 2003). Total estimated costs for those projects are aggregated into three main sectors: residential, non-residential and engineering construction, and in turn these are aggregated into indices for all construction (CPPPs). Further aggregation, including all economic sectors (e.g. manufacturing, services and so on) allows the production of PPPs at the level of GDP for national economies. The method used for producing construction specific indices as part of such an exercise has some specific characteristics that may differ from those required in discrete pricing studies. For example, GDP level PPPs are typically used to compare standard of living across many countries, upwards of 170 in the case of the ICP. Any method used across such a diversity of cultures, with varying levels of economic and technological maturity, must address problems of comparability and representativeness that are even more challenging than those that arise when wealthy developed countries are involved (Walsh and Sawhney, 2004).

3.2.3 Why are conversion factors needed?

At the most basic level, in pricing studies or similar exercises, the aim is to compare the actual cost of construction work in one country (or even at a specific location in one country) with that in another. Some observations can be made and conclusions drawn regarding the true relative costs of construction in the different locations. Clearly it is not feasible to compare costs unless they are in the same currency.

As a mechanism for bringing costs to a common base exchange rates are too volatile and too much affected by a range of factors such as interest rates and changes of government, so some alternative approach is needed (see earlier at 2.6). The notion of purchasing power parity (PPP) provides such an alternative as it can be argued that if two totally identical buildings were constructed in two countries then the cost of construction in the local currency of one country would be equivalent, in terms of “construction purchasing power”, with the total cost in the local currency of the other. From this an implied exchange rate, based on “construction dollars” might be calculated. This simplistic model has some obvious problems:

- It is unlikely that any two buildings will be completely identical. Differences in ground conditions and local regulations are two obvious factors that will be likely to produce some differences between completed buildings even if the basic designs are the same³ (OECD/Eurostat, 2001)
- It is very difficult to find buildings representative of all construction in each country, even within some defined grouping such as non-residential or in a more tightly defined grouping such as apartments or offices (Vermande and van Mulligen, 1999; Stapel, 2004; BWA, 2006).

At whatever level, from unit rate to whole project cost, it is inevitable that cost data will be gathered in local currencies and that data will need to be expressed in a common currency to allow direct comparisons (ECHarris, 2007). The purpose of this thesis is to develop a method for directly comparing the real cost of construction of specific building types in a variety of locations. In this context “real” cost means the cost equivalent based on the purchasing power of the respective national or local currencies at the various locations.

³ Castles (1995) discusses in general terms the problems of finding consumer items that are identical yet typical of local consumption in every location.

3.3 CONSTRUCTION OUTPUT

The nature of the output of the construction industry, regardless of location, is in itself a major complicating factor in any sort of comparative exercise (Walsh and Sawhney, 2004). Most manufacturing industries produce large numbers of relatively homogeneous products, such as automobiles or television sets. Even within these industries there may be significant variations between models made by a single producer (Silver and Heravi, 2002).

The “output” of service industries present other problems of comparability: for example, it is difficult to compare haircuts or visits to the doctor in different countries as the level (or quality) of service will vary from place to place.

Construction output generally varies considerably in many respects from project to project (Sergueev, 1997). These differences include scale, cost, standard of finish, extent of engineering services and so on. Even in projects that may appear to be the same (e.g. standard house designs) there are differences and variations due to individual client requirements and site conditions.

3.3.1 Construction as a service

Construction may actually be considered to be a service industry rather than a manufacturing industry as it is the management of the construction process that is the product that a head or general contractor provides to the client even though there is a physical product involved as well. Comparisons of industry performance are actually more about comparing the performance of the management function than anything else as it is the efficiency and/or effectiveness of management that determines the level of performance. Better performance can be defined as more efficient use of resources, where resources include not only the obvious factors of materials, labour and equipment but also capital and time. Ultimately the performance of the industry is measured by cost as it reflects resource use, not only in terms of the amount of resources used but also the mix of resources used. Greater capital intensity means more input of funds but can be expected to reduce construction time and labour hours and thus reduce overall costs. Once again it is shown that cost is the critical parameter, however, the unique nature of each construction project makes comparative cost studies particularly challenging.

3.3.2 The Law of One Price

The Law of One Price was introduced in the previous chapter (at 2.7). Whether the Law of One Price holds for any particular item depends on the item meeting four basis criteria (UBS, 2003:27). They are:

1. The item must be tradeable
2. There are no impediments to trade
3. There are no transaction costs (such as transport) involved in trade of the item
4. The item is perfectly homogeneous⁴ across all locations.

If all four criteria are met then the price of the item should be the same in different places at the same time. In that case the cost of an item in currency A should represent the same value as the cost of the same item in currency B.

3.3.2.1 Tradeability

Very few items meet all the criteria listed above: gold and securities are two that match quite closely and they are traded at more or less the same price around the world (UBS, 2003). Construction output, when considered at the whole-of-project level, is clearly neither tradeable nor homogeneous. At the levels of inputs, however, many components are tradeable and may be relatively homogeneous. While Vermande and van Mulligen (1999) suggest that materials such as bricks and concrete are mostly produced and used locally, and are therefore not expected to conform to the Law of One Price, in fact a considerable proportion of construction inputs may be traded regionally and internationally. It is unlikely, however, that the Law of One Price will hold perfectly for construction materials as transport costs will always play a part. Many materials are bulky and/or heavy and even if there are no tariffs to be paid on cross-border trade, transport costs, dependent on distance, will generally add some cost to imported materials. If additional transport costs are offset or exceeded by lower production costs then trade may still be viable.

⁴ In practice some commodities may vary slightly in quality or type but be substitutable, and for some commodities (notably iron ore) benchmark prices are set (Inside Business, 2006).

3.3.2.2 *Labour as a tradeable commodity*

Even labour may be a tradeable commodity – in Singapore, for example, much of the onsite building work is done by so-called “guest workers” (NEA, 2003; Ofori, 2006:12) who are imported from countries such as Bangladesh and Thailand where labour is relatively cheap. Similarly in the south western states of the US (e.g. Arizona) which lie on or near the Mexican border cheap migrant labour is readily available (Ernzen, 2004). While this labour may not be “tradeable” in the normal sense it is acting as a tradeable commodity as it does follow the pattern of arbitrage in that a commodity (labour in this case) is bought more cheaply in one place and sold in another. In this instance it just happens that it is the people performing the jobs that are transported rather than what they produce. As a consequence of globalisation supervisory and managerial personnel are routinely despatched to projects in all parts of the world and thus their skills are tradeable inputs to the construction industry.

3.3.2.3 *Concluding remarks*

From the preceding paragraphs it can be seen that the constituents of construction may in fact be tradeable at a number of levels even though built facilities⁵ themselves are clearly not. This leads to the proposition that many construction inputs may be expected to follow the Law of One Price to a much greater extent than suggested by Vermande and van Mulligen. On this basis it is proposed that the appropriateness of various conversion factors may be tested by looking at the results obtained using various conversion factors and looking for those that produce costs that most closely reflect convergence of prices in different locations to a single price. Such convergence is exactly what would be expected if the Law of One Price were to hold perfectly for construction prices.

3.4 PURCHASING POWER PARITIES

The concept of PPP, and its application in construction comparisons, is based on the notion of opportunity cost, i.e. that money spent on one possible choice (construction

⁵ Apart from some mobile structures such as relocatable houses and temporary accommodation.

in this case) is not then available for spending on other possible choices. Hence the value of the money spent on construction may be equated to the value of any number of other projects, commodities or services.

The Big Mac Index (BMI) previously described, equates the value (or purchasing power) of an amount of one currency to that of another by assuming the value of the standard hamburger to be equal in the home country of each currency. If the opportunity cost idea is applied in this situation then the equivalence that is implied is that the money that an individual would pay (in currency A) for a Big Mac in location A could be used, alternatively, to purchase other goods and services in that place. Those other goods and services are then of equivalent value to similar items that could be bought in location B (in currency B) where the amount of currency B needed is equal to the local cost of a Big Mac. This equivalence of value is what suggests that PPP is a better method for comparing costs internationally than exchange rates, as exchange rates can fluctuate significantly in the short term while the value of goods and services in each location will vary only slightly, if at all⁶.

3.4.1 Exchange rate movements over time

While exchange rates may move both quickly and unexpectedly, exchange rates averaged over time often show more stable relationships. The Lynton study (Lynton, 1993 – see 2.9.2) used exchange rates averaged over the previous ten years to convert estimated USD costs to GBP. Best (2007) compared average annual

⁶ For example Rawlinsons (1999) give cost/m² rates for three star hotels of AUD\$2218 (Sydney) and USD\$1200 (Los Angeles). Rawlinsons (2008) gives cost/m² for the same building type in the same places of AUD\$3315 and USD\$1722. In the period 1999 to 2008 the Sydney costs increased by 49%, the Los Angeles costs by 44%. If the 1999 AUD cost is converted to USD using the 15 January 1999 exchange rate (obtained from Oanda.com) the USD equivalent is USD\$1400. If the 2008 AUD cost is converted using the 15 January 2008 exchange rate it becomes USD\$2969. Comparing the costs expressed in USD in 1999 the Sydney cost (USD\$1400) appears to be just 17% greater than the Los Angeles cost (USD\$1200), however, when 2008 USD costs are compared the Sydney cost now appears to be 72% higher than the Los Angeles cost. Thus while local cost increases varied by only a few percent (49% and 44%) the apparent relative costs between the two cities appears to be far greater. This is due to the fluctuations in exchange rates that are not a reflection of actual changes in construction costs.

exchange rate movements and corresponding ten year average (10YA) rates for the AUD against three other currencies (JPY, GBP and USD). Figures 3.1, 3.2 and 3.3 show annual rates from 1981 to 2003 and 10YA rates from 1990 to 2003.

While short term fluctuations in annual rates are apparent in all three graphs the regression lines show clear trends over time with the value of the AUD falling against all three currencies. The graphs show that the 10YA values do smooth the short term fluctuations somewhat. This reduces the impact of those fluctuations on any snapshot of comparative costs but there is still little evidence to suggest that the 10YA approach is actually significantly more reliable, and as was demonstrated at 2.9.2, in the Lynton study it was no more than chance that the 10YA rates and other indices (PPPs and CPPPs) were much the same at the time the study was done (Best and Langston, 2006b).

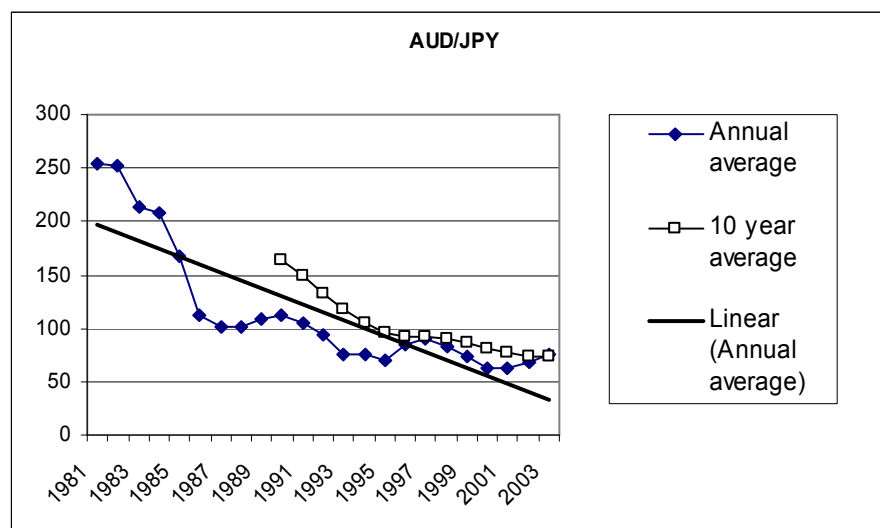


Fig. 3.1 Historical exchange rates: AUD to JPY (Best, 2007; exchange rate data from RBA, 2007)

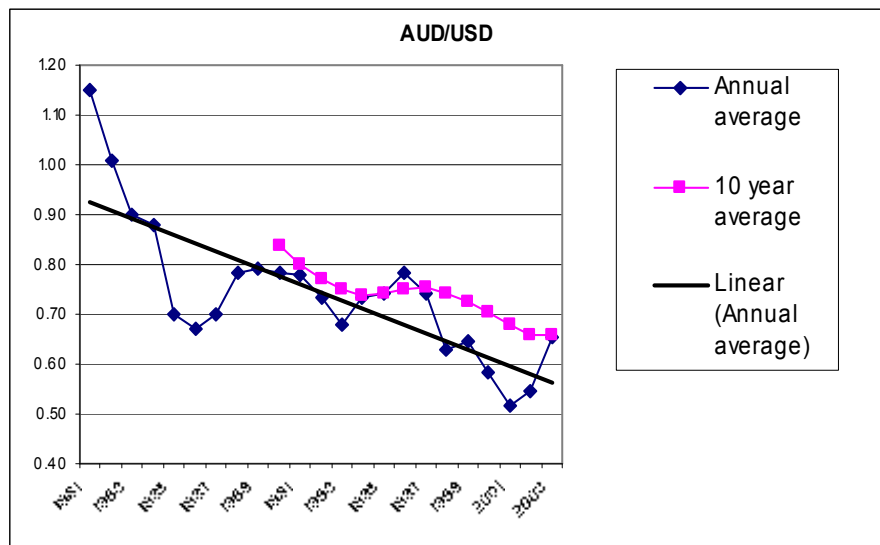


Fig. 3.2 Historical exchange rates: AUD to USD (Best, 2007; exchange rate data from RBA, 2007)

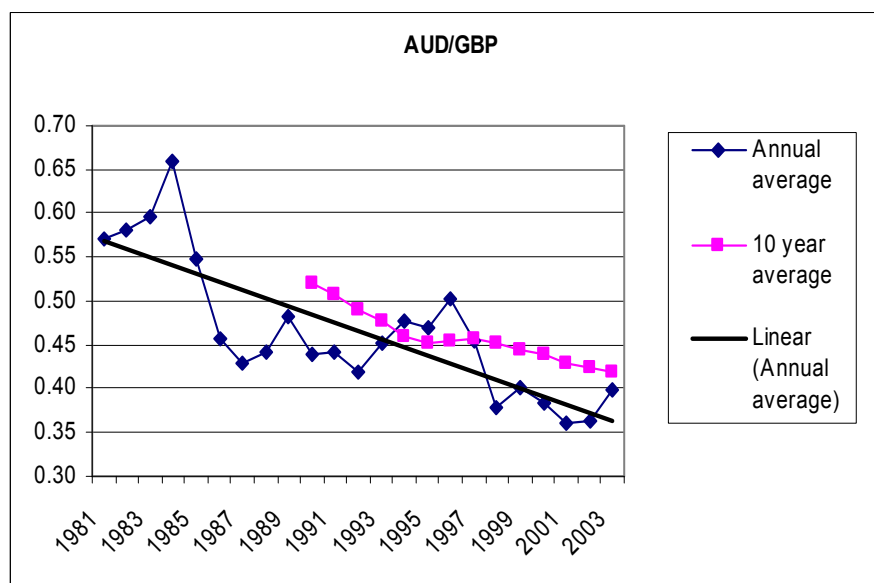


Fig. 3.3 Historical exchange rates: AUD to GBP (Best, 2007; exchange rate data from RBA, 2007)

3.4.2 Alternatives to exchange rate conversions

As noted earlier (at 2.7.2) several sets of PPPs are regularly produced including some that are specific to construction (CPPPs). Best and Langston (2006b) compared the

OECD/ICP general PPPs and CPPPs, and 10YA rates⁷ for the UK and the US over the period 1990 to 2003 (Fig. 3.4). While the general PPPs and 10YA rates did not fluctuate greatly and remained fairly stable over time (both individually and in comparison to one another⁸) CPPPs were clearly more volatile and deviated markedly from the other two indices.

3.4.3 Comparing PPPs and exchange rates

Best (2007) also compared the 10YA rates and the purchasing power of the AUD against three other currencies (GBP, USD and JPY). Figures 3.5, 3.6 and 3.7 show the results of those comparisons.

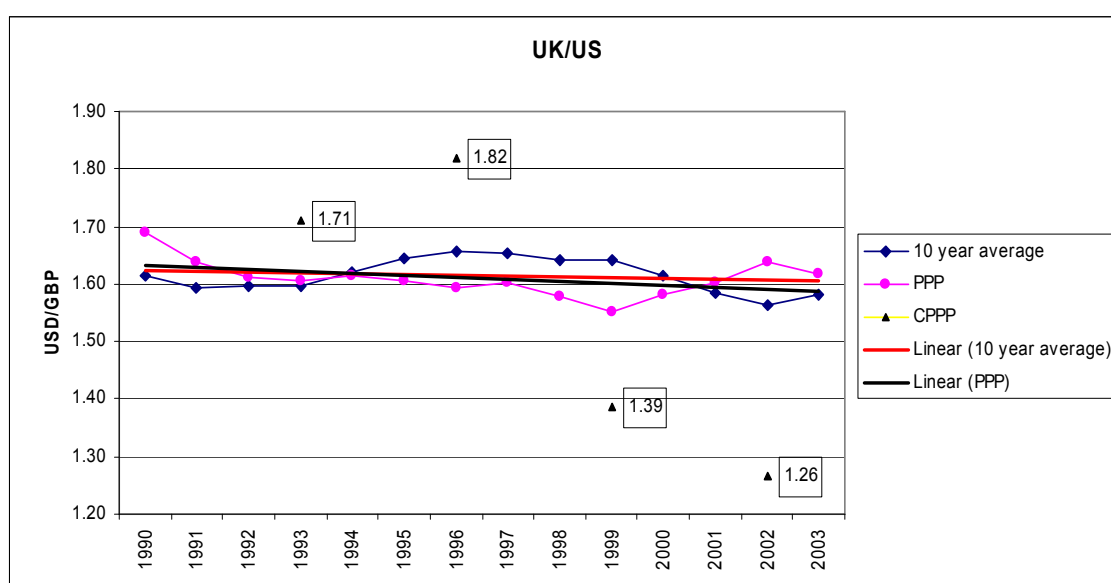


Fig. 3.4⁹ General PPPs, CPPPs and 10YA rates (Best and Langston, 2006b)

⁷ 10 year average exchange rates were calculated for the preceding ten year period using daily rates from the end of each quarter.

⁸ This close alignment is to be expected as PPPs and exchange rates over time are expected to converge (Rogoff, 1996; Papell, 2002).

⁹ Figure 2.3 shows the same data, however, the two trend lines have been added here to emphasise the relative stability of the two indices compared to the movement of the CPPPs.

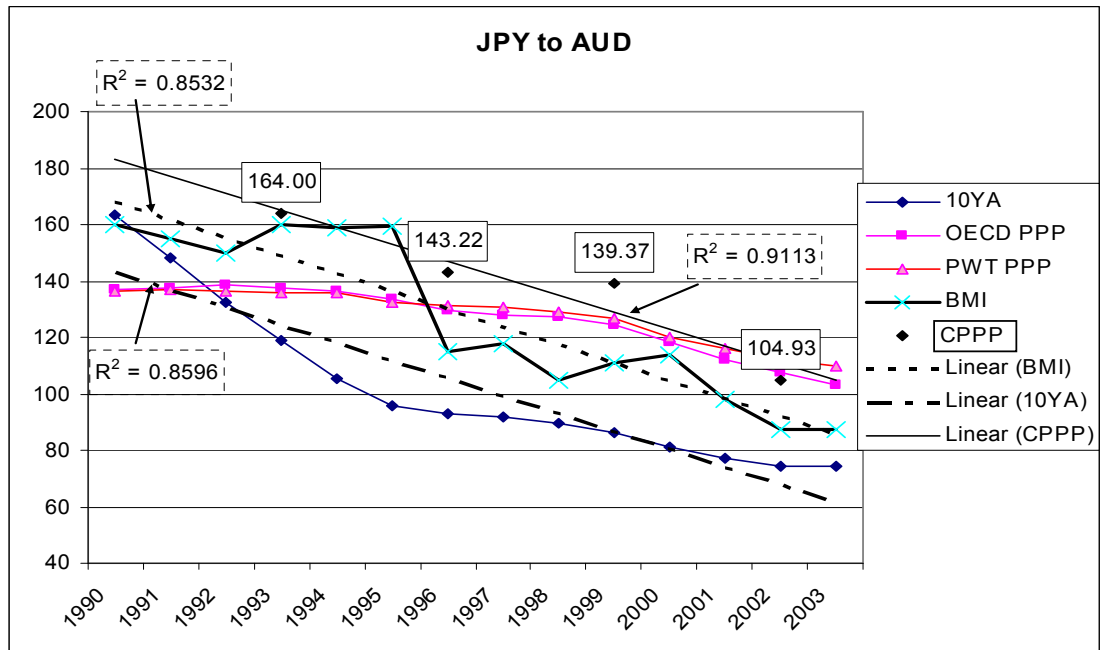


Fig. 3.5 Conversion factors: JPY to AUD (Best, 2007)

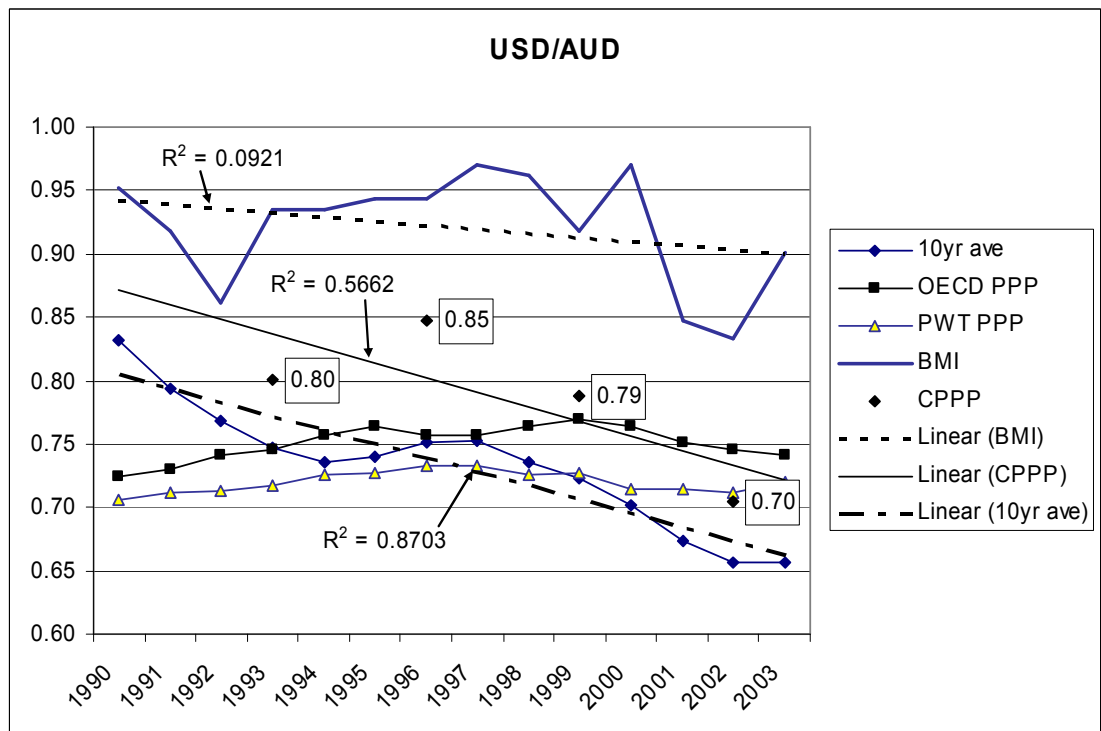


Fig. 3.6 Conversion factors: USD to AUD (Best, 2007)

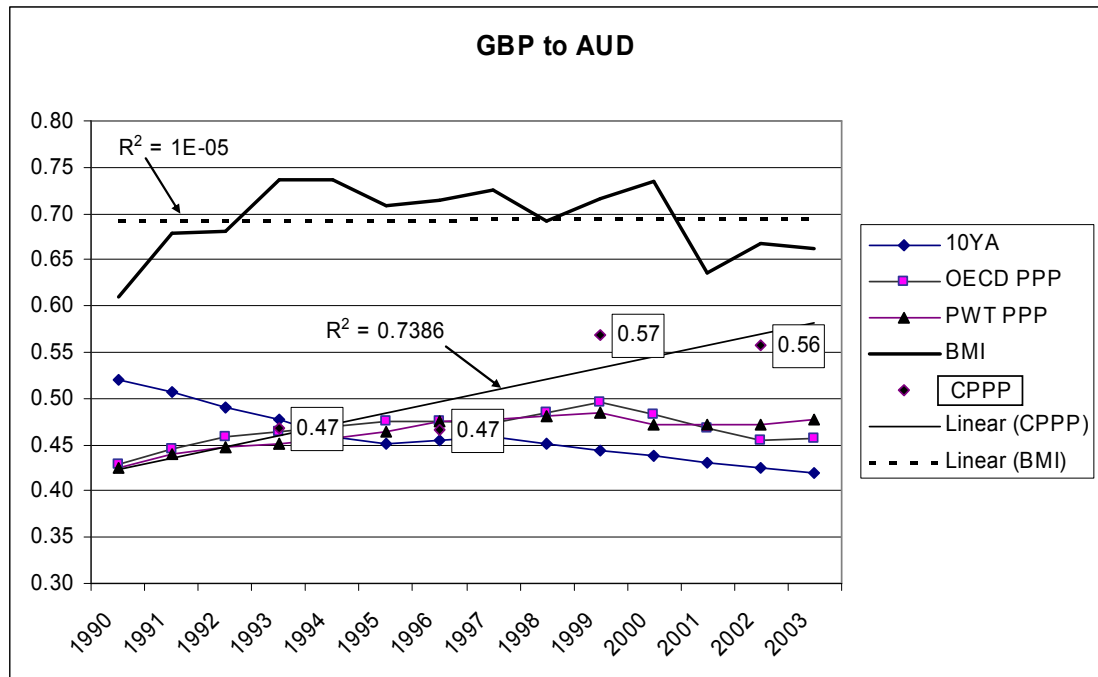


Fig. 3.7 Conversion factors: GBP to AUD (Best, 2007)

The three bilateral comparisons tell a mixed story with some consistency apparent but with a number of notable inconsistencies also evident. The JPY/AUD comparison (Fig. 3.5) shows that while numerical relativities for the BMI, CPPPs and the 10YA varied over time they showed nearly identical trends. The USD/AUD comparison (Fig. 3.6) shows similar but less closely aligned trends. The GBP/AUD chart, however, shows a different picture altogether with CPPPs moving upward while the 10YA moves down and the BMI shows short term fluctuations about a nearly horizontal trendline (Fig. 3.7).

The movement in the BMI strongly suggests that for the period shown it is not a reliable measure of price relativity between the US and Australia as the movements are much more volatile than the 10YA rates or the PPPs (Fig. 3.6). The low R^2 value (0.0921) reflects the wide fluctuations in the BMI over the 15 year period.¹⁰

¹⁰ This is reinforced by a t value of -1.10 and a p value of 0.291 .

3.4.4 Analysis of the comparisons

There is little in this analysis to suggest that 10YA rates are a more or less reliable method for converting construction costs between countries than other possible methods such as PPPs or hamburgers. As noted earlier at 3.4.1 it appears to be no more than coincidence that the 10YA, PPP and CPPP were all closely aligned in 1993 (see 1993 CPPP data points in Fig. 3.1) when the Lynton study was done. A similar alignment appears in the GBP/AUD comparison from 1993 to 1996 but, as Fig. 3.7 shows, by 1999 and through to 2003 the CPPPs and the other indices (apart from the BMI) move well apart. In contrast, while the USD/AUD chart shows a similar alignment in the 1993-1997 period, and a similar divergence thereafter, the CPPPs move quite differently and show a trendline with a slope that matches that of the 10YA line very closely. The Big Mac Index, although showing some similar trends in the comparisons with JPY and USD, shows quite different implied exchange rates for all three currencies against the AUD.

Comparisons such as the JPY/AUD example here, that show numerical relativities varying quite substantially but show very similar trends over time, lend some support to the suggestion made by Langston and Best (2000:37) that “international comparisons between developed countries are ... not sensitive to PPP adjustment”. That observation was, however, based on comparisons between only the BMI and OECD PPPs, and in that study, as is the case here, the UK was shown to be an exception. It should be noted, however, that as these are linear regressions the percentage change over time and between the different methods will still vary.

3.4.5 Observations

Stapel (2004) advises strongly against the use of general PPPs for industry level comparisons and the BMI is not only much more volatile than the other factors but in two of the three examples shows relative currency values that are markedly higher than those shown by the other measures (with AUD/JPY the exception). It is such exceptions that reinforce the need for reliable construction specific cost conversion factors as no currently available factor or method can be shown to be consistently better than any other.

Best (2007) concludes from this study that the only clear result from the analysis is that, as yet, there is no obvious, consistent result. It appears that reliable industry-specific PPPs are required as there is no great consistency across the other available methods. Current CPPPs are treated with caution by most that are active in this area of research yet there appears to be no better alternative currently available; further work may, however, improve their accuracy. Reliance on any single method will produce potentially unreliable results, and while it is not yet possible to determine if there is one “correct” method it appears that some comparison of results obtained using a variety of methods is advisable.

While Best’s study was limited to just three bilateral comparisons, with AUD as the common base, there is considerable diversity in the outcomes; Best observed that further bilateral comparisons between more countries were needed to establish whether these outcomes were typical.

3.4.6 Concluding remarks

From the foregoing discussion it is clear that while there are a variety of options available for currency conversions there is no option that can be shown to be clearly better than any other. As demonstrated at 2.9 applying different methods in comparative studies produces different results, and sometimes those results vary dramatically. Part of the problem stems from the use of conversion factors (e.g. general PPPs) that are not designed for the purpose of construction cost comparisons (Stapel, 2002), and the absence of accepted construction-specific PPPs (Ive *et al.*, 2004). Clearly a conversion mechanism that is designed for this particular purpose is needed if viable cost comparisons are to be made. The idea of purchasing power parity has widespread support (Ong, 2002; Papell, 2002; Pakko and Pollard, 2003; Meikle, 2004) and it is therefore accepted here as the basis for the development of a construction-specific cost conversion mechanism. The question then arises of how best to structure such a PPP mechanism for construction costs.

3.5 ISSUES RELATING TO THE PRODUCTION OF CPPPS

A number of issues must be considered in the design of a method for the compilation of construction specific PPPs. Some are relevant to all PPP exercises, e.g. the

questions of regional differences, and comparability and representativeness of items for which costs or prices are gathered. Others are more specific to construction, e.g. the practical concerns of the cost of gathering data and the need for personnel with special expertise in construction pricing.

3.5.1 Comparability and representativeness

The broad issue of identifying comparable and representative building projects for comparison purposes was outlined in the preceding chapter (at 2.4.6); the specifics of cost comparisons are explored in greater detail here.

The point is always made in discussions of comparing costs that the two key characteristics are comparability and representativeness of the costs that are being compared. This is generally true regardless of the exact method used. The aim is to find prices for commodities (including services) that are as similar as possible so that they can be directly compared and that they are reasonably representative of normal consumption in the location where they are being priced. This problem is by no means unique to the construction sector although the problems are exacerbated in construction as the output of the sector is recognised as being one of the most heterogeneous (UN, 1992; Vermande and van Mulligen, 1999; Walsh and Sawhney, 2004). As most buildings are bespoke, one-off creations it is difficult to find buildings, even within one country, that are truly comparable (Eurostat/OECD, 2006). The general problem is well illustrated by Castles (1995) who noted that, in data gathered for the formulation of OECD PPPs, of 81 petrol engine cars priced only five had a capacity of more than 2 litres and none were representative of the most common cars bought in Australia (which are locally produced models of over 3 litre capacity).

Blake *et al.* (2004) point out that buildings in Germany (for example) are built to “last forever” where the lifespan of buildings in the USA is typically much less, perhaps as little as 20 years. Consequently finding projects that are comparable and representative becomes even more challenging. As less durable buildings are expected construction in the USA is likely to be cheaper and faster and thus the

productivity of the industry in the USA will appear to be higher yet this perception will be based on comparisons of substantially different outputs.

3.5.2 Standard projects

The standard projects approach used by Eurostat and the ICP to collect construction cost data has been criticised for its lack of representativeness with the point being made that a typical house in Scandinavia is very different to one built in Spain or southern Italy. Indeed a house built in the alpine region of northern Italy is quite different to one built in Calabria in the south of the same country.

In the 1980s local variants were introduced into the Eurostat comparison program to make the generic BQs for the standard projects more representative of local practice. Typical variants were insulation thicknesses and cladding to external walls. In Europe quite extreme variations in such components would be expected due to climatic differences. The standard projects now include several house types that are intended to be representative of such variations at the project level. The inclusion of variants does, however, produce its own problems with DLC (2003) showing very significant cost differences between the standard specification and variants. Ward (2003) warns against taking flexibility in these exercises too far so that all comparability is lost with items of quite different quality being priced in different places. The Eurostat-OECD PPP manual (Eurostat/OECD, 2006: 118) also cautions against overly flexible interpretation of specifications lest the result is “marked differences in quality or in a different construction being priced.”

3.5.3 Dealing with variants

The substitution of variants is not without its own problems. The underlying concept is that of “functionally similar projects” rather “identical projects”, with equivalent functionality being the basis for comparison. This approach then equates a typical family dwelling, for instance, in one location with a typical family dwelling in another given that the function of the buildings is to house a family with reasonable comfort and security. This may mean a heavily insulated, centrally heated home in Norway being considered equivalent to a more lightweight, naturally ventilated house near the Mediterranean as both serve a similar function. This may be a reasonable approach when producing PPPs that are ultimately used to compare

standards of living between different countries and regions, but if the aim is to assess relative costs of construction then the approach is problematic as it is to be expected that the equivalent Nordic house will require more materials and services (particularly heating equipment) than its southern counterpart. Hence it would be misleading to compare costs between the two countries as the two buildings are really not comparable. The Eurostat/OECD method includes six standard houses for different regions and/or countries; each is priced only where it represents typical construction (Eurostat/OECD, 2006).

Sawnhey and Walsh (2004 and 2005) in their work for the World Bank spent a great deal of time and effort in identifying construction components or assemblies, rather than whole projects, that are not only functionally similar but that are constructed in very similar fashion (at least in terms of size and materials) in most locations and this must be acknowledged as a strength of the method they have developed.

3.5.4 Actual costs v. estimates

BWA (1993:200) suggest that “it must be made absolutely clear ... that there is no such thing as an accurate estimate of building costs.” It is, however, very difficult to obtain out-turn or actual price data for comparable and representative projects so there is generally little choice but to use estimates of costs in most instances. Once it is accepted that estimates in some form will be needed the problem then becomes one of gathering estimates that reflect actual project costs as accurately as possible.

Whatever the chosen method, costs gathered are generally input costs, i.e. what the contractor pays for materials, labour, plant and equipment. These input costs are theoretically actual supply costs, and can therefore be obtained from materials suppliers, published wage rates and hire/operating costs. Some degree of estimation still occurs, however, as labour inputs can only be forecast based on previous experience, and equipment costs will vary depending on whether a contractor owns or hires plant items, and to what degree specific items of plant are used for specific tasks. Walsh and Sawhney (2004:21) suggest that in pricing their BOCC “someone with construction-specific knowledge will be able to estimate how many hours of each type of labor [sic] and equipment [will be needed] quite readily”. In practice it is likely that such estimates will vary considerably from firm to firm, and from

estimator to estimator. In any such pricing exercise it is imperative that prices are obtained from a number of sources in each location to allow for some averaging of input costs that will smooth the results.

3.5.5 Context

Stapel (2002:5) suggests that “the principal determinants of price level [in construction] are probably scale, complexity and location rather than the type of work”. Meikle (2002:2) is quite definite about it. The two-stage study completed in Australia in 1999 (Page Kirkland, 1999; Langston and de Valence, 1999) supports the view that the type of project has little impact on cost differentials. Based on that research Langston and Best (2000) limited their study to a single building type (high rise commercial offices) as this was considered to be the most “generic” building type common to all the countries in their study.

3.5.5.1 Scale

It could be argued that even with the use of detailed BQs the issue of scale may not be addressed. Meikle (2002) shows that the projects currently priced in the Eurostat/OECD program do not properly represent the typical mix of projects (with regard to scale) usually built. He demonstrates (Meikle, 2002:4), for instance, that the hypothetical projects priced in the UK are generally unrepresentative of the size range of projects actually constructed. Furthermore it is doubtful that an estimator, producing an estimate for a “phantom project” (Business Round Table, 1994:2), would apply a level of care that would include pricing differently for projects of varying scale. There is also no incentive to price as low as possible in order to win the job, and the estimators can be sure that their companies will not have to build to their estimated cost (Pieper, 1990:256).

3.5.5.2 Location

Location (geographically speaking) can be addressed as it is now, by asking estimators to give national average prices (OECD/Eurostat, 2001), or by having estimates produced in several locations within a country. This could be done regardless of the commodity or set of commodities being priced. Location, (within projects, i.e. ground floor, 10th floor, 50th floor) has some impact on prices (Ashworth, 2004:91) but it is common practice for many levels of multi-storey

projects to be measured and priced together, particularly in countries such as Australia where there has been a definite move towards “concise” BQs in which the location of work items in the building structure are seldom described or which are grouped into single items across many locations (Jackson, 2007). Hoisting and scaffolding costs will affect unit rates for work at elevation but given that labour and materials generally make up the greater proportion of unit rates, and prices gathered are estimates of national averages, price distortions due to the inclusion or exclusion of within-project location in pricing exercises would be unlikely to vary beyond the normal limits of estimating accuracy (Scott, 2008). If overheads are spread within prices then the majority of fixed crane and hoist charges are likely to be embedded in unit rates anyway (Scott, 2008).

3.5.5.3 Complexity

Stapel’s third determinant, complexity, is more difficult to accommodate but if it is “average” prices that are sought, the effects of complexity of construction on some projects could arguably be discounted. Once again it is unlikely that estimates will vary beyond normally accepted limits of estimating accuracy.

3.5.6 Practical considerations

Even if an ideal method can be developed it may be that some basic practical concerns make such a method fundamentally unworkable.

3.5.6.1 Implementation

Kuznetsov (2002) for example put forward a data gathering methodology for average “building sites”¹¹ that requires the following data¹²:

- a) Average prices for materials and 3 items of fuel and energy resources
- b) Wages in construction (Z)
- c) Indicators of services in construction and other financial indicators important for formation of the price of building site in percentage of the wage, calculated from statistical reports about cost distribution: Social contribution (S), Depreciation (A), other costs in the cost price (B), profit in building (P)

¹¹ The paper as published is difficult to interpret as the English is quite poor – it is assumed that “building sites” is used to mean “building projects”.

¹² The list is reproduced *verbatim*

- d) Engineering (I)
- e) Value-added tax (VAT)

expressed as follows:

$$P_{mk} = \left[\left(1 + \frac{a}{100} \right) \sum_{j=1}^m P_{MJ} Q_{MJ} + \sum_{k=1}^l P_{ej} Q_{ej} + W * F * \left(1 + \frac{S + A + B + P}{100} \right) \right] * I * \text{VAT}$$

(Kuznetsov, 2002:4)

where ¹³

P_k = price of building site [project] k

m = number of homogeneous groups of materials

a = share of other materials

l = share of homogeneous groups of power resources

Q_{MJ} , Q_{ej} = volumes of use of materials and fuel in model k

W = the wage for one work-day

S, A, B, P = financial indicators for social contribution, depreciation, other costs and profit

I = engineering (design and prospecting activities, technical advice, control of the project and other service)

VAT = value-added tax

Even if the model is accepted as valid, and that is surely open to debate even if the language difficulties were to be resolved, the problems that would be encountered in gathering the required data would be enormous. It suggests that Kuznetsov considers that a great deal of data is needed for these comparisons. Some of data would potentially be unavailable while the rest would require very detailed guidelines. Subsequent validation of the data would be needed if any consistency in the data reported were to be achieved. This proposed model is complex and the data requirements are such that it appears quite impractical.

3.5.6.2 Program costs

One of the major concerns with the standard projects model is the cost of running the pricing rounds and dealing with the data that is collected. With some thousands of

¹³ Again this list is reproduced *verbatim* - no further explanation of how the equation is derived nor how it would be used is provided in the source paper, consequently its validity cannot be assessed. For example, it is not known how parameter I (engineering) is to be expressed – is it an index number, a percentage, a monetary figure or something else? Other parts of the equation are similarly ill-defined.

individual items to be priced across the bills of quantities (BQs) for as many as 15 projects the sheer quantity of data presents management problems. Pricing items of construction work requires people with specialist knowledge and this usually means that professional firms (e.g. quantity surveying offices) have to be engaged to carry out the pricing. This is expensive and does not always produce good results (Dubner, 2004). The cost of the exercise also means that prices in each country are usually only obtained from one source, and while it is usually "national average prices" that are asked for (Eurostat/OECD, 2006) there is no way of knowing how well such instructions are or can be obeyed.

Meikle (2005) suggests that even with extensive ongoing consultation it is difficult to achieve consistent pricing from location to location. Added to that is a large data validation exercise in which costs recorded for each item in each location are compared and major differences between countries identified. When this has been done and significant discrepancies are identified confirmation of unit rates is sought from those who have supplied the rates. For example, if a BQ item such as "concrete in strip footings" is priced in one location at a rate that appears many times the rate from another location¹⁴ confirmation of the validity of the rate is requested. In virtually all cases in recent validation exercises even large discrepancies (in the order of 1000%) have been confirmed by the in-country pricing personnel (Thomas, 2005). This raises questions about the basis of pricing and the level of effort applied to pricing and highlights the need for obtaining prices from more than one source in each country.

3.5.6.3 Data collection

Apart from the expense attached to gathering building cost data there is the need for consistency in the data. Vermande and van Mulligen (1999:278) noted that:

There is a big risk [in the Eurostat survey] of wrong interpretations of the bills of quantities by national cost experts, inaccuracies, non-corrected and

¹⁴ During this phase these comparisons must be based on exchange rate conversions but this is reasonable as it is only gross differences that are investigated and such differences will fall outside the range that typical exchange rate fluctuations might account for.

non-correlated extreme deviations up or down, and perhaps even errors in the calculations.

The standard project model with bills of quantities has often been criticised (Stapel, 2002; Dubner and Mackenzie, 2002) not only because of the amount of data gathered but also because the use of BQs is not common in many of the countries from which prices have been obtained (Meikle, 2004). In any location, regardless of whether the BQ or typical quantity surveying approach to cost is common, there is considerable scope for differences in interpretation of items to be costed (Thomas, 2006). Consistent interpretation of bill items is essential if comparable prices are to be obtained (Dubner and Mackenzie, 2002). In countries that use BQs there is invariably some form of standard method of measurement (Mills *et al.*, 2006) that defines what is to be measured and how measured items will be priced, particularly in terms of what is deemed to be included in prices and what is not. Even with very detailed guidelines an estimator may have to make assumptions about inclusions such as fixings, profit, site-specific overheads and general overheads; all of these will affect the prices that are entered (Meikle, 2004). In places where estimators are not familiar with the potential problems associated with BQs the likelihood of error and inconsistency in pricing is increased (Thomas, 2006).

3.5.6.4 Variants and specification of priced items

It is noted above (at 3.5.3) that some flexibility in the specification of items and projects in the Eurostat program has been included in recent rounds of construction pricing. Another approach is to use items for pricing that are not rigidly specified but instead are specified based on function or performance. Freeman (1981) describes a 1963 study carried out by the ECE¹⁵ into housing costs in European countries where the cost data collected was for one type of residential construction defined as “the tallest multi-storey buildings without lifts normally built in each country for social housing” (Freeman, 1981:2). The study concluded that the projects for which data were available could not be considered to be truly comparable or even typical of that sort of construction within a single country. There were numerous other problems

¹⁵ The UN Economic Commission for Europe

identified with inconsistency of data, differing methods of building measurement and varying construction standards.

Silver and Heravi (2002) discuss, at a general level, the trade-off between tightly specified items for international costing, which can result in low response rates when those pricing cannot provide prices for items that are not common in their country, and more loosely specified items which may gain good coverage but produce inconsistent pricing. Rittenau (2002) believes that clear and precise product descriptions are necessary if consistent and comparable prices are to be obtained, and that extensive in-country consultation between those managing the data gathering and those providing the price data is essential if reliable PPPs are to be produced.

3.5.6.5 *Specifying items in a construction context*

Both Silver and Heravi, and Rittenau discuss PPPs in a broad sense; others have considered the level of specification in the construction context. Proverbs *et al.* (1999a, 1999b) provided detailed drawings of a concrete framed structure when assessing contractor performance in several European countries and although cost was not part of their study the level of detail supplied provided respondents to their surveys with a clear understanding of just what was to be constructed. In this instance the basic simplicity of the structure reduced or avoided potential problems related to differences in quality and finish; structural concrete is less likely to exhibit regional and national variations than other building components.

Xiao and Proverbs (2002a, 2002b, 2002c) by comparison provided only a written description of the structure that was the focus of their study thus leaving respondents to make their own decisions about its design. The study is discussed above at 2.5.10 and at 2.9.5, and the questionable data that was obtained is noted. That study illustrates well the problems that a loosely specified product can cause.

3.6 SELECTING A METHOD

The preceding discussion identifies a number of potential problems that exist and suggests a range of desirable attributes that any viable method for cost conversions

might exhibit. The challenge is to select and develop a method that can alleviate as many of the problems as possible.

3.6.1 The standard commodity

Much has been written about mechanisms for cost conversion, usually as part of a larger exercise leading to GDP-level PPPs. Similarly a variety of methods have been used in attempts to compare performance and/or to benchmark performance both within and between countries. The focus here, however, is on the first problem and while there have been various mechanisms suggested and applied in recent years, none has emerged as being clearly superior to another. One of the reasons for that is that there is no “correct” answer for any outcomes to be compared against, and, to date, no obvious method for testing outcomes for reliability.

The Big Mac Index (BMI) is a monetary conversion mechanism based on the notion of purchasing power parity (PPP) and the use of a standard commodity. A hamburger made to a virtually identical specification in many locations is that standard commodity. The standard commodity can be used theoretically as a unit of currency. One way that it can be used is by dividing the cost of a good (a building, a bag of cement, an area of ceramic tiles fixed in place, a car, the hire of a hotel room) by the local cost of a Big Mac hamburger to produce the number of hamburger equivalents that represent the cost of the good (Langston and de Valence, 1999).

3.6.1.1 Representativeness of the Big Mac

Using the BMI in this way implies that the standard commodity is representative of some much larger basket of goods and services that is characteristic of all consumption in all locations. If used in a construction context then equally it is implied that the combination of materials (bun, meat, pickles etc) and labour and other inputs (such as rent, transport and cleaning) embodied in the hamburger is representative of the consumption of inputs in construction. While there is some support for the BMI as a comparison tool generally there has been little apparent support for its use in the context of construction and at least one group of authors strongly opposed to its use (Croce *et al.*, 1999). Langston and Best (2005) show that of a range of PPPs available, the BMI, when applied to a range of construction costs

across ten international locations, appears to be the one that produces the least consistent results.

3.6.1.2 *An index of affordability*

More recently the Building Cost Information Service (BCIS, 2006) included an Affordability Index in their comparison of Asian construction costs; in this instance costs per m² for various building types in each country were divided by the local cost of one litre of unleaded petrol so costs could be expressed as a number of litres of petrol. This method is very similar to the Big Mac approach used by Langston and de Valence (1999), however, the appropriateness of the standard commodity selected as a basis for cost comparisons is debatable as in most locations the petrol will be produced entirely from imported raw material (petroleum) and differences in petrol excise may distort results. It should be noted though that the BCIS call it an index of affordability and it is only intended for use as a secondary indicator without any claims being made about its validity as a conversion tool in comparative studies.

3.6.2 The options

The commonly described methods for deriving construction PPPs are all based on some form of standard commodity, although they are composite commodities in most cases just as the Big Mac is a composite of both physical items (e.g. bun, lettuce) and intangibles (e.g. rent and labour).

Meikle (2003a) summarised four recognised methods of gathering data for the derivation of construction PPPs:

- Standard projects: bills of quantities (BQs) are priced for a number of typical projects each of which is, in effect, a standard commodity comprised of many work items that include all or most of the typical components of construction cost, viz. labour, plant, materials, profit and overheads – the set of projects could be called a basket of projects, and such a basket could be considered as a sort of “standard commodity”, albeit a rather large one.
- Basket of goods and services (BOG): a set of items to be priced that comprises typical building materials and categories of labour. The size of the basket is variable but it is generally kept relatively small to contain the

cost of obtaining prices and/or to allow for more frequent pricing and pricing by more people in more places in each country. This basket is again a type of standard commodity but not as coherent a product as either a complete building or a hamburger.

- Basket of construction components (BOCC): this is similar to the BOG except that the constituents of the basket are assemblies or components (such as pad footings, or cement render of a nominated thickness applied to walls). The major difference is that in this case labour, materials and other factors are included in the cost of the individual components. Once again the basket represents a sort of standard commodity.
- Single project estimates: generally based on total cost per m² of gross floor area for various building types.

The first includes the standard projects approach currently used by Eurostat and previously used by the International Comparison Program (ICP), the second has been trialled in a restricted fashion by Davis Langdon Consultancy (DLC, 2003). The third is the method that has been adopted by the ICP although it is still under development by the World Bank (Walsh and Sawhney, 2004 and 2005; Walsh *et al.* 2006). and the last has been used in studies such as the *Asia Building Construction Survey* (BCIS, 2006).

Dubner and McKenzie (2002) also identified a range of alternative approaches and compared them to the current OECD BQ-based standard projects approach:

- Factor costs – similar to the BOG, comprising a weighted index of the costs of factor inputs, usually labour, materials and plant.
- Component costs – similar to the BOCC
- Quoted prices – similar to the single project estimate
- Schedule of prices – similar to the component costs approach but based on rates for actual projects

- Matched models – a simple model based on cost per square metre rates for functionally similar buildings¹⁶; data models of this type are routinely used by companies that publish construction costs commercially (e.g. Rawlinsons and Reed Data/Cordell in Australia).

Walsh and Sawhney (2004) make a similar set of comparisons but include the reduced BQ method (based on shorter BQs for the standard projects that include the most significant items) and the CIS method (Kuznetsoz, 2002). The latter, previously described, is a very detailed and specific method that would be extremely difficult to apply outside the CIS. It is worth noting that aim of Walsh and Sawhney, as part of the ICP, is broad, and their problems are consequently large – they are, in fact, trying to compare costs between upwards of 160 countries, which represent a very wide range of physical and political conditions, diverse building methods and products and very significant differences in usage of labour and equipment.

3.6.3 Expenditure shares

In all options listed above, however, a representative sample is used to produce conversion factors for the whole industry, and these in turn contribute to aggregated PPPs for whole economies (GDP or general PPPs). As part of the aggregation process the various components are weighted to reflect the share of expenditure that each constituent of the standard commodity (set of projects, BOG, and so on) represents in total construction costs typical of each location. This is a similar process to that used in typical Consumer Price Index (CPI) calculations (ABS, 2005) where the expenditure shares of the various goods and services included in the basket are calculated from extensive surveys of household expenditure.

