The Reliability of Currency and Purchasing Power Parity Conversion for International Project Cost Benchmarking

Relating to Commission Information Request 8.3

Abstract

Purpose: Project cost is normally a key performance indicator for all projects, and therefore features prominently in benchmarking exercises aimed at identifying best practice. However, projects in different locations first require all costs to be expressed in equivalent units. Failing to do this leads to erroneous and unreliable results.

Design/methodology/approach: Applying international construction as the focus for the study, cost data from 23 cities worldwide are compared using a range of methods including currency conversion and purchasing power parity (PPP). Coefficient of variation forms the test for identifying the method with the lowest volatility.

Findings: It is found that purchasing power is the preferable theoretical base for international cost conversion, and currency conversion (frequently used by practitioners) is not recommended. The *citiBLOC* PPP method has the lowest coefficient of variation across the dataset and therefore more closely reflects the *Law of One Price* that underpins the concept of PPP.

Originality/value: This research highlights the importance of a valid cost conversion methodology to properly understand the comparative performance of projects. Its application to benchmarking is demonstrated using the Data Envelopment Analysis (DEA) method.

Keywords

Performance measurement, purchasing power, cost conversion, coefficient of variation, international construction, data envelopment analysis

Introduction

Successful project management has long been communicated in terms of delivering projects on time, within budget, and to the required standard of quality (Ebbesen and Hope, 2013). There are other performance indicators as well, including risk management, innovation, stakeholder satisfaction, value for money, environmental impact, defect minimization, conflict avoidance, team development and continuous process improvement (Toor and Ogunlana, 2010). Nevertheless, project cost is normally a key performance indicator for all projects, and therefore features prominently in benchmarking exercises aimed at identifying best practice (Bryde and Robinson, 2005; Tabish and Jha, 2012). Benchmarking concerns drawing valid comparisons between projects. In the case of cost, benchmarking is complicated by differences in scope, quality standard, timing and location (Atkinson, 1999).

Investigations of comparative project cost performance may involve domestic or international benchmarking. The latter introduces the additional issue of different currencies. The routine approach is to first convert all costs into a common currency, usually taken as the US dollar (USD), so that a direct comparison can be made. Most practitioners appear to do this. Yet currency rates can be quite volatile. For example, the currency exchange rate between Australia and the United States was 1 AUD = 0.5 USD in 2001 and 1 AUD = 1.08 USD in 2012, yet the relative prices (or purchasing power) of domestic consumption was largely unaffected over this period.

Purchasing power parity (PPP) is an alternative to currency conversion. The concept has been around since the 16^{th} Century, but was developed into its modern form by Gustav (1918), and used by economists ever since. It assumes that, in the absence of transaction costs and official trade barriers, identical goods will have the same price in different markets when the prices are expressed in a given currency (Krugman *et al.*, 2010). Where this doesn't occur, the conclusion is that different countries have different domestic purchasing power.

A recent example highlights the cost conversion problem. The Business Council of Australia compared the performance of large infrastructure projects in Australia and the United States and concluded that Australia had become uncompetitive (BCA, 2012). Their press release was repeated in the national media:

> "*Australia has become such a high-cost and low-productivity nation that resources projects are now 40 per cent more expensive to deliver here than in the US, jeopardizing an investment boom that is crucial to propping up the national economy. Landmark research to be released today finds that, compared with the US, airports are 90 per cent more expensive to deliver, hospitals 62 per cent, shopping centres 43 per cent and schools 26 per cent*"
> (The Australian, 2012).

Included in the BCA report were data on cost/m^2 for airports, schools, shopping malls and hospitals in both countries obtained from a well-known published cost guide. The BCA study received ridicule from some analysts (e.g. Best, 2012; 2013) for ignoring the impact of purchasing power. The original study benchmarked Australian projects against the US Gulf States where the cost of living was lower than in many other parts of the country, resulting in different levels of domestic purchasing power. The BCA's observations enjoyed wide media coverage and were used politically to call for sweeping reform and productivity improvement, causing much angst and protest within the local construction industry.

The aim in this paper is to investigate the reliability of PPP and currency conversion for the benchmarking of international project cost performance. Appropriate cost comparison is essential to properly evaluate the success of projects. The construction industry is used as the context, but the principles discussed herein apply to all types of projects. Using recently published independent cost data for construction activity in 23 cities worldwide, this research concludes with recommendations about how to convert local construction prices to obtain a fair and valid international comparison.

Literature Review

Whenever the performance of the construction industry is called into question, the immediate reaction, and rightly so, is to attempt to benchmark performance against other countries. This can be done at the level of an item of work, a trade, a project, a contractor, a geographic region, or an entire industry (Chan and Chan, 2004).