In the pricing of BQs in the standard products approach weights are implicit in the pricing as whole projects are priced and the pricing of each item reflects the relative weight of that item. The BOG and BOCC approaches, however, involve the pricing of only selected parts of a limitless number of hypothetical projects and these parts must be weighted to reflect the relative contribution of each item or component in national construction output.

¹⁶ Equivalent to Meikle's single project estimate

In the calculation of construction PPPs data has most recently been gathered under three general headings: residential construction, non-residential construction and civil engineering construction. The proportions of total construction expenditure in different countries in respect of these three categories varies considerably¹⁷ (DLC 2003) as do the expenditure shares of various constituents in any BOG or BOCC. These variable shares must be accounted for in any aggregation of lower level costs to composite PPPs.

3.6.4 Discussion

While the talk is usually of *cost* conversion most people involved in this area actually try to gather *price* data that represent the prices paid by the consumer for building work done. In practice, however, obtaining out-turn prices is very difficult. While out-turn prices for completed buildings may be obtainable a host of problems arise when any attempt is made to compare these prices as it is largely impossible to find truly comparable projects.

The current standard projects method relies on estimates of such prices by having BQs priced by estimators in each country. These estimates are intended to be derived in the same way that rates in a priced BQ for an actual project would be derived. As such they should include all inputs plus overheads (specific and general) and profit, with the total estimated price being equivalent to the price that a contractor would charge a client for constructing the entire project. While this is sound in theory, in practice there are problems associated with using estimates. Estimators know they are not pricing a real job and their company will not be building on the basis of their estimate, so the level of effort and accuracy may not be high. Also there are concerns about the reliability of markups and overhead allowances in estimates such as these.

3.6.5 The productivity question

Input methods, such as the basket of goods and services, rely on the costs of inputs, principally materials and labour, and represent the cost to the contractor rather than the price to the consumer. Critics of input methods suggest that one of the

¹⁷ See Table 2.3.

weaknesses of input methods is that both productivity and the labour/equipment trade-off are automatically excluded in this case. The addition of notional or average markups is seen as unreliable and having the potential to skew results unacceptably.

There is a question here at least in regards to productivity: if we are searching for a way to compare costs (or prices) then is the inclusion of productivity relevant or even correct? To answer this it is necessary to again consider what the aim of the whole exercise is - and it is to be able convert the actual cost of construction work in one location with that in another, in order to make valid comparisons of the relative costs of construction in the different locations.

While differing levels of productivity in the various locations may provide at least a partial explanation for differences in cost, the initial exercise, i.e. converting the costs to a common base, does not require that productivity be included in the conversion method at all. What is being measured at this stage is cost and that should be nothing more than some form of representative cost of doing building work, whether net (cost) or gross (price).

Similarly the labour/equipment trade-off will be a factor in explaining differences in costs but is in fact just an inherent part of the costs – and it is the actual cost that is important in the conversion problem, not what causes costs in one place to be different to those in another. However, if a method can be devised that inherently reflects these factors then that may be an advantage, but it is not overly important if the problem of cost conversion is isolated from comparisons of performance, or productivity, or efficiency.

3.6.6 Data collection and cost conversion

Clearly there are two related problems here: one is gathering comparable and representative cost/price data in each location and then there is the problem of converting these costs/prices to a common base so that they can be compared. The two may be different views of the same problem, for example, when international comparisons are based on cost alone (e.g. Page Kirkland, 1999) but in many instances the conversion problem is part of a different sort of comparative exercise,

e.g. a single factor, macroeconomic style study comparing value added per construction worker hour (e.g. Croce *et al.*, 1999) where value added is typically measured as value of output (i.e. the value of constructed facilities measured in local currency) less the value of inputs (measured similarly). For international comparisons to be made both values have to be brought to a common base.

The conversion mechanism should be seen as a preliminary problem, and a problem which, when adequately solved, will provide a tool that enables more robust comparisons of performance (or whatever it may be called) to be carried out and then for subsequent analysis to seek reasons for differences in performance. But unless a useful method for comparing industry performance that does not include construction cost as a parameter can be devised (and this seems unlikely as cost is universally recognised as one of the three basic measures of construction performance) then the cost conversion question remains a fundamental concern as unreliable conversion methods undermine all subsequent comparisons and conclusions drawn (Best and Langston, 2006b).

3.7 COMPARING THE OPTIONS

Opinions vary as to which of the possible methods will produce the best results. Meikle (2003a) mapped the advantages, disadvantages, opportunities and barriers relevant to the four potential methods that he identified and showed that, on balance, the weighted BOG approach appeared the most promising. It should be noted, however, that this analysis included practical considerations such as the amount of effort and expense that would be required in order to apply the various methods and therefore the evaluation was not based solely on the potential for achieving the very best results.

3.7.1 Standard project(s)

This approach is the one that has been used by the ICP and Eurostat since the early 1970s (Stapel, 2002). Detailed bills of quantities are priced for a range of projects including civil engineering works such as roads and bridges. The ICP/Eurostat method has already been described but it can be applied in other ways, using as little as a single building as its subject.

3.7.1.1 The Davis Langdon approach

Davis Langdon Consultancy (DLC, 1999) used a set of three standard building projects¹⁸, priced in the three locations to compare construction costs between the UK, Ireland and the Netherlands.

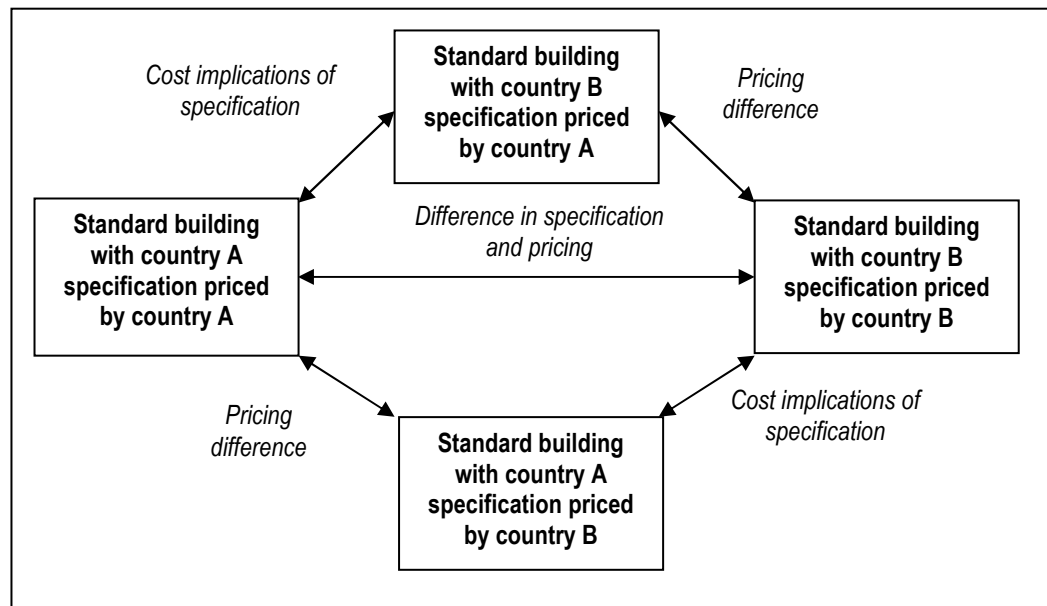


Figure 3.8 Basic comparison methodology (DLC, 1999:4)

The Davis Langdon study produced bilateral comparisons that separated cost differences due to differences in specification as well as those due to differing price levels. The basic methodology is shown diagrammatically in Fig. 3.8. A typical bilateral comparison is shown in Fig. 3.9.

The buildings were priced by experts in each country in national currencies. Total costs were then converted to European Currency Units (ECUs) to allow direct comparisons of cost.

The method was expanded to include differences in building geometry for residential buildings that were typical of the different locations. This allowed analysis of overall

¹⁸ A single storey factory/office (GFA 2,900m²); a multi-storey office block (GFA 4,500m²) and a single family dwelling.

cost differences between locations to show the relative effects of the three variables, viz. price level differences, specification differences and differences in building geometry (form).

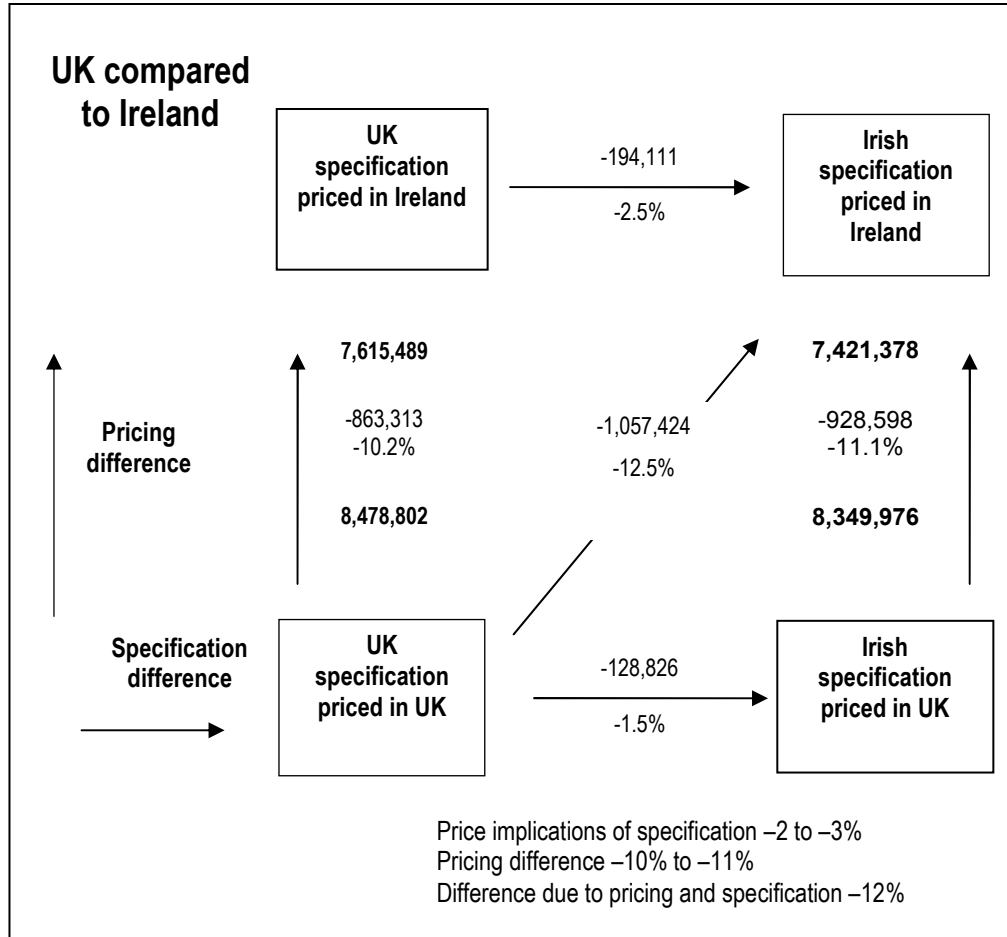


Figure 3.9 Office building price comparison – project prices in ECUs (base date September 1997) (DLC, 1999:18)

3.7.7.2 *The Faithful+Gould/RSMMeans approach*

International cost consultants Faithful+Gould in conjunction with RSMMeans regularly publish *International Construction Intelligence* (e.g. Faithful+Gould/RSMMeans, 2008). It contains international construction cost indices based on a PPP framework using a model building approach. The model building is a 13,900m² office/factory building. A weighted basket of 26 items that represent the model project is priced. Prices are intended to be “trade contractors’ in-place prices” and therefore are assumed to include labour, materials, equipment, overheads and profit. The basket is

priced in over 30 cities worldwide. Basket costs are used to calculate location-specific purchasing power parities for construction with Chicago as the base.

Few other details of the basket or of the procedure are available. For example, it is not clear whether the items in the basket are basic resources such as materials and labour or components such as spread (pad) footings or partitions. Some notes in Faithful+Gould/RSMMeans (2008) suggest that it is component based. It is also not clear why they quote parities in ranges¹⁹ given that it appears that prices are obtained from only one source in each city. The range of values for each city has a maximum that is around 10-15% above the minimum, however, if the parities are calculated by comparing the cost of the basket (or the project it represents) in one location against the cost in Chicago then a single value for each would emerge. Possibly the range is simply an acknowledgement of the level of approximation that is inherent in the method but this is not explained. A table of applicable taxes such as GST or VAT for the various locations is included but there is no mention of whether the basket prices include tax or not.

While the method appears to be theoretically very similar to that of the World Bank BOCC, the use of a limited number of items is similar to the method developed here and some comparisons of the outcomes of the two are discussed in Chapter 6.

3.7.2 Case studies

This method has been discussed earlier – examples include the studies by Flanagan *et al.* (1986) and Lynton (1993) discussed in Chapter 2.

3.7.3 Matched projects

Examples of studies that have used this approach include BCIS (2006) and BWA (2006). Costs per m² for various building types (e.g. hotel, office, warehouse) are published by various commercial construction cost specialists. This data is generally used for superficial estimating for proposed projects. Studies such as the BCIS study use this data as a basis for comparing costs between locations. Cost data may be collected for real completed projects but because of the difficulties associated with

¹⁹ For example, the parity range for Melbourne is 1.16 to 1.33 in the March/April 2008 edition.

obtaining such data standard cost models are typically priced regularly in various locations to produce estimated superficial rates (e.g. Reed Construction Data in Australia: Bozdag, 2008).

3.7.4 Basket of construction components (BOCC)

In their comparison Walsh and Sawhney (2004) come down strongly in favour of a BOCC approach although some of the reasoning behind their choice must be questioned. Their main concerns with the BQ approach are the effort required to price the projects and the basic problems of finding projects that are representative and comparable, and this is consistent with the views of numerous other authors. They are concerned that the BOG approach does not include productivity differences or the labour/equipment trade-off, but as outlined earlier this should not be a consideration in preparing cost conversion factors. They agree that prices for BOG items are relatively easy to obtain but express concern that unless markups are estimated that a BOG approach represents only input costs and not purchaser prices.

They suggest that their BOCC approach is superior yet the BOCC that has been developed includes some input costs (e.g. cement and sand) and the remainder of the basket (i.e. components such as reinforced columns and pad footings) is to be priced by estimators inserting unit rates for the supply of the various materials, amounts of labour of various classes required to fabricate and/or install the materials, and the cost associated with use of plant and equipment necessary to install the components. In effect the basket will be priced using input prices, with no allowance for markups or overheads; the only real difference will be that the individual items that might appear in a basket of goods will, in the BOCC, be aggregated into discrete components. The pricing advantages that Walsh and Sawhney claim for this method are not obvious as the outcomes will still depend on estimates of input costs based on calculated quantities of material but estimates (or averages at best) of labour and plant inputs. They go on to suggest (Walsh and Sawhney, 2004:22) that some construction experts may be able, from experience, to give estimates of the cost of whole components without pricing the individual materials, labour and plant items, and that this method may provide both a check on results obtained by detailed pricing and be a useful method for collecting prices from “multiple price points in

multiple cities”. For various reasons this appears to be too simplistic to be seriously considered, not least because it would always be unclear as to whether such “rule of thumb” estimates included markups.

Meikle also sees a number of problems with the BOCC, notably that it relies on estimated prices rather than actual prices and does not account for variations in size or complexity of projects. It can be argued, however, that the perceived lack of context does not necessarily invalidate the concept, as most of these concerns can be shown to be of relatively little consequence²⁰. As noted previously the fact that the best estimates routinely vary by as much as $\pm 10\%$ when compared to out-turn costs, supports this view as the sort of cost differences that arise through contextual variations are likely to be insignificant within such an estimate band.

If context is indeed a problem with the BOCC method then it is likely to be even more of a concern in a BOG approach. While scale may be addressed by asking for prices for differing quantities of the same item (e.g. 100m³, 10,000m³, 100,000m³ of excavation in rock) location and complexity would appear to be impossible to deal with without providing very detailed contextual information with every item in the basket. Such information would be very hard to convey accurately and the outcomes would most likely be no more or less reliable than those gained using other methods. More importantly, collecting more than one set of estimates from each country would do much to eliminate, or least reduce, the effects of contextual differences. In any case, as discussed above at 3.5.5, context appears to be less of a concern than either Stapel or Meikle suggest.

3.7.5 Basket of goods and services (BOG)

Some attempts have been made to apply the basket of goods approach to construction costs surveys; Stapel (2002) and Meikle (2003b) tested two approaches²¹ to the problem.

²⁰ See 3.5.3.

²¹ While they have produced papers on the subject individually Stapel (2002: 2) acknowledges Meikle’s direct contribution to her work for Eurostat in this area.

3.7.5.1 First attempt

Stapel (2002:17) outlines an attempt to test the feasibility of a BOG as a method for surveying construction costs/prices. While the method is described as a “weighted basket of goods” it does not appear that any systematic weighting procedure was employed; rather it seems that the basket was assembled intuitively on the basis of the author’s experience. The basket used is shown in Table 3.1

RESOURCE	QUANTITY
Unskilled labour	600 person hours
Semi-skilled labour	600 person hours
Skilled labour	600 person hours
Cement	15 tonnes
Mild steel reinforcement	1.5 tonnes
Structural steel	100 kg
Common bricks	2500 number
Softwood for joinery	50m3
Float glass	15m2

Table 3.1 Weighted basket of goods for construction work (Stapel, 2002:17)

The basket was priced using published data from several sources; results for the UK and Portugal are reported and compared to existing Eurostat data (presumably based on the current standard projects/BQ approach).

3.7.5.2 Results

While the trends over time²² shown by the basket of goods prices appear to be broadly in agreement with those obtained through the normal Eurostat standard projects approach there is considerable variation in some years. Stapel (2002:19) describes the outcome as “inconclusive”, partly because, as she points out, “we do not know what the ‘right’ answer is”. She acknowledges that the basket used is too

²² The study used time series data from 1985 to 1999. This was possible due to the use of published input costs data, an option which would be difficult to employ if “live” prices were sought from construction cost consultants.

simple and limited to properly represent the principal construction inputs, and notes that it does not account in any way for differences in labour productivity (as the ratios and quantities of labour are assumed to be the same for all countries). Stapel goes on (2002:20) to suggest that as well as the basket not including enough resources that the quantities used should be adjusted to reflect differing expenditure shares in different locations. Other concerns include the need for some adjustment to account for market conditions; as the basket method collects input costs only consumer (client) prices will be greater as they will include markups for profit and overheads (general and project-specific). Profit margins at least will vary according to market conditions and thus affect out-turn prices differently over time as markets fluctuate. There is no reason to assume that these market fluctuations will occur in parallel in different countries and, in fact, while there may be some common market movements due to global economic conditions it has been observed that at any point in time the building cycle in various locations can be quite different (Langston and de Valence, 1999:86).

3.7.5.3 Discussion

Apart from the problems outlined above there are wider concerns with Stapel's exercise. In particular it illustrates the problems of using broad averages as representative of a sector as diverse as construction. The Eurostat results against which the BOG results are compared are averages of housing, non-residential and civil engineering project results but there is no indication of any weighting of these sectors in the averages. Equally the implied weighting of the items in the basket seems to offer little representativeness for some sectors, e.g. 15m² of float glass, 50m³ of softwood for joinery and 15 tonnes of cement suggest highly unlikely ratios for the use of these materials in civil engineering work. This BOG approach (and this is true of the approach in general, not only to Stapel's exercise) makes no account of project scale. Meikle (2002) criticises the Eurostat standard BQs as being unrepresentative of the typical mix of construction projects (in terms of project size), however, by its very nature a single BOG that is assumed to be representative of all construction cannot make any allowance for price differences that may arise due to project scale. What the exercise does suggest, however, is that the general approach

may produce results at least as good as those produced using the much more resource-intensive standard projects method.

3.7.5.4 *Second attempt*

Meikle (2003b) conducted a more extensive test exercise on the BOG approach. This exercise expanded significantly on Stapel's initial test exercise in a number of ways.

- The basket used was considerably larger, comprising 35 items that included not only commonly used materials but also some pre-fabricated components (e.g. timber framed windows) and four types of construction labour (unskilled, semi-skilled, skilled and site manager).
- Three unit prices were sought for each item for their inclusion in small, medium and large projects. While the three divisions of project size were identified by indicative quantities for each item²³ only unit prices were sought, rather than extended prices for the stated quantities.
- National input/output (I/O) tables were used to determine the weights of individual items in the basket; this was foreshadowed in Stapel (2002:20). This method is described in more detail below as it is unique to this exercise but raises some problems of its own.
- Respondents were given the opportunity to provide prices for variants or alternatives that would better represent local practice/consumption, and were asked to provide comments on any regional price variations that might exist in their own country.

3.7.5.5 *Weighting the basket*

The approach used by Meikle is unusual, and probably unique. Rather than producing a standard weighted basket and then seeking price data for that basket, unit rates were gathered and these were used to assemble a basket of goods and labour that contained the same list of materials, products and labour categories but different quantities for each item. Quantities for each country were derived from

²³ For example, respondents were asked to provide unit prices for "Ordinary portland cement" in quantities of 20, 200 and 2000 tonnes, and "Ready mixed concrete (25N/mm²)" in quantities of 25, 250 and 2500m³.

national I/O tables. National accounts generally include figures that represent purchases of materials by the construction industry from other sectors and these provide a value weighting of inputs to the construction industry. Priced items in the BOG were assigned to various product groups in the input-output tables and the average contribution to the basket determined. The labour:materials split was assumed to be 40:60 with no separation of plant costs or profit and overheads. Plant typically represents less than 5% of total cost (Meikle, 2003b:12) and is therefore less cost significant. Similarly markups vary but in Australia markups are typically less than 10% and often less than 5% (Dubner, 2007). If plant and markup were somehow included in the weighting exercise both the materials and labour components would be reduced by the same proportion and consequently ignoring these factors does not affect the overall materials to labour ratios.

The unifying factor is that each national basket represents €1,000,000 of construction. Using the weights established from the tables quantities for each of the 35 items in the BOG quantities for each item were derived that, when priced and summed, equated to 60% of a UK standard basket worth €1,000,000. Labour weights for the four categories of labour that were priced were used similarly to complete the million euro basket. Table 3.2 shows a small section of the UK BOG.

Meikle (2003b:4) acknowledges that this means that direct comparisons between various countries cannot be made but bilateral comparisons can be carried out by comparing baskets as shown in Fig. 3.10.

Meikle suggests that this comparison indicates that construction price levels are higher in Country A but that the extent of the difference is influenced by different resource mixes. He compared these results with the 2002 Eurostat indices for the two countries, based on standard BQs, and observed that while the price level ratios differ between the two methods Country A (Poland) was shown to be consistently more expensive than Country B (Slovakia).

Item	Unit	Survey price GBP	Price € 0.628831	ONS ²⁴		Derived quantity	Unit
				Product group	% of €600,000	Value €	
Common bricks	each	0.20	0.32	53	4.59%	27,519	86,525 each
Clay plain roof tiles	each	0.24	0.38	51	1.48%	8,858	23,209 each
Chipboard sheet flooring	m2	2.88	4.58	31	1.60%	9,590	2,094 m2
Clay floor tiles	each	0.37	0.59	51	1.48%	8,858	15,055 each
Vinyl floor tiles	m2	5.00	7.95	48	6.65%	39,876	5,015 m2
etc							
						100% 600,000	
Unskilled	hours	8.00	12.72	12.00%	30.00%	120,000	9,432 hours
Semi-skilled	hours	11.00	17.49	12.00%	30.00%	120,000	6,860 hours
Skilled	hours	14.00	22.26	12.00%	30.00%	120,000	5,390 hours
Site manager	hours	18.00	28.62	4.00%	10.00%	40,000	1,397 hours
						100% 400,000	
Total value of basket						1,000,000	

Table 3.2 Quantity weightings for the basket of goods (Meikle, 2003b)

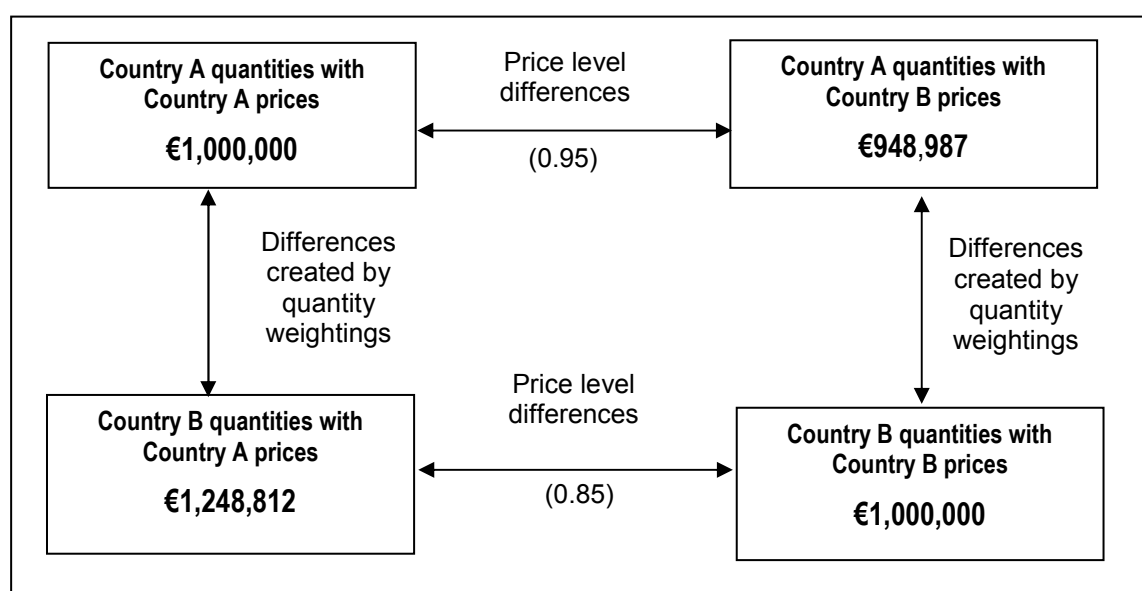


Figure 3.10 Bilateral comparison (after Meikle, 2003b:4)²⁵

3.7.5.6 Results

Thirteen countries were included in the survey. Meikle (2003b:2) identifies some issues with the completion of the survey. Most notable of these was that only nine countries provided prices for all three project size categories, three others only

²⁴ Office of National Statistics

²⁵ Meikle's comparison, and the costs shown here, are based on results from Poland (A) and Slovakia (B).

provided prices for “small” projects while one country gave the same prices for projects of all three sizes. This limited the potential for inter-country comparisons considerably and as a result only price comparisons for small projects were reported. Little information was collected regarding regional variations. Alternative prices were given, on average, for only 16% of the items, however, most of these variants involved changes of dimensions to “standard” items such as masonry units and tiles. This problem could be addressed, at least in part, by giving quantities for these items in m² rather than by number. Meikle, however, suggests that there are problems related to obtaining I/O data that is both up to date and consistent between different countries.

3.7.5.7 General observations

Apart from the limited use of this approach (in that it produces only bilateral comparisons) some other points should be noted. The model²⁶ is based on a nominal 60:40 materials:labour split; which seems to have been adopted as no more than a rule-of-thumb. It ignores plant and equipment and overheads and profit. Similarly an arbitrary split of labour types (30:30:30:10 ratio of unskilled, semi-skilled, skilled and site manager labour) is used. It is not clear whether these ratios were used for all countries or whether country-specific data was obtained. Meikle notes (2003b:13) that the UK example detailed in his paper “may not well reflect the mix of material and labour resources in other countries or in the UK in other years”; this suggests that specific data was not obtained for each country.

There are some concerns with the cost data obtained from the survey. While many of the countries surveyed use the euro, some do not. Where data was gathered in other national currencies it was converted to euros using mid-2002 exchange rates. There is an anomaly here in that exchange rates, which are recognised as being inappropriate as a conversion mechanism in this context, have been used as part of a process that is intended to obviate their use.

It is equally important that countries in the Eurozone still have differing price levels. OECD (2007a) shows that, in the period 2003-2006, while some of those countries

²⁶ Details are provided only for the UK; this is assumed to be typical for all the countries in the study.

had similar general PPPs (0.86 to 0.90 compared to the USD at 1.00) Greece, for example, had a significantly lower PPP (approx. 0.76) and Ireland was generally on a par with the US. This seems to be a fundamental flaw in the method used in this exercise as the very concerns that Meikle is seeking to avoid²⁷ are actually embedded in the method.

3.7.4.8 Evaluation

This attempt, while soundly based, has some practical problems as discussed above, and in the context here the greatest of those is that the results do not allow comparisons between many countries. The method used does largely solve (or avoid) some of the problems of comparability and representativeness of the items in the basket and the total basket itself but in so doing the basic goal of producing a set of conversion factors that can be used to bring costs from a number of locations to a common base is not really addressed. The use of I/O tables is identified by Meikle as a problem if for no other reason than that reliable I/O data in a consistent format and based on a consistent methodology is not readily available for all countries, even within the EU.

The items in the basket were arbitrarily chosen (although the choices were based on the author's extensive experience as a construction cost consultant) and some weightings (e.g. the weighting of the four categories of labour) were notional. The labour to materials ratio was also notional and a single ratio was assumed to be typical across all items in the basket. How accurate these estimates are is unknown. Finally the cost data is all based on input costs with no allowance for preliminaries or contractors' margins (profit and general overheads) hence there is no attempt to measure out-turn prices in this study and this is surely a weakness.

3.8 CONCLUDING REMARKS

In this chapter the problem of cost conversion and some approaches to dealing with it have been discussed. The views of other authors have been explored in respect of the various methods that have been used to date to produce mechanisms for cost

²⁷ Differences in price levels and the use of exchange rates.

conversion and those views have been evaluated. Based on the foregoing discussion the basket of goods approach appears, on balance, to be the most promising alternative.

The BOG has been chosen for the following reasons:

- In the view of this author, and of others (notably Meikle), the advantages of this method significantly outweigh the disadvantages
- The items (both materials and labour) included in such a basket, if chosen carefully, are such that they can be tightly specified yet be both comparable and representative for various locations
- It offers the opportunity to collect multiple responses from each location thus potentially alleviating the problems associated with the single pricing system currently used in the standard projects method
- It is a concise method that can be administered more cheaply and easily than current methods
- A robust test of the BOG approach will provide results that can be compared with those obtained by the World Bank (using the BOCC approach developed by Walsh and Sawhney); such comparisons will provide further insights into future development of methods for determining construction-specific PPPs.

In the following chapter the method for producing a refined basket of construction materials and labour is described and the implementation of a pilot study based on a shortened version of the basket is discussed.

CHAPTER 4

4.0 RESEARCH METHOD AND CONCEPT DEVELOPMENT

4.1 INTRODUCTION

In Chapter 1 four research questions were stated.

Research Question Q1 relates to the reliability and accuracy of methods currently used for international construction comparisons. Through a detailed analysis of the literature, including work published previously by this author, it has been shown that the methods used in previous studies are generally not reliable. Analysis of previous studies showed that conclusions drawn about relative costs were often based on cost conversions that were highly questionable. Hence the answer to Q1 is that existing methods are neither reliable nor accurate.

The second question (Q2) raised the issue of whether these methods could be improved. The literature suggests that there are methods that could be developed that should improve the reliability and accuracy of cost conversions. The outcome of that review and analysis was the selection of a weighted basket of construction materials and labour as the method to be adopted. This method was identified as the one that best combines feasibility of use with a sound theoretical basis.

In this and the following two chapters the remaining research questions are addressed. Research Question Q3 concerned the suitability of an index based on a fixed weight basket of goods as a conversion mechanism. The rationale for a fixed weight index and the methodology used to develop a representative basket are described in response to this question. Research Question Q4 concerned the use of

such a basket as an indicator of relative productivity. The theoretical underpinning of the use of the basket as a measure of productivity is discussed in this chapter and its application described in Chapter 6.

4.2 RESEARCH METHOD

In arriving at this point the research method used has been based on analyses of published work and some statistical analysis of secondary data such as exchange rates. Some statistical analysis developed in my previous work on the topics of industry comparisons and cost conversion (e.g. Langston and Best, 2005; Best and Langston, 2006; Best, 2007) has also been included in the analyses.

It is appropriate at this point to consider the nature of the third and fourth research questions (Q3 and Q4) stated above and the appropriate methodology and method or methods that can be applied to them. It is clear at the outset that the research method employed in attempting to answer the questions will be quantitative, and that numerical data is needed in order to pursue the research. Cost conversion is inherently quantitative in nature and all previous attempts to address the cost conversion problem as well as the larger questions of productivity and performance comparisons have involved the use of some form of numerical data even where the more potentially subjective parameters relating to quality are included (e.g. Xiao and Proverbs, 2002a; Brown and Adams, 2000).

The nature of these questions also provides the reasoning behind the decision to state a series of research questions rather than to follow the more common route of framing one or more hypotheses. For example, it may have been possible to frame Q3 as a hypothesis as follows:

“That a cost conversion index based on a fixed weight basket of materials and labour will provide more accurate and reliable cost conversions than those methods and indices currently in use.”

This hypothesis could be tested using the methods described later in this and the following chapters, however, it is not possible to either demonstrate conclusively that the hypothesis is true, nor to falsify it conclusively as it is only possible to infer from the results, based on the appropriateness and rigour of the procedures used, that the outcomes appear to be more or less “accurate and reliable”.

Indeed the nature of the questions is such that the notion of *Occam's razor* should be applied and the straightforward nature of the required research acknowledged (Runeson and Skitmore, 1999). Testing the chosen mechanism, i.e. the fixed weight basket of materials and labour, is partly about showing that the method can be successfully used in practice, in that a suitable weighted basket can be developed, the necessary data can be collected, and the data used to calculate indices that allow direct conversion of construction costs between countries. This positivist, quantitative approach is considered to be an appropriate approach for this research. The validity of the indices and thus the conversions based on them then depends on the soundness of the theory that underpins the method and the rigour with which it has been applied.

The method chosen for the exploration of Q3 and Q4 comprised a basic experiment that gathered construction cost data that is subject to normal market forces. The data was sourced from professionals in the market (construction estimators and quantity surveyors) whose input to the dataset would be expected to be both detailed and up to date, and would reflect prevailing market conditions. This is true of both simple quantitative data (e.g. the cost price of a cubic metre of readymixed concrete) and data which although quantitative would be based to some degree on the respondent's opinion (e.g. the market conditions in each respondent's location). That data and the opinion that determines it is still shaped, however, by normal market forces such as supply and demand and the building/property cycle.

4.2.1 Proposed method: Building BLOCs

The aim of this study is to use the concept of purchasing power parity to develop a method that allows direct comparisons of construction costs between different

locations. A weighted basket of materials and labour has been advanced as the most promising approach for converting costs in national currencies to a common base currency. It is proposed that the basket be referred to as a BLOC or “Basket of Locally Obtained Commodities” The BLOC is the framework used for gathering input cost data for construction work in various locations.

4.2.1.1 Multiple observations

It has been established that for several reasons it is advantageous to collect such data from a number of sources in each location. Bowen and Edwards (1985: 204) describe the use of single price rates from historical cost data in estimating as “a tactic fraught with risk”, and the same applies to data collection in this context. In the current Eurostat pricing method, for example, data is generally collected from just one source in each country and this is seen as a major shortcoming of the Eurostat CPPPs (Meikle, 2004 and 2008). The most practical method that would facilitate the collection of more cost data from each place is the incorporation of the BLOC into a questionnaire that can be used to seek responses from as many suitable sources in the target locations as is practical.

4.2.1.2 Data validation

In recent Eurostat pricing rounds data was tested through an extensive validation exercise (Thomas, 2004) and large price differences between countries for a significant number of items were identified. Respondents were asked to confirm their prices and in virtually all cases indicated that their prices were correct. Without gathering prices from more respondents in each place the Eurostat team was unable to make any judgement about the apparent discrepancies.

By using the BLOC/questionnaire approach it is anticipated that prices can be obtained from a range of different sources. Inconsistent data will then be easily identified as outliers in the datasets of unit rates for the various items in the BLOC.

4.2.2 The BLOC as a PPP tool

Pakko and Pollard (1996:5) say that the Law of One Price only leads to purchasing power parity under certain conditions. They suggest that as a PPP index is built up from a number of weighted average prices for various items then the Law of One

Price will only produce PPPs if the same items and their respective weights are the same for all locations. This means that the same single standard basket of items is used to gather prices in all locations. They go on to say that the weights of the component items are normally based on “actual consumption or production shares.” They describe this as “a *common* [original emphasis] market basket of goods.” The proposed BLOC meets all the requirements stipulated by Pakko and Pollard.¹

4.2.3 Comparative price levels

Schreyer and Koechlin (2002b:7) define comparative price levels as “the ratios of PPPs to exchange rates.” These ratios indicate the number of units of a common currency needed to buy the same volume of goods and/or services in different countries. The rates produced are termed “real” exchange rates while the typical money market rates that are used by travellers, for example, to convert money from one currency to another are “nominal” exchange rates. They are seldom the same.

Sergueev (1996) explains this as follows²:

For example, to buy in Austria a basket of goods worth of 100 ATS [Austrian shillings] one would need 100 ATS. To buy the same basket of goods in Hungary one would need, in terms of the purchasing power parity of the Hungarian currency, 415.7 Forints. However, if 100 ATS are converted into Forints at the official exchange rate³ one would get 790.7 Forints, that is almost the double of the sum needed to buy the above basket of goods. This shows that Hungary is a much cheaper country than Austria and that the Hungarian national currency is undervalued by the exchange rate as compared with its purchasing power parity.

The PPP described by Pakko and Pollard is termed “absolute PPP” as it directly compares the cost of the standard basket in local currencies. In this case a quantity of one currency can be compared to a quantity of another currency by comparing the purchasing power of each currency in its own country.

¹ For a more comprehensive discussion of these issues see Rogoff (1996), Vachris and Thomas (1999), Papell (2002), Dowrick (2002), NSI (2004).

² The exchange rates and PPPs used in Sergueev’s example are taken from OECD (1995). The paragraph is quoted *verbatim*.

³ i.e. the nominal exchange rate

4.2.3.1 Comparing the value of construction work

The aim here, in the context of construction cost comparisons, is to be able to compare the value of construction in different locations, where construction costs are initially measured in local currencies. Value is better measured in terms of purchasing power as the Sergueev example shows, as price level differences and moving exchange rates do not reflect comparative value for money. Hence if industry PPPs can be calculated that eliminate price differences in the construction industries between locations then “real” exchange rates can be determined that compare volumes of construction output without the distortions caused by price level differences. When real exchange rates, as defined above, are used to convert construction costs in one currency to another currency directly comparable costs are produced. These comparable costs are still time-specific, however, as both the nominal exchange rates and PPPs are based on market rates and costs at a particular time.

4.2.4 The BLOC as a unit of cost measurement

There is, however, an alternate approach that can be used which uses absolute purchasing power. This approach is based on the notion of opportunity cost. Langston and de Valence (1999) measured building costs in “hamburger equivalents” by dividing the cost of buildings in different countries by the local cost of a Big Mac hamburger. By calculating the opportunity cost of buildings in terms of hamburgers, they used the hamburger as a unit of construction cost. The BLOC can be used in the same way.

4.2.4.1 Example

Assume two locations, A and B, in the same country. They share the same currency and tax regime but construction costs may vary between the two locations. If a standard basket of construction goods (the BLOC) is priced in each location, and overall input costs (labour and/or materials) are cheaper in A than in B then naturally the cost of the BLOC will be less in A.

Assume two identical buildings are built in the two locations and the construction costs in both cases are the same. The cost of the building can be expressed in BLOCs by dividing the cost of the building by the cost of the BLOC in each location. As the

cost of the BLOC in A is lower than the cost of the BLOC in B, the building cost in A, expressed in BLOCs, will be higher than in B although the dollar cost is the same. Alternatively it can be said that construction price levels in B are higher than in A.

4.2.5 The BLOC as a measure of productivity

The assumption behind the use of fixed quantities of all inputs is that the buildings and the technology of construction are identical⁴. If this assumption is satisfied, it means that the PPP reflects differences in the costs of inputs only. Therefore, the BLOC will also function as a measure of relative productivity between various locations. This is best explained using the previous example.

If the buildings are identical the quantities of materials used must be identical. The variable factor is labour. If the building cost in A is represented by a greater number of BLOCs the amount of labour required in A to install the materials in the BLOC (measured in hours, not dollars) must be greater. Differences in costs expressed in the number of BLOCs required do not originate in materials that are the same in both buildings – they must be the result of more or less labour being required. In the example, given that more labour is required to install the fixed quantities of materials in the BLOC, the labour in A must be less productive.

The same logic applies even if the building cost varies between A and B, as the building cost is being measured using the BLOC as a common unit of construction cost or resources required. It applies equally where the two locations do not share the same currency as in any given location both building cost and BLOC cost are initially measured in the same local currency. Building costs per m² expressed in BLOC equivalents are directly comparable as they are expressed in the same units. As materials quantities in the BLOC are constant, fewer BLOC equivalents indicates higher labour productivity.

⁴ The assumption of identical technologies are common in economic theory, e.g. implicitly in perfect competition in micro-economic theory and explicitly in comparative advantage in international trade theory (see for instance Grubel, 1977).

4.2.6 Other variables that may affect BLOC costs

BLOC costs may vary between locations due to differences in factors other than labour productivity. Differences in preliminaries costs, contractors' markups and taxation may affect BLOC costs, however, each of these generally represents a considerably lower proportion of building costs than labour does. Similarly differences in factors such as building regulations and safety requirements may contribute to apparent productivity differences. If they do lead to different productivity levels then while this may be noted as being the result of factors that are beyond the contractors' control the lower productivity is still a reality, and it would require major differences in such practices to produce major productivity differentials.

The BLOC method deals with or negates the effects of these other influences; this is discussed in detail at 4.4.4.

As the preceding discussion shows the BLOC is a powerful tool as it not only provides a means for the production of construction specific PPPs but also identifies differences in productivity between locations.

4.3 RESEARCH PLAN

The procedure for the research from this point is outlined as follows:

1. Identification of the items of materials and labour that make up the basket or BLOC
2. Determination of the relative weights of the items in the basket
3. Formatting of the basket into a questionnaire and development of additional questions to gather supporting information for the basic cost data
4. Selection of a small number of items from the BLOC for use in a pilot study
5. Circulation of the pilot survey to selected companies in a small number of locations
6. Refinement of the main questionnaire as necessary based on experience gained from the pilot study

7. Circulation of the questionnaire to suitable potential respondents in the construction industry in a variety of locations
8. Validation of the responses
9. Adjustment of the cost data, if necessary, to normalise data in respect of factors such as differing taxation in the various locations
10. Calculation of the average cost of the BLOC in each location
11. Derivation of CPPPs for all target locations based on mean and median costs
12. Validating the method by comparison of BLOC-based CPPPs with other available conversion factors such as general PPPs.

4.3.1 The concept

The idea of a standard commodity, and the notion that such a commodity may be comprised of a number of components rather than being a homogeneous or coherent product (illustrated by previous uses of hamburgers and litres of petrol as measures of buying power), has been discussed previously. In this study the standard commodity is represented by a basket of construction materials (and in some cases fabricated components) and several classes of labour, referred to herein as the BLOC.

Previous attempts at implementing a BOG approach were based on *ad hoc* lists of items with quantities (volumes) for each item based on input/output tables (Meikle, 2003b) or more or less random estimates (Stapel, 2002). Equally these previous attempts were based on averages of all construction across entire countries. For these reasons the outcomes can only be treated, at best, as being broadly indicative of comparative costs; the method described here represents a superior example of the BOG approach as the items included in the basket have been identified through rigorous analysis of a completed project. The most cost-significant items in the project were identified⁵, those items were weighted according to the proportion of the total project cost that they represent and the amount and type of labour derived to reflect the quantity and type of materials included in the basket. Details of the

⁵ Numerous studies have explored the idea that a relatively small number of items in BQs represent the majority of the total cost; typically around 80% of the cost is in 20% of the items (e.g. Harmer, 1983; Saket *et al.*, 1986; Horner and Zakieh, 1996).

methods used to populate the basket and derive quantities (weights) are described below and in Appendix A1.

4.3.2 Deriving the BLOC

In order to test the proposed method a single building type of a defined standard (3-4 star hotel) was selected, a basket of materials and labour was assembled and prices were collected from three major Australian cities⁶ and three major international cities⁷.

Hotels of medium to high standard are generally similar in terms of size, layout and finish regardless of location, with hotels that belong to international chains such as Marriott, Hilton and Sofitel displaying very similar characteristics wherever they are located. This is particularly true if the properties are located in major cities in developed countries. Medium standard hotels were selected for this study as a building type that could be easily identified and described, and that respondents in the various locations could easily recognise based on their own experience even though there is no internationally agreed rating system for hotels⁸. Pricing rounds were conducted only in major cities in developed countries, where such buildings are common.

It should be noted, however, that the standard of the hotel has little bearing on many of the items in the BLOC. The price of common materials such as concrete and reinforcing steel will not vary as a result of the star rating of the finished hotel. For items for which prices may vary as a result of the standard of the hotel, such as joinery units and sanitary ware, written descriptions were accompanied by detail drawings of typical units to facilitate consistent pricing.

⁶ Sydney, Melbourne, Brisbane

⁷ Auckland, Singapore, Phoenix

⁸ Star ratings, for example, vary from place to place, however, hotel properties that are part of well-known international chains such as Marriott reflect company standards.

4.3.3 BLOC method

Bills of quantities for two suitable completed hotel projects in Australia were obtained from the consultant quantity surveying firms that handled the projects. These bills (BQs) had been priced by the contracting firms that had constructed the building as part of their contractual obligations. One of these, a 4.5 star, 196 room hotel located in the inner suburbs of Sydney and completed in 2003, was used as the base or reference project for analysis (Project A) while the second (Project B, a similar project located in Perth) was used for comparative purposes and to provide greater detail for analysis of the costs of engineering services as sufficiently detailed pricing for those elements was not available for the Sydney project.

Analysis of the priced BQ comprised several steps:

- Adjustment of the total project cost to remove the cost of those sections of the works that were site/project specific and were therefore considered not to be representative of typical hotel projects, e.g. substructure, landscaping, demolition.
- Identification of the trades that contributed most to the adjusted total project cost, and then identification of the most cost significant items within those trades.
- Decomposition of unit rates for the cost significant items to identify labour and materials components using published estimating data (Cordell, 2007).
- Calculation of the cost share of each material as a percentage of the adjusted total project cost (excluding GST).
- Identification of individual materials items that were considered representative of all the materials in a particular trade.
- Determination of quantities (volumes) of each representative material based on the cost shares calculated previously.
- Calculation of labour times for different classes of labour required for the installation/placement of the calculated quantities of the selected materials.

The outcome of this process was a basket of inputs (materials and labour) with the volume of each component reflecting the cost share of that component relative to the adjusted total project cost. Examples of the weighting process are described below.

4.3.4 Adjusting the total project cost

The contract sum in the priced BQ for Project A was \$23,782,668 (AUD⁹) which included *Preliminaries* as a separate line item (\$3,096,194) and 10% Goods and Services Tax (GST). A separate *Early Works* contract covered excavation and substructure so no adjustment was required in respect of that part of the project, however, *Siteworks*, *Demolition* and *Landscaping* were deducted as these vary according to the size and nature of each site and the associated costs are not part of the actual building costs (Stapel, 2002:5; Sinclair *et al.*, 2002:26). *Preliminaries* were also deducted as preliminaries costs are to some extent location specific – in Sydney, for example, preliminaries costs are substantially higher in the centre of Sydney’s CBD than they are in suburban locations (Rawlinsons, 2007a). The initial adjusted project cost was \$19,792,779. This was further adjusted by deducting the GST¹⁰, giving a final adjusted project cost (APC) of \$17,993,435.

4.3.5 Identifying and weighting items in the basket

Analysis of the priced BQ for Project A identified the most cost significant trades and analysis of those trades allowed identification of the most cost significant items within those trades. Complete details of the BQ analysis and the attendant calculations are contained in Appendix A1.

4.3.6 Materials

Formwork will be used here to demonstrate the identification and weighting process used.

⁹ Note that all costs in the following section are in AUD unless noted otherwise.

¹⁰ GST was deducted only to facilitate calculations; item prices are typically quoted excluding GST and calculations were carried out in a consistent manner by excluding GST. The same weights would have been produced if all rates and prices had been stated including GST. All rates in the following calculations are excluding GST.

4.3.6.1 Formwork

In the priced BQ the total cost (excluding GST) for formwork was \$915,875, or 5.1% of the APC, making it the sixth most costly trade in the BQ. While various classes of formwork were specified the most common was Class 3, with items relating to Class 3 formwork totalling \$812,942, or 88.7% of the total formwork cost. Of the items for Class 3 formwork it was assumed that formply would be the primary material used in forms to slab soffits, columns, stair landings and soffits, attached beams and walls. Indicative labour/materials splits were obtained from published data (Cordell¹¹, 2007) for each type of formwork and the number of re-uses of formply estimated for each situation. Unit rates for major items such as formwork to slab soffits were decomposed using the labour/materials splits; materials costs were then extracted in respect of the different locations and the different estimates of re-use.

The total cost in the BQ for Class 3 formwork to slab soffits was \$361,054. Published unit rates (Cordell, 2007) were used to ascertain not only labour/material splits but to estimate actual costs of materials within those published rates as follows:

- The published rate for soffit formwork (\$68/m²) includes \$55/m² labour and \$13/m² for materials (both excluding GST) – this must include bearers, sole plates, nails and the like. The cost of formply was estimated to be \$8/m² – the small component for falsework and consumables reflects the potential for many re-uses of timber bearers and the like, and the relatively small contribution of consumables (nails, form oil) to formwork costs. The purchase cost of formply (Cordell, 2007) is 24.98/m², suggesting three uses of formply in this situation. Therefore the cost of formply is derived by multiplying the total for soffit formwork (\$361,054) by the estimated rate for formply (\$8/m²) divided by the unit rate for soffit formwork (\$68):

¹¹ All references to Cordell throughout this thesis unless noted otherwise relate to the online construction cost services provided by Reed Construction Data. Access to these online services was granted for the purposes of this research. The online data was accessed over the period November 2007 to May 2008. Due to the nature of the online data there are no page references given. Historical data from Cordell (e.g. Cordell 2003) were obtained from library resources in hard copy.

$$\$361,054 \times \frac{8}{68} = \$42,477 \text{ (total cost of formply for soffits)}$$

- The process was repeated using appropriate materials/labour splits for the other Class 3 formwork items such as columns, sides and soffits of beams and stair soffits, with the total estimated cost of formply for Class 3 formwork being \$89,477 (excluding GST).
- This was then calculated as a fraction of the APC:

$$\frac{89477}{17993435} = 0.004972, \text{ or } 0.4972\%.$$

4.3.6.2 Other materials

A similar process was used for the other items that had been identified as the most cost significant materials in the project. Given the level of approximation in the calculations percentages were rounded up to two decimal places.