Project delivery success and its measurement feature in the literature over a long period. Generally the findings acknowledge the influence of scope, cost and time, but identify other success criteria that should be included. Cooke-Davies (2002) highlights the difference between success criteria (used for evaluating success) and success factors (inputs that lead to success). The list in both cases is long and criteria/factors are often specific to particular types of projects and sponsors (see Atkinson, 1999; Shenhar *et al.*, 2001; Bryde and Robinson, 2005; Müller and Turner, 2007; Ika, 2009; Al-Tmeemy *et al.*, 2011; McLeod *et al.*, 2012; Tabish and Jha, 2012; Davis, 2013).

Comparative international project cost performance is the focus of this paper. Underpinning the benchmarking of cost performance is the methodology used to convert prices in different currencies. Previous pricing studies have employed a range of methodologies, such as estimating the cost of identical standard projects (actual or hypothetical), or comparisons of functionally similar projects taking into account local practice, or a combination of both. In any event, the question soon arises as to how to compare costs on an equal basis, since whenever different currencies are involved the cost impacts cannot be immediately understood. Costs vary for a range of factors, not the least of which is time, but the issue of location is to be explored here and is central to the need to compare costs across national borders.

The exchange rate adopted to compare costs arising from projects in different locations is a critical factor for the usefulness of results that come from any international benchmarking study. Applying currency exchange rates is an obvious choice, but these change frequently and do not provide confidence that the relativity between construction industries in two different countries is actually being assessed. For example, the Asian economic crisis triggered in 1997 could be used to conclude that the dramatically lower cost of construction in some Asian countries, as calculated by falling exchange rates against their western counterparts, was a result of increased competitiveness in-country. The reality was that the local industry had not changed, but the value assigned to projects that were under construction or previously completed had sharply declined (Kendrick, 1999).

The use of PPP as an alternative to traditional currency exchange rates is generally regarded as a superior approach (e.g. Rogoff, 1996; Langston and Best, 2005). PPP is an attempt to measure the economic well-being of people according to the country in which they reside. While not pretending to be an indicator of living standards, it does reflect the cost of living in-country and therefore forms a new baseline against which construction costs can be interpreted.

PPPs can be calculated at the value of a particular good or service, or using a weighted basket of goods and services, and can be expressed in relation to gross domestic product or income capacity. In fact, PPPs have been calculated using items that are available in most countries worldwide, such as via use of the Big Mac Index regularly compiled by *The Economist* magazine. There are grounds to suggest that an approach specific to construction goods and services would be preferable to one that is generic of entire economies (Walsh and Sawhney, 2004).

PPPs are defined as exchange rates that replace traditional currency exchange rates by taking into account the differences in prices between countries (Pakko and Pollard, 2003). They convert local costs into 'international dollars' compared to a nominated base country. The philosophy behind PPPs is the *Law of One Price* – namely that the cost of a good or service should be the same in different countries – else people would buy goods cheaper from one country and sell them at a profit in another (Baffes, 1991).

Whether the *Law of One Price* holds for any particular item depends on the item meeting four basic criteria (UBS, 2003). 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 homogeneous 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 X should represent the same value as the cost of the same item in currency Y (Best, 2008).

The United Nations sponsored International Comparison Program (ICP) commenced in 1967 and now produces PPPs published by The World Bank Group for most countries on an approximate three-year cycle. These indices have been interpreted and extended to form the Penn World Table (PWT) produced by the University of Pennsylvania. The Eurostat-OECD joint program currently collects more detailed PPP data than the ICP, but for a much smaller set of countries. Indices for both ICP and Eurostat-OECD PPPs are expressed as a proportion of per capita gross domestic product. The Union Bank of Switzerland (UBS) has also been producing PPP data since 1970, again approximately on a three-year cycle. They use a basket of goods and services and express their data in three forms (using a base for Switzerland, United States or the Euro-zone respectively). One criticism of these programs is the time delay between data collection and publication. Another criticism is the cost of the process (Langston and Best, 2005).

Controversially, *The Economist* has published an alternate PPP index based on the McDonalds Big Mac hamburger price since 1986 for a number of countries. Known as 'burgernomics' (Lan, 2003), this approach has moved from a light-hearted look at fast food metrics to a quite seriously debated topic (e.g. Pakko and Pollard, 2003, who found a correlation of 0.73 between the PWT and the Big Mac Index using 2000 data). The Big Mac Index has the advantage that input data is relatively easy to collect and therefore enables it to be up-to-date and city-specific. *The Economist* now publishes their index several times each year. Cumby (1996) found that when the US dollar price of a Big Mac is high in a country, the relative local currency price of a Big Mac in that country is likely to fall during the following year. The index has been employed to identify currency over and under valuations, although this is not a recommended use.

The reliability of various methods is largely unknown as there is no correct value that each can be compared against, other than monetary exchange rates which are volatile and subject to influence from a number of external sources. Pakko and Pollard (2003:22) concluded that "*it is interesting to find that the simple collection of items comprising the Big Mac sandwich does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures*". Ong (2003) concurred. But over the last decade in particular, attention has now turned to developing indices that are industry-focused, such as comparing construction-related costs independent of general economy activity (Meikle, 1990; Walsh and Sawhney, 2004).

Langston (2012) proposed the *citiBLOC* as a construction-specific PPP. Rather than reflecting relative differences between prices in-country, it is computed per city, and a national average inferred by taking the mean *citiBLOC* value for the five largest cities by population, where relevant. Table 1 illustrates the approach.

Insert Table 1 here …

Perhaps the best way to describe PPP-adjusted values is to say that they express local prices in terms of purchasing power by weighting them according to a standard basket of construction items (comprising common material, labour and plant items) priced in-country. The higher the PPP-adjusted value, the higher are the relative costs of building in one location over another. The PPP 'exchange rate' alone does not tell you that, in the same way the USD exchange rate does not tell you anything. But when the local prices are divided by it, the result is a comparative 'international' value: in the case of *citiBLOC* using Sydney as the base. Selection of PPP over USD conversion eliminates the problem of short-term foreign exchange fluctuations due to macro-economic issues, and therefore is likely to be the superior conversion method for international construction cost comparison.

By pricing a representative basket of construction-related items covering labour, material and plant, a standard basket price in each city (in local currency terms) can be computed and act as a locality index. Thereafter, the cost of a project can be divided by the cost of the representative basket to obtain the equivalent number of baskets required to pay for the construction. Although the unit of measure is 'baskets', not currency, the answer is an indicator of cost performance that has no locational boundaries. For example, if Project A in Hong Kong was 5 baskets/m^2 and Project B in New Delhi was 4 baskets/m^2, then the construction cost in Hong Kong would be 25% more than that in New Delhi.

Method

Langston and Best (2005) first used coefficient of variation (CoV) as the test to determine which international PPP method was the most appropriate for construction cost comparison. They compared general PPPs produced by UBS and the World Bank, as well as USD currency conversion and the Big Mac Index. They found the latter was as good as any other method in some cities, but not in others. Hong Kong was a case in point, where the price of the Big

Mac was about half of its expected value. This highlighted that the hamburger is not really a standard commodity across the world, but if one could be found there would be some confidence that its use in international cost comparisons would be superior to more costly and time-consuming methods. Large discrepancies were also found between the more established indices, particularly over the accuracy of the ICP data for Bangkok. Exchange rates were generally more volatile and displayed the greatest dispersion, suggesting that PPPs were more appropriate for use in practice.

In this paper, CoV is used in the same way. Construction cost data are obtained independently from Turner and Townsend (2013). This source surveyed local prices across 23 cities, as listed in Table 2, and converted local prices into both USD and *citiBLOC* PPP equivalents. The local currency used is also indicated in the table.

Insert Table 2 here …

Three types of construction cost data are used in this study. First, average cost/m^2 for various building types (comprising residential, commercial, industrial, retail, hotels, hospitals, schools, carparks and airports) are compared. Second, unit rates for labour, material and plant are compared. Third, unit rates for composite work items comprising a mix of labour, material and plant components are compared.

CoV is calculated as standard deviation divided by mean, and expressed as a percentage. Values below 20% typically demonstrate low variance, values between 20 and 50% are considered normal given the nature of the base data, while values over 50% suggest the prices are either erroneous or heterogeneous.

Treating each item in the dataset as equal importance, the number of items where PPP conversion has a lower CoV than currency conversion is then determined. To draw a valid conclusion, an overwhelming majority is needed. The method with the lowest CoV is the preferred choice since it most closely reflects the *Law of One Price*.

There are a number of PPP methods that could be used and compared against currency conversion. The *citiBLOC* PPP is based on four common categories of labour, five common global construction materials, and one item of plant hire in equal proportions. This research also compares three other PPP methods constructed from readily available data. First, a basket of labour and material unit rates is derived using the full list provided in Turner and Townsend (2013). Second, a basket of composite work items is derived, also using the full list provided in Turner and Townsend (2013). Third, prices for a McDonalds Big Mac hamburger, considered as a 'standard' product, are sourced largely from *The Economist* (http://www.economist.com/content/big-mac-index) and from the *Expatistan Cost of Living Index* (http://www.expatistan.com). A total of five cost conversion methods are therefore tested.

Results

In the first instance, average construction prices for various building types in each city, expressed in both USD and PPP terms per square metre of gross floor area, are used to determine CoV. Table 3 shows these building types and computes the CoV across all 23 cities for each. Of the 27 building types listed in Turner and Townsend (2013), 25 of them (i.e. 93%) have a CoV that is lower for *citiBLOC* PPP than USD conversion. Furthermore, all but one of these values has a CoV between 20 and 50%.