In each case one item was selected and assumed to represent all similar items in the BQ, e.g. in the masonry trade concrete blocks were identified as the most cost significant item. From the BQ analysis it was determined that \$117,638 (out of a trade total of \$229,759) was in “hollow block” items. Published data (Cordell, 2007) suggests a labour/materials ratio of 64:36 for hollow blockwork so block supply cost was calculated as $0.36 \times \$117,638 = \$42,350$, or 0.24% of the APC. From the BQ 140 hollow blocks were determined as the most commonly occurring type of block and these were then assumed to represent blocks of all types, i.e. 140 blocks then became the material item representing the masonry trade, and thus the masonry item included in the basket.

4.3.6.3 Deriving materials quantities

To derive quantities for each material item in the basket the total cost (supply only) for each item was divided by the 2003¹² unit supply cost for each item (Cordell, 2003). These quantities set the scale of the quantities for the materials in the basket, based on the size of the original project that was analysed. It is suggested that the derived quantities indicate only the scale of the quantities of the particular type of

¹² The year that the reference project went out to tender.

material in the sample project, e.g. 140 hollow blocks as the material representing all blocks in the project. The scale of the quantities provides context (in terms of project size) for pricing. In the study by Meikle (2003b), respondents were asked to provide prices for small, medium and large quantities for each item, however, this approach did not produce the desired results perhaps (at least in part) because it increased the amount of time and effort required to price the basket. With the aim here being to find a basket that is representative of a project of a particular type and size it is sufficient to give quantities that are indicative of scale of the “typical” project. By having a single quantity providing a pricing context the time to complete the survey is kept to a minimum.

4.3.7 Labour

It is difficult to ascertain accurate ratios for different classes of labour in respect of individual BQ items or of trades in general. Meikle (2003b) in his trial BOG used a split of 10:30:30:30 for supervision, skilled, semi-skilled and unskilled labour, but this was largely notional, based on his experience and knowledge of the industry. In this study supervision is assumed to be included in *Preliminaries* and labour splits were estimated based on published data where available and on this author’s 20+ years of experience.

In Sydney site labour may be divided into various classes based on pay levels: tradesmen (in several broad classes with Class 1 including electricians and plumbers, Class 2 including carpenters and joiners, and Class 3 painters, plasterers, tilers and masons), semi-skilled labour (e.g. concrete placers) and unskilled (general) labour. Labour required for installation of the material items in the basket was identified (e.g. carpet laying was assumed to be 100% Class 3 tradesman, block laying as 80% Class 3 tradesman and 20% semi-skilled labourer- a complete breakdown is contained in Appendix A2) and weights calculated based on the relative weights of labour and materials for each item. For example, as noted earlier, for hollow blocks the labour/materials split is 64:36 and the derived supply cost \$42,350. The labour cost associated with that quantity of blocks is then:

$$\frac{\$42,350 \times 0.64}{1 - 0.64} = \$75,289$$

and of that amount 80% (\$60,231) is for tradesmen and 20% (\$15,058) is semi-skilled or unskilled labour¹³.

A similar method was used for each item in the basket and a total labour cost as well as a separate figure for each relevant class of labour was calculated. Using published hourly labour rates for 2003 (Cordell, 2003) the total number of hours of each class of labour required for the installation of given quantities of the various materials in the basket was then determined.

Given that the labour ratios are to some extent notional and that there may be differing divisions of labour in different locations, and to minimise the effort required for pricing, four classes of labour were used for this study: three categories of skilled tradesmen, and semi-skilled labour.

In the pricing instructions included with the basket the labour types were explained with “Tradesman Group 1” identified as electricians and plumbers, “Tradesman Group 2” identified as, for example, blocklayers and carpenters, “Tradesman Group 3” as, for example, tilers and carpet layers, and “semi-skilled labour” such as steel fixers. All labour was calculated to represent 46% of the basket, with tradesman hours representing 80% and semi-skilled labour 20% of the cost of the total basket.

Two price gathering surveys were conducted: a pilot study (described below) and a larger survey (described and analysed in Chapters 5 and 6). In the first survey (the pilot study) input prices for a reduced basket of materials and labour were gathered

¹³ It should be noted that the 80:20 skilled:semi-skilled labour split is an approximation and is based on cost rather than on time. As pay rates for the different classes of labour vary if the split were based on time the cost split would be different; the degree of difference would then depend on the difference in pay levels. Survey results and Cordell both suggest there is only a small difference between the rates paid for Class 3 tradesmen and semi-skilled labour, hence the difference between a time-based split and a cost-based split would be minimal. This assumption was subsequently supported by results obtained from the BLOC survey.

from a small number of people in three cities¹⁴. For the large exercise a pricing survey (see Appendix A5) and some explanatory notes that provided directions on how the pricing was to be done (e.g. excluding/including VAT/GST) were distributed to a number of quantity surveying and contracting firms in six cities; Sydney, Brisbane, Melbourne, Auckland, Phoenix and Singapore in February 2008. The survey and the results obtained are presented and discussed in Chapters 5 and 6.

4.4 ADJUSTING FOR LOCAL FACTORS

Construction price levels are affected by a range of factors, some that are project specific and others that are more pervasive up to the level of those, such as regulatory frameworks, that may impact at regional or national level. The BOG approach, by its nature, negates many of the factors that could affect cost conversions at the level of individual projects as well as at sectoral and national levels. Langston and de Valence (1999) identify sixteen separate contextual factors that they consider need to be addressed in comparisons between countries. Of those the following do not appear to directly affect input costs for the items in the BLOC:

1. Site location
2. Site conditions
3. Climatic variations
4. Corruption
5. Industry maturity
6. Innovation
7. Labour productivity
8. Environmental considerations
9. Site safety
10. Industrial disputes
11. Research and development

¹⁴ The pilot study is described in detail below starting at 4.5.

While they may not directly affect input costs some may affect the relative weights of items in the BLOC, for example, more stringent environmental regulations will lead to higher total labour costs as site staff must spend paid time dealing with such issues. This additional cost will be reflected in total project costs against which cost significant items are compared in order to determine expenditure shares for various materials. This effect is, however, only minor as most of these factors will have virtually no effect on the cost of the BLOC in any location. This can be illustrated by considering factors such as industrial disputes and site conditions. The other five factors identified by Langston and de Valence¹⁵ require further discussion (see 4.4.3 to 4.4.8).

4.4.1 Industrial disputes

If the likelihood of project disruption due to industrial action is high prices will rise as tenderers add contingencies for potential time lost due to strike action. While this will push overall project prices up the only effect that this may have on the cost of the BLOC will be indirectly through the influence of increased total cost on the weighting of individual items in the basket. In the method described above for the derivation of the BLOC and the weighting of its components labour inputs are determined on the basis of published labour constants and labour/materials ratios for specific items of work. These constants and ratios will be unaffected by increased overall labour costs that are due to either lost time or to additional payments made to appease trade unions except possibly for some minor impact on weightings. Walsh (2008, pers. comm.) suggests that in the BOCC exercise small differences in weightings have had little impact on results hence minor differences in weights in the BLOC are unlikely to be significant.

4.4.2 Site conditions

Site conditions can have significant effects on project costs due to factors such as the need for piling on sites where ground conditions are poor. This factor has been eliminated in the BLOC process as in the BQ analysis from which the BLOC was derived site specific costs (preliminaries and all substructure costs) were deducted from the total project cost and thus have no effect on the weights in the basket.

¹⁵ Regulatory standards, government controls, imported resources, market conditions, taxation.

4.4.3 Regulatory standards

Differences in building codes can have considerable impacts on project costs and would be expected to have some influence on the BLOC approach. For example, differing requirements for fire resistant construction will affect the type of materials used in particular situations, the relative quantities of certain materials (e.g. fire rated drywall materials versus non-fire rated) and so on. In an aggregated basket of items, however, it is unlikely that these differences will be of any real consequence. Determination of the extent of any such effects is beyond the scope of this study and it is assumed here that this factor can be disregarded

4.4.4 Government controls

Similar arguments apply to the question of government intervention through incentive schemes, benchmarking and the like. While, for example, the introduction of government schemes aimed at fostering improved productivity may, if successful, alter labour/materials balances as less labour is required to install more materials, once again this will have only minor effects on the weightings in the BLOC and have minimal effect on input costs.

4.4.5 Imported resources

The BLOC was defined earlier as a “Basket of Locally Obtained Commodities”, however, in practice it is difficult to compile a basket that truly comprises only locally manufactured or produced goods and “locally obtained” does not mean “manufactured” or “produced” locally. Locally produced materials include items such as ready-mixed concrete – in Singapore, for example, the components of concrete are largely imported e.g. sand and aggregate from Indonesia, cement from Japan (Tan, 2008)) but it is included as a locally obtained material. If commonly used materials, such as cement, are imported and the transaction costs (transport, insurance, excise *et al.*) increase the local cost of that item then this is part of the overall cost of construction. This is particularly so in this study as the aim is not to identify reasons for cost differences, but merely to develop a conversion mechanism.

As noted earlier even construction site labour in some places is not locally sourced, and it is generally recognised that much specialised machinery and equipment, for

example, are sourced from relatively few countries, typically the US, Japan and various EU countries.

4.4.6 Market conditions (building cycle)

Purchasing power parities are snapshots of price relativities between locations at a specific point in time. It is acknowledged that construction prices (shown in the levels of tender prices) do vary according to market conditions and therefore prices gathered in different locations at the same time are likely to be higher in markets where work is plentiful and lower in places where the market is quieter. This raises the question of whether it is appropriate to normalise cost data from different locations by deflating or inflating costs to bring them to some “average” level.

In some earlier studies respondents were asked to provide “normal” prices for building work, e.g. Page Kirkland (1999). In that study a standard projects approach was used to gather costs for seven different types of building project. Respondents were asked to provide costs that did not reflect unusual market conditions such as the impending Sydney Olympic Games. Hence there was some implied correction for apparent market distortions due to tendering/competition conditions that were acknowledged to be affecting prices at the time that that study was undertaken.

In Eurostat/ICP pricing rounds respondents are asked for national average prices, however, it is assumed that this direction is intended to negate regional price differences that may exist within individual countries. If the cost data collected are actually average costs, in terms of both market conditions and location within countries, then no further adjustment would be needed. It is, however, impossible to assess how diligent those supplying the data in the Eurostat exercises are in determining “average” costs.

As data is gathered from only a small number of sources in each country (typically only one) any discrepancies in the method of pricing used by a respondent may distort the PPPs that emerge. If prices are collected from multiple respondents in each place then the chances of gathering prices that are representative of average prices in each location are improved (Stapel, 2002:7).

4.4.7 The validity of adjustment for market conditions

Whether any adjustment should be made for variations in prices due to prevailing market conditions is a fundamental question. Langston and de Valence (1999:86) suggest that “the need to adjust prices according to overall economic performance is reflected in purchasing power parity calculations, and therefore it is important that estimated costs are not adjusted using some other index to account for building cycle position” but go on to say that the current state of the industry (in terms of where the industry in each location is on the building cycle) is an important factor if fair comparisons are to be made.

At a conceptual level it is debatable whether it is correct to make any adjustment to the cost/price data. If the aim is to compare price levels between locations at a specific time then it is arguable that market conditions and any consequent price fluctuations are simply one of the many diverse factors that determine construction costs in each place. It would, therefore, be no more appropriate to adjust costs for market conditions than it would be to adjust for factors such as different supply prices for materials due to different transport costs as both are just part of the set of factors that determine costs in any location at any given time.

It is a different matter if the aim is to establish some deeper, more fundamental cost relativities between locations. It is one thing to say that at a particular time construction work in one location (in terms of value gained by converting resources into construction output) is more expensive than it is in another, however, that price difference may be the result of variations in market conditions that reflect any number of possible causes. This may occur in research that is intended to determine if industry performance in one location is superior to that in another and then to identify the underlying reasons for the better performance. In that case it is imperative to normalise data as much as possible so that causative factors can be isolated and their effect on performance assessed with some confidence.

The aim of this study is to develop a mechanism for deriving CPPPs at a particular time, and to compare those CPPPs against other indices that are also based on conditions at specified times and it is therefore appropriate to make no allowance or

adjustment for prevailing market conditions in this context. It is appropriate, however, as part of this discussion to make, in some instances, some adjustments in order to ascertain whether the “snapshot” cost relationships are representative of more fundamental relationships or instead are the result of current conditions that may alter relativities significantly in the future (see Chapter 6 for market adjusted comparisons).

4.4.8 Taxation

In some instances it may be appropriate to adjust data to correct for different scales and patterns of taxation; for example, industry performance comparisons may be distorted if it is perceived that the industry in one place is less efficient than that in another place because of higher costs, yet the cost difference may only be a result of higher taxes. If any adjustment were to be made it would require the identification of all taxes that are embedded in the cost of any product and this will not always be easy. For example, prior to the introduction of a goods and services tax (GST) in Australia in 2000, different building materials and components were subject to various levels of sales tax all of which were replaced by a flat rate GST. In addition employers with payrolls above a threshold were obliged to pay payroll tax (this is still the case). While it may be easy to deduct GST from materials and labour costs it is difficult to account for all tax impacts (e.g. not all firms in the industry pay payroll tax). In other places different taxes apply: in the US there are varying state and federal taxes but no equivalent to Australia’s GST.

As in the case of adjustments for market conditions any attempt to address the taxation question would represent a further stage in this research. It would require a separate study to trace taxation trails through supply chains under varying taxation regimes in the different locations. Such an investigation is beyond the scope of this study, and for the purposes of this exercise BLOC costs have been calculated both including and excluding GST/VAT in order to test the sensitivity of the resultant CPPPs to the effects of such taxes (see 6.3.4).

4.4.9 Quality

The final concern relates to differences in quality that may influence any comparative study. Quality in construction may be considered in a number of ways

including code compliance, level of specification, recognised market standards (such as agreed standards of office space or star ratings for hotels) and standards of workmanship.

4.4.9.1 Code compliance

Compliance with codes and regulations is assumed, however, compliance indicates only the achievement of an acceptable minimum standard of design and construction. Level of specification may include design decisions such as the inclusion of double glazing, larger hotel rooms, more expensive finishes, the inclusion of atria and many more. These may or may not be linked to some market standard (e.g. type A, B and C offices in the UK). Level of specification may also include the provision of services and amenities in a building.

Code compliance is not an influencing factor in a basket of goods approach, and level of specification and relevant market standards have been addressed in this study by the limiting of the study to a particular building type of a recognisable standard. The basket includes materials items with specified and measurable characteristics (e.g. concrete of a certain strength or a specific type of steel reinforcement), or provides a context that defines a typical standard of specification (i.e. materials, such as tile and carpet, that are characteristic of a hotel of 3 to 4 star rating. In other cases details in the form of detailed drawings were provided to indicate clearly the type and quality of the item (e.g. timber joinery).

4.4.9.2 Workmanship, defects and rework

Of greater concern is the aspect of quality that pertains to standards of workmanship and general “finish” that any building displays. Flanagan *et al.* (1986: 4) suggest that quality is gauged subjectively and that “there is no recognised method of quality assessment.” Subsequently there have been various methods proposed and tested that represent attempts to assess quality in a variety of ways.

McKim *et al.* (2000) identify three quantifiable measures of quality performance;

- Estimated cost of rework and repairs
- Number of requests for rework and repairs

- Incidence of user complaints related to noise, dust, smoke and similar nuisances occasioned by building work¹⁶.

Brown and Adams (2000) measured “delivered quality” in individual projects numerically; they defined it as follows:

$$QE = \frac{1.0}{1.0 + d}$$

where QE is “delivered quality” and d is the number of defects in a given project at handover.

Xiao and Proverbs (2002a) attempted to assess quality in the context of contractor performance by asking questions that would measure quality in a hypothetical project (based on previous similar projects) in terms of anticipated or estimated number of defects and number of times called out for rectification work during defects liability periods. They also tried to establish some measure of the quality culture among contractors in their target countries, based on indicators such as the length of defects liability periods, employment of total quality management systems and the achievement of quality assurance certification.

4.4.9.3 Grading quality

Rittenau (2002) describes a system of quality adjustment indices or multipliers developed as part of the Eurostat PPP method. Experts involved in the construction segment of the Eurostat comparison program made visits to various construction sites in Vienna to gain an understanding of Austrian quality standards. Adjustment factors were then derived which allowed the national experts to assess quality levels in their own countries using the Austrian standards as a benchmark. While such a method must be subjective to some degree it does represent a real attempt to make allowance for identifiable quality differences between countries in comparative studies.

¹⁶ The study was focused on refurbishment and renovation projects and this was a legitimate concern in such projects, however, these factors are unlikely to be relevant in most newbuild projects.

4.4.9.4 *Quality in the BLOC method*

The BLOC approach may go some way towards eliminating the quality problems inherent in other methods, i.e. that quality of installed work may vary considerably from project to project and from location to location. Such variations cannot be accounted for in any satisfactory way and cheaper construction, for example, may simply reflect lower quality rather than any true price differential. By using primary material and labour costs the quality problem is at least reduced as basic standards of materials, clearly specified, such as concrete, plywood, concrete blocks and so on should not vary greatly, particularly between developed countries. Similarly labour rates should not be too much affected: a skilled tradesman (such as an electrician) would have similar skills in different locations if they are capable of doing work of an acceptable standard in projects typical of the type chosen as the basis for the BLOC. As hotels cater for international visitors and many have international operators as tenants or owners standards of construction, particularly in services and finishes, will be expected to meet appropriate standards in any location.

Contractors' margins and labour rates must be assumed to include allowances for the cost of rework and defect rectification; if not the contractors would fail to make a profit and would eventually go out of business. That being the case differences in factors such as the relative cost of rework and number of calls for repair or rectification work (as measured by Xiao and Proverbs for example) must be embedded in the costs collected using the BLOC and therefore such differences are indirectly accounted for.

As the identification and weighting of items in the BLOC, and the corresponding quantities of labour, are based on the analysis of an Australian project Australian quality standards are inherent in the BLOC itself. It could be argued that as the same BLOC is assumed to be representative of hotel construction in each target location that potential quality differences are nullified because the BLOC reflects Australian standards. This may be true to some extent but the problem is a great deal more complex. Even if separate BLOCs were derived for different locations, with each apparently reflecting quality standards typical of their location, this would not and could not account for differences such as the performance of skilled experienced

tradesmen compared to tradesmen of less skill and/or experience. For example, a well-trained and experienced electrician may wire and mount an electrical outlet more securely, safely and precisely than a lesser tradesman yet take less time to do it due to their higher levels of skill and experience. Such differences cannot be measured by the BLOC method, and if such differences were considered to be sufficiently important then some other method of adjustment for such differences, perhaps along the lines of the Eurostat method described above, would be required. The derivation and development of such a method would require considerable research and is well beyond the scope of this study and consequently no further attempt to adjust for perceived quality differences has been made.

4.5 PILOT STUDY

Prior to issuing the final survey with the complete building BLOC a reduced scale BLOC was produced using the methods described above. This pilot study, comprising six of the material items and two classes of labour, was sent to a number of quantity surveying firms and contracting firms in three cities: Sydney, Auckland and Singapore. The items were largely the same as the corresponding items in the final BLOC although further refinement of the methods used to determine the quantities attached to the various items resulted in some small variations in some of the materials quantities and an increase in the number of classes of labour.

There were several reasons for running this preliminary exercise:

- It established contact with individuals in the various companies who were best placed to complete the main survey
- By making direct contact with the most appropriate people and gaining their support through a very short survey (the pilot survey took only 5-10 minutes for an experienced person to complete) it was anticipated that when the main survey was issued these people would be more willing to complete it, particularly as around a quarter of the items and most of the supporting questions had already been priced or answered.

- It provided an opportunity to assess whether an appropriate level of detail had been provided so that respondents could price with some consistency.
- It tested the wording of the questions to ensure that they were clear and unambiguous and that the respondents could provide the data that was required; of particular concern were the questions related to market adjustments and contractors' markups.
- Running a study that was similar to the main study but on a reduced scale provided an opportunity to compare results and so gain some understanding of whether and how the number of items in the basket affected cost conversions made using the two baskets. It has long been acknowledged that the Pareto relationship is generally applicable to construction costs with a relatively small number of items contributing to the bulk of the cost of a project. The mini BLOC, based on 2003 costs, represents around 10% of the adjusted project cost while the full BLOC represents just over 25%.

4.6 COMPILING THE PILOT STUDY

The pilot study was based on six common materials selected on an *ad hoc* basis from the BLOC, and two categories of labour that covered the majority of work associated with the installation of the six materials. The six materials items and the proportions of the APC that they represent are:

1. 17 thick formply (0.50%)
2. 32MPa ready mixed concrete (delivered) (1.77%)
3. Acrylic paint (0.18%)
4. Precast concrete panels (0.73%)
5. 140 hollow concrete blocks (0.24%)
6. Carpet, 80/20 wool blend (1.10%)

Total supply costs for the six materials were calculated through analysis of the priced BQ and these were divided by published 2003 unit costs (Cordell 2003) to derive quantities of each item for inclusion in the basket. Analysis of labour/materials/plant splits for the six items (Cordell, 2007) provided basic labour to materials ratios for

the selected items. As the fraction of the total that is plant cost in the selected items is relatively small and major plant is presumed to be included in preliminaries (tower crane and concrete pumps for example) the plant component was ignored and simple labour/materials ratios adopted.

4.6.1 Materials weights

Weightings were adjusted to represent fractions of the material cost in the basket, e.g.

Formply: $\frac{0.4972}{4.5132} = 0.11$, i.e. formply represents 0.11 (11%) of the cost of the mini basket (where 4.5132 is the sum of the weights for the six material items in the basket). If materials in total represent 43 % of the basket then formply will represent $0.11 \times 43\% = 4.73\%$ of the total mini basket.

Similar calculations yield the following weights:

1. Concrete: 17.18%
2. Paint: 1.70%
3. Precast concrete: 7.09%
4. Hollow blocks: 2.28%
5. Carpet 10.67%

4.6.2 Materials quantities

Quantities of each item in the basket were calculated as follows:

The total supply cost for each selected item in the BQ was calculated as previously described. Dividing this by the 2003 supply cost for each item (Cordell, 2003) gave a derived quantity for each item. These quantities set the scale of the quantities for the materials in the basket, based on the size of the original project that was analysed. It is not suggested that the derived quantities are the actual quantities of these items in the sample project but rather that they indicate the scale of the quantities of the particular type of material in the sample project. For example, the quantity of 140 hollow blocks in the basket represents all blocks in the project. The scale of the quantities provides context (in terms of project size) for pricing while the actual quantities are used to compute the cost of each BLOC.

4.6.3 Labour weights

It is difficult to ascertain accurate ratios for different classes of labour in respect of individual BQ items or of trades in general. Meikle (2003) in his trial BOG used a split of 10:30:30:30 for supervision, skilled, semi-skilled and unskilled labour, but this was largely notional, based on his experience and knowledge of the industry. In this study supervision is assumed to be included in preliminaries (Dubner, 2007) and labour splits were estimated based on published data (Cordell, 2007).

In Sydney site labour may be divided into various classes based on pay levels: tradesmen (in several broad classes with Class 1 including electricians and plumbers, Class 2 including carpenters and joiners, and Class 3 painters, plasterers, tilers and masons) semi-skilled labour (e.g. concrete placers) and unskilled (general labourer). Labour required for installation of the six material items in the basket was identified (e.g. carpet laying was assumed to be 100% Class 3 tradesman, block laying as 80% Class 3 tradesman and 20% semi-skilled) and weights calculated based on the relative weights of labour and materials for each item¹⁷.

4.6.4 Assembling the basket

Table 4.1 shows the calculations for quantities of materials for the mini basket. Tables 4.2 and 4.3 show the derivation of labour quantities. Given that the labour ratios are to some extent notional and that there are likely to be differing divisions of labour in different locations, and to minimise the effort required for pricing, just two classes of labour were used for this pilot study, skilled tradesman and semi-skilled labour. In the pricing instructions included with the basket the labour types were explained with “tradesman” being identified as, for example, blocklayers and painters, and “semi-skilled” as, for example, concrete placers and precast fixers. All labour was calculated to represent 57% of the basket, with tradesman hours representing 25.81% and semi-skilled labour 31.57% of the total basket. Total costs for each class of labour were divided by 2003 hourly rates (Cordell, 2003) to derive the number of hours of each type of labour associated with all the materials items in

¹⁷ This process for concrete blocks is described at 4.3.7.

the basket. Using the procedures outlined above the mini basket or BLOC was derived (Table 4.4) with quantities rounded.

4.6.5 Using the mini BLOC to collect cost data

A short survey and some explanatory notes (see Appendix A5) that provided directions on how the pricing was to be done (e.g. excluding/including VAT/GST) was distributed with the list of materials and labour to a number of quantity surveying and contracting firms in three cities; Sydney, Auckland and Singapore.

Item	Material cost in BQ (2003\$,ex GST)	Generic material as % of APC	Material cost as % of BLOC	Unit rate (2003\$)	Unit	Derived quantity
Hollow blocks	42350	0.24%	5.40%	1.79	No	23659
Paint	31595	0.18%	4.03%	8.00	L	3949
32MPa concrete	318894	1.77%	40.66%	175.00	m3	1822
Precast concrete	131659	0.73%	16.79%	75.00	m2	1755
Carpet	170318	0.95%	21.72%	40.00	m2	4258
Plywood for formwork	<u>89477</u>	<u>0.50%</u>	<u>11.41%</u>	25.97	m2	3445
Totals	784294	4.36%	100%			

Table 4.1 Mini BLOC - calculation of materials quantities

ITEM	Labour cost (2003\$)	Derived labour %	Tradesman \$	Semi-skilled \$
Hollow blocks	75289	64%	60231	15058
Paint	94786	75%	94786	
32MPa concrete	124014	28%		124014
Precast concrete	374722	74%		374722
Carpet	50874	23%	50874	
Plywood for formwork	<u>336605</u>	79%	<u>269284</u>	<u>67321</u>
Totals	1056291		475175	581115

Table 4.2 Mini BLOC – calculation of labour costs

LABOUR	Labour cost (2003\$)	Unit rate (2003\$)	Derived quantity	Unit
Tradesman	475175	48.00	9899	hrs
Semi-skilled	581115	37.50	15496	hrs

Table 4.3. Calculation of labour quantities for the pilot study

MATERIALS	Unit	Quantity
140 blocks	No.	24000
Acrylic paint	L	4000
32MPa concrete	m3	1800
Precast concrete	m2	1750
80/20 carpet	m2	3800
17 formply	m2	3400
LABOUR		
Tradesman	hours	9900
Semi-skilled	hours	15500

Table 4.4 Mini basket of goods (mini BLOC) – rounded quantities

4.6.6 Data normalisation issues

As part of the pilot study respondents were asked two questions that were intended to provide the necessary information for costs to be adjusted in response to prevailing market conditions in each city in the event such adjustment was deemed appropriate.

In the first instance, respondents were asked to indicate where current tender price levels in their location were on a five point scale from Low to High, and to estimate percentage factors that could be applied to current materials and labour rates inserted in the survey to bring them to average prices. Several key points emerged from this process. In two cities, Auckland and Sydney, opinions of market conditions varied considerably, with responses spread across four of the five possible points on the scale; in contrast the respondents from Singapore all agreed that the market was strong and tender prices were high. The full results are shown in Table 4.5.

City	Low	Low - medium	Medium	Medium-high	High
Sydney	0	1	3	3	1
Auckland	0	3	1	1	1
Singapore	0	0	0	0	6

Table 4.5 Frequency of opinions of market conditions obtained from pilot study

Apart from the lack of consistency in the responses to the first question it proved difficult to frame the second question in such a way that it could not be misinterpreted and would elicit coherent and consistent answers. In response to the question as it was first worded several respondents indicated that tender price levels

in their location were medium-high to high yet suggested that the rates they had supplied should be inflated to bring them to average levels, while others provided forecasts of possible price movements in periods of up to a year into the future. These responses clearly indicated that the question was not sufficiently clear. Some respondents queried the question and did not provide an answer or indicated that they could not provide a single figure that would be suitable in all cases.

In an attempt to clarify these issues more information was sought directly (by e-mail) from selected respondents in each city. There was general agreement among those individuals that while labour prices will vary according to market conditions materials prices will seldom be affected to the same extent, and in most cases differing tender price levels are more the result of variations in contractors' margins than variations in input costs.

In consultation with one of the respondents the question relating to percentage adjustment factors was redrafted to clarify the intent of the question and elicit appropriate responses. The question was further refined in order to give respondents the opportunity to provide separate factors for materials and labour. The revised question was circulated to the respondents and some more consistency in the responses was evident. Some respondents, however, still seemed unsure of the intent of the question and the wording was further revised for the main study.

4.7 RESULTS FROM THE PILOT STUDY

In total twenty responses to the pilot survey (10 from quantity surveyors and 10 from contractors) were collected: eight from Sydney (three QS, five contractors), six from Auckland (three QS, three contractors) and six from Singapore (four QS, two contractors). While the sample is small it provided useful insights into the process and highlighted the need to distribute the main survey widely in the industry in order to gather a useful sample of prices as eliciting responses from firms for even the small survey that was used in this exercise was very difficult, even when the average time to complete the survey was just 17 minutes.

The mean rate for each material and labour item was calculated for each location. These unit rates were applied to the rounded derived quantities in the basket to produce a total cost for the basket in each local currency. From these basket costs CPPPs were derived relative to one AUD. Table 4.6 shows the basket costs, and Table 4.7 the CPPPs based on the whole basket and on the materials component only, with and without the addition of the mean estimated contractors' margins. It also shows a range of other possible conversion factors.

Item	Unit	Qty	Average Rates			MiniBLOC costs (M+L)			Mini BLOC costs inc. margins		
			AUD	NZD	SGD	AUD	NZD	SGD	AUD	NZD	SGD
Hollow blocks	No	24000	2.04	2.26	1.21	48900	54160	29000	52079	56868	31755
Paint	L	4000	9.95	10.78	6.96	39800	43100	27833	42387	45255	30478
32MPa concrete	m3	1800	159.00	187.83	133.33	286200	338100	240000	300510	355005	262800
Precast concrete	m2	1750	212.86	170.00	144.17	372500	297500	252292	396713	312375	276259
Carpet	m2	3800	32.50	33.13	54.17	123500	125875	205833	131528	132169	225388
Plywood	m2	3400	32.14	30.60	14.24	109286	104046	48427	116389	109248	53028
Skilled labour	hrs	9900	57.13	39.57	11.83	565538	391710	117150	602297	411296	128279
Semi-skilled lab.	hrs	15500	45.94	30.90	10.17	712031	478950	157583	758313	502898	172554
TOTALS						2169054	1736181	1021286	2305750	1822990	1118308

Table 4.6 Costs for the mini basket in local currencies using average rates from each city

	CPPP (all) No margin	CPPP (all) Inc. margin	CPPP (materials) No margin	CPPP (materials) Inc. margin	Penn WT PPPs (2004)	ICP PPPs (2005)	Exchange rates (02/08)	Big Mac Index (07/07)
Auckland	0.812	0.802	0.981	0.972	1.029	1.071	1.138	1.333
Singapore	0.481	0.495	0.827	0.854	0.892	0.786	1.265	1.145

Table 4.7 Conversion factors relative to 1 AUD

4.7.1 Market conditions

With regard to market conditions it emerged that in both Sydney and Auckland respondents generally agreed that current prices were currently close to average levels (i.e. neither inflated due to an abundance of work and weak competition, nor deflated due to scarcity of work and strong competition) and therefore there would be no reason for any adjustment. In Singapore, however, the respondents unanimously agreed that the market is booming and that tender prices are around 20% above levels that would be expected in an average market. If the cost of the basket is

deflated by 20% to bring the price in line with average tender price levels then the CPPP becomes just 0.40SGD = 1AUD (based on the cost of the BLOC including estimated contractors' margins) compared to 0.481SGD=1AUD when raw basket costs are used.

4.8 ANALYSIS OF THE PILOT STUDY DATA

Within the constraints of this preliminary study (i.e. a small number of materials and labour items and a small number of responses from each location) a number of significant results are easily identified from Table 4.7.

- As might be expected the use of exchange rates to compare construction costs is likely to produce quite distorted results.
- The Big Mac Index (BMI) also appears quite unsuitable for conversions between the locations surveyed in the this study
- The derived CPPPs are markedly different to the other factors that might be used such as ICP PPPs.
- The use of Penn World Tables PPPs from 2004 and ICP PPPs from 2005 (the most recent available) illustrates the problems associated with the intermittent publication of PPPs; furthermore, published CPPPs could not be located for Singapore for any year.
- For both Auckland and Singapore it is the difference in labour costs that is the major cause of the divergence of the CPPPs from other conversion factors (relative to the AUD).
- The inclusion or exclusion of contractors' margins makes little difference to the derived CPPPs.

4.8.1 Exchange rates and the Big Mac Index

The Singapore/Australia comparison in Table 4.6 illustrates the difference in the conclusions that may be drawn about relative costs of construction in the two locations depending on the conversion method used. Rawlinsons (2007) suggests an average cost for hotel construction in Sydney in 2007 of AUD3150/m² and SGD1650/m² in Singapore. If exchange rates are used to compare the two rates the Singapore rate becomes AUD1304/m² and that would suggest that the cost of hotel

construction in Singapore in 2007 was just 40% of the cost in Sydney. This means that hotel construction in Singapore is cheaper.

This gives the impression that the industry in Singapore is considerably more competitive and considerably more efficient than in Australia. Such conclusions have been drawn in earlier studies (e.g. Page Kirkland, 1999) If the BMI were to be used similar, equally questionable, conclusions could be drawn as the BMI is much closer to the exchange rate than to the derived CPPP.

Best and Langston (2006b) clearly demonstrated that such conclusions are dubious and this is confirmed here. When the CPPP derived from the preliminary study, which considers the cost and use of resources in construction is applied ($1\text{AUD}=0.485\text{SGD}$) the Singapore rate becomes $\text{SGD}3402/\text{m}^2$ and it then appears that Singapore may be, based on purchasing power parity, slightly more expensive than Sydney. It should be noted that PPPs are not absolute measures (Goodchild and Griffiths, 2004) and therefore it would be more accurate to say that construction costs, in terms of “construction dollars”, are quite similar in the two cities.

4.8.2 Other PPPs

The most recent PPPs from the Penn World Tables and the ICP have been used and these sit between exchange rates/BMI and the derived CPPPs. The time lag that is evident is an ongoing problem – the latest ICP PPPs were released in 2007 but are benchmarked to 2005, so it is possible that there have been changes in PPPs since the benchmark year that may alter the outcomes here. If the more recent PPPs (i.e. the 2005 ICP) are used the Singapore cost/ m^2 for hotel construction becomes $\text{AUD}2099/\text{m}^2$. This still suggests that Singapore is around 33% cheaper than Sydney.

City	Working time (mins.) needed to purchase		
	a Big Mac	1kg of rice	1kg of bread
Sydney	14	5	15
Auckland	14	5	13
Singapore	26	10	26

Table 4.8 Working time required to buy typical food items (Source: UBS, 2006)

4.8.3 Differences in labour and materials costs

CPPPs were calculated based on the whole basket and on the materials component only. For both Auckland and Singapore the materials only values vary markedly from the whole basket values although the effect is much greater for Singapore. In both cases the materials only CPPP is quite similar to the respective PWT and ICP PPPs.

Labour costs in Singapore are, by any measure, lower than those in Sydney or Auckland. UBS (2006) show unskilled/semi-skilled building labourers in Singapore earning around 70% of those in Auckland and only slightly more than half that earned by their Australian counterparts. Although incomes are compared in the UBS study using exchange rate conversion the difference is emphasised by the comparison of the time that an average worker in Singapore has to work in order to buy several basic food items; Table 4.8 illustrates this, with the Singapore worker having to work double the time that a worker in Sydney or Auckland works in order to buy each of the three items (UBS, 2006:11). It should be noted, however, that the numbers of labour hours in the basket are based on analysis of a Sydney project and therefore reflect the productivity of Sydney workers; if similar Singapore projects were analysed it may be that the lower labour rates would, to some extent at least, be offset by lower productivity.

4.8.4 Contractors' margins

The basket of goods approach has been criticised because it is based on input prices and so does not directly include contractors' margins for profit and general overheads (Stapel, 2002; Walsh and Sawhney, 2004). In the pilot survey respondents were asked to provide an estimate of contractors' markups for a project of the type analysed to produce the BLOC. CPPPs were calculated based on the cost of the BLOC with and without the addition of the average estimated markup for each city. As Table 4.6 shows the CPPPs for both places vary only slightly with the inclusion of markups and this suggests that unless the margins in some locations were considerably higher than in others then the question of markups is not important. In this study the average estimated margins were Sydney: 6.5%, Auckland: 5% and Singapore: 9.5% - the higher margin in Singapore presumably reflects the current

strong market there and could be accounted for by adjusting the BLOC cost for Singapore down to allow for the difference in market conditions between the three cities.

4.9 DATA QUALITY ISSUES

The pilot study provides some useful information regarding data collection and the quality of the data collected. Apart from confirming the difficulties inherent in asking busy people to take time to look at any survey some observations can be made regarding the nature of the data. Table 4.9 shows the mean price, standard deviation, median price and coefficient of variation for each item in the basket for each pricing location.

	Concrete \$/m3	Formply \$/m2	Paint \$/litre	Precast \$/m2	Blocks Each	Carpet \$/m2	Skilled \$/hr	Semi-skill \$/hr	Margin %	Prelims %
SYDNEY - AUD										
Mean	159.00	32.14	9.95	212.86	2.04	32.50	57.13	45.94	6.50	17.06
SD	11.01	10.19	2.10	19.49	0.65	7.56	10.12	11.39	5.03	2.39
CoV	6.93%	31.71%	21.13%	9.16%	31.70%	23.26%	17.72%	24.79%	77.42%	14.02%
Median	160.00	35.00	9.25	182.50	1.90	30.00	60.00	48.00	5.00	17.50
AUCKLAND - NZD										
Mean	187.83	30.60	10.78	170.00	2.26	33.13	39.57	30.90	5.00	13.25
SD	21.62	12.46	2.76	20.00	0.26	5.10	3.26	4.99	0.84	3.21
CoV	11.51%	40.73%	25.59%	11.76%	11.65%	15.39%	8.25%	16.14%	16.73%	24.19%
Median	179.50	27.50	9.38	170.00	2.26	33.00	39.70	32.50	4.75	13.75
SINGAPORE - SGD										
Mean	133.33	14.24	6.96	144.17	1.21	54.17	11.83	10.17	9.50	13.67
SD	10.33	8.26	4.01	54.99	0.59	14.29	2.58	4.34	3.34	3.79
CoV	7.75%	57.98%	57.59%	38.15%	49.13%	26.38%	21.82%	42.72%	35.11%	27.73%
Median	130.00	11.64	6.50	137.50	1.20	50.00	12.00	9.50	8.50	13.50

Table 4.9 Analysis of data from the pilot study showing the mean, standard deviation, coefficient of variation and median value for each mini BLOC item in each location.

Several points are notable:

- Concrete, carpet and preliminaries produced quite tight results in all locations with small differences between median and mean, and the coefficient of variation less than 30%.
- The results from Singapore show a generally broader spread of results than the other cities for most items, with considerably higher coefficients of

variation evident. This may be attributable to the current booming market in Singapore producing greater than usual volatility in prices.

- With a small sample of prices in each location a single outlier can distort results; one unlikely answer (17.5%) to the question concerning contractors' margins from a Sydney respondent produced a large coefficient of variation (77%) while if that answer were to be deleted from the data set the coefficient would drop to just 37%. The high estimate of margin may be due to the nature of the respondent's business; as the company is both developer and contractor on much of their work it is possible that the margin quoted is an overall profit target for developments rather a simple contractor's margin for construction work alone. Whatever the reason it appears, *prima facie*, that there is a much larger dispersion of the data around the mean than is desirable if consistency in pricing is to be achieved.
- Across all items there is no great difference between the mean price and the median price. One exception is in the Sydney data for precast concrete where the mean is around 15% higher than the median and the coefficient of variation nearly 30%; this is explained by one unusually high price which is most likely an erroneous value resulting from the insertion of a supply and fix rate rather than a supply only rate. If that result were to be deleted from the data set the mean becomes AUD\$190, the median AUD\$182.50 and the coefficient of variation is just 10.26%.

4.10 CONCLUDING REMARKS

In this chapter the chosen method is explained and developed. Details of the calculations carried out to determine the items in the BLOC and the weights or volumes applied to each item are given. The pilot study described above demonstrates that the basic method can be applied in practice and that purchasing power based conversion factors for multilateral cost comparisons can be produced using such a mechanism. It was noted earlier in this thesis that one of the factors that adds to the complexity of the conversion question is that there is no way of determining whether any approach or set of results is correct and that is the case with the results obtained from the pilot study. In the following chapter the collection of

cost data using a more comprehensive basket or BLOC to gather prices in six cities and the results of that exercise are discussed. Some comparisons are done to test the outcomes against the results from the pilot study and other published data, including some published construction-specific PPPs.

CHAPTER 5

5.0 DATA COLLECTION AND ANALYSIS

5.1 INTRODUCTION

In the preceding chapter a 12 point plan was outlined (at 4.3) and the execution of the first five steps of that plan was described. In this chapter the main research exercise is described and the data obtained is presented and discussed.

5.2 USING THE BLOC

Following the methods described earlier and detailed in Appendix A1 the final BLOC was developed; Table 5.1 outlines the items and quantities for materials and labour.

The inclusion of a larger number of items in the complete BLOC compared to that used in the pilot study, particularly the inclusion of some items related to engineering services (there were none in the pilot survey) necessitated the inclusion of two extra classes of labour. Tradesman Group 1 was added to cover the installation of electrical and hydraulics items and other tradesman labour was divided into two groups to accommodate the broader range of items included in the BLOC.

An Excel spreadsheet was used to facilitate the calculation of quantities of materials and labour; an extract from that spreadsheet is included in Appendix A3.

5.2.1 General information

The main survey¹ also included five general questions, similar to those in the pilot study survey; they are listed in Table 5.2. The first of these questions provided the data needed for BLOC prices to be adjusted to include margins for profit and overhead. The same approach was used in the pilot where it produced little difference in outcomes for Sydney or Auckland but had some effect for Singapore. The second question was also included in the pilot although it was not used in the analysis; the data gathered through this question allowed some cross-checking, described later, of results from the main study.

MATERIALS	Unit	Qty
32MPa concrete	m3	1,800
19 thick plywood for formwork	m2	3,500
16 diameter high yield steel reinforcing bar	t	200
Precast concrete wall panel, 150 thick	m2	1,700
Stressing steel, strand only	t	100
Structural steel - rolled sections, fabricated	t	60
390 x 190 x 190 hollow concrete blocks	No	24,000
10 thick toughened glass for frameless glass wall	m2	750
1600 x 1600 aluminium framed window	No	300
50 thick sawn sandstone facing	m2	75
Single one hour fire rated door set (including frame, hardware)	No	240
Single non-fire rated door (excluding frame, hardware)	No	400
13 thick gypsum plasterboard	m2	50,000
200 x 200 ceramic floor tiles	m2	6,000
80/20 wool blend carpet	m2	4,000
Low sheen acrylic paint – interior use	L	4,000
Timber wardrobe/minibar unit	No	300
Low voltage cabling (2C+E, 2.5mm2, PVC/PVC)	m	200,000
Low voltage downlight	No	12,000
Semi-recessed white ceramic vanity basin	No	900
100 dia cast iron waste pipe	m	5,000
15 dia copper water pipe	m	3,000
500 x 300 rigid sheet metal duct (excluding insulation)	m	2,500
200 dia flexible duct	m	1,200
LABOUR		
Tradesman Group 1 (e.g. electrician, plumber)	hrs	20,000
Tradesman Group 2 (e.g. carpenter, bricklayer)	hrs	40,000
Tradesman Group 3 (e.g. tiler, carpet layer)	hrs	8,000
Semi-skilled labourer (e.g. steel fixer)	hrs	25,000

Table 5.1 BLOC items and quantities

¹ A copy of the survey instrument is included in Appendix A5.

The third and fourth questions were similar to two asked in the pilot, however, in the main survey these questions were remodelled in response to the difficulties encountered in the pilot study described earlier at 4.6.6. The final question gauged the usefulness of the approach in terms of ease of use of the survey and the possibility of respondents taking the time to complete such a data gathering instrument; the less onerous the task of providing data is for respondents the more likely it is that multiple pricing in each location can be achieved without undue cost.

1	What would be a typical contractor's margin (profit and general overheads) on a project of this type (200 room, 3-4 star suburban hotel)?
2	What would you estimate Preliminaries (site/job specific overheads) to be for the same project as a percentage of total project cost?
3	How would you describe market (tendering) conditions in your location at present (High indicates a strong market with lots of work available and correspondingly high tender prices; Low indicates a slow market with intense competition for limited amounts of work)? ²
4	In your location what would you estimate to be the range of tender prices between a High market and a Low market in relation to "average" tender price levels when the market is Medium? (For example, tender levels might move around a Medium level by up to +20% when work is plentiful, and -20% when work is scarce and competition is at its highest)
5	How long did it take to complete this survey?

Table 5.2 General information questions from the main survey

5.2.2 Refining the questionnaire

Apart from the problems with the questions about market conditions the pilot survey worked well. The only major difference was that the main survey was developed as a fully online questionnaire whereas the pilot study was sent as a Microsoft Word document attached to an e-mail. While the pilot study survey could be completed on screen respondents then had to save the document and attach it to a return e-mail; some chose to convert it to a PDF file and then sent that as an attachment. The e-mail approach was appropriate for the pilot as that survey was distributed directly to a selected group of potential respondents, and a personal e-mail was a suitable vehicle for the survey. As the main survey was to be distributed widely through a variety of channels, including the e-mail lists of professional bodies such as the Australian Institute of Quantity Surveyors (AIQS), an online survey accessed by a web link was

² As in the pilot study respondents were given the choice of five options: High, Medium to High, Medium, Low to Medium and Low.

considered a better option. The copy of the survey in Appendix A5 is a direct download of the online survey.

As all the materials items, one of the labour items and several of the general questions in the pilot survey were included in the main survey a shortened version of the main survey was created that excluded those items covered in the pilot. A separate web link was created for the shorter survey and those who had completed the pilot survey were requested to complete the shortened version of the main survey. Only 11 of the 20 who responded to the pilot survey completed the shortened version of the main survey. Data from the pilot study was, however, included in the main study results, however, whether or not respondents to the pilot completed shortened survey with the additional items.

The main survey comprised five questions relating to the respondent (e.g. respondent's name, type of company, location), 24 materials items (supply price), four categories of labour (hourly rates) and the five general questions listed above. The shortened version comprised two respondent questions, 18 materials items, four categories of labour and a single general question (the fourth of those shown in Table 5.2 above).

Several items had graphical details attached to facilitate consistent pricing, viz. the precast concrete wall panel, wardrobe/minibar unit, vanity basin and downlight.

5.2.3 Survey instructions

Respondents were asked to provide specific data in the various sections of the survey.

5.2.3.1 Materials

For each of the materials items they were asked to provide the cost for the supply and delivery only of the item with no allowance for costs associated with installation (such as labour, plant or sundries such as electricity, water, nails, adhesive or other consumables). Costs were to be as close as possible to those actually paid by a contractor for the item with consideration of typical discounts that might apply to

quantities of the magnitude of those in the BLOC. The relevant quantities were stated as part of each of the questions in the materials section of the questionnaire. No allowance was to be made for any applicable goods and services tax (GST) or value added tax (VAT).

5.2.3.2 Labour

In respect of the labour items respondents were asked to provide hourly rates that reflected “all in” rates such as a contractor or subcontractor would use to calculate unit rates in preparing a tender. These rates were to exclude any allowance for profit and general overheads (contractors’ margin) and GST/VAT.

5.2.3.3 Variants

Each question was followed by two boxes into which respondents could enter a rate and any additional information that they deemed necessary. The instructions suggested to respondents that where a listed item was not precisely the same as a corresponding item common in their locality that they should enter a rate for the local variant and give details in the “Comments” box. An example of this is concrete strength: 32 MPa is a typical mix in Sydney but is not necessarily available in other locations. If the available strength were 30MPa, for example, there is little appreciable difference between the two items and respondents were asked to give a rate for the equivalent material available in their location.

Similarly different pricing strategies were offered for some items. Gypsum plasterboard, for example, could be priced by sheet or by m^2 ; respondents were invited to price either way but asked to note in the “Comments” box how they priced it, and if by sheet, to state the sheet size so that an equivalent $\$/m^2$ rate could be calculated.

5.2.4 Distributing the questionnaire

For the main survey data was sought from respondents in six locations. Different approaches were adopted in different locations in order to reach as many potential respondents as possible. Personal contacts and those people who supplied responses to the pilot were obvious starting points for Sydney, Auckland and Singapore. Personal contacts were pursued in all cities and contacts were sought through

existing contacts particularly those in firms with offices in other cities³. Estimators in contracting companies in Phoenix were approached through a personal contact in the school of construction at Arizona State University.

In addition to those direct requests various professional bodies provided assistance with promulgation of the research to their members. The AIQS circulated details of the survey with a web link to the survey site to all members via an e-mail broadcast; similar e-mail broadcasts were made in Australia by the Royal Institution of Chartered Surveyors (RICS), the Chartered Institute of Building (CIOB) and the Australian Institute of Building (AIB). Contacts in Auckland were provided by the New Zealand Institute of Quantity Surveyors and the New Zealand Institute of Building. The RICS also assisted with contacts through RICS members in Singapore and Auckland.

5.2.5 Responses to the survey

As was the case with the pilot study eliciting responses was not easy. It is not possible to report a response rate in the conventional manner as there is no way to gauge the number of people who even opened the broadcast e-mail requests sent by the professional bodies. Around 100 individuals accessed the online survey but many did not enter any data. Some submitted partially completed surveys. As noted earlier only 11 of the 20 who responded to the pilot survey followed up with a response to the main survey.

Table 5.3 shows the number, source and type of completed surveys received. A survey with 75% or more of the items priced has been counted as “complete”. Two responses from Sydney came from a firm that publishes construction cost data - the data were not the same from the two individuals so both were included, and these responses were counted as responses from quantity surveyors (QS) as the respondents are acting more as cost consultants than as estimators. Similarly one

³ Examples include Rider Levett Bucknall whose offices in Sydney, Auckland and Singapore supplied data following a personal request to the manager of the Sydney office. Additional data was also obtained through a personal contact in their Phoenix office..

response from Brisbane, from the Queensland Department of Public Works, has been included as a QS response. Where a respondent completed both the pilot survey and the additional survey the two responses were merged and recorded as a “complete”. Pilot study responses that were not followed up with the second survey were recorded as “partial”.

In total 39 fully completed surveys and 16 partially completed surveys were collected. Additional data for some items were obtained as part of the validation process from other sources such as local quantity surveyors who had not been asked to complete the surveys.

CITY	Contractors		Quantity surveyors	
	Complete	Partial	Complete	Partial
Sydney	4	3	8	4
Brisbane	0	3	4	0
Melbourne	2	2	3	0
Singapore	2	2	5	0
Auckland	2	1	2	1
Phoenix	7	0	0	0
TOTALS	17	11	22	5

Table 5.3 Survey responses: number and source for each location

5.2 DATA CHECKING AND VALIDATION

Once the raw data had been collected a process of data entry, analysis and validation was carried out in order to produce a consistent dataset of unit rates for all the items in the BLOC.