Insert Table 3 here …

A range of labour, material and plant items in each city, again expressed in both USD and PPP terms, are also used to determine CoV. The results are provided in Table 4. Of the 17 items listed in Turner and Townsend (2013), 12 of them (i.e. 71%) have a CoV that is lower for *citiBLOC* PPP than USD conversion. However, all but one of the labour items exceed 50% CoV. This is because labour prices vary significantly between cities, which can generally be classified as having high labour-cost industries (notably Los Angeles, Berlin, Sydney, Dublin, Amsterdam and Toronto) with more than a 40% labour component by value, and low labour-cost industries (notably Mumbai, Shanghai, Kampala, Johannesburg, Kuala Lumpur, Hong Kong, Doha and Muscat) with less than a 20% labour component by value. The prices for concrete block, standard brick, softwood timber, emulsion paint, copper pipe and copper cable appear too disparate and may contain errors.

Insert Table 4 here …

The items denoted with (#) are used to construct *citiBLOC* PPPs. In this paper, Turner and Townsend (2013) is used as the source for all *citiBLOC* computations to minimize unnecessary data conflict.

Finally, a range of composite items in each city are used to determine CoV. These outcomes are contained in Table 5. Of the 19 items listed in Turner and Townsend (2013), 14 of them (i.e. 74%) have a CoV that is lower for *citiBLOC* PPP than USD conversion. Items with high labour content characteristically have slightly higher CoVs (some over 50%) due to the reason described above.

Insert Table 5 here ...

Overall, PPP-adjusted prices have lower CoVs than USD-adjusted prices, and therefore adhere more closely to the *Law of One Price*. Of the 63 items studied, 49 of them (i.e. 78%) demonstrate this outcome. Currency conversion, on the other hand, generally has higher CoVs, and although the approach is still valid when pricing construction works located in another country, it is not appropriate when benchmarking international project cost performance.

PPP is shown to be preferable compared to currency conversion. But *citiBLOC* PPP is not the only choice available. Three alternative PPP methods are now added, so a total of five cost conversions strategies can be compared against each other. Once again, the method with the lowest CoV across the 23 cities represents the best available option.

Using the data from Turner and Townsend (2013), a labour+material (L+M) PPP is calculated based on local prices for the 5 labour items and the 11 material items provided earlier in Table 4. Labour and material are combined using the proportion of labour and material costs in each *citiBLOC* (plant cost is distributed evenly between them). For example, Sydney's *citiBLOC* has labour of AUD$41,665, material of AUD$52,075 and plant of AUD$10,500, making a total of AUD$104,240. The labour proportion is therefore (41,665+5,250)/104,240, or 45%, and the material proportion is (52,075+5,250)/104,240, or 55%. The relative value of a *citiBLOC* in a given city is computed as the local cost of the *citiBLOC* divided by the Sydney *citiBLOC* (base). Therefore the *citiBLOC* PPP for Sydney is 1. Similarly, a composite PPP is calculated based on local prices for the 19 items provided earlier in Table 5. Finally, prices for a McDonalds Big Mac hamburger are used to provide a non-construction alternative.

An equivalent average cost/m^2 for buildings in each city is computed from Turner and Townsend (2013) by taking the average local price for each of the categories listed in Table 3 (i.e. residential, commercial, industrial, retail, hotels, hospitals, schools, carparks and airports). While it is obvious that this resultant cost/m^2 does not apply to any particular building type, the average of all types is done so as to add more stability to the accuracy of in-country prices. This cost/m^2 is then divided by the relative PPP (i.e. *citiBLOC*, L+M, Composite, Big Mac and Currency, compared to the base for Sydney of 1). The results are shown in Table 6.

Insert Table 6 here …

Discussion

Cities investigated in this paper form three clusters on the basis of their *citiBLOC*-adjusted prices, defined as expensive, mid-range and good value. In each cluster, the lowest CoVs are found to arise from the *citiBLOC* PPP. The highest CoVs are for currency-adjusted prices, with the exception of the first cluster where the price of a Big Mac in Hong Kong is such a significant outlier that it causes the Big Mac-adjusted PPP to have a higher CoV. Nevertheless, this price is correct and perhaps is a result of a strategy by McDonalds to sell more hamburgers into this market. Ignoring Hong Kong, Big Mac-adjusted prices seem quite reasonable, although on balance the composite-adjusted PPP is the second best method.

The findings suggest that the most expensive city is Dubai (*citiBLOC*), Hong Kong (L+M, Big Mac and Currency) and Tokyo (Composite). The best value city is Kampala (*citiBLOC* and L+M), Mumbai (Composite and Currency) and Säo Paulo (Big Mac). Clearly the method of conversion does matter.

The average CoV across the three clusters indicates the preference order. Figure 1 summarizes the comparison. It should be noted that, in a 'perfect' world, a CoV of 0% (i.e. a horizontal line) would validate the *Law of One Price*. Yet the natural variability in the data would preclude such a result in reality. Hence the method that displays the lowest CoV is preferred. This is the *citiBLOC* PPP.

Insert Figure 1 here …

The approach taken in this paper has the advantage that virtually all of the data used in arriving at the research results comes from a single and reputable independent source. While it is true that construction costs can vary depending on the authority providing them, there is clear strength in using a consistent dataset compiled, checked and validated by recognized industry cost experts. However, a weakness is that all costs are estimated or computed from recent projects and reflect 'typical' conditions that may or may not be common on a global scale.

Benchmarking Construction Projects

Langston (2013) demonstrates the application of reliable cost conversion to construction project benchmarking for high-rise buildings in both Australia and the United States completed between 2003 and 2012. He uses construction efficiency (CE) and construction complexity (CC) as two important KPIs to understand the building procurement process. The technique of data envelopment analysis (DEA) is considered as an appropriate method for assessing the impact of multiple performance measures and to determine the best practice 'frontier' in construction (e.g. Chiang et al., 2012; Horta et al., 2012). His findings are used here as an illustration of the link between technical cost conversion and its ultimate application to project benchmarking.

DEA is a set of non-parametric programming techniques which assists with identifying which subset of projects or industries may be considered best practice. It is a linear programming procedure for a frontier analysis of inputs and outputs. DEA assigns a score of 1 to a unit only when comparisons with other relevant units do not provide evidence of inefficiency in the use of any input or output. DEA assigns an efficiency score less than one to (relatively) inefficient units. A score of less than one means that a linear combination of other units from the sample could produce the same vector of outputs using a smaller vector of inputs. The score reflects the radial distance from the estimated production frontier to the decision-making unit (DMU) under consideration (Coelli et al., 1998). It has been used in a variety of circumstances pertaining to financial institutions (e.g. Worthington, 1999; Berg et al., 1992), electricity and gas utilities (e.g. Färe et al., 1990; Price and Weyman-Jones, 1996), hospitals (e.g. Färe et al., 1994) and airports (e.g. Abbott and Wu, 2002).

The use of DEA to undertake benchmarking studies at the firm or project level concerning the construction industry are not common, even though it is likely that this approach would be useful. Some examples of DEA benchmarking for construction include Edvardsen (2005) on Norwegian construction firms, Ingvaldsen (2005) on Norwegian building projects, McCabe et al. (2005) on Canadian construction firms, El-Mashaleh et al. (2007) on firms in the United States (Florida), and Chiu and Wang (2011) on firms in Taiwan.

DEA helps to make sense of multiple criteria (whether they represent performance outputs or inputs) that might otherwise lead to conflicting conclusions. CE and CC are two important performance outputs because they enable time, cost and quality to be integrated and assessed holistically. Each output is given equal weight. DEA in fact identifies comparative performance for competing DMUs. Of course, there are many other potential performance measures that could be employed.

The generic technique of DEA is extended by adoption of a classic four-quadrant model to aid interpretation. A four-quadrant model is a means of displaying data according to specific *x* and *y* criteria. Furthermore, construction projects are considered as pseudo DMUs representative of the countless management decisions and procedures that occur on site, and the influence of the context within which buildings are procured. Projects that maximize the integration of efficiency and complexity, in this case, lie on the best practice frontier.

Based on data collected by Langston (2012) for 86 high-rise buildings in Australia and 251 high-rise buildings in the United States completed between 2003 and 2012 (representing 57% and 71% respectively of the known population), the top 20 construction projects are categorized according to 'very fast and complex' (ideal), 'very fast', 'very complex', and 'normal (typical)' performance. The results are illustrated in Figure 2. The level of efficiency for a particular DMU can be determined by the distance from the origin to the DMU divided by the distance from the origin through the DMU to the best practice frontier, expressed as a percentage. The closer to the frontier the higher is the efficiency level (maximum 100%).

These distances can be worked out using geometry, trigonometry or linear programming (with or without software support).

Insert Figure 2 here …

The scale limits used for the *x* and *y* axes are determined as three standard deviations from the mean of the full dataset. All the projects listed have means for efficiency and complexity well above national averages. In fact, mean performance is near the centre of the 'normal' quadrant, and it is computed that 82% of the dataset (i.e. 82% of 351 projects) falls into this part of the model. Only 4 projects are considered 'very fast and complex', 31 are considered 'very fast' and 23 are considered 'very complex'.

The use of a four-quadrant model combined with DEA provides context to the analysis. The results suggest that fast construction speed and high product sophistication are often mutually-exclusive. This is a significant wake-up call for the industry and highlights the marked difference between 'business-as-usual' and achieving 'best practice'.

Conclusion

Construction project costs between countries cannot be compared reliably using currency exchange rates, as this fails to take account of the local cost of living. The *citiBLOC* PPP uses a standard basket of 10 construction items, comprising notional 50% material, 40% labour and 10% plant, to calculate PPP values in each city. The average price of items in the standard basket for a particular city is then divided by the average price for a base city to calculate relative PPPs. When benchmarking international project cost performance, making relative cost comparisons between cities in different countries is necessary. PPP is the correct methodology to apply.