5.3.1 Data quality and associated issues

Several problems appeared during the data collection that had not affected the pilot study. The most serious of these was the inclusion of supply and fix rates for many items rather than the supply only rates that had been requested. In some cases it was clear that respondents had entered a mixture of supply only and supply and fix rates, often with no indication of which was which. Others did use the “Comments” box to indicate that they had inserted supply and fix rates for particular items.

5.3.1.1 Sources of cost data in Sydney

In order to calculate a 2007 Sydney benchmark BLOC cost current supply prices were obtained from a variety of sources. Prices that reflected typical discounts for the quantities in the BLOC were obtained wherever possible. Prices were gathered by telephone and e-mail as shown in Table 5.4.

ITEM	SUPPLIER (SYDNEY)
Concrete	De Martin & Gasperini
Plywood for formwork	Royal Plywood
Bar reinforcement	Smorgon Steel
Precast concrete	Rescrete/Hanson
Stressing steel	Austress Freyssinet
Toughened glass	Pilkington
Sandstone	Gosford Quarries
Vanity basin	Tradelink (Kirrawee)
Downlight	ECC Lighting
Window unit	Architectural Systems

Table 5.4 Sydney cost data sources - suppliers

Other prices were obtained through consultation with a building contractor/developer: Wal Zagoridis of Arkibuilt Pty Ltd (Zagoridis, 2008). In early 2008 Arkibuilt was nearing completion of a medium density residential development of similar scale to and located within 8km of the reference project. Current actual prices were obtained from Mr Zagoridis for the following items: structural steel, concrete blocks, doors, paint, tiles, carpet and plasterboard. These are all generic items and would be of similar specification whether installed in a hotel or residential development of medium standard.

Supply prices for the remaining services items (copper and cast iron pipe, air conditioning ductwork and low voltage cable) were obtained from Rider Levett Bucknall (Nowak, 2007).

All labour rates were obtained from Cordell (2008). Rates were averaged from charge-out rates for a variety of tradespeople and several classes of labourer.

5.3.1.2 Cost checking outside Australia

Validation of data from locations outside Australia was more challenging as there was restricted access to either published cost data or suppliers. In New Zealand some extra information was obtained from respondents when there was doubt about the validity of rates and another quantity surveyor was asked to provide comments on some problematic rates. Rawlinsons *New Zealand Construction Handbook* (Rawlinsons, 2007b) was also used as a cross-check for some rates.

Singapore presented additional problems as, due to the lower cost of labour, materials costs would be expected to represent a larger proportion of supply and fix rates than is the case in Australia or New Zealand. This factor made any attempt to differentiate between supply only rates and supply and fix rates more complex. Consequently confirmation of the nature of problematic rates was sought directly from survey respondents in Singapore.

Validation of rates from Phoenix was done by querying respondents on questionable rates and by obtaining information on some specific rates from a local quantity surveyor⁴. In addition rates were cross-checked using two online cost services (Get-A-Quote, 2008; Home Depot, 2008) and *Building Construction Cost Data* (RSMeans, 2007).

5.3.2 Data validation

The BLOC used in this study, comprising a basket of materials and labour, is in effect an estimate of the cost of a specific type of project. The BLOC is assumed to be representative of all the materials and labour required to construct the complete building. The BLOC is therefore analogous to a full estimate and can be expected to exhibit some characteristics of estimates generally. Similarly the characteristics of the data for the items comprising the BLOC should be similar to those of the individual items that make up an estimate.

⁴ Hedley (2008)

One basic difference between the BLOC and a conventional estimate is that the BLOC was used to gather input costs for materials and labour separately while the items in an estimate are typically composites of labour, materials and other inputs such as plant and equipment. In this study respondents provided reasonably consistent rates for labour with all but one coefficient of variation (CoV) less than 40%, with 18 of 24 having CoVs less than 30%. There was much greater dispersion of rates for materials and the discussion from this point forward is focused on the cost data for the materials component of the BLOC.

5.3.3 The nature of the BLOC data

The BLOC questionnaire asked respondents to provide input costs for a number⁵ of building materials and components. Specifically they were asked for a “unit rates for the supply and delivery ... exclusive of sales tax, value added tax (VAT) or goods and services tax (GST)”. Rates were further described as “those actually paid by a contractor”. As noted above many respondents provided rates that were not the material supply only rates that were asked for in the survey.

5.3.3.1 The raw data

Initially all unit rate data were entered into an Excel spreadsheet with the only adjustment being the exclusion of rates that respondents had specifically noted as “supply and fix”. The main concern was how to identify and deal with unit rates that may have been incorrect but were presented by respondents without explanation. Many potentially problematic responses were entered.

The mean rate, standard deviation, coefficient of variation and median rate for each item were calculated by formulae embedded in the spreadsheet. A spreadsheet linked to the raw data consolidated the calculated values and on that sheet all items in each

⁵ Originally 24 items but due to pricing difficulties with one item, stressing steel, this was reduced to 23 in the final analysis. See *Stressing steel* in Section 5.3.4 for a detailed discussion of the difficulties encountered with this item.

location for which the coefficient of variation (CoV) exceeded 40% were highlighted⁶. Those values are listed in Table 5.5.

Based on the raw cost data for the 24 materials items in the six locations 81 of the 144 datasets showed a coefficient of variation (CoV) greater than 40%. As the 40% CoV benchmark was not an absolute determinant all data were reviewed with the 40% level being used primarily to identify datasets for items that returned widely dispersed data. It also provided a target value that would indicate that data verification had reduced the spread of the data to a level that meant that most data likely to be incorrect due to irregular pricing by respondents had been removed.

5.3.3.2 Overpricing and underpricing

The potential for incorrect pricing of items was more likely to produce overpricing rather than underpricing. The use of supply and fix rather than supply only rates is not the only reason for this. For example, it is unlikely that respondents would have under priced due to the omission of some part of an item to be priced as nearly all the materials items comprised a single part⁷, such as a cubic metre of concrete, a litre of paint and so on. In contrast a number of items could be priced incorrectly by including other components such as patch fittings for the toughened glass in frameless glass walls, or frame and/or hardware for the non-fire rated door.

Overpricing could also occur if respondents did not read the instructions carefully or simply made an error when pricing; several examples⁸ are described in 5.3.4 all of which resulted in significant overpricing of items. In other instances some items in

⁶ The 40% value is to some extent arbitrary but was selected in consultation with Dr Narelle Smith (Smith, 2008), a statistician in the Department of Mathematical Sciences at the University of Technology Sydney. Any coefficient above 40% indicates a spread of data around the mean that is wide enough to suggest that some unit rates for such items are not the “supply only” rates that respondents were asked for in the survey.

⁷ There were few exceptions to this – the fire rated doorset was one and the window possibly another although separation of frame and glazing is not common.

⁸ See, for example, *Concrete blocks* and *Plasterboard* in 5.3.4.

some locations carry the potential for large discounts when bought in quantity. The use of list prices rather than “real” prices paid could also have led to overpricing.

MATERIALS							
	Concrete \$/m3	Formply \$/m2	Rebar \$/t	Precast \$/m2	Stress steel \$/t	Hot rolled sections \$/t	Blocks Each
SYDNEY - AUD							
Mean	169.66	40.58	1388.08	195.82	5400.00	4122.00	2.98
SD	18.90	22.54	324.81	63.52	2817.80	1915.51	2.00
CoV	11.14%	55.55%	23.40%	32.44%	52.18%	46.47%	67.03%
Median	169.00	31.00	1300.00	180.00	5500.00	4500.00	2.46
AUCKLAND - NZD							
Mean	187.83	30.60	1564.00	170.00	2275.00	2450.00	2.26
SD	21.62	12.46	385.33	20.00	1872.83	665.83	0.26
CoV	11.51%	40.73%	24.64%	11.76%	82.32%	27.18%	11.65%
Median	179.50	27.50	1700.00	170.00	1575.00	2650.00	2.26
SINGAPORE - SGD							
Mean	131.33	15.42	1358.57	127.84	5275.00	3778.57	1.25
SD	9.27	8.70	186.83	55.65	2051.10	1299.30	0.55
CoV	7.06%	56.45%	14.85%	43.53%	38.88%	34.39%	44.24%
Median	130.00	12.00	1330.00	125.00	5500.00	4500.00	1.20
MELBOURNE - AUD							
Mean	167.86	62.00	1432.00	203.29	4792.86	4733.33	2.34
SD	53.62	46.83	435.17	89.04	2677.13	2095.39	0.08
CoV	31.94%	75.53%	30.39%	43.80%	55.86%	44.27%	3.63%
Median	132.00	52.50	1250.00	200.00	6000.00	5600.00	2.34
BRISBANE - AUD							
Mean	153.50	43.80	1327.50	121.67	7750.00	5480.00	2.43
SD	21.27	22.87	45.58	53.46	1174.31	2574.30	0.11
CoV	13.85%	52.22%	3.43%	43.94%	15.15%	46.98%	4.37%
Median	143.50	38.00	1350.00	110.00	7500.00	6000.00	2.43
PHOENIX - USD							
Mean	127.71	10.82	1007.14	225.25	2537.50	2176.43	1.33
SD	16.07	3.82	108.43	100.30	363.72	871.76	0.63
CoV	12.58%	35.28%	10.77%	44.53%	14.33%	40.05%	47.30%
Median	120.00	10.76	960.00	194.50	2475.00	2350.00	1.18

Table 5.5 Analysis of the raw BLOC data showing mean, standard deviation, coefficient of variation (CoV) and median values for the item data obtained from the main survey. The coefficient of variation indicates the degree of dispersion of values around the mean. CoVs greater than 40% have been highlighted.

MATERIALS (Continued)								
	Tough glass \$/m2	Window unit Each	Sawn stone \$/m2	1 hour door Each	NFR door Each	Plaster board \$/m2	Floor tiles \$/m2	Carpet \$/m2
	SYDNEY - AUD							
Mean	405.40	757.49	177.16	960.09	288.92	10.08	45.09	39.98
SD	191.71	276.49	107.78	256.77	242.51	6.63	20.98	11.02
CoV	47.29%	36.50%	60.83%	26.74%	83.94%	65.76%	46.54%	27.55%
Median	373.00	895.00	150.00	900.00	150.00	6.50	40.00	37.50
	AUCKLAND - NZD							
Mean	211.25	890.00	193.33	730.00	258.75	11.93	41.25	33.13
SD	82.50	502.39	61.10	203.14	129.25	10.06	12.50	5.10
CoV	39.05%	56.45%	31.60%	27.83%	49.95%	84.34%	30.30%	15.39%
Median	207.50	1050.00	180.00	700.00	202.50	7.10	42.50	33.00
	SINGAPORE - SGD							
Mean	246.33	763.56	98.33	866.00	428.33	11.00	31.00	56.43
SD	210.35	216.56	58.79	250.40	241.07	10.90	7.39	14.35
CoV	85.39%	28.36%	59.79%	28.91%	56.28%	99.14%	23.85%	25.43%
Median	168.00	848.00	112.50	886.00	360.00	8.00	35.00	50.00
	MELBOURNE - AUD							
Mean	382.00	1025.00	326.00	1098.57	560.00	12.27	70.00	45.43
SD	238.19	216.22	160.87	276.91	365.72	11.23	47.96	10.36
CoV	62.35%	21.09%	49.35%	25.21%	65.31%	91.51%	68.51%	22.80%
Median	280.00	1075.00	250.00	1200.00	600.00	8.00	65.00	50.00
	BRISBANE - AUD							
Mean	255.00	635.83	175.00	775.00	401.67	23.33	43.33	41.25
SD	69.46	193.40	90.28	250.50	313.08	27.43	24.43	9.46
CoV	27.24%	30.42%	51.59%	32.32%	77.94%	117.55%	56.37%	22.95%
Median	230.00	645.00	155.00	775.00	250.00	8.00	32.50	37.50
	PHOENIX - USD							
Mean	154.80	709.57	118.58	796.43	177.50	3.87	34.35	34.21
SD	101.52	195.61	40.48	236.92	84.61	1.90	17.43	13.90
CoV	65.58%	27.57%	34.13%	29.75%	47.67%	49.26%	50.73%	40.62%
Median	100.00	750.00	124.00	875.00	185.00	3.79	40.00	33.00

Table 5.5 Dispersion of raw data (Continued)

MATERIALS (Continued)									
	Paint \$/litre	Wardrobe unit Each	LV cable \$/m	LV downlight Each	Vanity basin Each	Cl pipe \$/m	Cu tube \$/m	Rigid duct \$/m	Flex duct \$/m
SYDNEY - AUD									
Mean	10.66	2933.33	1.31	38.29	273.26	73.88	15.86	73.25	41.93
SD	2.19	1000.83	0.55	31.20	91.08	46.07	11.10	69.90	43.79
CoV	20.57%	34.12%	41.77%	81.48%	33.33%	62.36%	69.99%	95.42%	104.44%
Median	10.99	2950.00	1.23	20.69	258.00	45.15	10.60	65.00	25.00
AUCKLAND - NZD									
Mean	10.78	4198.00	2.06	82.66	276.25	100.33	21.62	115.00	35.75
SD	2.76	2437.42	1.39	113.88	90.13	56.22	17.49	24.15	38.50
CoV	25.59%	58.06%	67.53%	137.76%	32.63%	56.03%	80.94%	21.00%	107.69%
Median	9.38	4800.00	1.73	36.50	252.50	125.00	17.05	107.50	25.00
SINGAPORE - SGD									
Mean	6.96	3310.00	6.30	89.83	255.00	93.67	27.00	64.88	44.00
SD	4.01	1549.97	5.09	34.38	117.77	3.21	8.72	43.99	8.60
CoV	57.59%	46.83%	80.86%	38.27%	46.18%	3.43%	32.29%	67.80%	19.55%
Median	6.50	2300.00	4.25	84.00	270.00	95.50	24.00	49.70	40.00
MELBOURNE - AUD									
Mean	9.29	3920.00	2.08	81.25	347.50	85.00	26.50	101.67	17.67
SD	1.38	1639.21	1.01	63.03	75.88	42.72	13.67	57.95	2.52
CoV	14.86%	41.82%	48.50%	77.58%	21.84%	50.26%	51.60%	57.00%	14.24%
Median	9.00	4000.00	2.25	82.50	335.00	80.00	24.50	130.00	18.00
BRISBANE - AUD									
Mean	12.25	2790.00	1.00	43.50	375.00	71.29	22.67	81.67	15.00
SD	3.86	1520.86	0.50	38.63	132.29	30.34	21.08	60.48	8.66
CoV	31.53%	54.51%	50.00%	88.81%	35.28%	42.56%	93.00%	74.06%	57.74%
Median	10.50	3000.00	1.00	30.00	350.00	70.08	11.00	60.00	10.00
PHOENIX - USD									
Mean	3.61	2278.57	1.04	71.43	256.43	23.84	10.08	49.64	13.03
SD	0.80	1134.63	0.63	41.20	102.90	19.25	5.54	60.71	8.17
CoV	22.13%	49.80%	60.24%	57.68%	40.13%	80.75%	54.99%	122.31%	62.76%
Median	3.70	1950.00	1.06	60.00	275.00	15.58	9.02	26.00	13.00

Table 5.5 Dispersion of raw data (Continued)

LABOUR AND GENERAL ITEMS						
	Skilled 1 \$/hr	Skilled 2 \$/hr	Skilled 3 \$/hr	Semi- skilled \$/hr	Margin %	Prelims %
	SYDNEY - AUD					
Mean	58.68	49.68	44.45	42.64	6.45	16.16
SD	14.81	12.19	10.02	10.50	3.45	3.16
CoV	25.23%	24.55%	22.54%	24.62%	53.49%	19.53%
Median	62.00	53.00	44.00	40.00	5.00	16.75
	AUCKLAND - NZD					
Mean	43.80	34.50	33.00	30.90	5.00	13.25
SD	6.91	5.26	4.00	4.99	0.84	3.21
CoV	15.77%	15.25%	12.12%	16.14%	16.73%	24.19%
Median	42.00	34.00	35.00	32.50	4.75	13.75
	SINGAPORE - SGD					
Mean	11.71	11.43	11.86	9.67	10.06	13.61
SD	3.49	2.79	3.13	3.83	3.27	3.07
CoV	29.81%	24.39%	26.38%	39.65%	32.47%	22.55%
Median	12.50	12.50	15.00	9.50	9.25	12.50
	MELBOURNE - AUD					
Mean	70.00	63.67	62.00	57.50	5.50	13.50
SD	20.49	18.18	18.76	17.25	1.52	3.27
CoV	29.28%	28.56%	30.26%	30.00%	27.57%	24.23%
Median	72.50	65.00	62.50	60.00	5.50	12.50
	BRISBANE - AUD					
Mean	60.40	50.40	48.60	47.00	6.80	16.30
SD	16.83	11.76	10.83	12.53	2.05	3.63
CoV	27.87%	23.33%	22.29%	26.66%	30.14%	22.29%
Median	65.00	55.00	55.00	50.00	7.00	16.00
	PHOENIX - USD					
Mean	42.21	32.36	27.57	26.79	4.83	5.67
SD	13.05	10.32	9.32	12.14	2.14	1.08
CoV	30.92%	31.90%	33.82%	45.34%	44.21%	19.06%
Median	45.00	35.00	28.00	25.00	4.00	5.25

Table 5.5 Dispersion of raw data (Continued)

Given that there is little potential for underpricing beyond the limits of normal estimating variations it would be expected that that the distribution of rates for individual would be positively skewed. The following examples of the distribution of raw unit rates for several materials illustrate the point.

5.3.3.3 Distribution of unit rates in the survey

Figure 5.1 shows the distribution of the 19 unit rates obtained from Sydney for 32MPa readymixed concrete. The CoV is 11.14% indicating that the individual rates are not widely dispersed around the mean. As Figure 5.1 shows, however, the bulk of the responses are in the left hand side of the graph with a pronounced tail to the right.

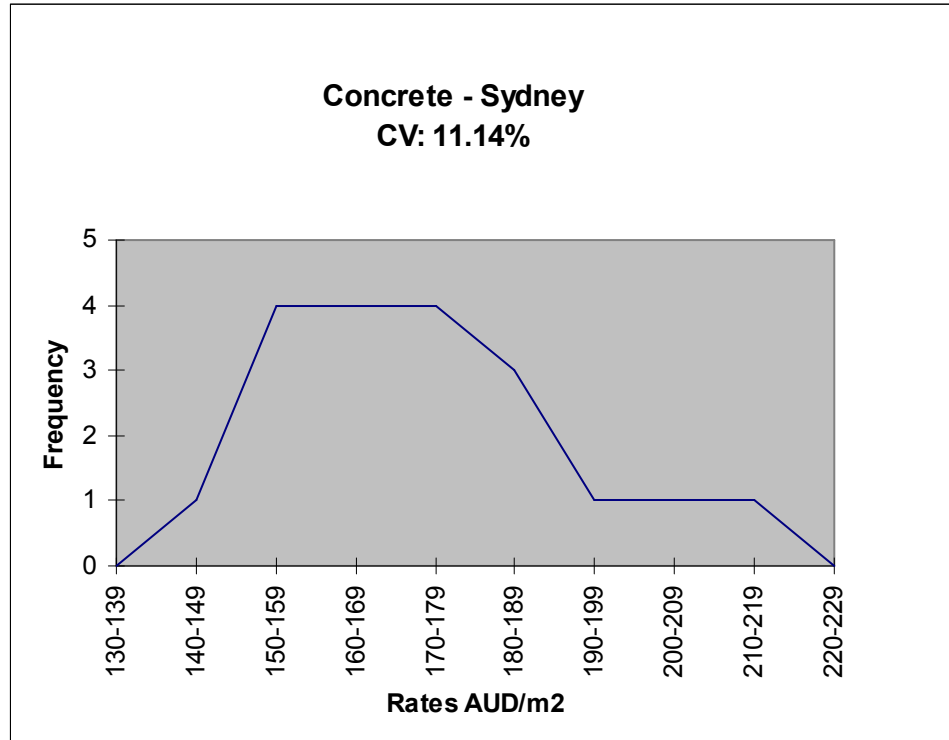


Fig. 5.1 Data distribution for concrete prices from Sydney showing a positive skew.

Figure 5.2 shows a similar situation with the unit rates from Phoenix for reinforcing steel. Once again the distribution is showing a clear positive skew with a longer tail to the right.

Figure 5.3 shows a similar result for concrete blocks, however, there are two outliers well to the right of the main part of the chart that indicate rates that are several times the magnitude of the main body of rates. Based on the raw data for this item there is a difference of more than 20% between the mean (\$2.98 per block) and the median (\$2.46 per block) and the coefficient of variation is 67.03%.

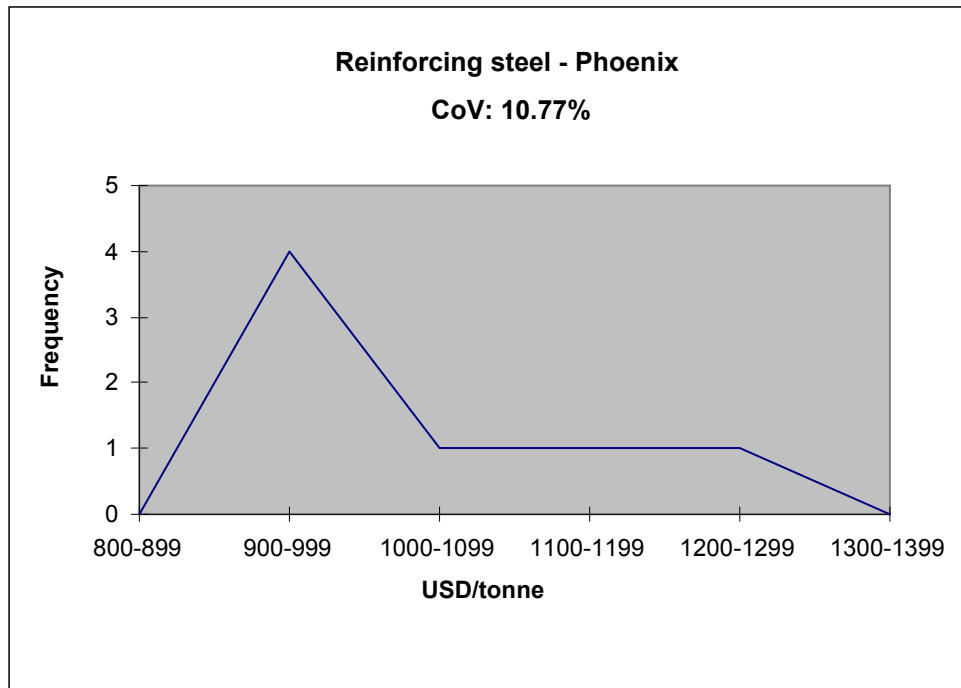


Fig. 5.2 Data distribution for reinforcing steel prices from Phoenix.

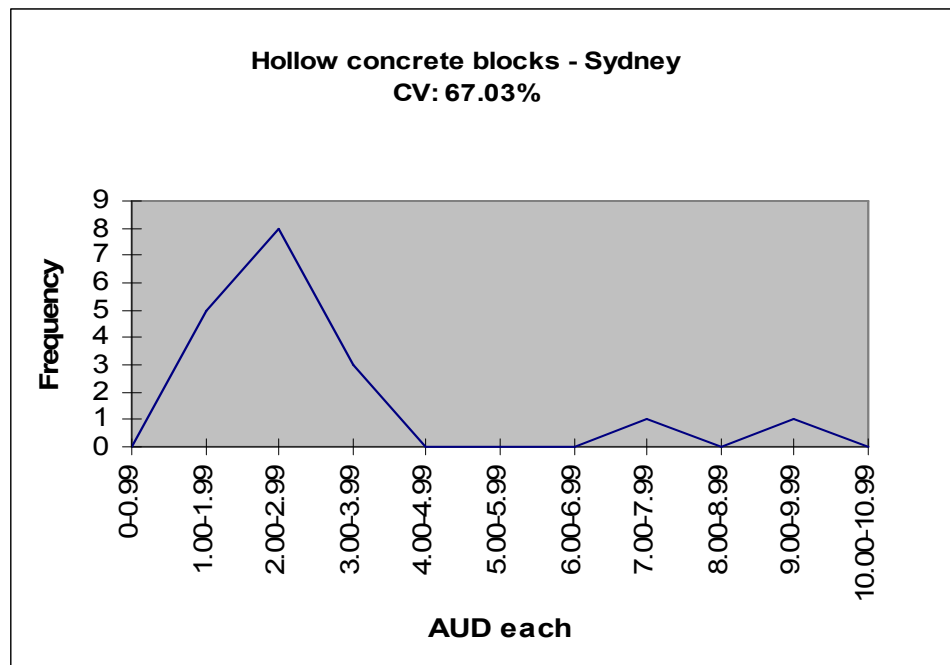


Fig. 5.3 Data distribution for concrete block data from Sydney. Prices are evenly distributed except for two outliers well to the right.

5.3.3.4 Effects of sample size

Too much should not be read into these distributions, however, as the samples are small. Some variations in pricing are always likely to occur simply because estimating is not an exact science. Morrison (1984:63) notes that “the majority of the spread of tender prices is due to the probability distribution which is a measure of the accuracy with which the contractor is able to predict the cost of the work.”

One of the strengths of the BLOC approach is that it separates materials costs and labour costs, and therefore reduces the effects of the most variable factor, which is labour productivity. It is the most variable factor as estimating is the prediction of cost and while quantities of materials, for example, can be calculated reasonably accurately, predicting labour output is much less certain. Labour productivity is embedded in the BLOC as it is based as far as possible on the actual productivity achieved in the reference project. Other factors that may affect quoted rates include varying discounts, differences in local market conditions, differences in interpretation of specifications and so on.

In this study the attempt to gather prices from a number of individuals in each location was intended to reduce if not eliminate the difficulties encountered in the ICP and Eurostat pricing rounds where the use of a single source of prices in each country often produces dubious results. Mean rates obtained from a large sample of prices from each location would be expected to produce more reliable average prices that reflect actual prices paid (Stapel, 2002:7).

Embodied in the rationale of the BLOC method used in this study are the opposing aims of (a) gathering data from multiple sources and (b) developing a process that is relatively inexpensive to implement regularly across many locations. Gathering very large samples of price data would satisfy the first but militate against the second. Added to that is the potential for incorrect pricing and positive skew that has been discussed and which the data gathered in this study exemplifies.

5.4 CENTRAL LIMIT THEOREM

Previous studies (Beeston, 1974; Benjamin and Meador, 1979; Morrison, 1984; Runeson, 1987) have shown that there are often large differences in individual unit rates among different estimates for the same project. Runeson (1987) analysed rates for eight typical BQ items in a large number of successful tenders and found CoVs ranging from 19% to 39%.

The dispersion of the estimate totals, i.e. the sum of all unit rates multiplied by the quantities in each estimate is, however, much narrower. Fine and Hackemar (1970) suggest a coefficient of variation (CoV) of around 5%, Grinyer and Whittaker (1973) suggest 6%. Runeson (1987) found CoVs for tenders varying from 6.9% to 8.8% but this range reduced to 4.66% to 5.53% when outliers were removed.

This shows that there is little or no covariance at the level of individual estimate items, i.e. one error has no influence on the sign or magnitude of other errors. In a comprehensive estimate, such as one based on a bill of quantities, there may be literally thousands of items and positive and negative variations tend to cancel themselves out.

This phenomenon can be explained by the Central Limit Theorem (CLT). This theorem states that the “means of samples of random measurements drawn from a population tend to possess, approximately, a bell-shaped sampling distribution” (Mendenhall *et al.*, 1986:259). In the context here this suggests that the means of many samples of unit rates for a specific item⁹, taken from a large number of estimates, will tend towards a normal distribution. Hence the majority of these sample means will lie close to the centre of the distribution, and the mean of the sample means will closely approximate the population mean. If the sample is large enough the effects of the outliers at the extremes of the normal distribution are negated by the weight of values in the centre of the bell curve.

⁹ For example, a BQ item such as “32MPa concrete in suspended slabs”.

The CLT is used to support inferences made about populations that are based on the means of samples drawn from those populations. Again, in this context, this allows that the average of a set of unit rates for a particular item can be assumed to represent the average of a large set of such unit rates.

5.4.1 Application of the Central Limit Theorem

For the CLT to apply, however, one of two conditions must be met: either the underlying population frequency distribution must be symmetrical about its mean, or a large sample size¹⁰ is required before the distribution of the means will approximate a normal bell-shaped curve. In the study described here the raw data does not meet either condition. The positive skew of the unit rate data has already been described. Reference to the raw data shows that the largest sample for any item comprised 19 unit rates for concrete supply obtained from respondents in Sydney, with as few as two rates for some items in other locations. The skewed distributions and the small samples mean that the CLT cannot be relied on this case.

In the sample used in this research, comprising only 24 items, there is not necessarily any cancelling out effect and the large deviations tend to have a correspondingly large effect on the total cost. This is true of both the effects on average unit rates for individual items and the total cost of the BLOC in the various locations. As a result the retention of rates that show large deviations would create an impression of large dispersions that would not be likely to exist in a complete cost estimate. For obvious reasons this would distort the comparisons not only within each city but also between cities and countries.

Hence, while large variations in unit rates are commonly observed when complete estimates are compared, in the context of this study these variations should be eliminated by discarding items outside a relatively narrow range, in this case generally delineated by the 40% value for the coefficient of variation.

¹⁰ A sample size of 30 is suggested as the minimum needed to produce a useful approximation of a normal distribution (Rumsey, 2003) but this varies depending on the circumstances. Mendenhall *et al.* (1986) suggest that a sample of ten may be sufficient when the underlying distribution is symmetrical about its mean, but when the population frequency is skewed, much larger samples are required.

5.5 VERIFYING MATERIALS DATA

The validation process involved examining the data for each item where a questionable spread of data had been noted. Additional information was sought, where necessary, in order to identify rates which were not supply only rates or were in error in some other way. This approach was not always conclusive, and in some cases queries to respondents went unanswered.

Other authors have acknowledged the need to apply such knowledge and experience in similar circumstances. Morrison (1984) discusses a study conducted by Barnes (1972) in which costs estimated by contractors and out-turn costs for 228 projects were compared. Barnes found that in one out of three cases the estimate was incorrect by 10% or more. Based on his professional knowledge he discarded a group of projects from the dataset where he believed that the contractor involved was “virtually out of control in his estimating”. He then assumed that a figure of 7% was more realistic.

Stapel (2002:8) also acknowledges the problem:

The issue of the validation of the prices is an important but difficult one, because there is no ‘right answer’. When it comes to PPPs results can only be assessed on a qualitative basis, i.e. whether they ‘look’ or ‘feel’ right.

In view of the points discussed above it was deemed necessary to exercise some discretion based on professional skill and experience in order to eliminate as much as possible prices that were most likely to distort the average rates used in the BLOC calculations described in the next chapter.

5.5.1 The verification process

As part of the process of deriving quantities for the BLOC the items in the basket were priced at 2003 Sydney rates using rates obtained directly from suppliers and published data (Cordell, 2003). Current rates were also gathered and the BLOC priced at 2007 prices as a benchmark for the rates obtained from the survey. The 2007 benchmark BLOC provided appropriate rates for the various items in Sydney, and to some extent in the other Australian cities, and in most cases supply and fix rates for the three locations could be identified with confidence. Where there was any

doubt an opinion was sought from an appropriate supplier and rates were also compared to those available in published construction cost books such as Cordell (2007) and Rawlinsons (2007a). Cordell, in particular, provided a useful cross-check as the rates in that publication are given with labour/materials breakdowns. Where such checks suggested strongly that a given price rate was too high to be a legitimate supply only rate the rate was not included in the final dataset.

5.5.2 First analysis

Based on the raw data as described just four materials items¹¹ returned CoVs of less than 40% across all locations while a further three¹² showed a CoV of more than 40% in only one location. All the labour items had a CoV below 40% while the responses to the question regarding contractors' margins showed a CoV greater than 40% in only one location.

Six materials items (i.e. 25% of the materials items) returned CoVs of more than 40% in four locations, while one, "non-fire rated doors" produced a CoV of over 40% in all locations. Further investigation of the data for all items with CoVs above the nominated benchmark was done in order to identify rates that required confirmation. In many cases, particularly with data from Australia, this could be done easily based on the 2007 Sydney benchmark BLOC and the published prices mentioned above. In Sydney particularly prices could be refined based on information gathered by means of personal communications and in some cases this was extended to include Melbourne and Brisbane.

5.5.3 Second analysis

The spreadsheet containing the raw data was copied to a fresh worksheet and rates checked for consistency. Rates that were considered not to be correct for the item stated in the survey were modified to appear as text and therefore remained visible but were no longer included in the calculations of statistical factors such as mean and median. These included those noted by respondents as "supply and fix" and some

¹¹ Concrete, bar reinforcement, fire rated door and carpet.

¹² Paint, vanity basin and window unit.

that were noted as having been priced in an unusual way¹³ which made it problematic to include them in the results with any confidence.

Rates were examined item by item and discrepancies identified. Respondents were asked for clarification of any problematic rates that they had provided, however, these queries were not always answered and information had to be sought from other sources. In some cases the queries led to discussion of the pricing of particular items and in several instances it became apparent that in some areas certain items presented significant difficulties for respondents. Some of these difficulties are discussed below¹⁴. In many cases adjustments were made based on published rates, or prices obtained directly from suppliers. Additional information was also sought from individuals in quantity surveying and contracting firms who had not taken part in the actual survey. While the notional benchmark of 40% CoV was used to identify items where there was a broad spread of rates, as pricing patterns became apparent all rates were scrutinised and a decision made in each case where rates appeared unusual in comparison to the rest of the data. The following analyses of the data for the various items in the BLOC illustrate the process.

5.5.3.1 Concrete

BLOC item: *32MPa ready mixed concrete, delivered to site, supply only.*

This item produced 51 useful prices from 53 responses, and proved to be the most consistently priced item in the basket, with CoVs (by city – calculated after data validation) ranging from 5.85% to 18.67%. Two rates from Melbourne (both \$240/m³) were disregarded as it appeared that they were supply and fix rates, based on the other five rates from that location (mean: \$139/m³; median \$128/m³) and published rates (material supply: \$175.25/m³; supply and place in suspended slabs, pumped: \$253.32/m³) (Cordell, 2008).

¹³ For example, two respondents supplied prices for concrete blocks in \$/m² with no indication of whether the price was supply or supply and fix; others priced air conditioning ductwork in \$/m² of face area.

¹⁴ Obtaining prices for the supply, or even supply and installation of post-tensioning steel in New Zealand, discussed later, provides a good example of the problems.

Cordell's rate for concrete supply in Sydney (\$214/m³) is well above the average discounted price that contractors pay (\$160/m³, ascertained by direct enquiries to De Martin and Gasperini in Sydney: Spinetti, 2008). The data from Melbourne suggests that their supply rate for that location is similarly above actual rates paid; this supports the decision to disregard the \$240/m³ for this item. Some rates from Phoenix were queried to ensure that the use of different units (cubic yards and cubic metres) did not produce incorrect prices. It was notable that some of the Phoenix estimators equated yds³ and m³ without being aware that in volume measurement the different units produce a 30% difference. Consequently in some instances rates per yd³ were given as being equivalent to rates per m³. Where this was identified rates were adjusted to account for the difference in measurement.

5.5.3.2 Plywood for formwork (formply)

BLOC item: 19mm thick plywood for formwork to produce a medium standard finish that is ready for paint (supply price only)

This item produced 30 useful prices from 46 responses, with CoVs ranging from 5.89% to 38.96%. This item caused some pricing problems with prices as high as AUD\$120/m² quoted, most likely due to rates being given for finished formwork rather than just supply of plywood. This is not surprising as formwork, at least in Australia, is generally carried out under subcontracts that include supply of materials and consequently estimators and quantity surveyors are not necessarily familiar with the base purchase price of these materials¹⁵.

Advice on Australian prices was sought from Royal Plywood, a large Sydney-based supplier. Discussion with their representative revealed that there are two general categories of formply available, i.e. locally manufactured and imported. The imported product is cheaper than the locally produced material but is of inferior quality and therefore cannot be re-used as many times as the Australian product.

¹⁵ One respondent queried the mention of paint in the item description, pointing out that formwork is not usually painted. This is another example of how different interpretation of information can lead to inconsistent pricing.

Royal Plywood's advice was to ignore supply rates above \$30/m² based on the cost of locally produced plywood; it was assumed that the lower re-use potential of the imported plywood would offset its lower supply cost. In Auckland and Singapore reasonably closely grouped rates were obtained with only one from six discarded from Auckland and two from seven discarded from Singapore. Phoenix produced a wider range of rates (CoV 35.28%, 5.6% difference between mean and median rates), however, all rates were retained as confirmation of average prices was not available and the spread of rates was below the 40% CoV level.

5.5.3.3 Bar reinforcement

BLOC item: *16mm diameter high yield steel reinforcing bar (supply only rate for bars cut, bent and delivered to site).*

This item produced 40 useful prices from 45 responses, with CoVs ranging from 3.43% to 26.25%. Five rates were disregarded based on similar evidence to that described in the concrete item. In Sydney in early 2008 the list price for bar reinforcement as described was around \$1700/tonne (Cordell, 2008). Further discussion with Smorgon, a major supplier, established that for quantities similar to those in the reference project contractors could expect to pay a discounted price of around \$1100/tonne.

This item illustrates well the problems of attempting to obtain "average" or "actual" prices paid. Cordell's published supply price is based on list price and therefore does not accurately reflect market prices paid by contractors. The mean rate provided by quantity surveyors (\$1436/tonne) was considerably higher than the mean contractors' rate (\$1144/tonne) suggesting that contractors quoted supply prices that were, in fact, actual prices paid and included substantial discounts in line with those advised by Smorgon. As the CoV for this item for Sydney, with all the rates supplied by respondents included (13 in all), was only 23.40% all rates were retained in the dataset. The resultant mean (\$1388/tonne) did not differ greatly from the median (\$1300/tonne) and was therefore deemed to represent a valid average actual price given that not all firms would be able to command the sort of discounts that others may enjoy.

5.5.3.4 Precast concrete

BLOC item: *Precast concrete wall panel – 7600 x 2800 x 150 thick façade panel with openings for windows – 2.5m³ concrete, 150kg reinforcement.*

Respondents were asked to price the typical panel on a cost/m² or whole panel basis. Most chose to price per m²; the panel prices were converted to a cost/m² rate for inclusion in the dataset. An elevation and a section of the typical panel were included in the survey.

After validation 39 useful rates were retained from the original 51. Raw rates varied widely in four locations with rates ranging, for example, from AUD\$68 to \$350/m² in Melbourne. Discarded rates were generally high and appeared to be supply and fix rates. Analysis of rates for precast concrete in Cordell (2008) (see Appendix A1) suggests that labour is the major component in precast rates (53-58%) in the Australian cities with materials (25-29%) and plant (16-21%) contributing less.

Cordell's 2008 rates (supply and install) for a typical wall panel are \$397/m², \$363/m² and \$351/m² for the three cities. The BQ rate in the reference project (2003 prices) was \$362/m² (supply and install, including margins and GST). Allowing for cost increases over five years the BQ rate and the Cordell rate are similar. By comparison RLB (2008a) suggest a labour: materials ratio of 20:80 for precast concrete, with no component for plant costs. This is quite different to the breakdown suggested by Cordell. Advice was sought from Hanson/Rescrete, a major precast supplier in Sydney; their advice was that panels of the sort described would cost around \$180-200/m² hence Australian rates exceeding AUD\$250 were discarded.

All Auckland rates were retained as the CoV was under 12%; rates from Singapore were not widely spread except for one high rate that was discarded. Three high rates from Phoenix were discarded following advice from a local quantity surveyor which suggested that those rates were more indicative of supply and fix rates. Apart from the high rates, most likely being supply and fix, this item worked reasonably well.

5.5.3.5 *Stressing steel*

BLOC item: *Stressing steel – strand only*

For several reasons this item proved to be unsatisfactory. The greatest problem was a general lack of knowledge among respondents of supply prices for the components of prestressing systems, including the most obvious component which is the multi-wire steel strands that are used in varying numbers to make up tendons embedded in concrete members such as slabs and beams. Obtaining consistent prices for this item was not possible and in all only six rates across the five locations apart from Phoenix were obtained that appeared to be reasonably close to expected rates, based on a supply cost obtained in discussions with a major prestressing subcontractor in Sydney (Austress Freyssinet). In contrast 20 responses were obtained that gave rates that appeared to be more consistent with subcontractors' all-in rates for the complete prestressing (post-tensioning) operation. Supply only data from Phoenix was quite consistent (four usable rates from six responses) and most rates were quoted as supply only for steel strand.

Rawlinsons in Australia (Rawlinsons, 2007a) give indicative prices for estimating purposes for average spans and slab thicknesses in terms of both cost per tonne of reinforcement (for various tendon lengths) and cost/m² for typical slabs. While a range of rates is given the range is not large, with a median price in Sydney for 40m tendons of AUD\$8250/tonne ranging up to \$9650/tonne for tendons 10m long. Cordell give a median price for all three Australian locations for post-tensioning with 30m tendons of \$6800/tonne. The difference between rates suggested by Rawlinsons and Cordell further illustrates the variability in prices for this item of work.

The raw data from Auckland further demonstrate the problem: only four rates were entered: NZD\$950, \$1150, \$2000 and \$5000 (NZD/tonne). Rawlinsons New Zealand price book (Rawlinsons, 2007b) gives very little information regarding prestressing of any sort and makes no mention at all of typical post-tensioning, which is a very common process in Australia. Further enquiries to several respondents in Auckland produced little additional information apart from ascertaining that subcontractors were reluctant to suggest any sort of indicative rate (Hanlon, 2008, pers. comm.)

without specific design details of tendon lengths, number of anchorages and the like. One respondent advised that strand is not manufactured in New Zealand and provided the figure of NZD\$1150/t based on the price paid for imported strand for a recently completed project. This provided a useful benchmark for validating supply prices from Auckland for this item, however, no supply price was obtained for Brisbane, and only one was entered for Singapore and Sydney (apart from the benchmark price obtained from Austress). By comparison only one all-inclusive rate was obtained from Phoenix while one rate that was possibly all-inclusive came from Auckland. The rate from Phoenix was expressed as USD per pound (\$2/lb) and was given together with a supply rate (\$1.50/lb) – this suggests a very high ratio of supply price to total price. The ratio is much higher than the ratio in Australia or New Zealand where the supply of strand is only around 20% of the all-inclusive sub-contractor rate for post-tensioning. This raises more doubts about the consistency of the pricing for this item. In view of the difficulties in obtaining prices with a consistent basis, and the significant variations in price suggested in the published rates for Australia the stressing steel item was eventually discarded from the BLOC.

5.5.3.6 Structural steel

BLOC item: *Hot rolled steel sections – fabricated. Supply and delivery of fabricated members – exclude erection*

For this item 32 rates of 43 obtained were retained. The rates discarded were all well above the rates that were retained. While in some cases it is likely that the high rates were supply and fix, there has been great volatility in the market for steel due to shortages caused by very high demand from China. These shortages have pushed prices in other countries, such as the USA and Australia, to unusual levels. Wal Zagoridis from Arkibuilt quoted prices for steelwork in relatively small quantities in the order of \$AUD10,000/tonne, however, evidence from other sources (e.g. Cordell) suggests that these prices are unusually high. Some survey respondents noted that prices vary markedly depending on size and type of sections, complexity of fabrication, number of attached fittings and the like. As a result settling on a representative average price for fabricated steelwork is problematic; in the dataset a wider spread of results were retained with the CoVs for Sydney and Melbourne both a little over the 40% limit, and for Singapore and Phoenix in excess of 30%. Except

for Melbourne differences between mean and median rates (based on the validated data) were not marked (ranging from zero to 8.2%) while Melbourne showed a difference of 24.2%. Structural steel appears to be a less than ideal item for the basket, at least unless there can be a more specific description of what is to be priced.

5.5.3.7 Concrete blocks

BLOC item: *390 x 190 x 190 hollow concrete blocks – plain finish*

This item produced 38 useful results from the 43 gathered initially. Discarded rates were both high and low suggesting that some prices were supply and fix while others may have been prices for a different item (e.g. smaller blocks). Verification of reasonable prices was done by querying respondents and this sometimes produced a revised rate, e.g. one rate from Phoenix was initially given as \$USD7.00 per block; this was queried and the respondent noted that the rate supplied was for a “ground-face block” rather than a plain hollow block and he subsequently amended the rate to \$1.50 per block. It is significant to note that in this instance it would have been reasonable to expect that the rate was wrong because it was supply and fix, however, the error was in pricing an item of a different specification.

5.5.3.8 Toughened glass

BLOC item: *10 thick toughened glass for frameless glass walls – supply cost of glass only*

This item did not produce a strong set of results. Eight of the 45 respondents who completed the main survey did not enter a price for the item; of those that were entered only 22 rates were retained from a total of 37. CoVs for the validated data ranged from 10.48% to 39.19% suggesting that even after more than 40% of the initial rates were discarded the remaining rates were still not very consistent.

Discarded rates were generally high, and in some cases extremely high, e.g. one rate from Melbourne was given as \$AUD800/m² - discussions with a major Sydney supplier suggest a supply rate of \$170/m². In this case it is most likely that supply and fix rates for complete frameless glazing systems were given. Such work is carried out by specialist sub-contractors who supply and install all components and

materials (glass, metal fittings, sealants and so on) and therefore supply costs for glass alone may not be well known by estimators or quantity surveyors who would routinely deal with all-in sub-contract rates for frameless glazing.

Differences in terminology and typical specification in various localities may also lead to inconsistency in rates; in some places laminated glass is used rather than toughened glass, and there are varying rates for plain glass and solar control glass. Additionally there are varying types of “toughened glass” including annealed, heat strengthened and fully tempered glass. All have different properties and are priced differently. A tighter specification is required if consistent prices are to be obtained, however, such a level of prescription may result in respondents choosing not to price the item at all if it does not correspond to a material that is typical in their location.

5.5.3.9 Windows

BLOC item: 1600 x 1600 window with one fixed pane, powder coated aluminium frame, glazed with 6mm grey laminated glass

In spite of the clear and specific description of this item the rates obtained were well spread with CoVs before validation ranging from 21.09% to 56.45%; 32 of 41 rates were retained and after validation the range of CoVs was 13.48% to 34.05%. Only three of the seven rates obtained from Singapore were retained as the remaining four were noted by the respondents as supply and fix.

Some of the variation in pricing, apart from those that suggested supply and fix pricing, may be due to differences in frame type. In the reference project the frame specified was of a type that results in the glazing being flush with the plane of the exterior wall surface; such framing is used both to produce a smooth look on the outside of the building and also to maximise usable interior space as measured under agreed standards for the calculation of rentable area in commercial buildings (PCA, 1997). Any price differential that choice of framing may make is not reflected in the item description and could not be identified in the results.

5.5.3.10 Sawn stone

BLOC item: *50 thick sawn sandstone facing*

Nine respondents who returned completed surveys did not enter a price for this item; 21 of 31 responses were retained. Discarded prices were all high and appeared to be supply and fix; several Australian prices were \$AUD500/m² and above yet a supply price of \$150/m² was obtained directly from a major Sydney supplier. The validated data showed CoVs ranging from 17.17% to 40.60% and variances between mean and median rates ranging from 1.3% to 12.6%. This shows that even after a third of the responses were discarded pricing was variable. It is not clear whether this was because the material is not as common in some locations as in others or perhaps variability in the quality of stone available in some locations led to pricing differences. The item description was clear and straightforward hence the variability in prices was unexpected.

5.5.3.11 Fire rated door

BLOC item: *Single one hour fire rated doorset including frame and hardware – ready for paint*

This item produced quite consistent results with just one price discarded from 42 received, and that was discarded only because the respondent noted the rate as “supply and install”. CoVs ranged from 25.21 to 32.78% suggesting that while there was some spread of prices it was not excessive and the spread was similar in all locations. The item description could be improved by defining more closely what hardware was to be included in prices as in some places automatic door closers are required on fire doors but this may not be universal. The inclusion or exclusion of closers could have affected prices but most respondents did not detail what they had included in their price.

5.5.3.12 Non-fire rated door

BLOC item: *Single non-fire rated internal door excluding frame and hardware – ready for paint*

For a variety of reasons this item did not produce good results. Only 21 of 40 rates were retained, and in two locations (Melbourne and Phoenix) only two useful prices

were obtained. Most discarded rates were very high suggesting that either there was confusion about inclusion or exclusion of frame and hardware, or that respondents gave supply and fix rates. In Phoenix only three respondents entered a rate for the item; two were deemed to be too high based on an independent rate obtained by a direct, detailed enquiry to a local quantity surveyor. Some respondents from Phoenix noted that doors are generally sourced as a package including frame and hence they were not familiar with a supply only price for the door alone. The data from Melbourne demonstrate the variability in the raw data; prices before validation ranged from AUD\$85 to \$1100. After discarding five rates ranging from \$600 to \$1100 only two rates were retained: \$85 and \$225. These were markedly different, however, the resultant mean rate of \$155 was reasonable, if a little high, as Cordell's rate for the supply of similar doors is \$110 (Melbourne) and \$143 (Brisbane). Pricing for this item could have been more variable than expected due to two other factors:

- internal doors may have hollow or solid cores – the type of core was not specified in the item description and while respondents could have given an average price to cover both types there was no instruction to inform respondents of this
- in some locations (notably Sydney) there is strong competition between door manufacturers and suppliers and discounted “specials” are routinely advertised with prices well below normal list price – one Sydney price of \$25, which is well below the mean rate (\$110), may be explained by this factor.

5.5.3.13 Plasterboard (sheetrock)

BLOC item: *13 thick gypsum plaster sheet lining*

While this appears to be a very simple item for pricing half of the prices obtained for this item were discarded, with only 19 rates retained out of the 38 entered. In most cases the discarded rates were very high, suggesting supply and fix. The variability of responses is illustrated by the results from Singapore: before validation rates ranged from \$SGD4/m² to \$55/m².

Inconsistent pricing was largely due to the typical procurement of plasterboard and similar linings under all-inclusive sub-contract arrangements with the sub-contractor

supplying all materials and labour. A number of respondents, when queried about high rates, replied that they were only accustomed to dealing with all-in rates for this sort of work and were therefore not familiar with current supply rates. This would imply that even if they were aware of current list prices they would have little, if any, information regarding the sort of discounted prices that a major sub-contractor may be able to negotiate.

The \$SGD55/m² rate mentioned above was queried and turned out to have been a supply price for two layers of plasterboard plus framing and insulation – this demonstrates how serious errors can arise even when quite straightforward items are priced if respondents do not exercise reasonable care when reading and completing the survey.

5.5.3.14 *Ceramic tiles*

BLOC item: *200 x 200 ceramic floor tiles – medium standard*

This item produced reasonably consistent results with 31 prices retained out of 43 entered in spite of the potential for significant variations in price due to varying quality of tiles available. Most Australian prices discarded were considered to be too high either because they were likely to be supply and fix or that they represented a supply price for tiles of a quality that would be beyond that expected in a building similar to the reference project. No prices were discarded from the datasets from either Singapore or Auckland as the raw data exhibited CoVs of 36.03% and 30.30% respectively. Two were discarded from the Phoenix data as they were considered to be too low to be applicable; clarification of these rates was sought from respondents but no further information was obtained.

5.5.3.15 *Carpet*

BLOC item: *80/20 wool blend carpet – excluding underlay*

This item produced excellent result with only 3 rates discarded from 49 entered. Two of those discarded were noted as “supply and install” by the respondents while one from Phoenix was discarded as it was well below all other rates from that location;

clarification of that rate was sought from the respondent but no further information was obtained.

5.5.3.16 Paint

BLOC item: *Low sheen acrylic paint – interior use*

Only five of 43 rates entered were not used; of those five one was discarded as the respondent entered a rate in \$/m², the remainder were all Australian rates that were considered to be too high as they were prices in the order of those that a handyman would pay for a one litre can of paint at their local hardware store rather than rates that would be typical of a tradesman or sub-contractor buying paint regularly in large quantities. Sydney rates were confirmed in discussions with Wal Zagoridis of Arkibuilt and Arthur Poulos, a painting sub-contractor. Cordell gives a supply rate of \$AUD10/litre for the three Australian locations and thus provided further confirmation of the general price levels for this item.

All rates from Auckland and Phoenix were retained as CoVs were well below the 40% limit. It was difficult to get confirmation of prices from Singapore so all Singapore rates were retained although the CoV was 57.59%

5.5.3.17 Timber joinery

BLOC item: *Timber hotel wardrobe/minibar unit, 2340 long x 2265 high x 645 deep, timber veneer finish on manufactured timber (MDF) substrate, including doors, drawers, mirror, stone bench top etc.*

Elevations and sections of the typical unit were included in the survey.

Given that installation costs for joinery items such as the one detailed represent a significant part of the cost of hotel projects (over 4% of the adjusted project cost in the case of the reference project) it was considered to be important that prices for such work were included in the BLOC. In spite of respondents having been provided with detailed annotated drawings of the unit to be priced the results for this item were generally widely spread. It was determined, at least for Australia, that installation costs represent a relatively small part of all-inclusive rates for these items. Cordell

suggests labour costs for installation of joinery units such as vanity counters and custom made kitchen cupboards that are fabricated offsite and delivered as units ready for installation to be only 4-10% of unit rates. It is unlikely therefore that the large variation in prices reflects the inclusion of supply and fix rather than supply only rates. It is more likely that the variations reflect several other factors:

- in some cases respondents indicated that they were not sure of the rate they supplied as a precise answer would have required enquiries to a specialist fabricator; one respondent from Auckland suggested a price range of NZD\$7,500 to \$12,000 per unit – not only was this a generous range but the lower limit was well above any other rate supplied from Auckland.
- even with detailed drawings there is considerable potential for price variations when prices have been obtained from specialist suppliers due to factors such as market conditions and the amount of work they have on the books and the availability of different materials (with different prices) for components such as benchtops that still fit the given description (e.g. “stone benchtop”)
- bespoke items such as large joinery units vary in price depending on complexity and on the method of production, particularly the degree of standardisation of component parts and the volume of standard or identical units being produced.

The majority of prices were retained (27 of 34) in spite of the spread of the data. Of those discarded one was noted as “supply and install”, the remainder were discarded as they fell well outside the range of the other prices from their locality.

5.5.3.18 *Low voltage electrical cable*

BLOC item: *PVC insulated and PVC sheathed low voltage cable suitable for domestic power circuits (2C+E, 2.5mm², PVC/PVC)*

This item produced poor results as many respondents chose not to enter a price, and the prices that were obtained varied significantly. In Sydney, for example, only four rates were entered, ranging from AUD\$0.80/m to \$2.00/m (CoV 41.77%, the lowest for any location); in Phoenix five rates were obtained, ranging from USD\$0.36/m to

\$1.85/m (CoV 68.36%). Twenty two of the 26 prices entered were retained in order to get some usable average rates although the prices obtained showed little consistency.

While appearing to be a straightforward item to price it appears that few of the respondents were familiar with the supply price for this material, no doubt as electrical work is seldom measured out in detail by quantity surveyors or head contractors as electrical work is covered by all-inclusive sub-contracts. This proved to be a common problem with a number of engineering services items. In Phoenix at least unit rates for supply vary considerably depending on the specific cable used and how it is purchased; for example, as Table 5.6 shows 15 Amp and 20 Amp 3 wire sheathed cable costs vary considerably depending on the length of roll and either type might be substituted for the item called for in the BLOC.

Roll	15 Amp	20 Amp
50ft	0.78	0.99
100ft	0.59	0.82
1000ft	0.29	0.47

Table 5.6 Cost of electrical cable per foot (USD) (Home Depot, 2008)

Given the size of the reference project it is reasonable to assume that the material would be bought in large rolls or coils, however, the price differences illustrate the difficulty in obtaining representative average rates.

5.5.3.19 Low voltage downlight

BLOC item: *Low voltage recessed downlight*

Manufacturer's drawn details of the typical unit were included in the survey.

This proved to be another unsatisfactory item with the raw results showing CoVs ranging from 38.27% (the only CoV below 60% for this item) to 137.76%. After removal of some obvious outliers CoVs still ranged from 25.44% to 104.13%. The inconsistency in pricing is likely due to a combination of factors with respondents not being familiar with unit rates for electrical components (as in the case of the cable item) and a broad range of types, designs, materials, quality and finishes of luminaires being available on the market.

An indicative price for the particular downlight specified in the reference project was obtained from the Sydney importer/supplier and this was used as a reference point in the validation process. Short of attempting to obtain prices for the specified unit in all locations, with no guarantee that that unit as specified would be available in all locations, there was little that could be done to further verify prices for this item.

5.5.3.20 *Vanity basin*

BLOC item: *Semi-recessed white ceramic vanity basin*

Manufacturer's drawn details of the typical unit were included in the survey.

This item produced a consistent set of prices with 33 of 36 rates retained; of the three rates discarded two were considerably lower than others in their group, the other much higher. The low prices are so far below the rest of prices that they are either incorrect (e.g. they are for a product of lower standard) or they may be legitimate but reflect discounts that few contractors could command. The high price is consistent with a supply and fix rate. The 33 prices retained show some dispersion around the mean with CoVs ranging from 21.84% to 32.76%. Such a spread of rates is not unexpected for a product that is available in many similar but different shapes and sizes and consequently the fairly consistent pricing suggests that this is a very useful item for the BLOC.

5.5.3.21 *Cast iron pipe*

BLOC item: *100 diameter cast iron waste pipe*

This item did not produce good results, with only 20 rates retained from 32 entered. Two of the 20 were from sources other than survey respondents in two locations (Auckland and Brisbane) as the survey produced only one valid rate from each city. All of the discarded rates were well above expected supply only rates and were assumed to be supply and fix. Additional information that suggested that the item is not manufactured locally and is therefore seldom used (hence the poor response from Auckland) was obtained from a quantity surveyor in New Zealand. As only one

useful rate for this item was obtained from respondents in Brisbane Cordell's rate was added to the survey data for that location.

5.5.3.22 *Copper pipe*

BLOC item: *15 diameter copper water pipe*

Only 21 of 34 rates for this item were retained. The retained rates showed significant dispersion which reflects, in some localities at least, the potential for large differences between list prices and possible discounted prices. Most discarded rates were very high and were possibly supply and fix, however, in New Zealand for example there are large differences between list prices and actual prices paid for similar items. Rawlinsons (2007b) give a supply price for 15 diameter copper pipe of NZD\$27.84/m, yet give a unit rate for the supply and installation of the same pipe of \$43.50/m with a note explaining that the unit rate is based on a 25% discounted supply price and that “discounts can be *much greater*” [original emphasis].

Four rates were initially obtained from Auckland: NZD\$7.36, \$9.10, \$25.00 and \$45.00/m – the lower rates were from contractors, the higher from quantity surveyors. To resolve the apparent anomalies in these prices a detailed query was sent to another quantity surveyor, including the four rates and requesting some further information. The QS consulted two suppliers and once again received conflicting answers; the rates quoted were \$49.00 and \$9.00. Apparently the \$49.00 price was for an unspecified standard length, while the \$9.00 rate was per metre and came with the proviso that it could be obtained more cheaply if large quantities were involved. In view of this advice the \$9.00 rate was included in the data set and the two high rates were discarded. The resultant mean rate of NZD\$8.49/m was considered to be a valid representative rate for this material in the context of a project such as the reference project.

5.5.3.23 *Rigid duct*

BLOC item: *500 x 300 rigid sheet metal air conditioning duct excluding insulation.*

Only 26 rates were obtained for this item and of those just 18 were retained. Mechanical work, like electrical work, is generally done under an all-inclusive sub-

contract and details of component costs are not readily available. As a result, if respondents priced this item at all their prices varied considerably. The four rates from Sydney, for example ranged from AUD\$13.00/m to \$150.00/m. A QS specialising in services costs (Nowak, 2007) provided an indicative price of \$88.00/m for the duct specified in the BLOC and this was used as benchmark for validation of Australian prices.

Pricing was further complicated in Phoenix as ductwork is normally priced quite differently in the USA; rather than pricing ducts of varying cross-sectional size per lineal metre all ductwork is priced in dollars per pound of material. Most respondents gave a rate in \$/m in the survey but they ranged from USD\$12.00/m to \$183/m. A local QS in Phoenix (an Australian and therefore more accustomed to costing in lineal metres) was asked for clarification. Based on his rate of USD\$26.00/m the five rates that were grouped reasonably closely (ranging from USD\$12.00/m to \$26.25/m) were retained while the two high rates (\$59 and \$183) were assumed to be errors or supply and fix rates and were therefore discarded.

5.5.3.24 Flexible duct

BLOC item: *200 diameter flexible air conditioning duct.*

Only 26 rates were entered by respondents for this item of which 21 were retained. In two locations (Auckland and Brisbane) CoVs remain well above 40%. Again it seems that many respondents were not familiar with unit rates for an item usually included in a larger sub-contract amount and as a result they chose either not to price the item or to insert a notional rate. There were also some specification issues, e.g. in the USA flexible duct constructed on a steel wire helix includes 50mm (2") thick insulation; in Australia flexible duct is typically used only for the final run to a diffuser and is generally made from a thin foil material on a metal helix without insulation.

5.5.3.25 Labour rates

BLOC items: Respondents were asked to enter rates as instructed for four classes of labour, described as Tradesman Group 1 (e.g. electrician or plumber), Tradesman Group 2 (e.g. carpenter, bricklayer), Tradesman Group 3 (tiler, carpet layer) and

semi-skilled labourer (e.g. steel fixer). The instructions to respondents were as follows:

Please complete this section of the survey by inserting typical all-in labour rates per hour such as a contractor or sub-contractor would use in calculating unit rates for items in a tender, exclusive of profit and overheads, and exclusive of VAT or GST.

The grouping of labour was based on nominal Australian labour categories and while it was expected that there may be some variation in how different types of labour would be classified and priced between locations the results obtained were reasonably consistent. Only one set of pre-validation responses (semi-skilled labour in Phoenix) returned a CoV greater than 40%; one outlier response was discarded as it was a rate for semi-skilled workers that was greater than that for two of the classes of skilled labour and was totally out of step with all other labour rates from this location.

In all but one location the hierarchy of hourly rates of pay was the same as expected based on Australian experience, i.e. rates decreased stepwise from Tradesman Group 1 to semi-skilled labourer. Singapore was the exception but the difference was very small with average rates for the three classes of tradesman being SGD\$12.13, \$11.63 and \$12.00/hour and a rate for semi-skilled labour of \$9.67/hour.

5.5.3.26 Margins

BLOC item: *What would be a typical contractor's margin (profit and general overheads) on a project of this type (200 room, 3-4 star suburban hotel)?*

Although not all respondents answered this question 48 responses were obtained, of which 47 were retained. The discarded rate (17.5%) was more than three times the mean rate (5.76%) and 7.5% higher than the next highest entered rate for that location. It was considered to be an outlier that was either an error or perhaps a rate that reflected an overall profit target for the company for whom the respondent was working (a multi-disciplinary development and construction company) rather than purely a margin to cover overheads and profit on building activity alone.

Responses were dispersed around the mean to varying degrees with CoVs ranging from 16.73% to 44.21%, with CoVs for four of the six cities being greater than 30%. The average margin across the three Australian cities surveyed was 6.02%, which aligns reasonably well with operating profits reported by the ABS (ABS, 2004) for non-residential/non-building construction in 2002-3¹⁶ of 6.2%. This suggests that the range of values collected produced a sound average for this item in Australia at least.

5.5.3.27 Preliminaries

BLOC item: *What would you estimate Preliminaries (site/job specific overheads) to be for the same project as a percentage of total project cost?*

This item worked well except in regard to Phoenix. Mean responses from the other five locations were all in the 13-16% range while the mean from Phoenix was only 5.67% (range: 4.5-7%). Discussions with an estimating lecturer at Arizona State University (Sullivan, pers. comm., 2008) and a local QS (Hedley, pers. comm., 2008) established that the normal method of pricing job specific overheads and non-building costs¹⁷ in the USA is substantially different to the method used in the other locations surveyed. Specifically costs such as site sheds and supervisory staff are costed separately to some costs that are included as part of preliminaries in other places. Most significant of these are major plant, such as tower cranes and scaffolding, and insurances. These items may add 3-4% to the general requirements (i.e. sheds and the like). Some firms include labour on-costs¹⁸ (additional costs related to labour over and above base rates such as long service leave and workers' compensation insurance) as part of job overheads rather than including them in unit rates for work items as is conventional practice in Australia for example.

Personal observation of a number of building sites in the city of Tempe, one of the smaller cities that make up Greater Phoenix, suggested that site conditions and access

¹⁶ The latest figures available.

¹⁷ Understood as "preliminaries" in countries where UK style cost management is the norm, i.e. generally Commonwealth countries, which therefore includes all the other locations in this study.

¹⁸ Referred to as "labour burden" in the USA.

generally do not constrain construction work as much as is common in places such as Sydney and Singapore. Most of Phoenix is very flat, streets are wide and many developments include extensive open areas for carparking which can be utilised for material storage, site accommodations, mobile crane movement and operation and so on. This makes site organisation noticeably simpler than in the other cities surveyed and reduces some overhead costs.

In view of the local knowledge acquired, and based on the opinions of the two informants noted above, the survey responses to the preliminaries question were discarded and an estimated rate of 12% was used for Phoenix. This was deemed to give a reasonable total cost for those items included in Preliminaries in the other cities. For the other five locations all 41 responses were retained as in all cases the CoV for this item was less than 25%.

5.6 FINAL DATASET

On completion of the validation process 25% of all the rates obtained, both from respondents to the survey and by direct requests to others who had not actually completed the survey (e.g. the locally-based QS in Phoenix), had been discarded. The retention rate for prices for the seven services items was similar with 24% of services rates discarded. Table 5.7 shows the distribution across the various locations.

Location	All rates discarded	Services rates discarded
Sydney	21%	24%
Melbourne	34%	28%
Brisbane	33%	26%
Auckland	14%	28%
Singapore	36%	27%
Phoenix	15%	23%

Table 5.7 Proportion of unit rates discarded in the validation process

The data shows that more robust overall datasets were obtained from three locations with a third or more of rates from the other three discarded. The possible relationship between the quality of data and the resultant PPPs is discussed in Chapter 6.

Table 5.8 shows the key values for each item in the BLOC after data validation. As before items with a coefficient of variation exceeding 40% are highlighted.

MATERIALS							
	Concrete \$/m3	Formply \$/m2	Rebar \$/t	Precast \$/m2	Stress steel \$/t	Hot rolled sections \$/t	Blocks Each
SYDNEY - AUD							
Mean	169.66	24.53	1388.08	173.50		3855.25	2.34
SD	18.90	5.67	324.81	39.25		1600.79	0.65
CoV	11.14%	23.13%	23.40%	22.62%		41.52%	27.74%
Median	169.00	25.00	1300.00	175.00		4000.00	2.38
AUCKLAND - NZD							
Mean	187.83	25.72	1564.00	170.00		2450.00	2.26
SD	21.62	3.95	385.33	20.00		665.83	0.26
CoV	11.51%	15.35%	24.64%	11.76%		27.18%	11.65%
Median	179.50	27.00	1700.00	170.00		2650.00	2.26
SINGAPORE - SGD							
Mean	131.33	11.20	1358.57	115.83		3656.25	1.38
SD	9.27	2.72	201.78	36.39		1299.30	0.49
CoV	7.06%	24.26%	14.85%	31.42%		35.54%	35.31%
Median	130.00	11.28	1300.00	117.50		2925.00	1.50
MELBOURNE - AUD							
Mean	139.00	24.00	1240.00	167.60		2733.33	2.34
SD	25.87	1.41	82.06	58.45		1101.51	0.08
CoV	18.61%	5.89%	6.62%	34.87%		40.30%	3.63%
Median	128.00	24.00	1225.00	190.00		2200.00	2.34
BRISBANE - AUD							
Mean	153.50	25.50	1327.50	113.75		2950.00	2.43
SD	21.27	6.36	45.58	46.44		70.71	0.11
CoV	13.85%	24.96%	3.43%	40.82%		2.40%	4.37%
Median	143.50	25.50	1350.00	100.00		2950.00	2.43
PHOENIX - USD							
Mean	133.43	10.82	1007.14	163.40		2262.14	1.45
SD	22.74	3.82	108.43	32.24		704.35	0.56
CoV	17.05%	35.28%	10.77%	19.73%		31.14%	38.65%
Median	120.00	10.76	960.00	163.00		2350.00	1.35

Table 5.8 Dispersion of validated data

MATERIALS (Continued)								
	Tough glass \$/m2	Window unit Each	Sawn stone \$/m2	1 hour door Each	NFR door Each	Plaster board \$/m2	Floor tiles \$/m2	Carpet \$/m2
	SYDNEY - AUD							
Mean	227.00	859.71	106.97	960.09	110.29	7.24	36.78	39.98
SD	31.77	175.79	43.43	256.77	44.59	2.83	11.01	11.02
CoV	14.00%	20.45%	40.60%	26.74%	40.43%	39.12%	29.93%	27.55%
Median	239.00	900.00	95.00	900.00	110.00	6.50	35.00	37.50
	AUCKLAND - NZD							
Mean	211.25	1133.33	193.33	730.00	195.00	6.90	41.25	33.13
SD	82.50	152.75	61.10	203.14	25.98	0.46	12.50	5.10
CoV	39.05%	13.48%	31.60%	27.83%	13.32%	6.64%	30.30%	15.39%
Median	207.50	1100.00	180.00	700.00	180.00	6.80	42.50	33.00
	SINGAPORE - SGD							
Mean	142.00	682.00	68.33	916.00	305.00	14.50	35.43	56.43
SD	38.16	223.54	22.55	272.09	124.50	3.54	12.77	14.35
CoV	26.87%	32.78%	32.99%	29.70%	40.82%	24.38%	36.03%	25.43%
Median	144.00	700.00	67.50	886.00	350.00	12.00	35.00	50.00
	MELBOURNE - AUD							
Mean	253.33	1025.00	210.00	1098.57	155.00	5.90	30.00	45.43
SD	27.54	216.22	36.06	276.91	98.99	2.97	7.07	10.36
CoV	10.87%	21.09%	17.17%	25.21%	63.87%	50.34%	23.57%	22.80%
Median	255.00	1075.00	200.00	1200.00	155.00	5.90	30.00	50.00
	BRISBANE - AUD							
Mean	208.33	635.00	133.33	775.00	186.67	7.50	34.00	41.25
SD	29.30	216.22	42.52	250.50	23.09	0.71	9.62	9.46
CoV	14.06%	34.05%	31.89%	32.32%	12.37%	9.43%	28.29%	22.95%
Median	220.00	650.00	135.00	775.00	200.00	7.50	30.00	37.50
	PHOENIX - USD							
Mean	112.75	709.57	118.58	796.43	105.00	3.24	44.63	38.56
SD	44.19	195.61	40.48	236.92	21.21	1.08	10.86	13.16
CoV	39.19%	27.57%	34.13%	29.75%	20.20%	33.48%	24.34%	34.14%
Median	96.00	750.00	124.00	875.00	105.00	3.23	47.84	34.75

Table 5.8 Dispersion of validated data (Continued)

MATERIALS (Continued)									
	Paint \$/litre	Wardrobe unit Each	LV cable \$/m	LV downlight Each	Vanity basin Each	CI pipe \$/m	Cu tube \$/m	Rigid duct \$/m	Flex duct \$/m
SYDNEY - AUD									
Mean	10.01	2933.33	1.31	25.36	273.26	40.54	8.77	132.50	22.41
SD	1.62	1000.83	0.55	16.36	91.08	3.76	2.23	24.75	4.07
CoV	16.18%	34.12%	41.77%	64.51%	33.33%	9.27%	25.46%	18.68%	18.18%
Median	10.00	2950.00	1.23	19.00	258.00	40.00	9.00	132.50	22.50
AUCKLAND - NZD									
Mean	9.93	4096.67	1.41	26.88	276.25	40.50	8.49	115.00	9.00
SD	2.04	1386.01	0.61	27.99	90.13	6.36	1.23	24.15	8.49
CoV	20.51%	33.83%	43.04%	104.13%	32.63%	15.71%	14.50%	21.00%	94.28%
Median	9.25	4800.00	1.50	14.00	252.50	36.00	8.23	107.50	9.00
SINGAPORE - SGD									
Mean	6.96	3750.00	4.13	77.80	290.00	95.25	24.00	59.80	44.00
SD	4.01	1601.56	1.75	19.79	90.28	4.11	2.83	21.62	8.60
CoV	57.59%	42.71%	42.42%	25.44%	31.13%	4.32%	11.79%	36.15%	19.55%
Median	6.50	3200.00	4.25	84.00	305.00	96.00	24.00	62.40	40.00
MELBOURNE - AUD									
Mean	9.29	4450.00	2.08	30.00	347.50	62.50	8.50	135.00	17.67
SD	1.38	1307.67	1.01	28.28	75.88	24.75	4.95	7.07	2.52
CoV	14.86%	29.39%	48.50%	94.28%	21.84%	39.60%	58.23%	5.24%	14.24%
Median	9.00	4750.00	2.25	30.00	335.00	62.50	8.50	135.00	18.00
BRISBANE - AUD									
Mean	10.33	3733.33	1.00	24.67	316.67	45.08	10.50	47.50	15.00
SD	0.58	1101.51	0.50	10.50	76.38	0.11	0.71	17.68	8.66
CoV	5.59%	29.50%	50.00%	42.58%	24.12%	0.24%	6.73%	37.22%	57.74%
Median	10.00	3200.00	1.00	25.00	300.00	45.08	10.50	47.50	10.00
PHOENIX - USD									
Mean	3.61	2278.57	0.49	41.25	279.17	13.72	5.90	19.86	11.72
SD	0.80	1134.63	0.19	18.87	91.46	5.04	1.81	6.44	4.38
CoV	22.13%	49.80%	39.80%	45.76%	32.76%	36.73%	30.68%	32.42%	37.34%
Median	3.70	1950.00	0.40	40.00	287.50	12.00	4.98	24.60	13.00

Table 5.8 Dispersion of validated data (Continued)

LABOUR AND GENERAL ITEMS						
	Skilled 1 \$/hr	Skilled 2 \$/hr	Skilled 3 \$/hr	Semi- skilled \$/hr	Margin %	Prelims %
	SYDNEY - AUD					
Mean	58.68	49.68	44.45	42.64	5.76	16.16
SD	14.81	12.19	10.02	10.50	2.01	3.16
CoV	25.23%	24.55%	22.54%	24.62%	34.88%	19.53%
Median	62.00	53.00	44.00	40.00	5.00	16.75
	AUCKLAND - NZD					
Mean	43.80	34.50	33.00	30.90	5.00	13.25
SD	6.91	5.26	4.00	4.99	0.84	3.21
CoV	15.77%	15.25%	12.12%	16.14%	16.73%	24.19%
Median	42.00	34.00	35.00	32.50	4.75	13.75
	SINGAPORE - SGD					
Mean	12.13	11.63	12.00	9.67	10.06	13.61
SD	3.49	2.79	3.13	3.83	3.27	3.07
CoV	28.80%	23.97%	26.07%	39.65%	32.47%	22.55%
Median	13.25	12.75	14.00	9.50	9.25	13.00
	MELBOURNE - AUD					
Mean	70.00	63.67	62.00	57.50	5.50	13.50
SD	20.49	18.18	18.76	17.25	1.52	3.27
CoV	29.28%	28.56%	30.26%	30.00%	27.57%	24.23%
Median	72.50	65.00	62.50	60.00	5.50	12.50
	BRISBANE - AUD					
Mean	60.40	50.40	48.60	47.00	6.80	16.30
SD	16.83	11.76	10.83	12.53	2.05	3.63
CoV	27.87%	23.33%	22.29%	26.66%	30.14%	22.29%
Median	65.00	55.00	55.00	50.00	7.00	16.00
	PHOENIX - USD					
Mean	42.21	32.36	27.57	22.92	4.83	5.67
SD	13.05	10.32	9.32	7.16	2.14	1.08
CoV	30.92%	31.90%	33.82%	31.24%	44.21%	19.06%
Median	45.00	35.00	28.00	23.75	4.00	5.25

Table 5.8 Dispersion of validated data (Continued)

Points to be noted from this table are:

- stressing steel has been discarded from the basket
- a number of items show CoVs slightly higher than the nominal 40% cutoff – given that the 40% figure is not a precisely defined limit no further rates were discarded from these items.
- the non-fire rated door item shows a CoV for Melbourne of 63.87% - this was retained as only two rates were obtained that were not clearly supply and fix.

These rates (\$85 and \$225) produce the high CoV but as explained previously the mean of the two rates is reasonably close to the Cordell price.

- the CoV for Melbourne for the plasterboard item is 50.34% - again this was retained as only two useful rates were retained and the mean was very close to the Cordell rate.
- the CoV for Singapore for the paint item is 57.59% - the mean rate and median rate were quite similar (SGD \$6.96 and \$6.50 respectively) which reflected an unbiased distribution of rates around the central values and therefore a decision was made not to discard any of the rates for this item.
- CoVs for the timber joinery (wardrobe) item range from 29.39% to 49.80% - as the aim of the survey was to obtain representative average prices for the various items these rates were not culled further and thus the mean rates reflect likely price differences between suppliers for this sort of item.
- as noted previously the low voltage cable item produced a relatively low number of responses and after validation only 22 rates were retained – five of the six locations returned CoVs of over 40% while the lowest (39.80%) was only just below the cutoff and that occurred only when an additional rate, determined after lengthy consultation, was included. Given the low response rate no further rates were discarded in spite of the relatively high CoVs.
- the low voltage downlight item produced even less satisfactory results however for similar reasons to those described for the previous item no further rates were discarded.
- the copper pipe item shows one high CoV (Melbourne, 58.23%) – this is similar to the plasterboard and door items mentioned above where only two useful rates were obtained, and the mean value of the two rates matched closely with the Cordell rate
- similarly the two high CoVs for the flexible duct item reflect the small number of valid prices and mean rates that match rates obtained from a services specialist.
- the CoV for Phoenix for the margins item belies the small range of values that were entered (3% to 9%) – had the highest been just one percent lower the CoV would have dropped below the cutoff to 37.53% while the mean

value would have only have moved from 4.83% to 4.67%. In view of this no rates were discarded from this item.

5.7 DATA NORMALISATION

In the preceding chapter a number of data adjustment or normalisation issues were discussed and it was concluded that most could be disregarded in the context of this study. Taxation and market conditions were two factors that were identified as having the potential to distort outcomes in some instances and therefore some sensitivity analysis of BLOC costs was deemed appropriate.

5.7.1 Taxation

Previously (at 4.4.8) the difficulties associated with any attempt to adjust for differing tax regimes in respect of construction costs were discussed. In the context of this study differing tax levels appears to be a relatively minor concern as the rates of GST/VAT applicable to construction in the target locations do not vary greatly.

Location	Applicable tax rate
Australia	10%
New Zealand	12.5%
Singapore	7%
Phoenix	5.0-5.4%

Table 5.9 Tax applied to construction in target locations

While the tax rates in this study only vary by a maximum of 7.5% (Phoenix/Auckland) some countries have much higher levels of taxation on construction work: Denmark and Sweden, for example, apply VAT to construction at 25%, while at least eight other European countries add VAT of 20-24% to construction (EC Harris, 2007). Rather than adjusting the data to allow for different tax levels (respondents were asked to give prices excluding tax), as suggested at 4.4.8 BLOC costs were calculated with and without VAT/GST and results compared (see 6.3.4).

The complexities associated with tax on construction work are further illustrated by the situation that exists in the USA, where tax is calculated in an unusual and complex fashion. There is no GST as such but there is sales tax on materials

Rates vary for different materials and as the sales tax rate may vary from county to county and even city to city, materials sourced locally may be taxed at different rates to similar materials sourced from interstate or even from a neighbouring city. For example, in Arizona the industry has agreed, for estimating purposes, to adopt a standard method for adding tax to estimates (Hedley, 2008). The method is based on a notional 35:65 labour to materials ratio and therefore a flat rate of 65% of the local tax is added to estimates at end of the of the estimating process¹⁹. Greater Phoenix, for example, includes *inter alia* the cities of Phoenix, Scottsdale and Tempe. The individual tax rates for the three cities respectively are 8.3%, 7.95% and 8.1%. The tax rate applied to construction work in Greater Phoenix is therefore around 5.0-5.4%.

5.7.2 Market conditions

In the pilot study there were problems associated with the questions relating to tender price levels and factors for adjustment of prices to reflect differing market conditions in the various locations (see Section 4.4.6). As a result in the main survey, while respondents were again asked for their opinion of current market conditions, while the supplementary question regarding the relativity of current prices to “average” prices was reframed (see Table 5.2). Respondents were asked to give their opinion of the likely range of tender prices about a “medium” or “average” level in times of greatest and least competition that might occur as the industry in each location moves through the so-called “boom and bust construction cycle” (RLB, 2008a:38)

Average market conditions were calculated by assigning numerical values²⁰ to the answers to the question on market conditions and averaging those values. The results are shown in Table 5.10. The table also shows the average percentage factors suggested by respondents in each city in relation to tender levels above and below a medium or average level. The deflators were calculated *pro rata* from these data by using the following approach:

¹⁹ This means that tax is added to preliminaries, contingencies and so on.

²⁰ From Low=1 to High=5

e.g. Sydney: market level 3.59, therefore the deflator is

$$\frac{0.59}{2} \times 10.4\% = 3.1\%,$$

where 0.59 is the difference between the survey result for market level and the average level (3) on the five point scale, and 2 is the difference between the highest market level (5) and the average market level.

Location	Market index	Factor (above med.)	Factor (below med.)	Deflator Apr-08
Sydney	3.59	+10.4%	-8.3%	-3.1%
Melbourne	4.50	+16.5%	-5%	-12.4%
Brisbane	4.33	+14%	-9.3%	-9.3%
Auckland	3.00	+13.3%	-11%	0.0%
Singapore	5.00	+20.4%	-3%	-20.4%
Phoenix	4.14	+22%	-18%	-12.5%

Table 5.10 Deflators to adjust for prevailing market conditions.

Apart from Auckland where the average level in the opinion of the respondents was “medium”, all locations were experiencing higher tender levels than would be considered as average. In Chapter 4 it was determined that in the context of this study market conditions are simply one of a number of factors that may affect construction costs at a particular point of time and therefore it is not appropriate to adjust outcomes to account for distortions that may arise due to fluctuating market conditions. It is, however, prudent to assess the possible impact that any such adjustment might have on the results of the study by applying a simple sensitivity analysis to the BLOC costs. The results of that analysis are reported in the next chapter in the discussion of final BLOC costs.

5.8 CONCLUDING REMARKS

In this chapter the execution of steps 6, 7 and 8 of the 12 point plan outlined in Chapter 4 has been described, and some further discussion relating to step 9 (data adjustment) has been presented.

Experience gained from the pilot study was used to refine the main basket, however, in general the pilot study showed that the approach chosen was suitable and

established contact with respondents in various locations. The major difference between the pilot survey (see Appendix A4) and the main survey (Appendix A5) was in the number and type of items included. Specific differences included:

- Changing the wording of some of the general questions in the last section of the questionnaire
- Adding items relevant to engineering services
- Adding more labour categories to cover the greater range of materials and their installation.

A detailed analysis of the data gathered, particularly in relation to the quality and validity of the data, has been described and a final dataset of materials and labour costs in the six target cities resolved. The remaining steps, culminating in a set of construction-specific purchasing power parities (CPPPs) for comparing and converting construction costs between the target locations, are described in the following chapter.

CHAPTER 6

6.0 DATA ANALYSIS AND RESULTS

6.1 INTRODUCTION

In this chapter the final three steps of the 12 point research plan are described. The BLOC costs from each city are used to derive a series of construction-specific PPP factors (CPPPs). These are discussed and tested against other indices such as general PPPs to assess the robustness of the CPPPs and the basket of goods method used to produce them.

6.2 CALCULATING BLOC COSTS FOR AUSTRALIA

With data gathering and validation complete BLOC costs in the three Australian cities were calculated. Initially several sets of costs for the BLOC were calculated, using average rates for all items (i.e. mean rates including all valid prices for each item). Only the Australian results were compared in the first instance in order to make some comparisons that would test the BLOC in a situation where some variables, such as taxation and, to a large extent, contractors' margins, were excluded from the mix.

6.2.1 BLOC costs in Australian cities

Costs (in AUD) of the BLOC in the three cities are shown in Table 6.1. The costs are shown for materials and labour only, then with the addition of preliminaries and finally with both preliminaries and contractors' margins added.

The average preliminaries costs for each city are as follows: Sydney: 16.16%, Melbourne: 13.50% and Brisbane: 16.30%. The average margins for each city are as follows: Sydney: 5.76%, Melbourne: 5.50% and Brisbane: 6.80%.

CITY	BLOC COST (labour and materials only)	BLOC COST (with preliminaries)	BLOC COST (with preliminaries and margins)
Sydney	9,436,540	10,961,485	11,592,455
Melbourne	11,391,328	12,929,157	13,640,260
Brisbane	9,356,800	10,881,958	11,621,932

Table 6.1 Basic BLOC costs in AUD in Sydney, Melbourne and Brisbane

The costs shown in Table 6.1 do not include the 10% GST that is uniformly applied to all costs in Australia. With GST added these costs would reflect the cost that a client would pay. It is not, however, the costs that are important but the relationship between cost levels. In all three scenarios the cost of the BLOC in Sydney and Brisbane is very similar, while the Melbourne cost is 18-21% higher.

6.2.2 Comparing Australian BLOC costs to superficial costs

Costs/m² for hotels in the three cities, of similar type to the sample project (Table 6.2), were obtained from commercially published price books (Rawlinsons, 2008; Cordell, 2008), Davis Langdon's annual *Blue Book* (Davis Langdon, 2008), *Riders Digest* (RLB, 2008a) and *The Building Economist* (2008). When the published costs were compared, it was clear that they did not align with each other or with the BLOC costs. The table shows that the calculated costs in Sydney and Brisbane are almost the same, with costs in Melbourne considerably higher. In contrast the published rates in two cases show Melbourne to be the least expensive (7-10% below Sydney) while the remainder place Melbourne between the other two cities.

The published rates themselves are not consistent. Two sources show Sydney to be the most expensive location with Rawlinsons suggesting that Brisbane is slightly more expensive than Melbourne, and Cordell suggesting the reverse; Davis Langdon shows a quite different situation with Sydney the cheapest and Brisbane the most expensive. RLB shows a relationship between Sydney and Melbourne similar to that shown by the BLOC (with Melbourne around 23% more expensive than Sydney) but it shows Brisbane to be 35% more expensive than Sydney. *The Building Economist*, while showing costs in Sydney and Brisbane to be similar, suggests that Melbourne is less expensive than Sydney. All are at odds with the cost differentials suggested by the BLOC results.

CITY	Rawlinsons	Cordell	Davis Langdon	RLB	<i>Building Economist</i>	BLOC costs
Sydney	3278	2645	2300	2385	2481	11,592,455
Melbourne	2977	2615	2650	2944	2315	13,640,260
Brisbane	3060	2545	2750	3225	3172	11,621,932

Table 6.2 Hotels – average cost (AUD) per m² of GFA for 4-6 level medium quality hotels. Rawlinsons and Cordell rates include typical contractors’ margins but exclude “fitting out” and GST. The Davis Langdon rates are for 3 star budget hotels and include furniture, fittings and equipment (FF&E) but it is not stated whether they include margins or GST. Rates from RLB include margins but exclude GST and FF&E. The *Building Economist* rates are for medium to high rise 3 star city hotels; they include profit but exclude GST. It has been shown that margins vary only slightly. BLOC costs are included for comparison. (Sources: Rawlinsons, 2008; Cordell, 2008, Davis Langdon, 2008, RLB, 2008a and *The Building Economist*, 2008)

In view of the lack of consistency in cost relativities in the published cost/m² rates, material supply and labour costs (Cordell, 2008) were used to price the BLOC for the three cities. Not all items could be priced in this way as Cordell does not give material supply costs for all items (e.g. carpet), however, as many items as possible were included (14 materials items and four classes of labour). Labour hours for each category of labour were adjusted so that they reflected the hours associated only with those items priced in the reduced BLOC. While these BLOC costs cannot be directly compared to those calculated using rates obtained from the survey due to the different composition of the baskets, the relativities are directly comparable. Table 6.3 shows the results for the reduced BLOC priced using Cordell’s rates

CITY	BLOC COST (AUD) (with preliminaries and margins)
Sydney	6,107,346
Melbourne	5,880,470
Brisbane	5,689,792

Table 6.3 BLOC costs including preliminaries and contractors’ margins estimated from Cordell rates (14 materials and 4 labour items) (Source: Cordell, 2008)

Table 6.4 compares the relativities, with the BLOC costs (including preliminaries and margins) from Tables 6.1, 6.2 and 6.3 expressed as indices. Sydney is taken as the base with an index of 1.000 in each instance.

CITY	Index based on BLOC costs from Table 6.1	Index based on Cordell's \$/m² rates from Table 6.2	Index based on reduced BLOC costs from Table 6.3
Sydney	1.000	1.000	1.000
Melbourne	1.177	0.989	0.963
Brisbane	1.003	0.962	0.932

Table 6.4 Comparing relative costs with Sydney as a base (index=1.000), based on values from tables 6.1 – 6.3.

The relative costs for the three locations for the reduced BLOC align reasonably closely with the superficial rates from Cordell (Table 6.2) as they match the relativities suggested by the Cordell \$/m² rates. It is, however, important to note that the Cordell cost/m² rates are not based on any survey of actual costs for completed projects. They are derived from estimates of standard projects (Bozdog, 2008, pers.comm.) in which a cost model for a “typical” building in each class (hotel, warehouse and so on) is priced. As a result it would be expected that the BLOC costs based on their unit rates and the area costs calculated using the same cost database would produce similar relative costs. The relativities shown by the BLOC costs in Table 6.4 suggest that the published rates do not reflect the actual cost differences between the three cities as they were at the base date of this study. At the very least this means that further investigation of the relative costs of building in the three cities is warranted.

6.2.3 Differences in costs in three Australian cities

In an attempt to identify the reasons for the lack of agreement in the results from the various approaches further investigation of prices in the three cities was conducted using Cordell rates (Cordell, 2008). Both the BLOC and the published cost/m² rates include labour as well as materials although the two components are priced separately in the BLOC. Unit rates for the supply and installation for a number of

representative items in the BLOC (14 in total¹) were compared. In addition, prices for some composite services items were compared. Full details of that pricing exercise are contained in Appendix A3. Some observations can be made from the analysis:

- Basic labour costs, with only a few exceptions, were highest in Sydney and lowest in Brisbane². Exceptions included blocklaying (blocklayer rate: \$58.00/hr in Melbourne compared to \$51.50 in Sydney and \$48.00 in Brisbane); structural steel (erection costs for Melbourne and Sydney nearly the same at \$1310 and \$1300/tonne respectively and Brisbane at \$1231/tonne although hourly labour rates vary differently with Group 1 labourer rates of \$41.00/hr in Sydney, \$39.00/hr in Melbourne and \$39.50/hr in Brisbane), and bar reinforcement (placing and tying steel in Sydney most expensive at \$527/tonne, Brisbane \$507, and Melbourne marginally lower at \$500 with hourly labour rates in this case, unlike those for structural steel, varying similarly to the output labour costs).
- Services labour costs varied with electricians in Melbourne (\$67.50/hr) being paid around 7.4% better than their Sydney counterparts (\$62.50) and 10.6% better than those in Brisbane (\$61.00/hr); plumbers in Sydney (\$65.00/hr), by comparison, earn slightly more than those in Melbourne (\$59.00/hr) or Brisbane (\$60.00/hr).
- Materials costs fluctuated between the three cities with no clear pattern evident. Structural steel supply was most expensive in Sydney (\$1958/tonne), least expensive in Brisbane (\$1652/t) with Melbourne in between (\$1875/t); in contrast supply costs for concrete were highest in Sydney (\$213.45/m³), lower in Brisbane (\$187.75/m³) and lowest in Melbourne (\$175.25/m³).

¹ Due to their nature some items could not be compared in this manner, e.g. the wardrobe/minibar joinery unit was as a specific design for which drawings were supplied, as part of the survey, to facilitate uniform pricing, and as such could not be priced from published rates. Rates for some other items, such as air conditioning ductwork, were not available as published air conditioning rates are generally based on cost/unit area.

² All rates in this section are in AUD.

- Plant costs were consistently highest in Sydney; for example, concrete pump hire (\$190/hr in Sydney, \$165/hr in Melbourne, \$130/hr in Brisbane). Plant costs for erection of structural steel showed similar relativities, with costs highest in Sydney and lowest in Brisbane. Plant costs for erection of precast spandrel panels showed Sydney to be more than 30% more expensive than Melbourne and Brisbane.

6.2.3.1 Labour costs

Average labour costs gathered in the survey show labour rates generally in Melbourne to be considerably higher than those in Sydney or Brisbane. This is shown in Table 6.5. The total labour component in the Melbourne BLOC is 28% higher than the same component in the Sydney BLOC and 23% higher than in the Brisbane BLOC. Melbourne respondents indicated that tender price levels in their area were currently medium high to high, while respondents in Sydney indicated that tender levels were somewhere between average and medium high. This could go some way towards explaining the higher Melbourne costs, however, Brisbane respondents assessed tender levels to be nearly on a par with Melbourne yet, as Table 6.5 shows, labour rates and BLOC costs for labour in Brisbane are much closer to those from Sydney than to those from Melbourne.

CITY	Tradesman Group 1 \$/hr	Tradesman Group 2 \$/hr	Tradesman Group 3 \$/hr	Semi- skilled \$/hr	Labour cost in BLOC
Sydney	58.68	49.68	44.45	42.64	4,411,905
Melbourne	70.00	63.67	62.00	57.50	5,650,167
Brisbane	60.40	50.40	48.60	47.00	4,599,800

Table 6.5 Average labour rates and BLOC costs (labour only) obtained from survey responses (AUD).

6.2.3.2 Services costs

In the analysis several services items were examined. They were not included in the smaller basket used in the analysis as the items are not measured or priced in the same manner.

Two electrical items in Cordell, one a single power outlet the other a single light point, both described and priced as “complete”, were compared. Although the labour rate for electricians (Cordell, 2008) was shown as higher in Melbourne (\$67.50/hr) than in Sydney (\$63.50/hr) or Brisbane (\$61.00/hr) the item cost for both electrical items was significantly higher in Sydney than in Melbourne or Brisbane (Table 6.6).

CITY	Power outlet	Light point
Sydney	60.40	80.90
Melbourne	40.70	53.10
Brisbane	40.40	52.80

Table 6.6 Comparative rates – electrical installation (Source: Cordell, 2008)

As the table shows, the Sydney prices for both the power outlet and light point are around 50% higher than in the other cities. These price differences are difficult to explain as no breakdown of the sub-contract prices is given. A possible explanation is that there is a shortage of skilled labour in electrical trades in Sydney and that could be pushing sub-contractor prices up, however, the price differences for both items are considerable.

Cordell does not provide any detailed prices for air conditioning work but they do give superficial rates for estimating purposes. For a system that would be typical of the reference project (high velocity, variable air volume, medium standard) the rates are similar in the three cities with Sydney only marginally more costly (\$305/m²) than Melbourne or Brisbane (both \$290/m²). These rates do not differ greatly, and with the Melbourne rate being slightly lower than the Sydney rate this offers no insight into the higher BLOC cost for Melbourne as shown in Table 6.1.

6.2.3.3 Materials costs

Total materials costs in the Melbourne BLOC are over \$700,000 (14%) higher than those in Sydney and nearly a million dollars (21%) higher than those in Brisbane. Nearly two-thirds of the extra cost in the Melbourne figure (compared to Sydney) is due to a single item, the timber wardrobe unit, for which the Melbourne cost exceeds the Sydney cost by \$455,000; a further \$210,000 of the extra cost is in the two electrical items. If the materials costs in the BLOCs for Sydney and Melbourne are recalculated excluding these three items the difference in materials cost falls to just

\$112,738 and the Melbourne cost is just 2% higher than the Sydney cost, a negligible difference in a construction estimating context³.

6.2.3.4 Summary

The foregoing analysis identifies several factors that may explain the higher total BLOC costs for Melbourne. The cost of the materials component of the BLOC is greater largely due to the influence of just three items in the basket, all of which have been identified in Chapter 5 as having produced very variable prices and may therefore be considered to be problematic components of the BLOC. There are, however, significant items as the wardrobe represents a very significant component of hotel costs, and the other two represent all the electrical services, an even more cost significant component.

The higher labour costs in the Melbourne BLOC are due to higher hourly labour rates for the four classes of labour included, and this in turn has contributed significantly to the higher total BLOC costs from Melbourne compared to those from Sydney and Brisbane.. It is worthwhile noting that the average of the hourly rates for the four classes of labour supplied by Melbourne respondents who are quantity surveyors was just \$49.08, while the same average rate supplied by contractors was \$77.50/hr. This strongly suggests that, at the time of the survey, labour rates in a strong construction market environment were indeed above usual levels, a fact that contractors would be keenly aware of but that quantity surveyors would be less in touch with.

6.2.4 Recalculating BLOC costs using median prices

BLOC costs for Sydney, Melbourne and Brisbane were also calculated using median rates for each item rather than mean rates. Table 6.7 shows the results for BLOCs based on mean and median rates with the inclusion of preliminaries and margins.

The validation process ensured that there was little difference between mean and median rates for most items. This meant that there were only small differences between BLOC costs based on the two sets of rates. While the cost of the BLOC in

³ See Section 2.5.10.

Sydney fell by around 1.0% and the cost in Melbourne rose slightly (+2.3%), the Brisbane BLOC barely changed. For the Australian cities at least there is no appreciable difference in the results, hence there is no merit in pursuing this particular analysis any further.

CITY	Mean rates	Median rates
Sydney	11,592,455	11,483,318
Melbourne	13,640,260	13,948,135
Brisbane	11,621,932	11,614,968

Table 6.7 BLOC costs based on mean and median unit rates

6.3 BLOC COSTS IN ALL LOCATIONS

BLOC costs in local currencies were calculated for the remaining locations with various adjustments (tax, margins, materials only). The results for the six cities were then used to calculate purchasing power parity factors. The US dollar was used as the common currency base as this is the base currently in general use for other PPPs. Mean unit rates were used in the calculation of BLOC costs.

6.3.1 BLOC costs – input costs for materials and labour only

The first set of BLOC costs contained only the input rates for materials and labour with no additions or adjustments. The results are shown in Table 6.8.

CITY	BLOC cost (B)	CPPP	Exchange rate⁴
Sydney	9,436,540	1.433	1.104
Melbourne	11,391,328	1.730	1.104
Brisbane	9,356,800	1.421	1.104
Auckland	8,538,663	1.297	1.265
Singapore	7,747,425	1.177	1.408
Phoenix	6,583,267	1.000	1.000

Table 6.8 Basic BLOC costs (B) (local currencies, no adjustments), the derived CPPPs and the official exchange rates relative to the USD for the six locations.

⁴ The exchange rates shown in this and the following tables are first quarter 2008 averages based on the daily spot rates published by the US Federal Reserve (Federal Reserve, 2008).

The CPPPs shown indicate the “amount” of four star hotel construction that could be bought with each currency compared to the amount that could be bought using USD in Phoenix⁵ given the assumptions discussed previously in Chapters 3 and 4⁶. For example, in Sydney AUD\$1.433 must be spent in order to buy the same amount of hotel construction that USD\$1.00 would buy in Phoenix. Except in the case of Auckland the CPPPs are substantially different to the three month average exchange rates.

6.3.2 BLOC costs including preliminaries

These costs were recalculated with the cost of preliminaries for the basket added, based on the mean percentage rate obtained from survey respondents; see Table 6.9.

CITY	Average prelims.	BLOC cost (P)	CPPP	Exchange rate
Sydney	16.16%	10,961,485	1.487	1.104
Melbourne	13.50%	12,929,157	1.754	1.104
Brisbane	16.30%	10,881,958	1.476	1.104
Auckland	13.25%	9,670,036	1.312	1.265
Singapore	13.61%	8,801,850	1.194	1.408
Phoenix	12.00%	7,373,259	1.000	1.000

Table 6.9 BLOC costs (local currencies) and derived CPPPs. BLOC Cost (P) includes preliminaries percentages. Exchange rates are relative to the USD.

These BLOC costs and the resultant CPPPs represent base construction costs as they do not include value added taxation or contractors’ margins. These costs were then used as the basis for the following cost analysis with various scenarios. The slightly higher proportion of preliminaries in Singapore compared to Phoenix brings the CPPP for Singapore closer to the exchange rate, while Auckland moves a little further away. The Australian cities all continue to show a weaker construction dollar against the USD.

⁵ It should be noted again that the CPPPs relate to cities, not whole countries. RLB (2008b) suggest costs per ft² for three star hotels in various US cities ranging from USD\$105-170 (Denver) to \$195-265 (San Francisco). Phoenix sits around the median level at \$145-195/ft².

⁶ i.e., that buildings, technology and productivity are the same in all locations.

6.3.3 BLOC costs including contractors' margins

BLOC costs were again recalculated with average contractors' margins added. CPPPs were recalculated based on the revised BLOC costs.

Location	Average margin	BLOC cost (PM)	CPPP (PM)	Exchange rate
Sydney	5.76%	11,592,455	1.500	1.104
Melbourne	5.50%	13,640,260	1.765	1.104
Brisbane	6.80%	11,621,932	1.504	1.104
Auckland	5.00%	10,153,537	1.314	1.265
Singapore	10.06%	9,687,536	1.253	1.408
Phoenix	4.83%	7,729,634	1.000	1.000

Table 6.10 BLOC costs (local currencies, including margins) and derived CPPPs. BLOC cost (PM) includes preliminaries and margins.