This paper demonstrates that *citiBLOC* PPPs have the lowest CoV of any of the five methods investigated, and using the *Law of One Price* as the test, certainly out-perform currency conversion in terms of lower volatility. Given that most practitioners still use USD currency conversion to draw conclusions about relative cost performance in different locations, it seems that many of their conclusions may be unreliable or erroneous. While presentation of construction project costs in terms of USD or other standard currency has its place, *citiBLOC*

PPP is the preferred method whenever judgements about relative project cost performance are involved.

Using DEA can help to identify projects that exhibit best practice characteristics according to selected KPIs. These may relate to time, cost, quality or indeed any criterion considered important to overall project success that can be objectively measured. Where best practice is identified, the reasons for this can then be explored in more detail. Cost conversion is an important step in presenting data that can be compared on an equal basis, thus limiting unnecessary distortion or bias as often appears to happen in practice.

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Table 1: Representative construction items for *citiBLOC* (Langston, 2012)

Item	Standard Description		Unit	Quantity (weighting)	Local Currency (ex-tax)
Material *(supply only including CBD delivery)*					
A	32 MPa ready-mixed concrete	(1 m^3 = 35.31 cu. feet)	m^3	45	11,144
B	Steel in 250 x 25.7kg/m 'I' beam	(17.3 lb/foot)	t	6.8	9,350
C	10mm clear tempered glass	(1 m^2 = 10.76 sq. feet)	m^2	44	10,472
D	13mm thick gypsum plasterboard	(½" thick)	m^2	1,300	10,140
E	100 x 50mm sawn softwood stud	(1 m = 3.28 feet)	m	2,750	9,873
Labour *(charge-out rate including on-costs)*					
F	Electrician		hr	150	9,900
G	Carpenter		hr	185	10,915
H	Painter		hr	200	10,400
I	Unskilled labour		hr	275	10,863
Plant *(third party hire rate including operator and fuel)*					
J	50 t mobile crane		day	5	10,200
		average price per item (i.e. 1 citiBLOC):			**10,326**

SYDNEY, AUSTRALIA (2012)

Current Market Conditions: ☑ very competitive (low profit) ☐ normal ☐ overheated (high profit)

Table 2: Surveyed locations

City	Country	Currency
Berlin	Federal Republic of **Germany**	EUR
Dublin	Republic of **Ireland**	EUR
Amsterdam	**Netherlands**	EUR
London	**United Kingdom**	GBP
Los Angeles	**United States** of America	USD
Toronto	**Canada**	CAD
Sydney	Commonwealth of **Australia**	AUD
Tokyo	**Japan**	JPY
Singapore	Republic of **Singapore**	SGD
Kuala Lumpur	**Malaysia**	MYR
Seoul	Republic of Korea (**South Korea**)	KRW
Dubai	**United Arab Emirates**	AED
Muscat	Sultanate of **Oman**	OMR
Doha	State of **Qatar**	QAR
Shanghai	People's Republic of **China**	CNY
Mumbai	Republic of **India**	INR
Ho Chi Minh City	Socialist Republic of **Vietnam**	VND
Warsaw	Republic of **Poland**	PLN
Moscow	**Russia**n Federation	RUB
Johannesburg	Republic of **South Africa**	ZAR
Kampala	Republic of **Uganda**	UGX
Säo Paulo	Federative Republic of **Brazil**	BRL
Hong Kong	**Hong Kong** SAR, People's Republic of China	HKD

Table 3: Coefficients of variation (average cost/m^2)

Building type	% (USD)	% (PPP)
Residential		
Individual detached house medium standard	59	**48**
Individual detached house prestige	53	**48**
Townhouses medium standard	46	**41**
Apartments private medium density	47	**36**
Apartments high rise	45	**34**
Aged care/affordable units	50	**38**
Commercial		
Offices - business park	39	**25**
CBD offices - up to 20 floors medium (A-Grade)	42	**27**
CBD offices - high rise prestige	41	**26**
Industrial		
Warehouse/factory units - basic	46	**44**
Large warehouse distribution centre	47	**40**
High tech factory/laboratory	52	**50**
Retail		
Large shopping centre including mall	49	**38**
Neighbourhood incl. supermarket	54	**45**
Prestige car showroom	53	**47**
Hotels		
3 star travellers	**40**	40
5 star luxury	35	**35**
Resort style	**41**	44
Hospitals		
Day centre (including basic surgeries)	53	**38**
Regional hospital	56	**38**
General hospital (e.g. city teaching hospital)	57	**38**
Schools		
Primary and secondary	46	**38**
University	46	**31**
Carparks		
Multi storey above ground	49	**45**
Multi storey below ground	70	**61**
Airports		
Domestic terminal, full service	35	**29**
Low cost carrier, basic service	36	**28**

bold figures indicate lowest CoV

Table 4: Coefficients of variation (labour, material and plant)