As estimated margins for five of the cities are very similar the only major change is in the CPPP for Singapore where the profit margins are high due to the current boom in the construction industry. The cost of the Singapore BLOC increased by around twice as much as the costs of the BLOCS in the other cities when margins were added and the CPPP reflects that difference.

6.3.4 BLOC costs including contractors' margins and taxes

In the fourth iteration BLOC costs were recalculated with average contractors' margins and applicable taxes added. CPPPs were again recalculated based on these revised BLOC costs (Table 6.11).

CITY	Added tax	BLOC cost (PMT)	CPPP (PMT)	Exchange rate
Sydney	10.00%	12,751,701	1.568	1.104
Melbourne	10.00%	15,004,287	1.845	1.104
Brisbane	10.00%	12,784,125	1.572	1.104
Auckland	12.50%	11,422,730	1.405	1.265
Singapore	7.00%	10,365,663	1.275	1.408
Phoenix	5.20%	8,131,575	1.000	1.000

Table 6.11 BLOC costs in local currencies and derived CPPPs. BLOC cost (PMT) includes preliminaries, margins and tax.

Higher levels of taxation in Australia and New Zealand naturally increase the resultant CPPPs for those locations in relation to those for Singapore and Phoenix. While the difference is not great in this study, as noted earlier, the effect would be much greater in countries with higher levels of taxation.

6.3.4.1 Dispersion of BLOC costs in different locations

In the preceding chapter (at 5.3) the dispersion of unit rate data was discussed and the process of data validation that produced datasets with less dispersion was described. Equally important, however, is the spread of total BLOC costs from different locations. As Runeson (1988) shows the dispersion of total estimates in which unit rates have been multiplied by project quantities to produce a tender price are much smaller than those for individual estimate items. This is true whether the estimates are based on BQ trade items or elemental quantities.

BLOC costs (labour and materials only) were calculated for Sydney and Phoenix using sets of rates⁷ from respondents in each location. All seven respondents' rates from Phoenix were used; 13 sets of rates from the 19 obtained from Sydney were used. The Sydney rates not used came from partially completed surveys where rates for less than 50% of the items had been provided.

The exercise was initially conducted using the raw data, with only the rates nominated by the respondents as supply and fix being excluded. While the CoV for the raw individual item rates from Sydney ranged from 11.51% to 104.44%, the CoV for the complete BLOC costs for Sydney was just 15.40%. For Phoenix the individual CoVs ranged from 10.77% to 122.31%, the CoV for the complete BLOCs was 20.91%.

The exercise was repeated using the validated rates with outliers removed. Again where values were missing, either because a respondent had not priced the item or where an outlier had been discarded the median value from the original rates was

⁷ A set of rates refers to the rates for all items in the survey provided by a single respondent. Not all respondents were included nor were for all items included. In the first instance some respondents returned partially completed surveys while others who had completed the pilot survey did not respond to the main survey. In the second instance too few prices were obtained for some items for them to be included. Where items were missing prices from individual respondents the median rate for that item was used as a dummy value. As discussed in Chapter 5 it has been established that there is little or no covariance apparent in respect of individual unit rates in construction estimates, hence it would not be appropriate to enter dummy values based on the rest of the rates supplied by a respondent.

used as a dummy. Using the validated rates the CoV for the individual item rates from Sydney ranged from 9.27% to 64.51%, whereas the CoV for the complete BLOC costs for Sydney was only 8.91%. For Phoenix the individual CoVs ranged from 10.77% to 49.80%, the CoV for the complete BLOCs was 15.42%. Table 6.12 summarises these results.

CITY	RAW DATA			VALIDATED DATA		
	Individual rates		Total BLOCs	Individual rates		Total BLOCs
	Low	High		Low	High	
Sydney	11.51%	104.44%	15.40%	9.27%	64.51%	8.91%
Phoenix	10.77%	122.31%	20.91%	10.77%	49.80%	15.42%

Table 6.12 Dispersion of total BLOC costs based on raw and validated data from the survey.

This result is consistent with what could be expected according to the Central Limit Theorem⁸. The Central Limit Theorem states that if single items from each of a series of individual independent probability distributions are added – and this is repeated until a set of sums is assembled - the mean of the resultant distribution will be equal to the sum of the means of the original distributions. The variance of the distribution will be equal to the sum of the variances of the individual distributions as long as there is no covariance (Runeson, 1988). This means that as item after item is added to each respondent's BLOC, the large variations in each of the unit rates tend to cancel themselves out and the total comes closer and closer to the true total. In this case, for the individual items there are CoVs of up to more than 100% for the unadjusted data and 50–60% for the adjusted data. When these are added together to get the distributions for the BLOCs, the result is 15–20% for the unadjusted data and 10–15% for the adjusted data. This corresponds to some 4–8% for complete tenders (Runeson, 1987).

While the large variations are a seemingly inevitable aspect of estimating, by the time the hundreds and hundreds or thousands of items in a BQ are added together into an estimate, the large number of items produces a quite narrow distribution of the tenders. In the BLOC, on the other hand, the number of items is not large enough

⁸ See 5.4.

to accommodate the cancelling out effect and any outlier, for whatever reason, tends to distort the results. This distortion cannot be avoided, but it may be minimised by removing outliers and arriving at a set of BLOCs that have a distribution similar to that of tenders around a mean that is close to the true value.

6.3.5 Adjustment for market conditions

In order to assess the impact of current market conditions the BLOC costs (including preliminaries, margins and tax) were deflated using the factors previously described (see Table 5.10). Table 6.13 shows the outcomes.

CITY	Market deflator	BLOC cost (MA) ⁹	CPPP (MA)
Sydney	-3.1%	12,368,284	1.711
Melbourne	-12.4%	13,349,009	1.847
Brisbane	-9.3%	11,696,363	1.618
Auckland	0.0%	11,422,730	1.580
Singapore	-20.4%	8,609,355	1.191
Phoenix	-12.5%	7,228,066	1.000

Table 6.13 Deflated BLOC costs (local currencies, including preliminaries, margins and tax) and derived CPPPs

These CPPPs show relative cost levels without the effects of the building cycle, net of the market conditions. Based on purchasing power the cost of hotel construction in the three Australian cities and Auckland is shown to be considerably higher than in Phoenix or Singapore although the difference is more marked in respect of Phoenix. Without adjustment for market conditions (see Table 6.11) the only appreciable difference is that Singapore, instead of being on a par with Phoenix, is some 28% more costly. Melbourne still shows the highest price levels of the six cities although the difference is less marked as Sydney, Brisbane and Auckland show higher cost levels than they do when market conditions are ignored. As previously discussed, however, this set of CPPPs demonstrates cost relativities that are more fundamental and are not the snapshot view that PPPs usually provide of relative cost levels at a point in time.

⁹ (MA) Costs adjusted for market conditions

6.3.6 Separating labour and materials costs

BLOC costs for materials only and labour only, and associated PPPs, were also calculated. Table 6.14 shows the results.

CITY	BLOC cost (Mat)	CPPP (Mat)	BLOC cost (Lab)	CPPP (Lab)
Sydney	6,789,844	1.430	5,961,857	1.762
Melbourne	7,562,071	1.592	7,442,216	2.200
Brisbane	6,499,453	1.369	6,284,672	1.858
Auckland	7,183,484	1.513	4,239,245	1.253
Singapore	9,019,017	1.899	1,346,646	0.398
Phoenix ¹⁰	4,748,635	1.000	3,382,941	1.000

Table 6.14 BLOC costs and C PPPs based on materials and labour only

Some of the relativities change markedly, most notably Singapore where material costs are high but are balanced by much lower labour rates. Melbourne's position as the costliest place to build is shown to be due to both high materials costs and high labour rates, while comparative cost levels for Sydney and Brisbane are pushed up more by labour rates than materials costs. Auckland shows the reverse with lower labour rates contributing to generally lower cost levels than the Australian cities.

6.3.7 BLOC based C PPPs and 10 year average exchange rates

In Chapter 2 some comparisons were made between various PPPs and ten year average exchange rates as in the Lynton study¹¹. The following table shows the comparison between several of the C PPPs calculated from the BLOC data and average exchange rates (relative to one USD) for the ten years preceding the date of the BLOC data (i.e. first quarter 2008). The ten year averages are the average of spot daily exchange rates at the end of each quarter of each year (i.e. 31st March, 30 June and so on). The C PPPs based on data adjusted for market conditions (C PPP (MA)) are shown for comparison but are theoretically not closely related to the average exchange rate. Exchange rates fluctuate due to many and various market forces and therefore it is not valid to attempt to equate those rates with C PPPs that are based on data that have been adjusted to negate the impact of certain market forces.

¹⁰ The labour only cost for Phoenix does not include tax as tax is only applied to materials.

¹¹ At 2.9.2.

Location	CPPP (PM)	CPPP (PMT)	CPPP (MA)	10 YR Average
Sydney	1.500	1.568	1.711	1.484
Melbourne	1.765	1.845	1.847	1.484
Brisbane	1.504	1.572	1.618	1.484
Auckland	1.314	1.405	1.580	1.719
Singapore	1.253	1.275	1.191	1.653
Phoenix	1.000	1.000	1.000	1.000

Table 6.15 Comparison between three C PPPs and 10 year average exchange rates

The results are not consistent. The C PPPs (excluding the C PPP(MA) as discussed above) for Sydney and Brisbane align closely with the average exchange rate. The C PPP(PM) for the other cities, however, are significantly different with differences of +19% (Melbourne), -31% (Auckland) and -24% (Singapore); similar differences occur for the C PPP(PMT) results. The magnitude of the differences, particularly for Auckland and Singapore suggests strongly, as postulated in Chapter 2, that the ten year average is not a reliable method for cost conversion, and the concordance with other conversion factors at the time of the Lynton study (1993) was no more than a fortunate coincidence.

6.4 COMPARING RESULTS FROM THE PILOT STUDY AND MAIN STUDY

In the preceding chapter the pilot study and its results were described and discussed. The following analysis compares the results obtained using the full BLOC from the main study and the mini BLOC from the pilot study. Note that all unit rates gathered from both surveys have been used in the calculation of mini BLOC costs and resultant mini BLOC C PPPs (Table 6.16). The aim of this comparison is to determine whether or not the smaller basket produces C PPPs similar to those produced by the more comprehensive basket.

These results demonstrate that while the small basket does produce similar results for most of the locations in one case the two C PPPs are quite different. The C PPPs derived for Sydney and Brisbane are very close; those for Auckland and Melbourne are close in the context of PPPs generally. Singapore, however, shows a very

different result with the CPPP falling by 33%. Further testing is required to determine the validity of this result.

CITY	CPPP Full BLOC	CPPP Mini BLOC
Sydney	1.568	1.599
Melbourne	1.845	1.737
Brisbane	1.572	1.544
Auckland	1.405	1.286
Singapore	1.275	0.850
Phoenix	1.000	1.000

Table 6.16 CPPPs derived from the mini BLOC and full BLOC studies

6.5 MODIFYING THE BLOC

In Section 5.5 a number of items in the basket were shown to have produced inconsistent data, and one, the stressing steel item, was discarded from the basket as it proved impossible to get comparable cost data for the item from all locations. A number of other items, however, each produced only a small set of data. These were included in the BLOC costs used in the foregoing calculations of CPPPs, however, it is appropriate now to recalculate the CPPPs using BLOC costs that do not include the problematic items.

The items identified as having produced questionable data, either due to an unexpected spread of results, or because few valid prices were obtained were:

- toughened glass
- non-fire rated door
- low voltage downlight
- flexible air conditioning duct

Material quantities and related labour hours for these items were deleted from the basket and BLOC costs recalculated. The following Table (6.17) compares CPPPs (based on mean rates, including preliminaries, margins and tax) derived from full BLOC costs with costs for the reduced BLOC that did not include the four items listed above.

CITY	CPPP (PMT) Full BLOC	CPPP (PMT) Reduced BLOC	Difference
Sydney	1.568	1.636	+4.3%
Melbourne	1.845	1.925	+4.3%
Brisbane	1.572	1.635	+4.0%
Auckland	1.405	1.465	+4.3%
Singapore	1.275	1.231	-3.5%
Phoenix	1.000	1.000	n/a

Table 6.17 CPPPs based on costs of full BLOC and reduced BLOC with four items removed. The CPPP(PMT) values are based on costs that include preliminaries, margins and tax.

The removal of four of the 23 materials items produced minor shifts in the CPPPs ranging from -3.5% to +4.37%. It is impossible to say whether such shifts are the result of insufficient data attached to the problematic items in the full BLOC skewing the results, or if it is simply coincidence that these items carry significant real price differences with them. If it is the latter the CPPPs change because data that does convey such price differences has been lost when the items were deleted from the BLOC. The shifts between the two sets of CPPPs are not large, however, the effect is increased when the pairs of CPPPs are compared to the Phoenix base, e.g. it becomes necessary to expend \$AUD1.636 to buy the equivalent of USD\$1, an increase of 6.8%.

These differences might be reduced by issuing more tightly specified items and/or by detailed research in the various locations carried out by an experienced surveyor. This could ensure that like items were being priced and that the prices obtained were actual prices paid. For example, the major problems encountered with the non-fire rated doors were lack of precision in the specification and/or the lack of familiarity on the part of respondents in Phoenix with the price of such doors without frame and/or hardware. Further development of the BLOC is required to alleviate these problems

6.6 THE IMPACT OF SERVICES COSTS

According to RLB (2008a) costs in hotel buildings similar to the reference project related to engineering services represent around 35% of total project costs. In

acknowledgement of the significance of these costs the BLOC specifically includes seven services items; two electrical, three hydraulic and two mechanical. In the discussion in the preceding chapter (at 5.5.3) the variability of prices for many of these items was noted and in the reduced BLOC discussed above two of the four items removed from the BLOC were services items.

6.6.1 BLOC costs minus services

In order to test the sensitivity of the resultant CPPPs to services costs another reduced BLOC was constructed that did not include any of the seven services items but did contain the other two problematic items (non-fire rated doors and toughened glass)¹². This left a reduced BLOC of 16 materials and three labour items; Tradesmen Group 1 included only electricians and plumbers and was therefore not required in this reduced BLOC. Table 6.18 shows the comparison between the CPPPs based on the full BLOC (PM) and the second reduced BLOC.

CITY	CPPP (PMT) Full BLOC	CPPP (PMT) Reduced BLOC (no services)	Difference
Sydney	1.568	1.571	+0.2%
Melbourne	1.845	1.817	-1.5%
Brisbane	1.572	1.511	-3.9%
Auckland	1.405	1.456	+3.6%
Singapore	1.275	1.141	-10.5%
Phoenix	1.000	1.000	n/a

Table 6.18 CPPPs based on costs of the complete BLOC (all materials and labour) items and the reduced BLOC (no services items or related labour)

The differences are more marked than those shown in the previous table, ranging from +3.6% (Auckland) to -10.5% (Singapore). Except for Singapore, however, the deletion of all the services items in the BLOC produces relatively minor changes in the CPPPs, and even the Singapore difference is hardly beyond normal estimating tolerances. This outcome suggests that whether the BLOC includes services items may not be very significant. Unless services items can be tightly specified and

¹² Stressing steel was discarded as part of the data validation process and was not used in any subsequent calculations of BLOC costs.

consistently priced they could be ignored and the reduced BLOC may well produce results that do not differ greatly from those produced from the full BLOC. The cost significance of services in total construction costs means, however, that further research into this question is warranted.

6.6.2 Dealing with the services issue

It should be noted that not all services items produced variable results: the vanity basin item worked well in the sense that it produced prices that were reasonably tight¹³. Both the copper pipe and rigid duct items produced useful results after some further investigation was carried out. The cast iron drain pipe, although a significant item in the reference project, did not translate well into the international context, however, the use of various plastic pipes (PVC and the like) for the same application appears to be common in many locations and this item could be recast easily and tested to see if it produces less variable results.

In the ICP's BOCC (Walsh and Sawhney, 2005) there is only one services item of any sort in the baskets for non-engineering construction (an electrical outlet), while in the engineering basket it is an infrastructure item (a large pipe) that is not relevant to building construction. In Davis Langdon's test of the basket of goods approach (DLC, 2003) there are four items under the heading *Sanitary Installations* and three under *Mechanical and Electrical*. It is useful, in view of the results reported in this thesis, to review the items included in the Davis Langdon basket and consider their viability. They are:

- white glazed domestic WC suite
- white glazed domestic hand basin
- clay drain pipes, 100mm diameter, with socket joints
- cast iron drain pipes, 150mm diameter, with mechanical coupling joints
- copper pipe, 15mm diameter
- plastic pipe, 15mm diameter, suitable for drinking water
- PVC insulated and PVC sheathed cable suitable for domestic power circuits

¹³ CoV for raw rates ranged from 21.84% to 46.16%.

Only one of these items is electrical and the only mechanical items are actually related to water supply. From the BLOC survey some observations can be made about the likely utility of the items in the Davis Langdon basket.

6.6.2.1 *Sanitary fittings*

The vanity basin item in the BLOC survey produced fairly consistent results perhaps because drawn details of the specific item were included in the survey. The WC and basin items in the Davis Langdon basket, however, could be expected to produce a broad range of results as little explanatory detail is provided. There is no indication of quality, not even a general instruction to price for “average” or “medium” quality¹⁴. Other details that affect the price of such items is not given, e.g. is the basin wall mounted, a pedestal type or a recessed or semi-recessed vanity type basin or even something different such as the free-standing benchtop type now in vogue in some residential buildings. Prices for such items vary considerably depending on specific type and size and without a tighter specification to inform the pricing exercise it is highly likely that the prices obtained would be spread across a wide range. This does not necessarily mean the item will fail to produce valid results but it would require a large number of sources of cost data to arrive at a sound representative average price.

6.6.2.2 *Drain pipes*

Clay drainpipes are no longer widely used in Australia, although they are still available. Cordell, for example, no longer include prices for these pipes in their cost guides; similarly in the US context RSMeans (2007) does not mention clay pipes. In view of the decline in use of these pipes in some areas it is most unlikely that this item would produce satisfactory prices.

An item in the BLOC, virtually identical to the cast iron pipe item, eventually produced a reasonable set of prices. It appears, however, that an item based on PVC pipe, which is now widely used for both stormwater and sewer drain applications,

¹⁴ Respondents were, however, asked for mid-year prices for “a national average location”.

would produce more robust results without the need for the further investigation that was needed to resolve the anomalies in the original dataset.

6.6.2.3 *Water pipes*

Small diameter copper pipe provided a reasonably sound set of results in the BLOC although there were issues with the very substantial discounts available in Auckland (and across the rest of New Zealand) that led to the potential for large variances between list prices and actual prices paid. These problems were largely resolved with some further research and therefore it has been shown that this item can produce satisfactory results.

Polyethylene pipes are now used widely in Australia and the USA for water supply; Rawlinsons New Zealand (Rawlinsons 2007b) gives prices for small diameter water pipe in both PVC and polybutylene which would be comparable. Any of the three materials would satisfy the description of “plastic pipe.... suitable for drinking water”, and it would appear that this would be a satisfactory item.

6.6.2.4 *Electrical cable*

This item in the Davis Langdon basket is nearly identical to the respective item in the BLOC, which produced the poor results described earlier. It is not considered to be a suitable item in this context due to the variability of responses unless prices could be obtained from sub-contractors for specific quantities of a tightly specified item.

6.6.3 Possible solutions to the services problem

The CPPPs shown in Table 6.18 that were based on the BLOC with all services items deleted suggest that the exclusion of services from the basket of goods approach does change the outcomes, with variations in the resultant CPPPs (compared to CPPPs based on the complete BLOC) of up to 10%. Although the changes in the CPPPs were for the most part not large, it is suggested for several reasons that services costs should be included in the basket if possible to produce robust results:

- engineering services represent a substantial proportion of building costs for most building types and the omission of services costs may appear to weaken the validity of the method

- some services items in the BLOC have shown considerable variability in prices
- that variability of prices may have distorted the CPPP values calculated based on the full BLOC that included the services items thus giving a false comparison between the two sets of CPPPs.

As mentioned above further investigation of the effects of the inclusion or exclusion of services items from the BLOC is required. Singapore CPPPs showed considerable variation when services were excluded. On the basis of this study alone it would be premature to conclude that services items can be ignored without significantly affecting the resultant CPPPs.

6.6.3.1 *Hydraulics*

It has been shown that hydraulic services items can be identified and specified in such a way that valid datasets of prices can be obtained. Sanitary fittings and pipework, if selected and described with care, will produce solid results.

6.6.3.2 *Mechanical*

Mechanical services are less easy to deal with although some lessons learnt from the BLOC survey show that if difficulties with differences in typical specification and methods of pricing are identified and planned for in advance then comparable prices for some ductwork can be obtained. Another approach might be to use the sort of cost/unit area approach for air conditioning that is used by Cordell (described earlier) to compare inclusive rates for servicing typical spaces such as offices rather than searching for a set of cost significant components to represent complete mechanical installations. This would, however, seriously impair the viability of the BLOC as a productivity metric as will be demonstrated below. As the productivity aspect of the BLOC is an important feature of that approach, the cost/unit area method is not recommended.

6.6.3.3 *Electrical*

Electrical services appears to be the most challenging area, however, the problems associated with this element can be addressed. Two items were included in the BLOC: cable and light fittings. The cable item did not work well due to lack of

familiarity with the cost of the item among respondents (shown by the relatively small number of responses) and variations in prices due both to differences in similar materials that would be suitable and considerable differences in unit prices in respect of the quantity purchased (shown by the variability in prices even after obvious supply and fix rates were discarded).

The downlight item, even with drawn details supplied, produced very variable results, most likely because there is such a diversity of downlights available. Although the item was described as “low voltage” and the detail showed a small diameter fitting (65-75mm diameter) it is not clear whether respondents noted these points as prices were spread widely. The prices from Phoenix, for example, ranged from USD\$25 to \$130 each and while the higher figures may have been supply and fix rates equally it may be that respondents were pricing something different. A search of three US building cost resources (RSMeans, 2007; Get-A-Quote, 2008; Home Depot, 2008) failed to find any mention of the sort of low voltage fitting installed in the reference project and described in the BLOC, which suggests that these fittings are not commonly used in the USA at present. In fact the term “downlight” does not appear at all in the index of RSMeans or the index to the electrical section of Get-A-Quote.

6.6.3.4 Concluding remarks

Clearly the challenge here is to find some items that are similar and in common use that can be included. These then need to be tested in the field in order to ascertain whether consistent results can be obtained. Unless very large price samples can be collected that will provide representative averages from widely dispersed datasets the selected items need to be quite tightly specified so that the sort of problems encountered with some of the services items in the BLOC are eliminated.

6.7 COMPARING DERIVED CPPPS TO OTHER CONVERSION FACTORS

A set of CPPPs was derived from the BLOC costs and the outcomes have been presented earlier in a series of tables. Of those CPPPs those that are based on the cost

of the full BLOC, including preliminaries, margins and tax, are arguably those that will give the truest picture of relative construction costs in the six cities. The weighting of the items in the basket reflect the cost shares of the various items, and the addition of preliminaries, margins and tax produces a total cost that reflects the amount a client would actually pay for the materials in the basket and the labour necessary to incorporate them into their building. Table 6.19 shows the comparison between the CPPP (PMT) and a range of other conversion factors.

LOCATION	PPP World Bank 2004	PPP OECD 2007	10 YR Average 2007	10 YR Average 2008	Exchange rate Apr 2008	iPod Index Jan 2007	Big Mac Index Apr-2008	CPPP(PMT) BLOC Mar 2008
Australia	1.4	1.43	1.526	1.484	1.104	1.47	1.27	1.662
New Zealand	1.6	1.54	1.767	1.719	1.265	1.66	1.57	1.405
Singapore	1.5	n/a	1.664	1.653	1.408	1.66	1.27	1.275
USA	1.0	1.00	1.000	1.000	1.000	1.00	1.00	1.000

Table 6.19 Comparisons of BLOC(PMT) based CPPPs and other conversion factors (See below at 6.7.1 for identification and discussion of data sources).

As all available PPPs and other factors are country based rather than city or location based the individual cities in the BLOC study have been taken as proxies for national indices; for the three Australian cities a simple mean of the individual CPPPs has been used as a proxy for all Australia. As noted earlier in the case of the USA, Phoenix costs, at least for hotel construction, are close to the median level for those US cities included in the *Riders Digest* (RLB, 2008b) and therefore the use of Phoenix as a proxy is justified. Singapore is a basically one city while the New Zealand edition of Rawlinsons (Rawlinsons, 2007b) gives regional indices that show construction price levels in Auckland to be only marginally higher than those in other locations in New Zealand (i.e. +1.6% to 2.2% compared to Christchurch, Dunedin and Wellington).

6.7.1 Notes on data and sources

Before considering the implications of the figures in the table some points should be made about the various factors that have been used. The World Bank general PPPs are the latest available from the ICP (World Bank, 2006); the OECD PPPs are

similarly the latest available from the OECD (OECD, 2008) and as Singapore is not included in the OECD no 2007 OECD PPP was available.

The two sets of ten year average exchange rates are included to provide a synchronised comparison between the indices and exchange rates. As the iPod Index was based on January 2007 prices (CommSec, 2007) the ten year average for the period ending first quarter of 2007 is included; similarly the ten year average for the period ending first quarter of 2008 is included to match the time during which the BLOC prices were collected. Current (April 2008) exchange rates illustrate the volatility of spot exchange rates.

The iPod Index figures were calculated from data included in CommSec (2007). That document only listed prices for the 2GB iPod Nano in USD for the 26 countries included in their study. It did, however, give the current Australian price and from that it was possible to work out the date at which the conversion to USD had been made and thus to locate appropriate exchange rates (Federal Reserve, 2008) for the relevant currencies and so calculate prices in national currencies.

The Big Mac Index was calculated based on current prices in the target countries as at May 2008¹⁵.

6.7.2 Observations

In Table 6.19 the CPPP's derived from the BLOC are compared against two sets of general PPPs, three sets of exchange rates and two single commodity indices. Some points are worthy of discussion:

- The two sets of PPPs, although three years apart, show very similar relativities for the AUD and NZD in respect of the USD
- Current exchange rates are substantially different to the ten year average rates and this highlights the volatility of nominal exchange rates and their unsuitability for most cost comparisons

¹⁵ See Appendix A7.

- The two commodity indices suggest some substantial differences in implied purchasing power with the iPod Index higher than the Big Mac Index by 16%, 5% and 31% for Australia, New Zealand and Singapore respectively
- The CPPP(PMT) indices show quite different relativities between the various national currencies and the USD when compared to all of the other indices.

6.7.3 Comparing construction dollars

These C PPPs must be considered in light of the differences in timing between the formulation of the various conversion factors (i.e. the BLOC prices reflect late 2007/early 2008 prices and therefore include significant price rises in some important commodities, notably steel and copper). The magnitude of the differences, however, is such that the results provide strong evidence of the existence of different relativities between construction costs and other costs such as the cost of particular manufactured items like as the iPod and the general expenditure on goods and services that is represented by general PPPs. This emphasises the need for construction-specific PPPs as the use of other conversion factors can distort results. This is particularly true for Singapore where the C PPPs suggest that one Singapore “construction dollar”, measured by purchasing power, has only around 28% less construction purchasing power than one US construction dollar in USA, i.e. SGD\$1.28 buys around same amount of hotel construction to that bought by one USD. Use of the other conversion factors, however, shows that anywhere from \$SGD1.35 (based on the Big Mac) to SGD\$1.65 (based on the more recent ten year average exchange rate) would need to be spent in order to buy one USD worth of hotel construction. Clearly these are significant differences and once again these results reinforce the comparisons made in Chapter 2 where it was shown that the use of various conversion factors can dramatically alter the conclusions drawn about relative costs, and thus project and contractor performance and competitiveness.

The C PPPs also show very different relativities between Singapore and Australia: where the use of any of the other indices listed would suggest that one SGD buys less construction in Singapore than one AUD buys in Australia, the C PPPs show that

AUD\$1.30 needs to be spent to buy what just one SGD buys¹⁶. All other indices show, to varying degrees, that the purchasing power of the NZD is less than that of the AUD yet the CPPP suggests that one New Zealand construction dollar will buy the equivalent of \$1.18 in Australian construction dollars.

6.8 EVALUATING THE CPPPS

Earlier, at 6.2.2, relative hotel construction costs were assessed using BLOC costs from Sydney, Melbourne and Brisbane. It was shown that the relative cost of construction in the three locations was not mirrored in published cost/m² rates for hotels obtained from a number of different sources. It was also noted that the relativities shown by the various sets of superficial rates did not agree.

6.8.1 International superficial rates

The comparison was extended to include all six cities, however, only three sets of rates for cities outside Australia were obtainable¹⁷. The rates are shown in Table 6.20. The Rawlinsons (2008) and Davis Langdon (2008) rates for Phoenix were calculated *pro rata* from comparative rates for Los Angeles and Phoenix taken from RLB (2008b) as neither publication gives specific rates for Phoenix while RLB does. The Davis Langdon rates were converted from the USD rates (as published) to local currencies using the second quarter 2007 exchange rates listed in that same publication. The RLB rates were converted to local currencies using those same exchange rates, as it is noted in the 2008 *Riders Digest* (RLB, 2008b) that costs had been converted to USD at mid 2007 exchange rates. As the absolute values for each of the rates cannot be directly compared, due to potential inconsistencies in regard to what is included in the rates, any minor differences in exchange rates between the sets of rates (*i.e.* second quarter versus mid year) can be ignored. While absolute values cannot be compared directly the relative price levels are comparable

¹⁶ Note that this comparison and the one that follows (NZD and AUD) have been determined not from the indices in Table 6.18 but by direct comparison of BLOC (PMT) costs for the various locations.

¹⁷ Cordell, referred to extensively in this thesis, does not publish comparable international rates.

CITY	Rawlinsons	Davis Langdon	RLB
Sydney	3278	2300	2630
Melbourne	2977	2650	3288
Brisbane	3060	2750	3427
Auckland	3250	2900	2628
Singapore	1975	3022	3259
Phoenix	1540	2100	1829

**Table 6.20 Three star hotels: average cost¹⁸ in local currencies per m² of GFA
(Sources: Rawlinsons, 2008; Davis Langdon, 2008; RLB, 2008b)**

It is immediately clear from Table 6.20 that there are substantial differences between the three sets of rates. Even allowing for possible differences in inclusions and exclusions between the three sets of rates relativities within each set vary considerably. For example, if Sydney and Brisbane rates from Rawlinsons and RLB are compared it can be seen that one source shows Sydney to be 7% more expensive than Brisbane while the other source suggests that Brisbane is 30% more expensive than Sydney. Such differences cannot be explained by, for example, the inclusion of FF&E costs in one set of rates and not in the other.

6.8.2 Implied CPPPs derived from published superficial rates

Table 6.21 shows implied CPPPs based on the rates in Table 6.20, using the USD as the base. This clearly illustrates the degree of variation within each set of rates.

CITY	Rawlinsons	Davis Langdon	RLB	BLOC (PMT) CPPP
Sydney	2.129	1.095	1.438	1.568
Melbourne	1.933	1.262	1.798	1.845
Brisbane	1.987	1.310	1.874	1.572
Auckland	2.110	1.381	1.437	1.405
Singapore	1.282	1.439	1.782	1.275
Phoenix	1.000	1.000	1.000	1.000

Table 6.21 Implied CPPPs based on published \$/m² rates (Sources: Rawlinsons, 2008; Davis Langdon, 2008; RLB, 2008b)

¹⁸ As noted the costs may not be completely comparable due to differences such as the inclusion or otherwise of FF&E costs, however, the relative price levels between the three sets of rates are comparable.

The only consistent outcome is that the cost of building in Phoenix is, in each case, the lowest of the six locations. Rawlinsons' rates show the greatest price differentials with Sydney and Auckland both appearing to be more than twice as expensive as Phoenix. Davis Langdon's rates produce the closest grouping of cost levels but in stark comparison to Rawlinsons suggest that Sydney is only marginally more expensive than Phoenix. It is only the RLB rates that produce indices that are at all similar to the CPPPs derived from the BLOC costs, with Singapore once again a notable exception.

There is no obvious cause for the Singapore anomaly. As Table 6.14 shows while the price levels for building materials are higher in Singapore than in Phoenix, labour is a great deal cheaper by any measure. UBS (2006) compares general wage levels in over 70 cities worldwide. Phoenix is not included, however, four other major US cities are with New York used as the base with an index of 100. Chicago (88.3), Los Angeles (86.3) and Miami (67.6) all show lower wage levels than New York but even Miami, with the lowest wage levels of the US cities has wage levels well above those in Singapore (32.3).

The same publication lists gross annual wages for builders' labourers; Singapore labourers earn only 56% of that earned by their counterparts in Miami and just 37% of those in Chicago. It is reasonable to assume that the difference in wage levels between Phoenix and Singapore would be at least as marked as between Miami and Singapore.

Lower wages are generally accepted to be mirrored by lower productivity (Ong and Mitchell, 2000, citing Balassa, 1964; Ong, 2002, citing Oulton, 1994). Even if lower productivity means that total labour costs in Singapore may be higher than the BLOC results suggest (given that a Singapore derived BLOC could show different labour and materials weights to the Sydney derived BLOC) the suggestion that Singapore levels are nearly 80% higher than those in Phoenix appears untenable.

6.8.3 Ranking cost levels

Table 6.22 ranks the cities by cost level, from least expensive to most expensive, based on the CPPPs in Table 6.21. The lack of consistency is immediately apparent. While it appears that Rawlinsons and Davis Langdon agree on the ranking of four of the six cities and that the CPPPs based on the RLB rates and those based on the BLOC produce rankings that are broadly similar, the preceding table (Table 6.21) shows that the relative cost level differences are substantially different even where rankings are similar.

CITY	Rawlinsons	Davis Langdon	RLB	BLOC (PMT) CPPP
Sydney	6	2	3	4
Melbourne	3	3	5	6
Brisbane	4	4	6	5
Auckland	5	5	2	3
Singapore	2	6	4	2
Phoenix	1	1	1	1

Table 6.22 Comparative cost levels – rankings are based on CPPPs from Table 6.21¹⁹

6.9 COMPARING CONSTRUCTION COSTS USING CPPPS

In this section construction costs are compared in several ways using the derived CPPPs. The mechanism used is the typical reference project. The question is asked: what would be the cost, in local currencies, to construct a hypothetical hotel building costing AUD\$20 million in Sydney in each of the other locations based on various conversion factors?.

6.9.1 In-country comparisons

For comparisons within countries locally produced regional indices for non-residential construction are available (e.g. Rawlinsons, 2007a), although it should be noted that as has already been shown for cost/m² rates for hotel construction in Sydney, Melbourne and Brisbane different sources do not show the same cost relativities. Similarly published regional indices do not agree: Cordell suggests, for example, lower construction costs in all regional centres in New South Wales

¹⁹ Where 1 = least expensive, 6= most expensive.

(compared to costs in Sydney) while Rawlinsons suggests exactly the opposite – Table 6.23 shows regional indices for several centres outside Sydney and demonstrates clearly the difference in cost levels suggested by the two sources.

Location	Rawlinsons	Cordell
Sydney	100	100
Newcastle	105	96
Wollongong	100	98
Armidale	110	86
Tamworth	105	82

Table 6.23 Some regional cost indices for New South Wales. (Sources: Rawlinsons, 2008; Cordell, 2008).

The differences in costs between capital cities in Australia have already been discussed. In addition the differences between the various published rates have been explored as well as the different relativities suggested by the BLOC exercise. The following analysis therefore focuses on costs between different currencies and therefore excludes Melbourne and Brisbane.

6.9.2 Current exchange rates

It has been stated repeatedly that exchange rates do not provide a sound basis for comparing costs between countries. In this analysis it simply provides a starting point and a basis for some comparisons between methods of cost conversion.

CITY	Local currencies (millions)
Sydney	20.000
Auckland	23.994
Singapore	26.790
Phoenix	18.683

Table 6.24 Hypothetical project cost – local currencies, based on current exchange rates²⁰

Table 6.24 shows the value in the three offshore locations for the hypothetical AUD\$20 million project based simply on nominal exchange rates. Note that these costs do not reflect any regional differences, nor do they reflect the nature of the

²⁰ Rates for AUD against other currencies obtained online from Oanda on 5 May 2008. 1AUD = 1.1997NZD, 1.2757SGD, 0.934USD.

project. They are based on spot market rates as at 5 May 2008. The figures are only the amounts of the various local currencies that one would have been realised in exchange for \$AUD20m.

It should be noted that this is a hypothetical scenario and does not in any way reflect the relative cost of construction in the various locations.

6.9.3 Construction specific PPPs

Using the CPPPs presented earlier, based on purchasing power that reflects the costs of the resources used in the construction. Assuming that all the projects use the same resources, the comparative cost of the same hypothetical project was calculated for each location. The results are shown in Table 6.25.

CITY	Local currencies (millions)
Sydney	20.000
Auckland	17.916
Singapore	16.263
Phoenix	12.755

Table 6.25 Hypothetical project cost – local currencies, based on CPPPs

These figures represent the expected cost at the base date of the BLOC survey (late2007/early 2008) in the various national currencies based on the cost of resources in each location, i.e. the purchasing power. These costs are equivalents, i.e. they suggest that a hotel building identical to one costing \$AUD20m in Sydney could be constructed for \$NZD17.92m in Auckland, \$SGD16.26m in Singapore and \$USD12.75m in Phoenix. These costs reflect the same standard and type of building and are again specific to a particular time. They represent, for example, the costs that a company with an active presence in each city (and so supplying or raising funds at the same location) would expect to pay in local currency for a building identical to one constructed at the same time in Sydney at a cost of \$AUD20 million. As it is time-specific it reflects market conditions at the base date. It should be noted that foreign exchange rates play no part in this calculation.

The differences are considerable. The cost of the project now appears \$NZD6.08million (25%) cheaper in Auckland²¹, \$SGD12.64 million (47%) cheaper in Singapore and \$USD5.93 million (32%) cheaper in Phoenix. This again highlights the dangers of making exchange rate conversions and then drawing conclusions about competitiveness and relative productivity based on such cost comparisons (see 2.9).

6.9.4 Building costs that reflect different price levels

The foregoing equivalent costs do not, however, provide an indication of the amount that would be required in currency A to finance construction in location B. For example, if the same hypothetical project costs \$AUD20m in Sydney then the question becomes what would be the predicted cost in AUD of an identical building in Phoenix. This would be pertinent if a client in Sydney wished to build in Phoenix.

If the current exchange rate (1AUD=0.934USD²²) were to be used the predicted cost would be \$USD18.68m as shown in Table 6.24. This figure, however, makes no allowance for differences in construction prices between the two cities. These price differences are eliminated by applying the CPPP. The CPPP for Sydney is 1.568, relative to Phoenix (CPPP=1.00) hence the expected cost as shown in Table 6.25 is \$USD12.76m. Therefore at the current date the amount of AUD required to pay for the construction in Phoenix will be

$$\frac{12.76}{0.934} = \$AUD13.66m$$

This figure is the predicted amount in AUD that the Sydney client would have to convert to USD in order to pay for the building in Phoenix. So it could be said that, in this specific context, Sydney is some 46% more expensive than Phoenix at the stated date (because the current exchange rate at a particular date has been used). Applying the same method to costs in Auckland and Singapore (Table 6.26) shows

²¹ Compared to costs derived using current exchange rates; this should not be interpreted as any sort of absolute difference in relative costs between the cities.

²² 3 May 2008 (Source: oanda.com)

the cost of building in Sydney to be 34% higher than in Auckland and 56% higher than in Singapore.

CITY	Nominal exchange rates ²³	CPPPs ²⁴	Real exchange rates
Sydney	AUD20.00m	AUD20.00m	AUD20.00m
Auckland	NZD23.99m	NZD17.92m	AUD14.96m
Singapore	SGD26.79m	SGD16.26m	AUD12.78m
Phoenix	USD18.68m	USD12.76m	AUD13.66m

Table 6.26 Comparative costs based on nominal exchange rates, CPPPs based on BLOC costs and real exchange rates derived from current nominal exchange rates and CPPPs.

Comparing the values in the first column with those in the second column clearly illustrates how the use of nominal exchange rates distorts relative construction costs. The values in AUD shown in the last column provide a true picture of relative construction costs between the various locations.

Using those real exchange rates that remove the effects of different price levels between locations, it is possible to calculate the cost in Phoenix of a building in Sydney, without requiring complete drawings and/or cost estimates. For example, superficial rates can be calculated from local data, i.e. if the cost/m² is known in the currency of the base location it can be easily converted to either a cost/m² in the local currency in the target location, or an equivalent rate calculated in the base currency.

This is much better than using published superficial rates as these have been shown to vary markedly from source to source. In addition the published rates are stated as ranges with rates often $\pm 15\text{-}25\%$ of the median rate (e.g. RLB, 2008b).

6.9.5 Comparing PPP adjusted costs and published superficial rates

To illustrate the last point the \$AUD20m project is again used. RLB (2008) suggests median superficial rates for three star hotels of \$AUD2385/m² for Sydney and

²³ From Table 6.24

²⁴ From Table 6.25

\$USD1829/m² for Phoenix. Therefore based on the given cost and cost/m² rate the Sydney hotel would have a floor area of:

$$\frac{20,000,000}{2385} = 8368\text{m}^2$$

The same building in Phoenix would have an estimated cost of

$$8368\text{m}^2 \times \$1829 = \$\text{USD}15.31\text{m}$$

This is \$USD2.55m (20%) more expensive than the CPPP estimate suggests.

6.9.6 Comparing BLOC CPPPs and OECD CPPPs

The OECD publishes CPPPs for a limited number of countries roughly every three years. Indices are available for Australia, New Zealand and the USA but not for Singapore. The most recent available were published in 2005 but the benchmark year is 2002 (OECD, 2005). General PPPs are updated on a monthly basis between benchmark years. Based on movements in general (i.e. GDP level) PPPs in the period 2002 to 2007 the latest published OECD CPPPs have been updated to 2007. Singapore was excluded from this exercise due to the lack of PPP data. Table 6.27 shows the PPPs and CPPPs for three locations for 2007.

Location	2002		2007		2008 BLOC CPPPs
	PPP	CPPP	PPP	CPPP ²⁵	
Australia	1.30	1.27	1.43	1.40	1.662
New Zealand	1.43	1.92	1.54	2.07	1.405
USA	1.00	1.00	1.00	1.00	1.000

Table 6.27 Comparison of general PPPs and construction-specific PPPs (OECD, 2005; 2008) and BLOC-based CPPPs.

The predicted CPPP for Australia aligns reasonably closely with the BLOC derived CPPP. Given that the OECD based CPPP (1.40) is predicted on the assumption that construction PPP would move in the same way that general PPP did over the five year period the difference is not significant. The New Zealand result, however, shows a considerable difference with the 2008 BLOC derived CPPP (1.405) matching the 2002 OECD figure but showing a marked difference from the predicted 2007 figure (2.07). Although this comparison is restricted in scope it does provide

²⁵ Predicted values

some evidence to support the view that the OECD CPPPs are not reliable for construction cost comparisons as demonstrated by, among other things, the New Zealand example (see Table 6.27).

6.9.7 Comparing BLOC CPPPs and Faithful+Gould parities

Earlier (at 3.7.7.2) the Faithful+Gould/RSMMeans (F+G/RSM) parity method was briefly described. It employs a method that is broadly similar the BLOC method hence it is appropriate to compare their parities against the CPPPs developed here.

The F+G/RSM parities are city specific and use Chicago as the base and it is only US city included. The most recently published parities (Faithful+Gould/RSMMeans, 2008) include Melbourne, Singapore and Auckland. To compare the BLOC based CPPPs with the F+G/RSM parities the parities for Chicago and the other relevant locations were converted to match the base used here (Phoenix =1.000). Location indices were obtained from RSMMeans (2008) that show construction costs in Chicago to be 28% higher than those in Phoenix. Using that factor the relevant parities were recalculated with Phoenix as the base. The results are shown in Table 6.28

CITY	BLOC CPPPs ²⁶	F+G/RSM parities Chicago base	F+G/RSM parities Phoenix base
Melbourne	1.85	1.24	1.59
Auckland	1.41	1.33	1.70
Singapore	1.28	1.30	1.66
Chicago	n/a	1.00	1.29
Phoenix	1.00	0.78	1.000

Table 6.28 Comparison of BLOC CPPPs and parities from by Faithful+Gould/RSMMeans (2008). Values in italics were calculated using regional indices from RSMMeans (2008).

There is little agreement between the two sets of factors. The absolute values vary considerably for each city and the relative price levels do not match, with Melbourne appearing to be the least expensive of the three cities outside the USA and Singapore sitting between Auckland and Melbourne.

²⁶ The F+G/RSM parities are published to base 100 hence the CPPPs have been rounded to two decimal places for consistency in this table.

Given the uncertainty regarding the details of the F+G/RSM method is not possible to make any assessment of what produced the differences. It is, however, apparent from the information published by F+G/RSM that prices are obtained from only one source in each city²⁷. The problems associated with single sources of data have been discussed earlier. As the BLOC CPPPs are based on multiple observations they have a more robust foundation in that regard at least. Similarly while the F+G/RSM basket is weighted to reflect cost shares of the items that comprise it no details of how that weighting is achieved are available; nor it is known whether the model project and its base costs are actual or hypothetical.

6.9.8 Market adjusted CPPPs

One characteristic of the CPPPs used in the foregoing comparisons is that they reflect the levels of competition within the construction industries in the various locations prevailing at the base date. If market-adjusted CPPPs (see Table 6.13) that bring market conditions to a medium level are used more basic cost relativities may be identified. Table 6.29 shows those cost relativities for the same hypothetical project.

CITY	BLOC(PMT)	BLOC(MA)
Sydney	AUD20.00m	AUD20.00
Auckland	NZD17.92m	NZD18.47
Singapore	SGD16.26m	SGD13.80
Phoenix	USD12.76m	USD11.69

Table 6.29 Comparison of hypothetical project costs (in local currencies), calculated using BLOC(PMT) based CPPPs and market adjusted CPPPs.

These results shows decreases in costs in Singapore and Phoenix while Auckland costs show a small increase. It can be inferred, for example, from these market-adjusted project costs that the underlying comparative cost to build in Phoenix compared to Sydney, with allowance for differences in current competition levels in the two cities, can be determined by using a construction dollar exchange rate of 1AUD = 0.5845USD. Similar conversion factors can be calculated for the other locations.

²⁷ For example, for Melbourne it is Padghams, a firm of quantity surveyors.

These conversion factors provide a more robust basis for cost comparisons in studies such as Flanagan *et al.* (1986) (discussed at 2.9.1). The aim of that study was to look for fundamental differences in efficiency and performance between the construction industries in the USA and the UK. Out-turn costs for a set of matched pairs of very similar projects were obtained in GBP and USD respectively for each project in each pair. Where measuring differences in productivity in the medium term, for example, is the aim then costs must be normalised as far as possible if valid comparisons are to emerge. Removing distortions due to market conditions is important in that context and hence the market-adjusted CPPPs used in the foregoing comparisons can be useful.

6.10 THE BLOC AS A METRIC OF INTERNATIONAL CONSTRUCTION COSTS

The BLOC costs can be used to compare construction costs directly, using the BLOC as a unit of construction costs. This method parallels the method employed by Langston and de Valence (1999) who expressed building costs in hamburgers/m² by dividing project costs (in local currency) by the local cost of a Big Mac. Here construction costs at the project level are expressed as the number of BLOCs that equal the cost of a project, calculated by dividing the estimated cost for a hypothetical project by the cost of the BLOC with both costs expressed in the same local currency.

Using the cost/m² rates from RLB (2008b), which with the exception of Singapore show the closest match of relativities to those produced by the BLOC-based CPPPs, the cost of a hypothetical hotel building was calculated in terms of the equivalent number of BLOCs²⁸ in the various cities. Table 6.30 shows the outcomes and includes a new BLOC Index (BI) that indicates the relative cost in BLOC equivalents of a 10,000m² hotel in the various locations, once again with Phoenix as the base (BI = 100). Project costs are based on median rates for three star hotels from RLB

²⁸ In all cases the BLOC used in this part of the analysis includes preliminaries, markups and tax, i.e. the BLOC(PMT).

(2008b). Note once again that exchange rates play no part in this comparison as BLOC costs for each location were compiled in local currencies and building costs are similarly expressed in local currencies.

CITY	Project cost (Local currencies - millions)	BLOC equivalent	BLOC Index
Sydney	23.85	1.8703	83.15
Melbourne	29.44	1.9621	87.23
Brisbane	32.25	2.5227	112.15
Auckland	26.28	2.3007	102.29
Singapore	32.59	3.1439	139.77
Phoenix	18.29	2.2493	100.00

Table 6.30 Project costs expressed in BLOC equivalents and BLOC Index values derived from those BLOC equivalent costs.

This comparison produces some very significant results. As the table clearly implies, in Phoenix around 17% more resources are required to build than are required in Sydney²⁹, while Singapore uses nearly 72% more resources than Sydney. The relativities shown here are very different to those shown in any of the preceding analyses. The meaning and significance of these results are discussed below.

6.10.1 Relative productivity

In Chapter 4 (at 4.2.5) it was proposed that the BLOC could be used in the manner described here and that it could serve as a measure of relative productivity between locations. The comparison between Sydney and Phoenix in Table 6.30 shows that a typical 10,000m² hotel building in Sydney would cost \$AUD23.85m and the same type and size hotel building in Phoenix would cost \$USD18.29m (based on cost/m² rates from RLB, 2008b). This implies a CPPP of 1.304 for Sydney with Phoenix as the base (CPPP = 1.000). The BLOC based CPPP for Sydney was calculated earlier (see Table 6.11) as 1.568. If the Phoenix cost is used as a base and the BLOC CPPP applied the expected cost in Sydney becomes

$$\text{\$USD18.29m} \times 1.568 = \text{\$AUD28.68m}$$

Dividing this by the Sydney BLOC cost:

²⁹ This accords with the finding by Access Economics (1999) discussed in Chapter 2 where productivity in the Australian construction industry was assessed as 10% better than that in the USA.

$$\frac{28.68}{12.75} = 2.249 \text{ BLOC equivalents}$$

This is the same as the BLOC equivalent cost in Phoenix, and this will always occur as the CPPP is derived from the same BLOC costs for the two locations. The BLOC Index shown in Table 6.29 does, however, identify some very significant relativities not so much in terms of cost but in terms of productivity. Sydney now emerges as the most productive location in terms of the ratio of labour input to construction output. As discussed in Chapter 4 (at 4.2.3) as the quantity of materials in the BLOC is constant differing BLOC equivalents (i.e. construction cost divided by BLOC cost) can only mean that different amounts of labour were required in order to install the materials in the BLOC³⁰. As the cost of the hypothetical hotel expressed as the number of BLOC equivalents is lowest in Sydney it follows that that the industry in Sydney is the most productive compared to those in the other five locations.

Singapore is shown to be the least productive in spite of displaying the lowest construction cost when expressed in AUD (see Table 6.26). This is consistent with the low labour rates in Singapore and the belief that lower paid workers are less productive (Langston and de Valence, 1999; Ong and Mitchell, 2000; Ong, 2002 citing Oulton, 1994).

6.11 SENSITIVITY ANALYSIS – VARYING SUPERFICIAL RATES

As it has been shown earlier that published superficial rates for hotel construction vary considerably depending on their source a sensitivity analysis of the RLB rates was conducted. In order to test the effect of variations in the superficial rates, several scenarios were used with Phoenix and Sydney as the test locations. The initial BLOC

³⁰ It should be noted that to produce valid purchasing power parities the items in the BLOC must have the same fixed weights for all locations. This is an essential element of the PPP approach and it assumes that productivity is the same in each location. Differences in BLOC equivalents between locations, however, indicate that productivity varies as if we are comparing identical buildings then the quantities of materials must be identical – hence differences in BLOC equivalent cost must indicate differing productivity.

Index for Sydney (from Table 6.29) is 83.15. Building costs were adjusted up and down to reflect possible differences in local rates. In each scenario building costs were adjusted as stated in each scenario description, the building cost in each location was divided by the local cost of the BLOC and the BLOC Index recalculated. For example, Scenario 1 shows how the BLOC Index would vary against the base index for Phoenix if hotel construction costs in Phoenix were actually 10% lower than suggested by the RLB rates.

6.11.1 Scenario 1 – Phoenix cost 10% lower, Sydney cost unchanged

The building costs (in local currencies) would be \$USD16.63m in Phoenix, with the Sydney cost unchanged at \$AUD23.85m.

Location	Phoenix cost –10%, Sydney unchanged		
	Building cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	23.85	1.8703	91.43
Phoenix	16.63	2.0455	100.00

Table 6.31 Varying cost/m² rates – Scenario 1

The BLOC equivalent for the Phoenix cost becomes 2.0455 (down from the original 2.2493) and if Phoenix is retained as the base with a BLOC Index of 1.00 the new BLOC Index for Sydney becomes 91.43 (cf. the original of 83.15). Hence this test shows Sydney still to be more productive than Phoenix as 8.5% fewer resources are required to build the same hotel. Tables 6.31 show the results of this test.

6.11.2 Scenario 2 – Phoenix cost unchanged, Sydney cost 20% higher

The building costs (in local currencies) would be \$USD18.29m in Phoenix, with the Sydney cost becoming \$AUD28.62m.

Location	Phoenix cost unchanged, Sydney +20%		
	Building cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	28.62	2.2477	99.80
Phoenix	18.29	2.2493	100.00

Table 6.32 Varying cost/m² rates – Scenario 2

This test shows similar resource use in both cities assuming that the BLOC cost does not vary and the two buildings are identical. If the published RLB rates used in the earlier analysis of superficial rates are low then increasing the building cost produces a larger BLOC equivalent. The larger value for the BLOC equivalent for Sydney must reflect lower productivity as more labour would be required to install the same quantity of materials.

6.11.3 Scenario 3 – Phoenix cost 10% lower, Sydney cost 10% higher

The building costs (in local currencies) would be \$USD16.63m in Phoenix, with the Sydney cost becoming \$AUD26.23m.

Location	Phoenix cost –10%, Sydney +10%		
	Building cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	26.23	2.0576	100.59
Phoenix	16.63	2.0455	100.00

Table 6.33 Varying cost/m² rates – Scenario 3

This test again shows similar resource use in the two cities with the BLOC Index almost identical for both locations.

6.11.4 Scenario 4 – Phoenix cost 15% lower, Sydney cost 15% higher

The building costs (in local currencies) would be \$USD15.90m in Phoenix, with the Sydney cost becoming \$AUD27.43m.

Location	Phoenix cost –15%, Sydney +15%		
	Building cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	27.43	2.1514	110.01
Phoenix	15.90	1.9557	100.00

Table 6.34 Varying cost/m² rates – Scenario 4

With a substantial downward change in Phoenix rates and a similar upward change in Sydney rates, Sydney now appears to use 10% more resources than Phoenix.

6.11.5 Discussion of sensitivity analysis results

The preceding analysis shows that it requires a considerably lower estimated cost in Phoenix coupled with a similarly higher cost in Sydney for Sydney to be judged less productive than Phoenix (Scenario 4). On balance it appears that Sydney is, at worst, 10% less productive than Phoenix (see Scenario 4). If the RLB rates used are consistent, inasmuch as they are comparable rates for comparable buildings, then there is, however, strong evidence for the conclusion that construction operatives in Sydney are more productive than their counterparts in Phoenix.

6.12 SENSITIVITY ANALYSIS – VARYING MATERIALS COSTS

A similar analysis was carried out to gauge the effect of variations in materials cost of on the BLOC Index. The proportions of materials in the building costs in each location are as shown in Table 6.35.

CITY	Labour %	Materials %
Sydney	47%	53%
Melbourne	50%	50%
Brisbane	49%	51%
Auckland	37%	63%
Singapore	13%	87%
Phoenix	42%	58%

Table 6.35 Labour/materials ratios in BLOCs for the six cities surveyed.

Again several scenarios were tested using Sydney and Phoenix as the examples. The initial index for Sydney (from Table 6.29) is 83.15. Building costs for a 10,000m² hotel, based on RLB (2008b) rates, have been adjusted to include the nominated variations in materials costs only. In this analysis BLOC costs have also been adjusted to reflect the nominated differences in materials costs. The following tables show the results of the three scenarios tested.

6.12.1 Scenario 1 – Materials cost: Phoenix unchanged, Sydney 10% higher

In this instance (see Table 6.36) higher materials costs in Sydney have virtually no impact on the BLOC Index.

Location	Materials costs			
	Phoenix unchanged, Sydney +10%			
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	25.12	13.43	1.8705	83.16
Phoenix	18.29	8.13	2.2493	100.00

Table 6.36 Varying materials costs – Scenario 1

6.12.2 Scenario 2 – Materials cost: Phoenix 10% higher, Sydney 10% higher

In this case once again the BLOC Index hardly changes (See Table 6.37).

Location	Materials costs			
	Phoenix +10%, Sydney +10%			
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	25.12	13.43	1.8705	83.23
Phoenix	19.35	8.61	2.2474	100.00

Table 6.37 Varying materials costs – Scenario 2

6.12.3 Scenario 3 – Materials cost: Phoenix 10% higher, Sydney unchanged

Similarly the BLOC Index shows almost no change (Table 6.38).

Location	Materials costs			
	Phoenix +10%, Sydney unchanged			
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)	BLOC equivalent	BLOC Index
Sydney	23.85	12.75	1.8705	83.22
Phoenix	19.35	8.61	2.2474	100.00

Table 6.38 Varying materials costs – Scenario 3

6.12.4 Discussion of Sydney/Phoenix sensitivity analysis results

For these two cities variations in materials costs only make almost no difference to the Sydney BLOC Index relative to Phoenix. As the cost of materials in the BLOC increases so do the total building costs with a net result of little or no change in the index. This is to be expected as in this analysis, unlike the preceding exercise, BLOC costs have been adjusted to reflect the changes in input costs described in each scenario. This is expected as BLOC costs would naturally vary in accordance with changes in input costs. In the preceding analysis, however, BLOC costs were not changed as it was published superficial rates that were adjusted³¹ and the effects of possible differences in those costs that were assessed.

6.12.5 Phoenix/Singapore comparison

As the labour and materials ratios for Singapore and Phoenix show greater variation than the ratios for Sydney and Phoenix, similar scenarios were tested comparing outcomes between those two cities. The procedure is as for the Sydney-Phoenix comparison. The initial BLOC Index for Singapore (from Table 6.29) is 139.77. The following tables show the results of the three scenarios tested.

6.12.6 Scenario 1 – Materials cost: Phoenix unchanged, Singapore +10%

Due to the high proportion of materials costs in the Singapore BLOC a modest increase in materials costs produces a marked effect on the BLOC Index, which drops 15 points to around 125.

Location	Materials costs			
	Phoenix unchanged, Singapore +10%			
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)	BLOC equivalent	BLOC Index
Singapore	35.43	12.62	2.8074	124.81
Phoenix	18.29	8.13	2.2493	100.00

Table 6.39 Varying materials costs – Scenario 1

³¹ These rates have been shown (at 6.2) to vary considerably depending on their source.

6.12.7 Scenario 2 – Materials cost: Phoenix +10%, Singapore +10%

This test produces a result almost identical to the previous scenario. Once again it is the high proportion of materials in the Singapore BLOC that produces the change in the BLOC Index.

	Materials costs Phoenix +10%, Singapore +10%		BLOC equivalent	BLOC Index
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)		
Location				
Singapore	35.43	12.62	2.8074	124.92
Phoenix	19.35	8.61	2.2474	100.00

Table 6.40 Varying materials costs – Scenario 2

6.12.8 Scenario 3 – Materials cost: Phoenix +10%, Singapore unchanged

In this case a 10% in materials costs has little effect on the BLOC Index, which in this scenario is 139.49 and thus virtually identical to the original index of 139.77.

	Materials costs Phoenix +10%, Singapore unchanged		BLOC equivalent	BLOC Index
	Building cost (millions – local currency)	Adjusted BLOC cost (millions – local currency)		
Location				
Singapore	32.59	10.36	3.1349	139.49
Phoenix	19.35	8.61	2.2474	100.00

Table 6.41 Varying materials costs – Scenario 3

6.12.9 Discussion of Phoenix/Singapore sensitivity analysis results

The relatively high proportion of materials in the Singapore costs results in significant shifts in the BLOC index in those scenarios where materials costs are higher in Singapore. In all cases, however, the BLOC Index shows Singapore labour to be considerably less productive than labour in Phoenix.

6.13 USING CPPPS AND THE BLOC INDEX

It was noted in Chapter 2 (at 2.8) that general PPPs were not suitable for a number of uses including industry comparisons and productivity measurement. The CPPPs and BLOC Index presented here, however, perform several related but different functions. They have been shown to be suitable for some of those applications for which general PPPs are not recommended as:

- they eliminate price level differences between locations so that the comparative value of construction work between locations can be assessed
- they produce, when used in conjunction with current nominal exchange rates, real exchange rates based on construction specific purchasing power, and thus facilitate the estimation of the amount required in one currency to buy a quantity of construction work in another currency
- they allow, when used as a common unit of construction cost, construction costs in different currencies to be directly compared whilst eliminating the need to use any other exchange rates
- they provide, when used to measure construction costs in BLOC equivalents, a robust measure of relative productivity between locations.

6.13.1 Time issues

All available conversion factors, including the CPPPs presented here, are time-specific, i.e. they represent a snapshot of relativities at a specified date. Nominal exchange rates vary daily and as a result real exchange rates, calculated using PPPs and nominal exchange rates, vary similarly. A feature of the BLOC approach is that while BLOC costs in various locations will vary with time it is expected that those variations will occur much less slowly and hence established relativities will remain valid for longer periods. For example, price increases in one or two building materials, such as those that have been seen with steel and copper in recent times, will not have a major impact on BLOC costs in the short term; similarly increases in labour costs alone will not produce major shifts in relative BLOC costs.

This is useful, for instance, where longer term analysis of industry performance is the aim. Variations in market conditions over time can be accounted for as previously

described, however, as has been shown the resultant differences in relativities between locations when CPPPS are adjusted to account for varying competition levels are not large.

6.14 CONCLUDING REMARKS

In this chapter the application of the validated cost data has been described and the production of construction-specific PPPs based on a particular building type explained. Those CPPPs were compared to other potential conversion factors and the CPPPs show significantly different cost relativities for hotel construction at least, and by inference suggest that there are likely to be similar differences for the cost of construction of other building types.

It should be noted that PPPs of any type beyond those that are based on a single item (e.g. the Big Mac hamburger) do not provide precise cost comparisons between locations (Schreyer and Koechlin, 2002b: 4). An index such as the Big Mac Index shows precisely the relativity in purchasing power but only in respect of the one discrete item. Any attempt to interpolate from that to other consumer items or to the level of whole projects, whole industries or whole economies is not theoretically valid and is likely to be misleading. Purchasing power parities such as those produced by the OECD or the CPPPs derived herein indicate general relativities and while differentials calculated based on such PPPs cannot be considered to be exact they do produce very useful information. Hence, based on the CPPPs presented here some general comparisons can be made with confidence, and the differences identified are certainly large enough to lend strong support to the observations made about relative costs of construction and labour productivity in the target locations.

The widely held view (e.g. Ive *et al.*, 2004; BWA, 2006) that the CPPPs currently available are not reliable has been discussed previously. The method used to produce the BLOC based CPPPs presented in this chapter addresses a number of the problems that have been identified in relation to other CPPPs, notably:

- The conformity with the theory of purchasing power parity

- The use of a pricing instrument, that is simpler in use than the existing standard projects (BQ) approach, which can be priced with greater confidence in various locations.
- The opportunity that this gives to gather cost data from more than one respondent in each location.
- The use of a basket of items that are sufficiently generic that it can be priced with reasonable confidence in all locations.
- The potential for testing and adjusting outcomes based on various inclusions and exclusions such as contractors' margins and taxation, which allows straightforward sensitivity analysis of the resultant CPPPs.

Overall the method presented here has been shown to be theoretically correct and a robust measure of both real comparative construction costs and of relative productivity levels. It can be extended or modified to apply to any location and building type. It has been shown to be relatively insensitive to changes in the composition of the basket, demonstrated by the results obtained using the reduced BLOC with services items excluded. It has also been shown to produce consistent results when a range of base conditions, such as building costs and materials costs, are adjusted.

In the following chapter some final observations are made and areas for future research that builds on the BLOC method are proposed.

CHAPTER 7

7.0 CONCLUSION

7.1 INTRODUCTION

In the preceding chapters the development and testing of a method for determining construction cost conversion factors based on purchasing power parity has been described. The method uses a weighted basket of construction materials and labour as the vehicle for the collection of input costs for a reference project, a medium standard hotel located outside the central business area of a major city. Final costs for the basket, or BLOC, were calculated with and without the inclusion of several factors such as contractors' margins and local taxes. In this chapter the performance of the BLOC as a mechanism for deriving cost conversion factors is reviewed and discussed and some conclusions about its fitness for the purpose are drawn. In addition facets of the method used in this study that require further investigation and refinement are noted and directions for further research are outlined.

7.2 SUMMARY OF THE RESEARCH

In the foregoing chapters an extensive research project has been described. It proceeds from a general overview of comparative studies of construction industry activity and performance to the identification of a specific need. From there it describes the development and testing of a mechanism that satisfies that need.

7.2.1 The need for a cost conversion mechanism

The identified need is for a better method for converting construction costs in various national currencies to a single base currency. Such conversions are a feature of virtually all international comparative studies and some rely entirely on cost conversions and comparisons. The shortcomings of existing conversion methods were clearly demonstrated.

7.2.2 Purchasing power parity

The principles of purchasing power parity (PPP) were explored and its applicability to construction cost comparisons was established. Based on a review of potential mechanisms a weighted basket of materials and labour was selected as the one that offered the greatest potential. This selection was based not only on the soundness of the theory that underpins it but on its appropriateness as a vehicle for PPP based comparisons and the potential for its economical application in the field. The basket of goods was termed a BLOC.

7.2.3 Testing the BLOC concept

In order to test the method a two stage empirical study was carried out. Using a completed Sydney hotel project as the reference a set of the most cost significant materials was identified. A priced bill of quantities for the reference project was used for both materials item selection and establishing the relative weights of the materials in the BLOC. The weights reflect the cost shares of the various materials in the total cost of the completed project. The hours of labour input required to install the derived quantities of materials were calculated based on published materials/labour ratios for representative work items.

7.2.3.1 Pilot study

Initially the concept was tested using a small basket comprising six materials and two classes of labour. Cost data was gathered from only three locations. The pilot study provided proof of the viability of the basic approach as well as some feedback that assisted in refining some parts of the survey used in the main study. Preliminary conversion factors were calculated based on the data gathered in the pilot study.

7.2.3.2 Main study

The survey used in the main study comprised 24 materials items and four classes of labour. This survey was used to gather input cost data from six locations: Singapore, Auckland (New Zealand), Phoenix (USA) and three Australian cities, Sydney, Melbourne and Brisbane. The data gathered was subjected to a rigorous validation process to ensure that consistent datasets were used in the subsequent stages of the study.

7.2.4 Using the data

The validated data were used to produce two sets of indices: construction-specific purchasing power parities (CPPPs) and a new BLOC Index. The CPPPs were shown to infer construction cost relativities substantially different to those suggested by any of the other conversion methods which they were tested against. The BLOC Index was shown to represent a sound method for assessing relative productivity levels in different locations.

7.3 A REVIEW OF THE RESEARCH QUESTIONS

In Chapter 1 four research questions and associated research aims were stated. Each of those has been addressed in turn and the outcomes are summarised below.

7.3.1 Research question Q1

How reliable and accurate are existing methods for international comparisons of construction costs?

A comprehensive review of previous studies and current programs identified and evaluated various existing and proposed cost conversion mechanisms. A number of earlier comparative studies were revisited and a variety of alternative cost conversions applied to the data. It was demonstrated that the conclusions drawn in those studies were generally shown to change, often dramatically, when different conversion methods were used. This established conclusively the fundamental importance of having a robust and reliable cost conversion mechanism that measured what it set out to measure in the context of regional and international comparisons.

It was shown that none of the existing methods could be considered to be reliable measures of comparative costs. Nominal “money market” exchange rates are acknowledged as being inappropriate for the sort of currency conversions needed in comparative studies. The notion of purchasing power parity (PPP) is seen to be a more appropriate approach as it removes resource price differences and allows the comparison of real construction costs.

Many authors note the need for industry specific PPPs, however, it was established that existing construction-specific PPPs (CPPP) are only available for a limited number of countries and that these CPPP are generally considered to be unreliable. A comparison of published CPPP and BLOC derived CPPP showed significant differences between the two.

Other potential mechanisms were explored including medium term average exchange rates and indices based on single manufactured products such as the Big Mac hamburger. These were also shown to have limited application in the construction context.

Hence, the answer to question Q1 is that existing methods are not very accurate for comparing international construction costs.

7.3.2 Research question Q2

Can these existing methods be improved?

It was concluded from the review of past and present research and practice that a construction specific mechanism was needed that would provide sound comparisons of construction cost. A number of current and proposed mechanisms were evaluated. Purchasing power parity was identified as providing a suitable theoretical basis for the design and development of a cost comparison mechanism that could be focused exclusively on construction costs.

It was noted that there is ongoing work in this area being conducted by the World Bank and the method chosen for this study was selected to complement the approach being pursued by the World Bank. The method chosen was based on the compilation of a basket of construction materials and components and various classes of construction labour. The items in the basket were selected and weighted based on a comprehensive analysis of an actual reference project. The resulting basket (or BLOC) was specific to a particular building type and a particular location. The BLOC was then tested through a cost data gathering survey using a questionnaire containing the various items and weighted quantities.

The answer to question Q2 is that the theory of purchasing power parity can provide the foundation for a more accurate and reliable method.

7.3.3 Research question Q3

Can an index with fixed weights provide more accurate and reliable conversion factors?

The basis for the BLOC was shown to be theoretically sound. Careful and thorough analysis of the data gathered through the survey established a robust dataset of input costs for each of six locations. Some statistical analysis of the data demonstrated that the data samples were consistent and appropriate for the purpose.

Once the datasets were validated a series of calculations were carried out to produce cost conversion and comparison mechanisms of several types based on the notion of purchasing power parity. The results obtained were compared to results based on other mechanisms such as average exchange rates and single commodity indices. The outcomes were markedly different to those produced using existing conversion methods. This provides strong evidence of the need for a more robust cost conversion mechanism. With its sound theoretical basis and carefully validated datasets the BLOC exercise reported here has been shown to provide an excellent method for construction cost conversions particularly in the context of international comparisons.

The answer to question Q3 is that a fixed weight index with the weights determined empirically satisfies both theoretical and empirical demands for accuracy and reliability.

7.3.4 Research question Q4

Can this method provide a guide to comparative productivity in construction?

It has also been shown that the BLOC method provides a useful method for comparing relative productivity in the construction industry in different locations.

The theoretical basis for this was established and it was shown that the BLOC approach provides a well-grounded, uncomplicated method for assessing relative productivity that avoids many of the problems that are generally associated with productivity comparisons.

The answer to question Q4 is that the CPPP (or BLOC) index described here provides a uniquely comprehensive method of comparing productivity in different locations.

7.4 OUTCOMES

The study produced a set of useful outcomes prompted by the original research questions.

7.4.1 The BLOC as a comparative tool

Overall the BLOC method was shown to meet the needs established in the early chapters of the thesis, viz.

- It provides the basis for a straightforward but robust method for gathering input cost data from which a variety of comparative indices or factors can be calculated.
- The resultant indices can be used as location or city specific indices or aggregated to produce national indices.
- Item weights reflect real cost shares from actual completed projects and therefore provide a realistic picture of building costs.
- It allows the economical collection of cost data from multiple sources in any location.
- It allows for more frequent pricing rounds than existing methods such as the Eurostat pricing rounds that occur on a three to five year cycle.
- It can easily be expanded and modified to cover different building types and/or different locations.
- It can easily be applied to show relative productivity in different locations.

7.4.2 Results of the empirical study

Two very significant sets of results emerged from the empirical study.

1. Construction cost relativities established by use of the BLOC data vary considerably from those based on other conversion mechanisms. In past international comparisons firm conclusions have been drawn based on cost comparisons that have been shown here to be seriously flawed. Had the same comparisons been based on BLOC-derived CPPPs in most cases the conclusions drawn could have been quite different.
2. Some significant findings emerged in regard to comparative productivity in the various locations included in the study. A strength of the BLOC method is that it provides direct comparisons that show cost differences in tandem with productivity differences. For example, it was shown that building costs in Phoenix are lower than they are in Sydney. This is due in part to construction labour in Sydney being more highly paid than in Phoenix. However, Sydney labour is shown to be considerably more productive. The problems associated with measuring productivity, particularly in construction, were highlighted in Chapter 2; the BLOC approach has been shown to provide a straightforward method for comparing productivity levels.

It was also shown that in most cases, with Singapore the exception, a considerably smaller basket of materials and labour produced similar CPPPs to those based on the more comprehensive basket. While some further investigation of this is needed to confirm the similarities and explain the Singapore anomaly, this suggests that a properly constituted small basket may provide a robust mechanism that would be both less expensive and quicker in use.

The importance of these findings cannot be overstated. Firstly, the study extends the scope of purchasing power theory in the specific case of construction. Construction PPPs and their contribution to wider PPP exercises have not previously been adequately addressed by research. The practical application of a PPP-based method

for construction costs comparison and conversion described in this thesis represents an important step forward in this area.

Secondly, in Australia in recent years governments, unions and commentators have relied on the results of studies based on inappropriate cost conversion to variously suggest that the Australian construction industry is under performing or conversely that it is highly competitive in a global market. Improving productivity in construction in Australia has also been a focus of the Australian government for some years. Clearly having reliable assessments of comparative cost and productivity are vital if suitably informed decisions are to be made.

7.5 FURTHER RESEARCH

The findings of this research open up a number of possibilities for further research to extend, test and validate the findings reported here.

7.5.1 Refining the BLOC

The research reported here was limited to six major cities in developed countries. Even with that limited number of locations, problems were encountered in regard to differences in how materials are described, measured and priced. Further refinement and testing of the hotel BLOC in respect of the items that are included and how they are specified is needed to ensure that pricing rounds can proceed smoothly and consistent pricing occurs.

It was shown (see Section 6.6) that the exclusion of the services items from the BLOC produced only minor differences in the resultant CPPPs. Services do, however, represent a very significant proportion of total building cost in most types of commercial buildings. Further investigation of the significance of services in the BLOC approach is therefore warranted before firm conclusions can be drawn as to whether services need to be included in the BLOC. It should be noted that the difference in CPPPs based on BLOCs that included or excluded services were minor. BLOC costs that did include services were, however, based partly on rates for services items that for which prices obtained from different sources varied widely.

Hence further testing is required to determine to what degree the minor differences in CPPPs that were reported were influenced by this variable data. If it were to be shown that services items could be removed from the BLOC without reducing the accuracy of the outcomes then the entire BLOC process would be further simplified without reducing the integrity of the method. This would be particularly advantageous as it was apparent that many of the QS/contractor respondents did not have ready access to supply prices for many of the services items in the BLOC.

It was also shown (Section 6.4) that for most of the cities surveyed that the use of the full BLOC produced only minor differences in CPPPs compared to those calculated using the costs obtained from a much smaller “mini BLOC”. Further testing of this aspect of the BLOC method is certainly recommended as the smaller the effort required by respondents who price the BLOC the greater the likelihood that they will take the time to complete the survey. If a BLOC comprising less than ten items could be shown to produce equally robust results then the BLOC method would become an even more attractive option.

7.5.2 Testing the BLOC for other building types

The BLOC used in this study was based on a single building type. Further testing is required to ascertain whether a single BLOC such as this will produce reliable results if applied to other building types. If a single BLOC could be used across a variety of building types then it becomes a more useful tool than if different BLOCs need to be assembled and priced. The construction sector is typically divided into the three sub-sectors of residential, non-residential/commercial¹ and engineering construction. Extensive testing is required to determine whether the BLOC used here is representative even of non-residential/commercial construction. It is unlikely that it is representative of low-rise residential construction as it contains materials such as toughened glass, commercial grade windows and fire rated doors that are not common in such construction, however, this cannot be assumed and some testing is

¹ This often includes high-rise residential to differentiate from low-rise (cottage) residential construction.

required to determine if the BLOC can be used in this context, and if not, what the make-up of a residential BLOC might be.

It is even less likely that the BLOC would be suitable as a proxy for engineering construction. For example, a significant component of the BLOC is in labour classed as Tradesman Group 1, largely comprising electricians and plumbers. Electrical and plumbing work is found in engineering construction but in many situations (e.g. road construction) these items are much less cost significant.

If the BLOC approach were to be extended to the production of aggregated construction sector PPPs that are representative of all construction then a considerable amount of additional research is required in order for the BLOC method to be applied in that manner.

7.5.3 Testing the BLOC in other locations

As noted above the scope of the study was limited to only six cities in four countries. One city, Singapore, produced less consistent results than the others. While the concept and basic application of the BLOC approach have been clearly demonstrated in this thesis further application of the BLOC in other places is needed in order to assess its applicability across more diverse locations.

This is not merely a matter of trying the BLOC in a few more cities. The problems alluded to above regarding differences in specification, measurement and pricing as well as potential problems associated with commonality of items included in the BLOC all need to be addressed through extensive testing across a broad selection of locations. Ideally a single BLOC or even a small set of BLOCs that could be used to assess comparative costs and productivity across most or all locations of interest would make international comparisons more reliable and robust and less expensive than the methods currently in use.

7.5.4 Testing the impact of different labour profiles

The study was based solely on a BLOC derived from a Sydney project. The weights applied to the items in the BLOC were fixed and therefore reflected Sydney

conditions. The fixed weight approach is necessary if derived PPPs are to properly reflect purchasing power (see 4.2.2), however, for the reliability of the BLOC to be confirmed, particularly as a productivity comparator, further testing is required. In particular labour weights from other locations should be applied to the BLOC and the outcomes compared. For example, the labour/materials ratios for Singapore and Phoenix are quite different not only to each other but also to the ratio for Sydney (see Section 6.12). Testing the impact of the application of, for example, Singapore and Phoenix labour weights to the BLOC would enable a more detailed assessment of the consistency of the outcomes of the BLOC method.

7.5.5 Testing the reliability of cost data

In the BLOC study cost data was gathered variously from quantity surveyors and contractors. Nothing appeared in the data analysis that suggested that one source provided better data than the other. For some items average rates from contractors were higher than average rates from quantity surveyors, in other cases the reverse was true. Unless respondents made enquiries to suppliers and sub-contractors, and this was noted by only a handful of respondents, supply costs were apparently obtained from experience, current estimates and historical data. For some trade items at least sub-contractors may provide more reliable data. Engineering services for example are mostly procured by all-inclusive sub-contracts; head contractors and quantity surveyors often do not see any breakdown of costs beyond a separation into a few major cost areas (see Table A1.1 in Appendix A1). Further investigation of the use of sub-contractors as sources of cost data may lead to improved pricing of parts of the BLOC, particularly those covering services.

The data gathered in respect of labour rates was shown to be much more consistent than materials cost data (see 5.3.2). Given the variability observed in materials pricing the possibility that the labour cost data, although consistent, may have been consistently biased cannot be discounted. Further research is warranted to determine whether the apparent consistency indicated that the great majority of respondents had actually diligently priced labour in accordance with the survey instructions. This is particularly relevant in the case of Singapore where the rates of pay for construction labour appeared very modest.

It was noted that average labour rates supplied by quantity surveyor respondents in Melbourne were substantially lower than those supplied by Melbourne contractors. It was suggested that this difference may indicate that contractor respondents are more attuned to upward pressures on labour costs perhaps due to current skills shortages in a strong Melbourne market. This proposition, however, requires further investigation to ascertain if the reasons suggested are correct. Such research could also determine whether contractors may generally be a better source of price information due to their closer understanding of current market conditions, especially at the level of individual materials costs and labour rates.

7.5.6 Investigating the Singapore anomalies

In a number of parts of the thesis it was noted that data from Singapore, and subsequently the indices derived from that data, appeared anomalous. For example, where CPPPs for the other locations based on the mini BLOC were not very different from those based on the full BLOC, the results for Singapore varied considerably (see 6.4).

The anomalies that arose with regard to Singapore did not only emerge in the BLOC results but were also observed in the published cost/unit area rates (see Table 6.21). Further research is required in order to verify the results reported for Singapore. That research should be aimed at verifying both the cost data supplied by the respondents and at collecting reliable historical superficial rate data. Both types of data contributed to the anomalies noted in the thesis.

One area deserving of further investigation is that of labour rates in Singapore. A lot of onsite construction work in Singapore is performed by low paid guest workers from countries such as Bangladesh, and consequently labour rates are low. The very different labour/materials cost ratio for Singapore described earlier (see Table 6.14) confirms the low cost of labour in Singapore construction costs. It might be expected that the cost of construction Singapore would therefore appear to be significantly lower than it is in the other locations yet the CPPPs for Singapore and Phoenix showing the cost of building (in terms of purchasing power or opportunity cost) to be

substantially lower than those in Singapore.. Further research is needed to ascertain the fundamental causes of these cost relativities identified by the BLOC method.

7.5.7 Testing the BLOC in developing countries

The research reported in this thesis was restricted to several industrialised countries. It was noted that the method was developed in that context. It would be useful to assess the applicability of both the general method and the specific BLOC used in this research in developing countries. Lower labour costs and different construction methods are two of the factors that mean that the specific BLOC used herein may not be relevant in such a different context.

The apparent anomalies that emerged from the Singapore leg of the BLOC survey suggest that Singapore may be considered something of a hybrid. While it is an industrialised country with a highly developed economy in the area of construction at least it is characterised by its large imported force of “guest workers”. As the survey showed construction labour is generally paid at much lower levels than in the other countries surveyed. Further application of the BLOC in developing countries may reveal that the BLOC needs to be refined or modified before it will work successfully in the different context. This in turn may provide some insight into the apparent anomalies in the BLOC outcomes reported for Singapore.

7.5.8 Verifying BLOC outcomes for Melbourne

The BLOC results showed Melbourne building costs to be considerably higher than those in Sydney. In Section 6.2 this result was compared with some published superficial rates and the differences noted and discussed. Some investigation of the variations in relative costs was reported but further testing of this result is required in order to confirm the cost differential reported and to seek firm evidence that either supports and explains it or identifies reasons for the BLOC results not being consistent with the actual cost differential.

7.5.9 Using the BLOC as an alternative to superficial rates in estimating

The BLOC method could be used as a method for preliminary estimating of building costs in the same way that superficial rates are now used. The very different cost relativities suggested by the superficial rates available from various sources was

described earlier (see Tables 6.4 and 6.20). The BLOC should be tested to see if it could serve as an alternative to historical data for preliminary estimating.

7.5.10 Testing the Law of One Price in an integrated market

The Law of One Price is the foundation of the doctrine of purchasing power parity. Whether or not the Law of One Price may hold for construction output or any of its components (including labour and supervision) has been discussed (see 3.3).

The European Union now presents a potential focus for research into this question. Of the 27 member countries 15 have adopted the euro in place of their traditional national currencies. With relatively free movement of goods, labour and capital within the EU, it may be expected that differences in price levels that existed previously would start to disappear. This would presumably be most likely in those countries that share the euro as their common currency. There is great potential for research into price convergence in non-tradeable products like construction in the EU context.

This could be done by using published construction costs per m² for a number of different building types in EU countries at several points in time both pre-euro and post-euro. Where costs are naturally expressed in euros costs can be directly compared; costs from countries outside the Eurozone could be converted to euros using available purchasing power parities of several types. The BLOC method could then be used to gather input cost data as it was done in the study described in this thesis. Comparisons of the cost relativities and purchasing power identified through such a study would provide a great deal of valuable information about the relevance of the Law of One Price and the reliability of various PPPs in the construction context.

7.5.11 Bilateral comparisons using project pairs

While the BLOC method facilitates cost comparisons and measures relative productivity it does not directly provide any indication of the underlying reasons for apparent cost and/or productivity differences. If clear evidence could be found that supported such findings then the accuracy and reliability of the BLOC mechanism would be verified.

One way that this could be done is through studies such as the Lynton study referred to in this thesis (e.g. at 2.9.2). That study was based on a single pairwise comparison based on a completed project and it provided strong evidence regarding the relative costs of construction in two locations. A similar approach could be used to compare results for pairs of cities included in this study, for example, Sydney and Phoenix where lower costs were observed in Phoenix but Sydney workers appeared more productive. While some of the cost difference may be attributable to higher real labour costs in Sydney, without further investigation it is not possible to predict to what degree the cost difference is attributable to higher labour costs. Similarly it is not known what other factors may contribute to the cost difference nor to what degree they contribute. In the Lynton study it was indicated that much of the cost difference may have been a matter of design differences rather than actual differences in productivity (see 2.9.2).

The Lynton approach could be designed in such a way as to test the assumptions used in this project. The approach used by Davis Langdon Consultancy (see 3.7.1), which shares some similarities with the Lynton method, could be incorporated into such studies to produce a clearer understanding of the causes of the observed differences in cost and productivity. Support from such studies would increase the confidence in the accuracy and reliability of the BLOC approach by triangulating empirical research.

7.5.12 Verifying data regarding contractors' margins

The validity of input cost approaches such as the BLOC method have been questioned because they do not gather data that includes contractors margins for profit and general overheads. In contrast, in the BLOC study data were collected that included estimates of typical margins for projects similar to the reference project that reflected current market conditions and resultant levels of competition. The data gathered for this item were reasonably consistent (see 5.3.3.26) with only one outlier being discarded. In spite of the consistency of the results for two reasons further research into this aspect of the BLOC approach would be beneficial.

First, it may be that estimates of margins could be influenced by reluctance on the part of contractors to reveal what they may consider to be confidential information about company performance. It is entirely possible that they would downplay actual profit margins to maintain a view of contractors as working to tight margins and be lean and highly competitive organisations.

Second, the BLOC survey respondents were asked for estimates of markups that would include both profit and general overheads. As was the case with materials it is possible that respondents in different locations or even between different firms may have approached this item in varying ways.

While it noted that contractors' margins represent a relatively small proportion of total to BLOC costs further research would be useful. The criticism of an input cost method such as the BLOC based on the question of margins can only be satisfactorily answered by further empirical research.

7.5.13 The influence of market conditions

It was noted that the BLOC method could be used to assess fundamental cost relativities between locations. Survey respondents were asked to give an opinion of the state of the market in their location and the effect of market conditions on input costs. In most locations (with Singapore the exception) opinions varied considerably in respect of both questions. The results obtained could only be taken as broadly indicative of the true situation thus further more rigorous research into this aspect is required.

Such research could be based on analysis of tender prices and their movements as well as the collection of input costs (using a BLOC style method) over time. This should produce clearer results of both prevailing market conditions and the movement of prices as the building cycle moves through its various phases. This, in turn, would produce a truer picture of underlying cost relativities between locations.

7.5.14 The influence of taxation on apparent cost relativities

The issue of taxation applied to construction work was discussed earlier (at 4.4.8) and differences in GST/VAT type taxation identified. Arguments for and against the

inclusion or exclusion of such taxes in the BLOC method were explored. While the inclusion of tax in the context of PPPs as a snapshot of cost relativity at a particular base date is reasonable it is arguable that if the identification of more fundamental cost relativity is the aim then tax should be excluded from costs. At least it may be useful to look at cost comparisons with and without the effects of differing tax levels.

It was argued that such an investigation was beyond the scope of this thesis, partly because it would be a major exercise to identify taxes applied to materials and labour at various levels and at various stages of the supply chain. For some uses of the index, however, it would be necessary to carry out such an investigation. Such research would ascertain whether the total of taxes applied to construction when summed across all levels of the supply chains and the assembly of the construction project actually varies significantly from location to location. If large variations are apparent then it would be prudent to analyse the influence that taxation has on construction cost differences as such differences may influence relative productivity levels measured by the BLOC Index.

7.5.15 Comparing the BLOC and the BOCC

Numerous references have been made to a basket of construction components (BOCC) being implemented for the first time by the World Bank. Both the contents of the baskets and the weighting procedures are substantially different. It would be very useful to compare the outcomes from the two approaches (the BLOC and the BOCC) to see if there are differences in the CPPPs produced. If there are significant differences then further research would be required to determine the causes of the differences and thus potentially refine and improve both baskets.

7.6 FINAL REMARKS

The research reported in this thesis represents a major step forward in the area of comparative studies in construction. The method described and tested and the results produced are work that adds substantially to the unravelling of a set of problems that have been the focus of research since Gustav Cassel first put forward his theories on purchasing power parity in the early part of the 20th century. The preceding section

sets out a number of suggestions for further research which would build on this work and contribute further to the resolution of the complex problems of cost comparison and productivity measurement.

APPENDIX A1 BQ ANALYSIS

A1.1 INTRODUCTION

Bills of quantities for two hotel projects were analysed in order to identify the goods/materials that were most cost significant. The bills had been priced by the successful tenderers so that costs/prices were as close to the actual prices paid by the clients as possible.

A1.2 REFERENCE PROJECTS

The projects are referred to as Project A and Project B. Priced bills were obtained from the consultant quantity surveyors who handled the projects.

Project A is a 196 bed hotel, rated at approximately 4.5 stars¹, located in suburban Sydney. The project was completed in 2003. The final contract sum (as per the priced BQ) was AUD 23.78 million. The trade breakdown is shown in Table A1.1. Site development and substructure works were carried out under a separate Early Works package and are not part of that figure. For this analysis several other sections have been taken out of the calculations as they are deemed to be too project-specific and therefore not necessarily typical of projects; the sections are *Landscaping*, *Demolition* and *Siteworks*. The project cost excluding those sections was AUD22.89 million. The adjusted project cost (APC) was \$17,993,435, i.e. the project cost less GST and *Preliminaries*². This project was used as the primary basis for the

¹ The star rating refers to the standard of accommodation not other ratings such as an energy efficiency rating.

² See 4.2.5 for more details

identification of the cost significant items and the derivation of representative quantities.

Project B was a similar project located in Perth and completed at approximately the same time as Project B. This project was used mostly to obtain cost breakdowns for services trades where such data was not available for Project A. As it was used only to ascertain proportions of cost in some trades differences in building costs between Sydney and Perth³ were ignored.

A1.3 CALCULATION OF WEIGHTS FOR THE BLOC

The following sections show the calculations that were carried out in order to ascertain the contribution of each of the cost significant items to the overall project cost. The process is described at 4.2.6 – here the calculations for each of the items included in the basket are detailed. Detailed explanations of the process used for formply and concrete blocks are at 4.2.6 and hence are not included here. Labour and materials ratios in supply and fix unit rates are derided from Cordell (2007) unless noted otherwise. All rates and costs from the bills of quantities and other sources are stated excluding GST

A1.3.1 Ready-mixed concrete

The BQ total for concrete was \$489,646. Of this \$442,907 was for *in situ* concrete work items. Cordell (2007) suggests an average split of 22:76:6 (L:M:P) for *in situ* concrete. Thus the supply cost for concrete is

$$0.72 \times \$442,907 = \$318,893$$

$$\frac{318,893}{17,993,435} = 1.7723\% \text{ of the APC}$$

³ Building a project of this type in Perth was around 15% cheaper than in Sydney in 2003 (Rawlinsons, 2003).

As just over 90% of the cost of the Concrete trade⁴ was in *in situ* concrete items, the supply of ready-mixed concrete was chosen as the representative item for this trade; 32MPa was identified from the BQ as the most common strength.

A1.3.2 Bar reinforcement

Steel reinforcement represented 3.3% of the adjusted project cost. The major reinforcement components were deformed bars and prestressing, each accounting for very close to 50% of the combined cost of \$581,134 out of the total cost of reinforcement (\$590, 177). Conventional bar reinforcement items totalled \$291,128.

Bar reinforcement comprised 500MPa deformed bars (designated as N bars in Australia) in various diameters from 10 to 32mm. Different labour costs are quoted in Cordell (2007) for different bar diameters and in some cases for installation in different situations (e.g. suspended slabs and columns) however all diameters and locations were priced identically in the BQ. Through analysis of various items from Cordell (e.g. for N16 bars in walls, slabs, stairs and columns) an average labour:materials split of 21:79 was determined. As the materials component would include items such as wire and chairs it was assumed that an average of 75% of the unit rate for bars fixed in place would be for the supply of bars cut, bent and delivered to site.

Supply of rebar was then calculated as

$$0.75 \times \$291,128 = \$218,346$$

$$\frac{218,346}{17,993,435} = 1.2135\% \text{ of the APC}$$

The item selected for pricing was a typical N16 bar, this being the most common reinforcement in the reference project.

A1.3.3 Precast concrete

The BQ total for precast concrete panels was \$506,381. Analysis of a range of unit rates for precast panels (Cordell, 2007) showed that the materials component of these

⁴ Note that precast concrete was covered by a separate trade section in the BQ.

rates was fairly constant at around 26%. Hence the supply cost and cost share (weight) were calculated as:

$$0.26 \times \$506,381 = \$131,659$$

$$\frac{131,659}{17,993,435} = 0.7317\% \text{ of the APC}$$

The most common panel, a 150 thick spandrel panel, was selected for pricing. As such precast panels may vary considerably in size, thickness, finish and complexity, a typical detail was included in the survey, and indicative quantities of concrete and reinforcement in the chosen panel were calculated and included in the survey question.

A1.3.4 Stressing steel

The BQ total for prestressing was \$290,006. Cost information was obtained from Austress, a major Sydney subcontractor. An approximate subcontractor rate of \$5000 per tonne (cost to the head contractor) for the prestressing operation (including labour, materials, design, supervision/project management) and a breakdown of the price were provided by Rick Comita of Austress. An overall ratio for prestressing of 40% materials to 60% labour (including design and supervision) was suggested. Based on that information the cost for the supply of stressing steel strand was calculated to be 22% of the subcontractor rate and therefore the major part of the materials component. As steel strand is taken to be the representative item for all materials in the prestressing section the weight for this item is based on the full prestressing materials component of the cost, i.e.,

$$0.40 \times \$290,006 = \$116,002$$

$$\frac{116,002}{17,993,435} = 0.6447\% \text{ of the APC}$$

A1.3.5 Structural steel

The BQ total for structural steel was \$234,667. Published unit rates for steelwork (Cordell, 2007) show considerable variation in rates depending on the type of steel members and total quantities. The reference project contained approximately 52 tonnes of steelwork and for a project of this scale an average materials component of

60% was calculated from various unit rate breakdowns. The material cost and weight were then calculated:

$$\text{Material cost: } 0.60 \times \$234,667 = \$140,800$$

$$\frac{140,800}{17,993,435} = 0.7825\% \text{ of the APC}$$

As the project contained various sizes and sections the representative item for pricing was described as hot rolled sections (fabricated).

A1.3.6 Glass

The BQ total for glass walls was \$338,123. Paul Farrugia from Express Glass in Sydney provided an average labour: materials split of 40:60 for frameless glazing of the type in the reference project. As the glass alone was selected to be the representative item for pricing the material cost and weight was determined as:

$$0.60 \times \$338,123 = \$202,874$$

$$\frac{202,874}{17,993,435} = 1.1275\% \text{ of the APC}$$

A1.3.7 Windows

The BQ total for aluminium framed windows was \$301,282. A representative from Architectural Systems in Sydney provided an average labour: materials split of 25:75 for the supply and installation of windows the type in the reference project. The material cost and weight was determined as:

$$0.75 \times \$301,282 = \$225,962$$

$$\frac{225,962}{17,993,435} = 1.2558\% \text{ of the APC}$$

The most common item in the project was a 1600 x 1600 fixed window glazed with either 6.38mm or 10.38mm grey glass. Total costs for the two types in the BQ were similar; the item selected for pricing was a typical 1600 x 1600 unit with 6.38mm glass.

A1.3.8 Stonework

The BQ total for stonework was \$638,101. Cordell (2007) suggests that 36% of the supply and fix rate is for supply of materials. The material cost and weight was determined as:

$$0.36 \times \$638,101 = \$229,716$$

$$\frac{229,716}{17,993,435} = 1.2767\% \text{ of the APC}$$

The most common material was 50 thick sawn sandstone facing.

A1.3.9 Doors

Hotel buildings have many doors of various types, both fire rated and non fire rated. Two typical doors were chosen for pricing.

A1.3.9.1 Fire rated doors

BQ total for fire rated doors: \$138,817

Materials component: 94% of supply and fix unit rate

The material cost and weight:

$$0.94 \times \$638,101 = \$138,817$$

$$\frac{138,817}{17,993,435} = 0.7252\% \text{ of the APC}$$

The representative item for pricing: single, one hour fire rated internal door, ready for paint, including frame and hardware.

A1.3.9.2 Non fire rated doors

The BQ total for doors requiring no fire rating was \$51,965. The materials component of unit rates for these doors is 69% (Cordell, 2007).

The material cost and weight was determined as:

$$0.69 \times \$51,965 = \$35,856$$

$$\frac{35,856}{17,993,435} = 0.1993\% \text{ of the APC}$$

The representative item for pricing: single, non fire rated internal door, ready for paint, excluding frame and hardware.

A1.3.10 Plasterboard

Identifying the material cost for plasterboard in the BQ required a lengthy analysis of a range of items in two trade sections: Plasterboard/Drywall Partitions and Suspended Ceilings. The project contained wall and ceiling configurations of a number of different types involving various combinations and thicknesses of standard, water-resistant and fire resistant plasterboard. From the analysis a total material cost of \$337,213 was calculated based on an average labour:materials split of 60:40. Various unit rates for plasterboard items from Cordell (2007) were used to estimate the materials cost for each of the wall and ceilings configurations in the project

.

The material weight:

$$\frac{337,213}{17,993,435} = 1.8741\% \text{ of the APC}$$

The representative item for pricing: 13mm thick gypsum plaster sheet lining.

A1.3.11 Ceramic tiles

The total cost for the supply of tiles was calculated using labour:materials splits for wall and floor tiling, and total BQ costs for wall and floor tiling.

BQ total for floor tiling: \$139,155

Materials component: 41% of supply and fix unit rate

The material cost:

$$0.41 \times \$139,155 = \$57,053$$

BQ total for wall tiling: \$283,715

Materials component: 47% of supply and fix unit rate

The material cost:

$$0.47 \times \$139,155 = \$133,346$$

The cost share (weight) for tile supply:

$$\frac{190,399}{17,993,435} = 1.0582\% \text{ of the APC}$$

Given the range of types and sizes of tiles available a generic item was described for pricing that reflected the type of building involved: 200 x 200 ceramic floor tiles, medium standard.

A1.3.12 Carpet

BQ total for carpet: \$278,526 (excluding GST)

Materials component: 77% of supply and fix rate

The material cost:

$$0.77 \times \$278,526 = \$214,464$$

The material cost includes underlay. The total BQ cost (\$306,377 including GST) was divided by the unit rate in the BQ (\$50.47 to derive the area of carpet:

$$\frac{306,377}{50.47} = 6070\text{m}^2$$

The cost of underlay : $6070\text{m}^2 \times \$7.27/\text{m}^2 = \$44,129$

Therefore, supply cost for carpet only: $\$214,464 - \$44,129 = \$170,335$

The cost share (weight) for carpet supply:

$$\frac{170,335}{17,993,435} = 0.9466\% \text{ of the APC}$$

The representative item was described as 80/20 wool blend carpet, as this was the most common carpet specified in the project.

A1.3.13 Paint

The calculation of supply costs and weighting for paint required a number of steps. The most cost significant painting operation in the project was the application of interior acrylic paint to walls and ceilings, comprising \$175,530 of a BQ total for painting of \$274,835. The common BQ item was described as “one undercoat plus two coats of acrylic paint” to various surfaces. Cordell (2007) gives a unit rate for this item of \$12.30/m², comprising \$9.00 labour and \$3.30 materials. As sundries in the material component (such as brushes and thinner) represent a very small portion

of the materials cost, and undercoat is less expensive than finishing paint, the cost of the finishing paint was assumed to be two-thirds of the material cost, i.e. \$2.20/m².

Overall the split is 73% labour (L) and 27% materials (M) (based on the Cordell rate), i.e.

$$\frac{M}{M+L} = \frac{3.30}{12.30} = 27\%$$

Therefore the paint for the finishing coats represents 18% of the material cost (two-thirds of 27%).

The material cost:

$$0.18 \times \$175,530 = \$31,595$$

The cost share (weight) for paint supply:

$$\frac{31,595}{17,993,435} = 0.1756\% \text{ of the APC}$$

The representative paint item was described as low sheen acrylic paint for interior use.

A1.3.14 Timber joinery

BQ total for purpose-made timber joinery to guestrooms: \$819,545

Materials component: 94%

The material cost:

$$0.94 \times \$819,545 = \$770,372$$

The cost share (weight) for joinery supply:

$$\frac{770,372}{17,993,435} = 4.2814\% \text{ of the APC}$$

The representative item selected was a combined wardrobe/minibar unit. Given the wide range of materials, finishes and configurations possible for such items a set of details of the typical unit from the reference project was included in the survey to facilitate consistent pricing.

A.1.3.15 Electrical cable

Electrical services were not measured and priced in detail in either of the reference project BQs, however, Project B did contain a breakdown under headings as shown in Table A1.1.