Item	% (USD)	% (PPP)
Labour (cost/hour)		
Group 1 tradesman (e.g. plumber/electrician) #	89	**65**
Group 2 tradesman (e.g. carpenter/bricklayer) #	87	**63**
Group 3 tradesman (e.g. carpet layer/tiler/plasterer) #	84	**62**
General labourer #	95	**72**
Site foreman	76	**49**
Material (cost/unit)		
Concrete 30 MPa (m^3) #	41	**34**
Reinforcement bar 16mm (tonne)	**27**	31
Concrete block 400 x 200mm (thousands)	89	**68**
Standard brick (thousands)	**62**	65
Structural steel beams (tonne) #	33	**28**
Glass pane 10mm tempered (m^2) #	54	**49**
Softwood timber for framing 100 x 50mm (m) #	63	**62**
13mm plasterboard (m^2) #	46	**44**
Emulsion paint (litre)	**69**	78
Copper pipe 15mm (m)	**65**	86
Copper cable (3C+E) 2.5mm PVC (m)	123	**120**
Plant (cost/day)		
Hire 50 tonne mobile crane + operator #	**39**	40

 # items used to construct citiBLOC PPP *bold figures indicate lowest CoV*

Table 5: Coefficients of variation (composite work items)

Item	% (USD)	% (PPP)
Excavate basement (m^3)	90	**77**
Excavate footings (m)	58	**58**
Concrete in slab (m^3)	33	**32**
Reinforcement in beams (tonne)	**24**	26
Formwork to soffit of slab (m^2)	75	**46**
Blockwork in wall (m^2)	62	**37**
Structural steel beams (tonne)	34	**32**
Pre-cast concrete wall (m^2)	**48**	60
Curtain wall glazing including support system (m^2)	53	**40**
Plasterboard 13mm thick to stud wall (m^2)	**51**	58
Single solid core door including frame/hardware (no.)	51	**47**
Painting to walls, primer + two coats (m^2)	69	**52**
Ceramic tiling (m^2)	44	**34**
Vinyl flooring to wet areas (m^2)	38	**37**
Carpet medium tufted (m^2)	**35**	51
Lighting installation (m^2)	49	**44**
Copper pipe 15mm to wall (m)	57	**49**
Fire sprinklers (m^2 serviced area)	57	**43**
Air conditioning including main plant (m^2 serviced area)	**45**	50

bold figures indicate lowest CoV

Table 6: Average cost/m^2 (various conversion methods)

Item	Local Currency	citiBLOC	L+M	Composite	Big Mac	Currency
Expensive						
Dubai	7,397	**4,257**	3,536	3,125	3,107	2,217
Hong Kong	23,648	4,149	**4,454**	3,249	^ **7,011**	**3,357**
Tokyo	285,648	4,138	4,335	**4,518**	4,499	3,210
Muscat	736	3,919	3,249	3,119	3,052	2,130
Doha	7,748	3,880	3,133	2,870	3,719	2,341
Seoul	1,527,510	3,769	3,523	2,712	1,974	1,508
Dublin	1,882	3,642	3,769	3,033	2,621	2,725
London	1,881	3,489	3,526	3,471	3,523	3,182
	CoV (%)	***6.84***	*12.91*	*17.07*	***41.69***	*25.01*
Mid-range						
Singapore	2,941	3,233	3,275	2,480	3,153	2,547
Moscow	63,131	3,125	3,171	2,328	3,657	2,104
Amsterdam	1,870	3,117	3,029	2,325	2,603	2,706
Warsaw	3,324	2,861	2,794	1,874	1,821	1,153
Ho Chi Minh City	19,894,010	2,805	2,364	2,640	2,635	1,032
Kuala Lumpur	3,947	2,616	1,803	2,725	2,725	1,334
Berlin	1,726	2,581	2,357	2,334	2,403	2,498
Sydney (base)	2,574	2,574	2,574	2,574	2,574	2,574
Toronto	2,706	2,495	2,477	2,904	2,466	2,890
	CoV (%)	***9.85***	*17.64*	*12.07*	*19.00*	***34.52***
Good value						
Mumbai	40,242	2,063	1,321	**1,330**	2,254	**763**
Los Angeles	2,042	1,983	2,117	2,428	2,257	2,246
Shanghai	5,808	1,749	1,328	1,888	1,830	1,042
Johannesburg	9,687	1,718	1,622	2,521	2,664	1,087
Säo Paulo	2,994	1,701	1,851	1,646	**1,258**	1,445
Kampala	2,450,731	**1,448**	**762**	1,778	1,445	1,039
	CoV (%)	***12.39***	*31.61*	*23.85*	*24.65*	***41.33***
	Average CoV (%)	***9.69***	*20.72*	*17.66*	*28.45*	***33.62***