ITEM	AUD
Preliminaries & setting up	5,500
Manuals	1,200
HV switchgear	20,659
HV cable reticulation	13,300
Power transformers	51,180
Standby generator	83,752
LV switchboards	123,035
Main & submain cable system	57,735
LV reticulation	607,685
Supply - interior luminaries	447,544
Install - interior luminaries	63,220
Telephone/data cabling system	144,388
Fire detection/EWIS	183,654
Audio visual	63,000
Master antenna TV system	88,461
Access control system	61,381
Lighting control system	48,053
Miscellaneous	36,263
TOTAL	2,100,010

Table A1.1 Electrical services – Project B – figures include GST

Based on that breakdown low voltage reticulation was calculated to represent 28.94% of the BQ total for Electrical Services in that project. The same percentage was applied to the BQ total for Electrical Services in the reference BQ (Project A) and the cost for low voltage reticulation (supply and install) was calculated as:

$$\$2,076,127^5 \times 0.2894 = \$600,831$$

Greg Nowak, a quantity surveyor specialising in engineering services costs from the Sydney office of Rider Levitt Bucknall suggested (Nowak, 2007) an average labour:materials split for the installation of low voltage cabling of 60:40 (L:M). Hence the supply cost for this item was calculated as:

$$\$600,831 \times 0.40 = \$240,332$$

⁵ BQ total for electrical services from Project A – GST excluded.

The cost share (weight) for materials supply (including cable trays and the like as well as cable):

$$\frac{240,332}{17,993,435} = 1.3357\% \text{ of the APC}$$

On advice from Greg Nowak the representative item selected was PVC insulated and PVC sheathed low voltage cable suitable for domestic power circuits (2C+E, 2.5mm², PVC/PVC)

A1.3.16 Luminaires

Based on the breakdown for Project B the supply cost for luminaires was calculated to be 21.31% of the total BQ cost for electrical services. The same percentage was applied to the BQ total for Electrical Services in the reference BQ (Project A) and the cost for interior luminaires (supply only) was calculated as:

$$2,076,127 \times 0.2131 = \$442,443$$

No split for labour and materials was needed for this item as the cost breakdown form Project gave supply only of interior luminaires as a line item.

The cost share (weight) for the supply of luminaires:

$$\frac{442,443}{17,993,435} = 2.4588\% \text{ of the APC}$$

A low voltage downlight was selected as the most common fitting and a detail of the typical fitting from the reference project was included in the survey.

A1.3.17 Sanitary fittings

Hydraulic services were not measured and priced in detail in either of the reference project BQs, however, Project B did contain a breakdown under headings as shown in Table A1.2. Based on that breakdown fixtures/tapware (including supply and installation) was calculated to be 20.87% of the total hydraulics cost. The same percentage was applied to the BQ total for Hydraulic Services in the reference BQ (Project A) and the cost for fixtures/tapware (supply and install) was calculated as:

$$\$1,724,894^6 \times 0.2087 = \$359,985$$

Labour/materials ratios for sanitary fixtures vary considerably depending on both the type and quality of fixture. Analysis of a variety of unit rates for the supply and installation of fixtures (including taps) gives an average labour:materials split for various sanitary fixtures of 20:80. Hence the supply cost for sanitary fixtures and tapware was calculated as:

$$0.80 \times \$359,985 = \$287,988$$

The cost share (weight) for supply of fixtures/tapware:

$$\frac{287,988}{17,993,435} = 1.6005\% \text{ of the APC}$$

The representative item chosen for pricing was a white ceramic semi-recessed vanity basin. A pictorial detail of the unit specified for Project A was included in the survey.

ITEM	AUD
General items	246,252
Fixtures/tapware	651,093
Soil, wast & vent including insulation	908,124
Cold water service	316,435
Hot water services including insulation	625,494
Fire service	130,428
Gas service	45,007
Stormwater including insulation	195,194
Completion	1,975
TOTAL	3,120,002

Table A1.2 Hydraulic services – Project B – figures include GST

A1.3.18 Drain pipe

From the Project B breakdown soil, waste and vent pipework (supply and installation) was calculated to be 29.11% of the total hydraulics cost. The same percentage was applied to the BQ total for Hydraulic Services in the reference BQ (Project A) and the cost for drainage pipework (supply and install) was calculated as:

$$\$1,724,894 \times 0.2911 = \$502,117$$

⁶ BQ total for hydraulics from Project A – GST excluded. Note that in the BQ for Project A hydraulics and fire services were in separate trade packages while in Project B the two were combined in a single trade. The total BQ cost for hydraulics in Project A includes both relevant sections

A typical materials split of 43% was used to calculate the supply cost of drainage pipe:

$$\$502,117 \times 0.43 = \$215,910$$

The cost share (weight) for supply of pipes:

$$\frac{215,910}{17,993,435} = 1.1999\% \text{ of the APC}$$

The most common material was identified from the reference BQ as 100 diameter cast iron pipe, and this was selected as the item for pricing.

A1.3.19 Water reticulation

From the Project B breakdown cold water services⁷ (supply and installation) was calculated to be 10.14% of the total hydraulics cost. The same percentage was applied to the BQ total for Hydraulic Services in the reference BQ (Project A) and the cost for water supply pipework (supply and install) was calculated as:

$$\$1,724,894 \times 0.1014 = \$174,904$$

A typical materials split of 15% was used to calculate the supply cost of water pipe:

$$\$174,904 \times 0.15 = \$26,236$$

The cost share (weight) for supply of pipe:

$$\frac{26,236}{17,993,435} = 0.1458\% \text{ of the APC}$$

The most common material was identified from the reference BQ as 15 diameter copper tube, and this was selected as the item for pricing.

A1.3.20 Air conditioning ductwork – rigid and flexible

No breakdown of mechanical services costs was available for either of the reference projects. Nowak (2007) suggested that ductwork comprises around 15% of total mechanical services costs in hotel projects similar to those analysed here, and a ratio

⁷ Water reticulation was restricted to cold water service as hot water services was assumed to include other major components such as boilers/calorifiers for which the calculations could not be adjusted due lack of a more detailed cost breakdown.

of cost for rigid and flexible ductwork of 93:7. He also suggested a typical labour:materials split for ductwork of 30:70. Applying this factors to the BQ total for mechanical services for Project A gives the following:

$$\$2,372,807 \times 0.15 = \$355,921 \text{ (total cost of ductwork)}$$

$$\$355,921 \times 0.70 = \$249,145 \text{ (supply only cost of ductwork)}$$

$$\$249,145 \times 0.93 = \$231,705 \text{ (supply only cost of rigid duct)}$$

$$\$249,145 \times 0.07 = \$17,440 \text{ (supply only cost of flexible duct)}$$

Given the difficulty of finding suitable mechanical services items for pricing and the overall significance of the trade in the total cost of the reference projects (over 13% of the adjusted project cost for Project A) two ductwork items were included in the survey, 500 x 300 rigid duct and 200 diameter flexible duct. The second was included, although it was of relatively little cost significance in the total project cost, as it is seen as a proprietary item that could potentially be priced more easily and consistently than purpose-made sheet metal duct.

APPENDIX A2 LABOUR ANALYSIS

A2.1 LABOUR BREAKDOWN FOR EACH MATERIAL

Based on Australian labour categories from Cordell (2007) the following labour breakdown was identified:

BLOC item	Labour group (Cordell)	Labour group (BLOC)	%
In situ concrete	L1/2	Semi-skilled	100
Formwork	SK2	Trade2	80
	L1/2	Semi-skilled	20
Rebar	L1/2	Semi-skilled	100
Precast concrete	L1/2	Semi-skilled	100
Stressing steel	L1/2	Semi-skilled	100
Structural steel	L1	Semi-skilled	100
Hollow blocks	SK3	Trade3	80
	L3/4	Unskilled	20
Toughened glass	SK3	Trade3	100
Window	L1/2	Semi-skilled	100
Stone facing	SK2	Trade2	100
Doors (both types)	SK2	Trade2	100
Plasterboard	SK2	Trade2	100
Floor tiles	SK2	Trade2	100
Carpet	SK3	Trade3	100
Paint	SK3	Trade3	100
Wardrobe	SK2	Trade2	100
LV cable	SK1	Trade1	100
Downlight	SK1	Trade1	100
Vanity basin	SK1	Trade1	100
CI waste pipe	SK1	Trade1	100
Cu pipe	SK1	Trade1	100
Ductwork (both types)	SK2	Trade2	100

Table A2.1 Labour breakdown by category

SK1 = Tradesman Group 1 (Trade1) i.e. electricians, plumbers

SK2 = Tradesman Group 2 (Trade2) e.g. carpenters, joiners

SK3 = Tradesman Group 3 (Trade 3) e.g. painters, plasterers, tilers

Labourer Groups 1 and 2 = semi-skilled labour e.g. concrete placers

Labourer Groups 3 and 4 = general (unskilled) labour

It the final BLOC unskilled labour was included with semi-skilled as the contribution of unskilled labour to the BLOC was minimal. The labour percentages refer only to onsite installation and do not reflect labour associated with offsite fabrication of components such as structural steel or precast concrete elements.

APPENDIX A3 – DERIVING THE BLOC QUANTITIES

A3.1 INTRODUCTION

The following tables are extracts from the working spreadsheets that were used to develop the BLOC.

MATERIALS								LABOUR						
								Labour break-up						
Item	Material cost in BQ (2003 \$, inc GST)	Material cost in BQ (2003 \$, exc GST)	Generic material as % of APC*	Material cost as % of BLOC	Unit rate (2003\$)	Unit	Derived qty	Derived labour component	Total labour cost	Trade 1	Trade 2	Trade 3	Semi-skilled	General
Hollow blocks	46585	42350	0.2354%	0.8803%	1.79	No	23659	0.64	75289			60231		15058
Low sheen acrylic paint	34755	31595	0.1756%	0.6567%	8.00	L	3949	0.75	94786			94786		
Windows	248558	225962	1.2560%	4.6970%	450.00	No.	502	0.25	75321				75321	
Glass wall	223161	202874	1.1275%	4.2165%	270.00	m2	751	0.40	135249			135249		
32MPa concrete	350783	318894	1.7723%	6.6278%	175.00	m3	1822	0.28	124014				124014	
Precast concrete	144825	131659	0.7317%	2.7363%	75.00	m2	1755	0.74	374722				374722	
Carpet	187350	170318	0.9466%	3.5399%	40.00	m2	4258	0.23	50874			50874		
Single non-fire rated door	39441	35855	0.1993%	0.7453%	97.30	No	369	0.31	16109		16109			
Single one hour fire rated door	143537	130488	0.7252%	2.7120%	550.00	No	237	0.06	8329		8329			
Plywood for formwork	98425	89477	0.4973%	1.8597%	25.97	m2	3445	0.79	336605		269284		67321	
Structural steel - rolled sections	154880	140800	0.7825%	2.9263%	2400.00	t	59	0.30	60343				60343	
Ceramic floor tiles	209439	190399	1.0581%	3.9569%	31.50	m2	6044	0.55	232710		186168			46542
Stone facing	252688	229716	1.2767%	4.7744%	75.00	m2	3063	0.57	304508		304508			
Stressing steel	127602	116002	0.6447%	2.4109%	0.00	t		0.60						
Plasterboard	370934	337213	1.8741%	7.0085%	6.50	m2	51879	0.60	505819		505819			
Wardrobe unit	847410	770373	4.2814%	16.0109%	2400.00	No	321	0.06	49173		49173			
N16 bar reo	240181	218346	0.9708%	3.6304%	1025.00	t	213	0.21	58041				58041	
LV downlight	486665	442423	2.4588%	9.1950%	38.00	No	11643	0.30	189610	189610				
LV cabling (2C+E, 2.5mm2, PVC/PVC)	264366	240333	1.3357%	4.9950%	1.10	m	218484	0.60	360499	360499				
100 dia cast iron pipe	237051	215501	1.1999%	4.4872%	43.00	m	5012	0.57	285664	285664				
15 dia copper pipe	28859	26235	0.1458%	0.5452%	9.30	m	2821	0.85	148668	148668				
Vanity basin	316786	287987	1.6605%	6.2097%	300.00	No	960	0.20	71997	71997				
Rigid duct	254875	231704	0.0969%	0.3625%	88.00	m	2633	0.70	540644		540644			
Flexible duct	19184	17440	1.2877%	4.8155%	15.00	m	1163	0.70	40694		40694			
		4843945	26.7405%	100%					4139667	1056437	1920727	341141	759762	61600

Table A3.1 BLOC development – deriving quantities of materials and labour

LABOUR	\$	Unit rate (2003\$)	Derived quantity	Unit
Tradesman Group 1	1056437	50.00	21129	hrs
Tradesman Group 2	1920727	46.00	41755	hrs
Tradesman Group 3	341141	44.00	7753	hrs
Semi-skilled/general labourer	<u>821362</u>	42.00	19556	hrs
	4139667			

Table A3.2 BLOC development – deriving labour quantities

APPENDIX A4 – PILOT STUDY

A4.1 INTRODUCTION

The following pages are the pilot study questionnaire and accompanying notes. This survey was distributed by e-mail through personal contacts to quantity surveying firms and building contractors in three cities: Singapore, Auckland and Sydney.

INTERNATIONAL CONSTRUCTION COSTS STUDY

LABOUR AND MATERIALS COST

The attached survey is part of a pilot study for a research project aimed at establishing a mechanism for comparing construction costs in different localities. This initial study is being conducted in three cities: Auckland, Sydney and Singapore.

The survey is very short, comprising just six material items, two classes of labour and a few general questions about market conditions and the like. It shouldn't take more than 20 minutes to complete. No individual response will be referred to or published in any way so there should be no confidentiality concerns.

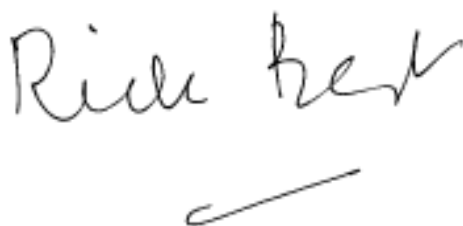
There are some explanatory notes and guidance regarding the pricing attached.

It would be much appreciated if you could help with this work. If you can there are a couple of options: you can either complete the survey on screen, save it and e-mail it back to me at rick.best@uts.edu.au or print it out, complete it and fax it me on +61 2 9514 8051.

If you have any suggestions for changes to the survey that would make it more user-friendly or to improve it any way please let me know.

Thank you in advance for taking the time to complete the survey.

Regards



Rick Best FAIQS MRICS
Centre for Applied Built Environment Research
UTS

10 October 2007

INTERNATIONAL CONSTRUCTION COSTS STUDY

Please complete the survey by providing the following:

For items 1-6 insert suitable unit rates for the supply and delivery of the nominated material exclusive of sales tax, value added tax (VAT) or goods and services tax (GST). The quantities shown provide an indication of the scale of the project for pricing purposes.

For items 7-8 please insert a typical all-in rate such as a contractor or sub-contractor would use per hour in calculating unit rates for items in a tender exclusive of profit and overheads, and exclusive of VAT or GST.

For pricing purposes assume that the items listed are for a multi-storey 4 star hotel project, approximately 200 rooms, located on an inner suburban site (i.e. not in the downtown or CBD area of your city). The quantities give an indication of the scale of the project and rates should reflect average prices for quantities of that size. **All rates should be in your local currency. All materials rates should be supply only including delivery to site.**

The remaining questions are self-explanatory, however, if further clarification of anything is needed please don't hesitate to send a query.

Rick.Best@uts.edu.au

MATERIALS

32MPa concrete – ready-mixed – supply only

1800m ³	\$	per m ³

17mm thick plywood - for use as formwork to produce a medium standard off-form finish ready for painting – supply only

3400m ²	\$	per m ²

► Alternate: price per standard sheet – give size of sheet, rate per sheet

Sheet size		Rate per sheet	\$

Low sheen acrylic paint – for interior use - supply only

4000 litres	\$	per litre

Precast concrete wall panel – 150 thick façade panel with openings for windows – supply only – typical detail attached

1750m ²	\$	per m ²

► Alternate: price per panel for the standard panel shown in the detail

150 No.	\$	per panel

Hollow concrete blocks – plain finish - supply only – nominal size 390 (L) x 190 (H) x 140 (T)

20,000 No.	\$	each

► Alternate: price per m²

\$	per m ²

80/20 wool blend carpet – supply – excluding underlay

4000m ²	\$	per m ²

LABOUR

Tradesman (e.g. plasterer, carpenter)

13,000 hrs

\$

per hour

Semi-skilled labourer (e.g. concrete placers)

11,000 hrs

\$

per hour

GENERAL INFORMATION

How long did it take you to complete this survey?

mins

What would you estimate current contractors' margins to be on projects of this type and scale?

%

What would you estimate to be the Preliminaries to be (as a percentage of net cost) for a project of the type described (i.e. 200 room hotel)

%

How would you describe the current construction market in your city at present in terms of tender price levels?

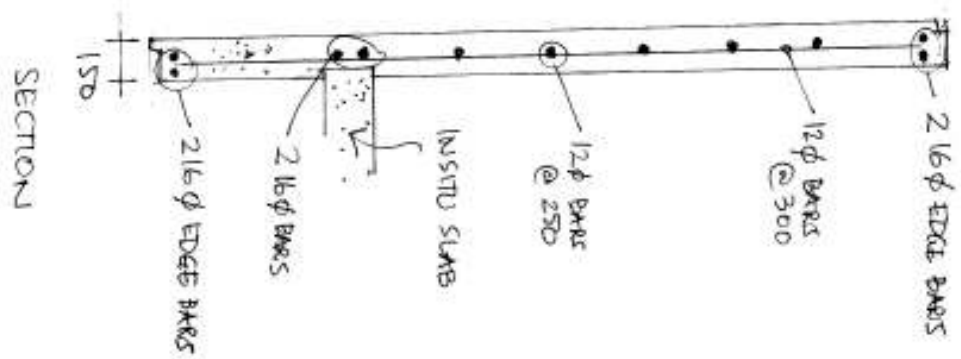
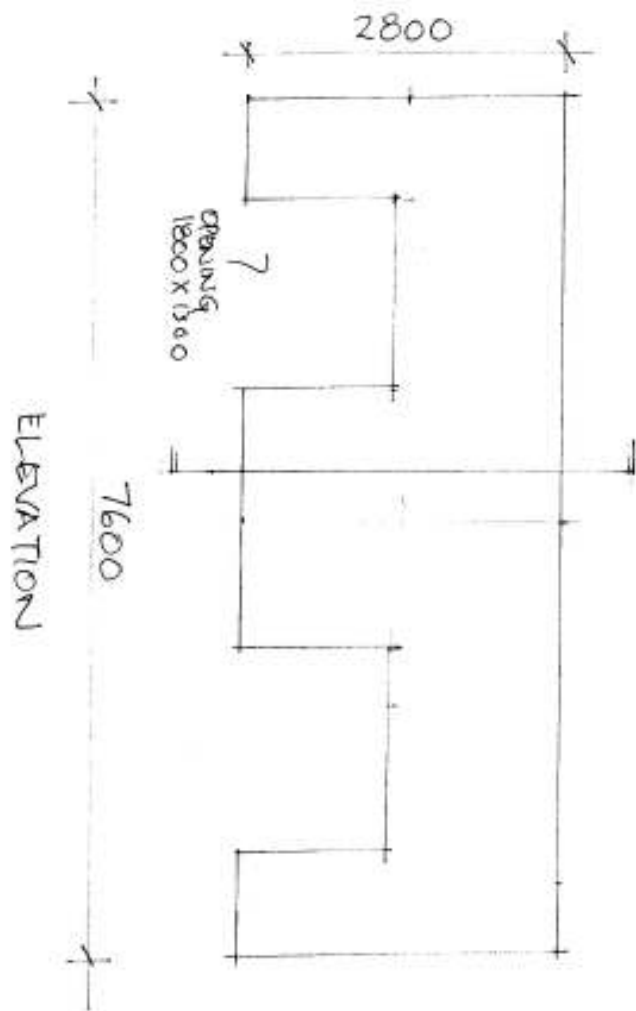
High (H), medium-high (MH), medium/average (M), low-med (LM) or low (L)?

If market conditions in your city were currently midway between "boom" and "bust" would you expect the material and labour costs for the items in the survey in Questions 1-8 to vary from those that you have given, and if so, by what factor? For example, if tender levels were currently "average" would you expect the unit rates for materials to be lower or higher by some percentage or would they remain the same as those that you have given in your answers? Ditto for labour rates. Please remember to indicate whether the percentage is plus or minus.

Materials %

Labour %

Thank you for taking the time to complete this survey – your assistance is greatly appreciated and without such assistance research into construction would be virtually impossible.



TYPICAL PRECAST WALL PANEL.

APPENDIX A5 – THE MAIN SURVEY

A5.1 INTRODUCTION

The main survey was produced using an online service, the Survey Monkey⁸. The following pages were printed directly from the Survey Monkey site. They are the main survey in its complete form (i.e. not the shortened version that was designed for those respondents who had previously completed the pilot survey).

The survey was completed online and submitted online. The Survey Monkey allows the researcher to view consolidated data and individual survey responses. Data was extracted from each completed and partially completed survey and manually transferred to an Excel spreadsheet. A complete set of results was downloaded in Excel format and archived for future reference.

⁸ <http://www.surveymonkey.com/>

UTS Construction Cost Study

1. International Construction Cost Survey conducted by the University of Techn...

LABOUR AND MATERIALS COST

The attached survey is part of a research project aimed at establishing a mechanism for comparing construction costs in different localities. The study is being conducted in a number of cities in Australia as well as in Auckland, Phoenix and Singapore.

The survey is quite short, requiring a number of unit rates for materials and several classes of labour - there are some general questions about market conditions and the like. It shouldn't take more than 30 minutes to complete. No individual response will be referred to or published in any way so there should be no confidentiality concerns.

There are some explanatory notes and guidance regarding the pricing attached.

It would be much appreciated if you could help with this work. Thank you in advance for taking the time to complete the survey.

Regards

Rick Best FAIQS MRICS MAIB
School of the Built Environment
UTS

February 2008

UTS Construction Cost Study

2. RESPONDENT INFORMATION

1. What sort of organization do you work for?

- ☐ Quantity surveyors
☐ Building contractors

Other (please specify)

2. What city are you located in?

- ☐ Sydney
☐ Brisbane
☐ Melbourne
☐ Auckland
☐ Singapore
☐ Phoenix

Other (please specify)

Your contact details will only be used if clarification of a response is required - no details will be passed to any third parties and your responses to this survey will only be seen by the researcher.

3. What is your name? (optional)

4. What is your company's name? (optional)

5. What is your e-mail address? (optional)

UTS Construction Cost Study

3. MATERIALS

Please complete this section of the survey by inserting suitable unit rates for the supply and delivery of the nominated material exclusive of sales tax, value added tax (VAT) or goods and services tax (GST). The quantities shown provide an indication of the scale of the project for pricing purposes. Rates should be those actually paid by a contractor.

For pricing purposes assume that the items listed are for a multi-storey 4 star hotel project, approximately 200 rooms, located on an inner suburban site (i.e. not in the downtown or CBD area of your city). The quantities give an indication of the scale of the project and rates should reflect average prices for quantities of that size. All rates should be in your local currency. All materials rates should be supply only including delivery to site.

Please answer as many questions as you can in this section. If an item description is unclear or the item is not available in your location please move to the next question. If the specification of an item is similar but not quite the same as a corresponding item in your location (e.g. 30MPa concrete rather than 32MPa as specified, please enter a rate for the item that is typical of your location and add a note in the Comments box).

1. 32 MPa concrete, ready mixed, delivered to site, supply only (1800m3)

Rate (\$/m3)

Comments

2. 19mm thick plywood for formwork to produce a medium standard finish that is ready for paint (supply price only) (3500m2)

Rate (\$/m2 OR \$/sheet)

- specify size below if
pricing per sheet

Comments

3. 16mm diameter high yield steel reinforcing bar (supply price only for bars cut, bent and delivered)(200 tonnes)

Rate (\$/tonne)

Comments

4. Precast concrete wall panel – 7600 x 2800 x 150 thick façade panel with openings for windows – 2.5m3 concrete, 150kg reinforcement– typical detail attached (1700m2)

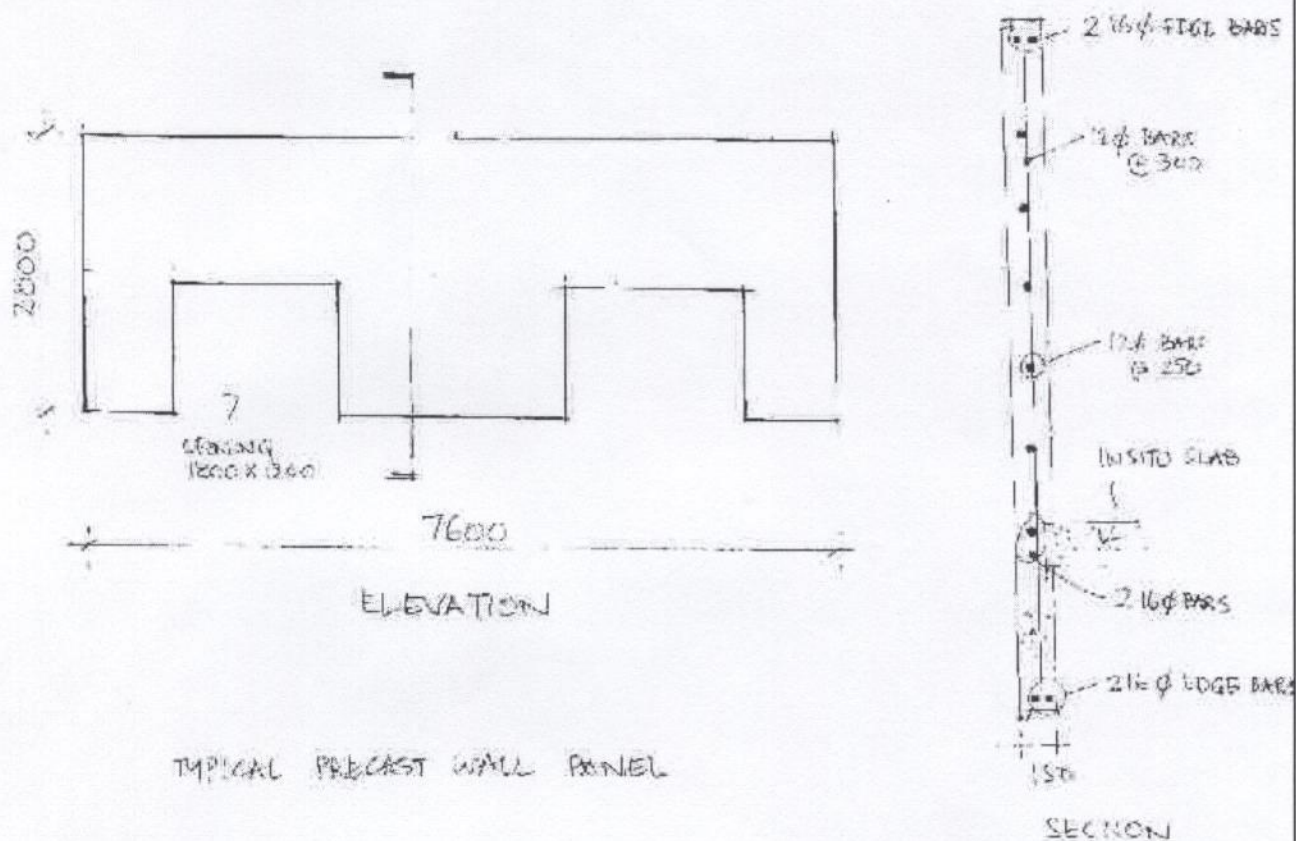
Rate (\$/m2 OR cost per panel - please specify the pricing method used below in the Comments box)

panel - please specify the
pricing method used
below in the Comments
box

Comments

UTS Construction Cost Study

Typical precast panel details



5. Stressing steel - strand only (100t)

Rate (\$/tonne) - if supply
rate for steel only is not
known please insert
subcontract rate and
specify in the Comments
box

Comments

6. Hot rolled steel sections - fabricated (60 t)

Rate (\$/tonne) - supply
and delivery of fabricated
members - exclude
erection

Comments

7. 390 x 190 x 190 hollow concrete blocks - plain finish (24,000 No. blocks)

Rate (\$/block) - supply
and delivery cost only

Comments

UTS Construction Cost Study

8. 10 thick toughened glass for frameless glass walls (supply cost of glass only) (750m²)

Rate (\$/m²)

Comments

Please note that all rates in this section, as noted against the preceding items, are for supply and delivery of the nominated materials/components only - if you can only give a supply and fix rate please do so but add a note in the Comments box confirming the rate you've given.

9. 1600 x 1600 window with one fixed pane, powder coated aluminium frame, glazed with 6mm grey laminated glass (300 No.)

Rate (\$/unit)

Comments

10. 50 thick sawn sandstone facing (75m²)

Rate (\$/m²)

Comments

11. Single one hour fire rated doorset including frame and hardware - ready for paint (240 No.)

Rate (\$/unit)

Comments

12. Single non-fire rated internal door excluding frame and hardware ready for paint (400 No.)

Rate (\$/unit)

Comments

13. 13mm thick gypsum plaster sheet lining (50,000m²)

Rate (\$/m² OR \$/sheet)

- specify size if pricing
per sheet

Comments

14. 200 x 200 ceramic floor tiles - medium standard (6,000m²)

Rate (\$/m²)

Comments

15. 80/20 wool blend carpet - excluding underlay (4,000m²)

Rate (\$/m²)

Comments

16. Low sheen acrylic paint - interior use (4,000 litres)

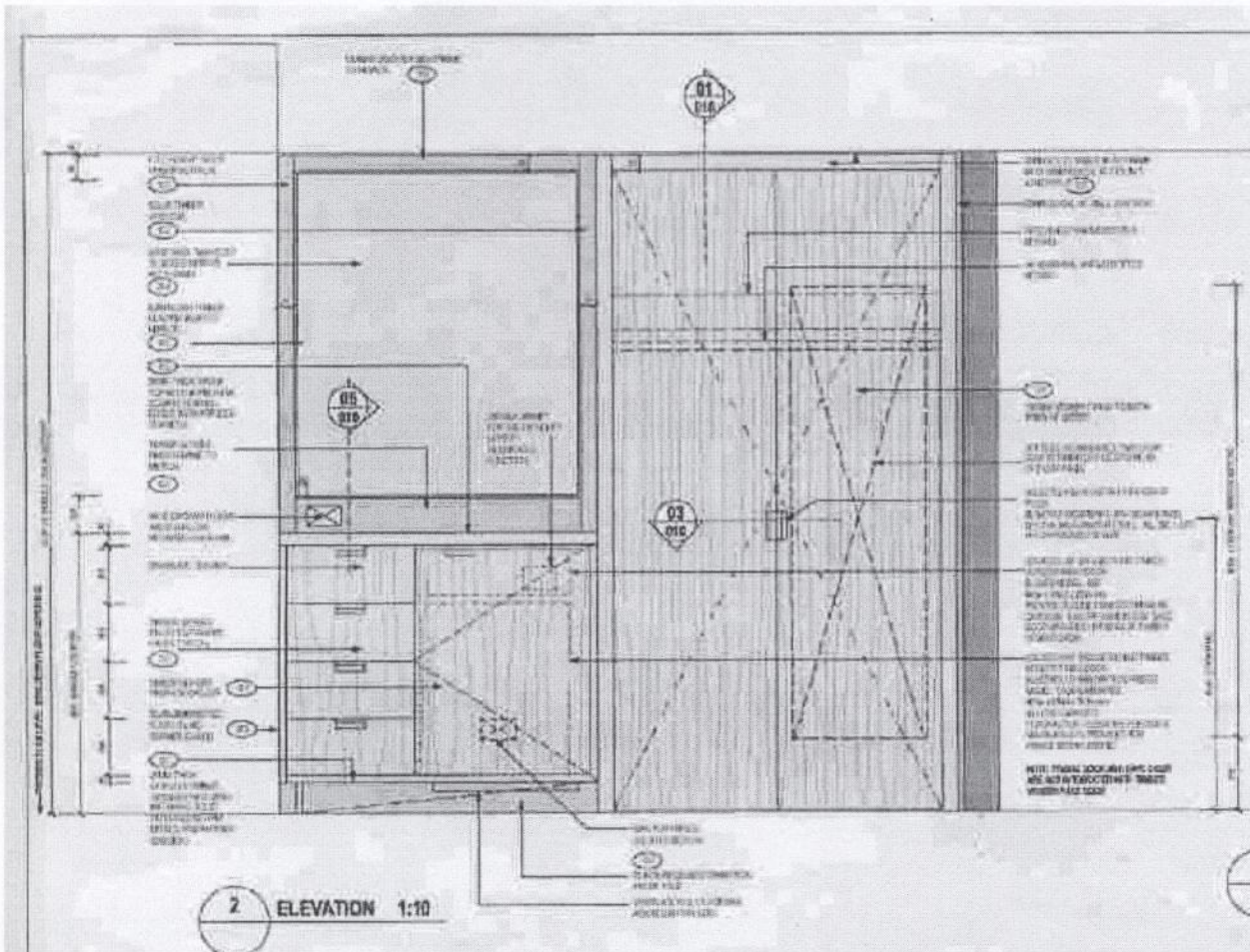
Rate (\$/litre)

Comments

UTS Construction Cost Study

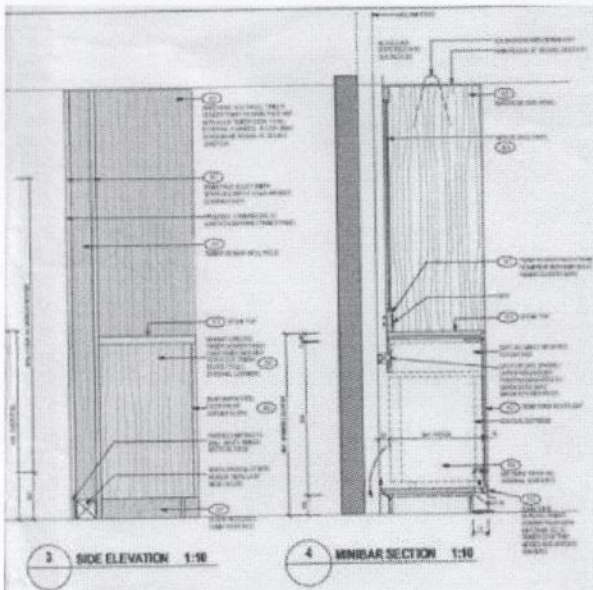
17. Timber hotel wardrobe/minibar unit, 2340 long x 2265 high x 645 deep, timber veneer finish on manufactured timber (MDF) substrate, including doors, drawers, mirror, stone bench top etc (typical details below)(300 units)

Wardrobe - elevation



UTS Construction Cost Study

Wardrobe - section



18. PVC insulated and PVC sheathed low voltage cable suitable for domestic power circuits (2C+E, 2.5mm², PVC/PVC) (200,000m)

Rate (\$/m)

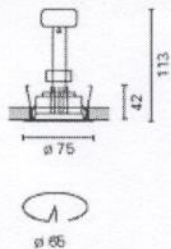
Comments

19. Low voltage recessed downlight (see typical detail below)(12,000 No.)

Rate (\$/unit)

Comments

Downlight detail



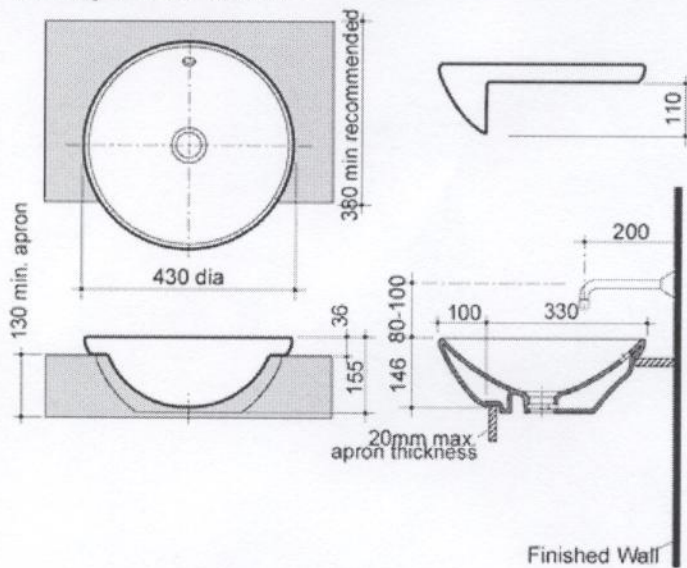
20. Semi-recessed white ceramic vanity basin (see typical detail below)(900 units)

Rate (\$/unit)

Comments

UTS Construction Cost Study

Vanity basin detail



21. 100 diameter cast iron waste pipe (5,000m)

Rate (\$/m)

Comments

22. 15 diameter copper water pipe (3,000m)

Rate (\$/m)

Comments

23. 500 x 300 rigid sheet metal air conditioning duct excluding insulation (2,500m)

Rate (\$/m)

Comments

24. 200 diameter flexible air conditioning duct (1,200m)

Rate (\$/m)

Comments

UTS Construction Cost Study

4. LABOUR

Please complete this section of the survey by inserting typical all-in labour rates per hour such as a contractor or sub-contractor would use in calculating unit rates for items in a tender, exclusive of profit and overheads, and exclusive of VAT or GST.

1. Tradesman Group 1 (e.g. electrician, plumber) (20,000hrs)

Rate (\$/hour)

Comments

2. Tradesman Group 2 (e.g. carpenter, bricklayer) (40,000hrs)

Rate (\$/hour)

Comments

3. Tradesman Group 3 (e.g. tiler, carpet layer) (8,000hrs)

Rate (\$/hour)

Comments

4. Semi-skilled labourer (e.g. steel fixer) (25,000hrs)

Rate (\$/hour)

Comments

UTS Construction Cost Study

5. GENERAL INFORMATION

*** 1. What would be a typical contractor's margin (profit and general overheads) on a project of this type (200 room, 3-4 star suburban hotel)**

Rate (percentage)

Comments

2. What would you estimate Preliminaries (site/job specific overheads) to be for the same project as a percentage of total project cost?

Rate (percentage)

Comments

3. How would you describe market (tendering) conditions in your location at present (High indicates a strong market with lots of work available and correspondingly high tender prices; Low indicates a slow market with intense competition for limited amounts of work)

☐ High

☐ Medium to high

☐ Medium

☐ Low to medium

☐ Low

4. In your location what would you estimate to be the range of tender prices between a High market and a Low market in relation to "average" tender price levels when the market is Medium? (For example, tender levels might move around a Medium level by up to +20% when work is plentiful, and -20% when work is scarce and competition is at its highest)

High market variance + %

Low market variance - %

Comments

5. How long did it take to complete this survey?

Time to complete
(minutes)

Comments

APPENDIX A6 – ANALYSIS OF PUBLISHED UNIT RATES

A6.1 INTRODUCTION

This appendix contains a detailed breakdown of selected unit rates published in Cordell Estimator (Cordell, 2008) for various items representative of items in the BLOC as well as several composite services items. All costs/rates are in AUD. Rates do not include contractors' margins or GST.

A6.2 SELECTED UNIT RATES

In each of the following cases a single work item has been selected to represent a generic item in the BLOC. A BQ style description of each item is given and the cost breakdown and other details such as base labour rates and materials supply rates are listed.

A6.2.1 Ready-mixed concrete

32 MPa concrete in suspended slabs - pumped				m3
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney (S)	54.60	234.80	18.80	308.20
Melbourne (M)	51.80	183.37	18.15	253.32
Brisbane (B)	52.50	206.53	15.70	274.73

Table A6.1 Rate breakup – *in situ* concrete

Labour rates; \$39.00/hr (S), \$37.00/hr (M), \$37.50/hr (B)¹

Supply cost for concrete: \$213.45/m³, \$175.25/m³, 187.75/m³

Pump hire: \$195.00/hr, \$165.00/hr, \$130.00/hr

Pumping charge: \$5.00/m³, \$6.00/m³, \$6.00/m³

¹ Rates herein are typically given in the order Sydney (S), Melbourne (M) and Brisbane(B) unless noted otherwise.

A6.2.2 Formwork

<i>Class 3 formwork to slab soffits (slabs 100-200 thick)</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	66.60	14.20	1.88	82.68
Melbourne	66.00	16.96	1.88	84.84
Brisbane	60.60	20.44	1.88	82.92

Table A6.2 Rate breakup – formwork

Labour rates (carpenter and labourer): \$55.50 and \$39.00/hr; \$55.00 and \$37.00/hr; \$45.50 and \$37.50/hr.

Supply cost for formply: \$31.00/m², \$37.78/m², \$27.65/m²

A6.2.3 Bar reinforcement

<i>N16 bars in suspended slabs and stairs</i>				<i>tonnes</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	526.50	1957.53	0	2484.03
Melbourne	499.50	1973.68	0	2473.18
Brisbane	506.25	1408.54	0	1914.79

Table A6.3 Rate breakup – bar reinforcement

Supply cost for N16 bars: \$1707.00/t, \$1736.70/t, \$1231.80.

Labour rates (labourer group 1, labourer group 2): \$41.00 and \$39.00/hr; \$39.00 and \$37.00/hr; \$39.50 and \$37.50/hr.

A6.2.4 Precast concrete

<i>150 thick precast reinforced concrete spandrel panel, smooth off-form finish</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	215.28	97.91	83.82	397.01
Melbourne	210.34	93.28	60.36	363.98
Brisbane	186.55	100.51	63.16	350.22

Table A6.4 Rate breakup – precast concrete

Note: Cordell estimator gives no details of component rates in precast items.

A6.2.5 Structural steel

<i>Universal beams with welded fitments</i>				<i>tonnes</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	1300.67	2701.19	474.70	4476.56
Melbourne	1310.00	2614.04	432.40	4356.44
Brisbane	1230.67	2379.89	371.30	3981.86

Table A6.5 Rate breakup – structural steel

Supply cost for steel (UB): \$1958.00/t, \$1875.00/t, \$1652.00/t.

Labour rates (labourer group 1): \$41.00/hr; \$39.00 /hr; \$39.50/hr.

A6.2.6 Concrete blocks

<i>Hollow concrete blocks, 400 x 200 x 200, grey finish, laid in 1:1:6 mortar</i>				<i>hundred</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	425.00	273.00	0	698.00
Melbourne	445.00	289.00	0	734.00
Brisbane	340.00	272.00	0	612.00

Table A6.6 Rate breakup – blockwork

Supply cost for blocks: \$2.46 each, \$2.64 each, \$2.46 each.

Labour rates (blocklayer, labourer group 3): \$51.50 and \$37.00/hr, \$58.00 and \$35.00/hr, \$48.00 and \$36.00/hr

A6.2.7 Sandstone facing

<i>50 thick sawn sandstone facing including 20 thick mortar bed and cement grout</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	142.90	93.44	17.07	253.41
Melbourne	128.30	86.98	17.07	232.35
Brisbane	128.55	138.89	17.07	284.51

Table A6.7 Rate breakup – stone facing

Supply cost for sandstone: \$82.00/m², \$76.65/m², \$124.11/m²

Labour rates (stonemason): \$45.00/hr, \$40.00/hr, \$40.00/hr.

A6.2.8 Doors

As in the BLOC two typical doors were chosen for pricing.

A6.2.8.1 Fire rated doors

<i>Single fire door and frame, 2040 x 820 x 45, painted plywood, one hour rated, including frame and hinges,</i>				<i>No.</i>
LOCATION	LABOUR	MATERIALS	SUBCON	RATE
Sydney	44.40	0	667.00	711.40
Melbourne	44.00	0	667.00	711.00
Brisbane	36.40	0	667.00	703.40

Table A6.8 Rate breakup – fire rated doors

Supply cost not stated but sub-contract rate is exclusive of labour hence supply cost must be the same for all three locations.

A6.2.8.2 Non fire rated doors

<i>Single solid core flush internal door, 2040 x 820 x 35, ready for paint, excluding frame and hardware,</i>				<i>No.</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	55.50	108.40	0	698.00
Melbourne	55.00	112.40	0	734.00
Brisbane	45.50	145.50	0	612.00

Table A6.9 Rate breakup – non-fire rated doors

Supply cost for doors: \$106.00 each, \$110.00 each, \$143.00 each.

Labour rates (carpenter): \$55.50/hr, \$55.00/hr, \$50.50/hr

A6.2.9 Plasterboard

<i>13 thick standard plasterboard, screw fixed to metal framing</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	15.52	7.31	0	22.83
Melbourne	16.64	6.31	0	22.95
Brisbane	14.08	7.31	0	21.39

Table A6.10 Rate breakup – formwork

Supply cost for plasterboard: \$6.50/m², \$5.50/m², \$6.50/m².

Labour rates (plasterer and labourer): \$48.50 and \$37.00/hr; \$52.00 and \$35.00/hr; \$44.00 and \$36.00/hr.

A6.2.10 Ceramic tiles

<i>Ceramic floor tiles (medium quality) including 20 thick mortar bed, straight joints and grouting</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	59.40	36.98	0	96.38
Melbourne	60.00	35.74	0	95.74
Brisbane	58.80	36.00	0	94.80

Table A6.11 Rate breakup – ceramic floor tiles

Supply cost for tiles: \$28.00/m², \$28.00/m², \$28.00/m².

Labour rates (tiler): \$49.50/hr; \$50.00/hr; \$49.00/hr.

A6.2.11 Paint

<i>One coat sealer and two coats acrylic paint on plasterboard walls</i>				<i>m2</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	10.50	3.76	0	14.26
Melbourne	10.50	3.76	0	14.26
Brisbane	9.03	3.76	0	12.79

Table A6.12 Rate breakup – painting

Supply cost for paint: \$10.00/litre, \$10.00/litre, \$10.00/litre.

Labour rates (painter): \$50.00/hr; \$50.00/hr; \$43.00/hr

A6.2.12 Drainage

<i>100 diameter cast iron waste pipe bracketed to masonry</i>				<i>m</i>
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	65.00	48.53	0	113.53
Melbourne	59.00	48.53	0	107.53
Brisbane	60.00	48.53	0	108.53

Table A6.13 Rate breakup – cast iron pipework

Supply cost for pipe: \$45.15/m, all locations.

Labour rates (plumber): \$65.00/hr; \$59.00/hr; \$60.00/hr

A3.2.13 Water reticulation

15 diameter Type B copper tube bracketed to masonry				m
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	13.65	7.79	0	21.44
Melbourne	12.39	6.85	0	19.24
Brisbane	12.60	8.21	0	20.81

Table A6.14 Rate breakup – copper water pipe

Supply cost for pipe: \$5.90/m, \$5.00/m, \$6.30/m.

Labour rates (plumber): \$65.00/hr; \$59.00/hr; \$60.00/hr

A6.2.14 Sanitary fittings

White vitreous china vanity basin				No.
LOCATION	LABOUR	MATERIALS	PLANT	RATE
Sydney	52.00	374.72	0	426.72
Melbourne	47.20	367.64	0	414.84
Brisbane	48.00	454.85	0	502.85

Table A6.15 Rate breakup – vanity basin

Labour rates (plumber): \$65.00/hr; \$59.00/hr; \$60.00/hr

No supply price for basin provided.

A6.2.15 Electrical work

As Cordell Estimator does not provide detailed cost breakdowns for electrical work two typical items were used in the analysis as follows:

Single power outlet, single phase (complete) fixed in timber framed wall				No.
LOCATION	LABOUR	MATERIALS	SUBCON	RATE
Sydney			60.40	60.40
Melbourne			40.70	40.70
Brisbane			40.40	40.40

Table A6.16 Rate breakup – power outlet

<i>Light point (complete) batten holder, single switch, fixed to concrete or masonry</i>				<i>No.</i>
LOCATION	LABOUR	MATERIALS	SUBCON	RATE
Sydney			80.90	80.90
Melbourne			53.10	53.10
Brisbane			52.80	52.80

Table A6.17 Rate breakup – light point

Labour rates (electrician): \$62.50/hr; \$67.50/hr; \$61.00/hr

A6.2.16 Air conditioning

No detailed cost breakdown was available for air conditioning installations. Cordell Estimator provides approximate costs/m² for high velocity variable air volume systems of medium standard as follows:

Sydney: \$305/m²

Melbourne: \$290/m²

Brisbane: \$290/m²

APPENDIX A7 – UPDATING THE BIG MAC INDEX

A7.1 INTRODUCTION

Prices for the standard Big Mac hamburger were directly from each of the target cities in the study and April 2008 indices calculated related to one USD.

A7.2 CURRENT BIG MAC PRICES

Prices were obtained from direct enquiries to the various locations. Prices as at 29 April 2008.

Sydney, Melbourne, Brisbane	\$AUD3.95 (including 10% GST)
Auckland	\$NZD4.90 (including 12.5% GST)
Singapore	\$SGD3.95 (including 7% GST)
Phoenix	\$USD3.12 (including 8% city tax)

A7.3 BIG MAC INDEX

Location	Big Mac Local \$	Big Mac Index
Australia	3.95	1.27
New Zealand	4.90	1.57
Singapore	3.95	1.27
USA	3.12	1.00

Table A7.1 Big Mac Index: April 2008

APPENDIX A8 – EXPLANATION OF ACRONYMS

A8.1 INTRODUCTION

A number of acronyms have been used throughout the thesis; the following lists expand each of them to assist the reader. Abbreviations in general use such as UK and US should not require explanation. Abbreviations in references are expanded in the corresponding citations in the References and Bibliography.

A8.2 CURRENCIES

The abbreviated names for currencies that have been used are the standard three letter codes from ISO 4217:2001.

AUD	Australian dollars
ECU	European Currency Units
EUR	Euros
GBP	Great Britain pounds
JPY	Japanese yen
NZD	New Zealand dollars
SGD	Singapore dollars
USD	US dollars

A8.3 GENERAL TERMS

10YA	ten year average exchange rates
ABS	Australian Bureau of Statistics
BLOC	<u>B</u> asket of <u>L</u> ocally <u>O</u> btained <u>C</u> ommodities – the basket of materials and labour derived in the study.
BMI	Big Mac Index

BOCC	basket of construction components
BOG	basket of goods and services
BQ	bill(s) of quantities
CLT	Central Limit Theorem
CoV	coefficient of variation
CPPP	construction- specific purchasing power parity (PPP)
CPPP(B)	basic CPPP calculated using only the costs of materials and labour in the basket (BLOC)
CPPP(Lab)	CPPP based on labour costs only
CPPP(MA)	market adjusted CPPP with costs adjusted to reflect prevailing market conditions
CPPP(Mat)	CPPP based on materials costs only
CPPP(P)	CPPP based on costs including allowance for Preliminaries
CPPP(PM)	CPPP based on costs including allowance for Preliminaries and allowance for contractors' margins
CPPP(PMT)	CPPP based on costs including allowance for Preliminaries, contractors' margins and tax
ECE	UN Economic Commission for Europe
FF&E	furniture, fittings and equipment
GDP	gross domestic product
GFA	gross floor area
GST	goods and services tax
ICP	International Comparison Program
IMF	International Monetary Fund
L:M:P	ratio of labour, materials and plant costs in a unit rate
LP	labour productivity
MFP	multi-factor productivity
Mini BLOC	the basket of eight items (six materials and two classes of labour) used in the pilot study
OECD	Organisation of Economic Co-operation and Development
ONS	Office of National Statistics
PPP	purchasing power parity/parities
PWT	Penn World Tables

QS	quantity surveyor(s)
RLB	Rider Levett Bucknall
TFP	total factor productivity
TP	total productivity
UBS	Union Bank of Switzerland
VAT	value added tax

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