^ Big Mac price in HK is a clear outlier *bold figures indicate highest and lowest cost/m^2 or CoV*

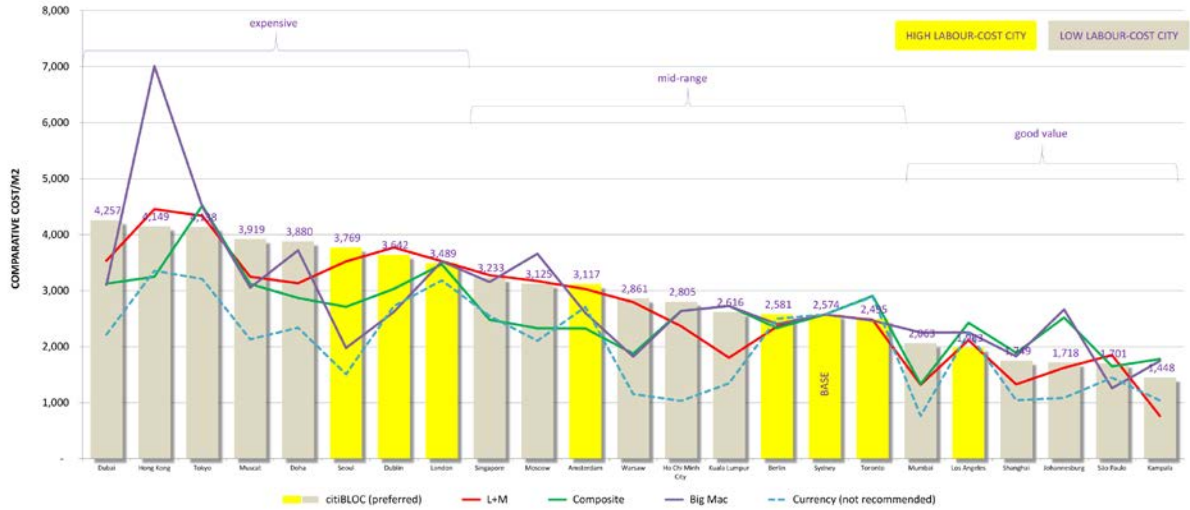

Figure 1: International cost benchmarking (various conversion methods)

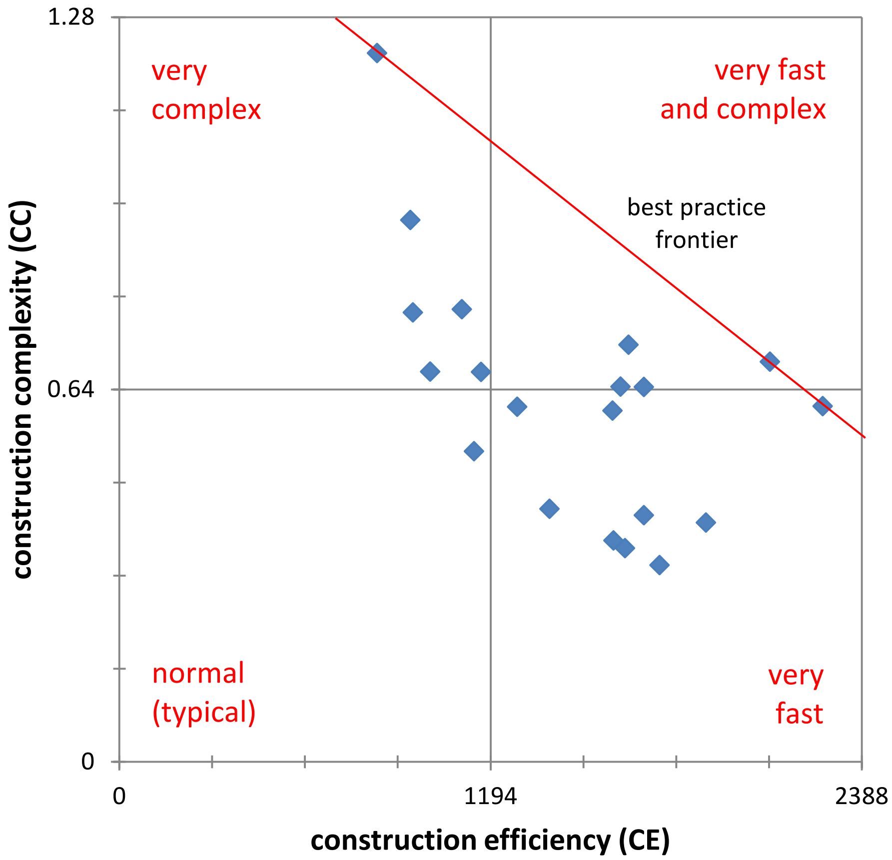

Figure 2: DEA chart based on top 20 project efficiency and complexity (Langston, 2013)