The challenges of measuring and accounting for construction

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Chapter 1

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Introduction

Measuring construction used to be a straightforward exercise. Work was physically measured on completion and those who did the work were paid based on the quantities of work measured. People who carried out the measurement or 'surveying' work became known as quantity surveyors.

Gradually the practice of measuring and estimating the cost of construction before the start of the work, usually from some sort of drawing(s), replaced the measurement of work after it was completed. A handwritten estimate for the building of a cottage in Wales prepared in 1809 (see Lethbridge 2008) included the following items:

- For digging stones for building 294 yds @ 8d = £ 9.16.0
- For building the house 294 yds @ 14d = £17. 3.0
- 220 feet of timber @ 4/6 per foot = £49.10.0
- All sorts of nails = £ 3. 0.0
- Hinges, latchets and smyth's work = £ 0.15.0

The entire estimate comprised just 14 items. In Commonwealth countries at least, such measurement and estimation developed into the detailed measurement and pricing of building works, with measurement based on precise rules compiled and published by professional bodies such as the Royal Institution of Chartered Surveyors (RICS).

This sort of approach, with variations, has worked well and is still used, albeit with quantities now being extracted from digital 3D building models and linked to databases containing unit rates for specific work items. In this book, however, and its precursor, *Measuring Construction* (Best and Meikle 2015), the focus is not on the measurement of work items. In these books a range of more challenging questions are explored; they relate to the measurement of different aspects of construction (such as productivity), at project level, at the firm level, at the level of national industries and even the measurement of construction as a whole, as a worldwide affair. That includes how the creation of the built environment (which includes infrastructure such as roads and bridges as well as buildings of all shapes and sizes) is accounted for by national statistical agencies.

Accounting for construction at these broader levels requires measurement and that takes many forms. Each presents its own set of challenges. Before exploring some aspects of the larger problems in more detail it is worth revisiting the need for such measurement.

Why measure?

It is commonly held that measurement is an essential part of management and the adage 'if you can't measure it, you can't manage it' is often repeated in support of this notion. Actually the quote is incomplete and misleading. It should be: 'It is wrong to suppose that if you can't measure it, you can't manage it – a costly myth' (Deming, 1994). Deming was talking about managing things that could not be measured in the context of business improvement. Harrington (1987), also in the context of business improvement, linked measurement to understanding, and suggested that measurement enabled understanding, understanding made it possible to control, and control could then lead to improvement. The search for understanding is often the primary reason for the sort of measurement discussed here; for example, understanding differences in how buildings are measured, or how different parts of the construction industry are accounted for in the national statistics of different countries. It is measurement that provides the information that enables governments and their agencies to account for construction in the context of economic activity and whole economies and it is the understanding that is achieved that enables researchers and others to more correctly interpret the statistics related to building and construction activity.

In some instances, the key driver is the intent to draw comparisons. Sometimes this is in the context of performance improvement (e.g. increasing productivity) and in other cases it is more about establishing metrics that can provide reliable data to decision-makers (e.g. real GDP per capita – see ICP 2015). In most cases there is the need to measure some aspect or aspects of the industry, e.g. productivity, cost, quality, time to complete, or some combination of such factors. While construction is often described as 'comparison-resistant' (see, for example, Meikle and Thomas 2012) many attempts at comparisons of cost and productivity (*inter alia)* have been made, and there is ongoing research in this area. Measurement of some sort is invariably at the heart of any attempt to compare aspects or segments of the industry or to compare whole industries. Equally, it is industry measurements of varying types that define and describe construction in national accounts.

Defining an industry

One fundamental accounting concern is how we define the construction industry and thus how we define what it is that we are measuring, and how we include it in national accounts. Is it restricted to firms that are actively engaged in physically constructing projects or should it include, for example, suppliers of materials and components, and designers and managers of construction projects?

Building work undertaken as part of maintenance, renovation and refurbishment is an added complication; in many places this sort of work represents a large part of total construction activity, but its value may or may not be included in measures of construction industry activity.

Informal construction, part of the so-called 'shadow economy', is building activity that is often unrecorded but may represent a significant proportion of the total, particularly in developing economies where building work is often done by households. Those who assist are often unpaid or are paid in cash or in kind; in either case the value is often neither reported nor recorded.

Even the exact nature of the industry is not clear; it has some similarities to manufacturing while having some unique characteristics that set it apart from manufacturing, the most notable being the heterogeneity of its products. The problem of what constitutes the industry makes even an apparently simple measure, such as construction's contribution to a country's GDP, a tricky question that requires more than just a number to describe it adequately. National accounts in different countries measure construction activity in different ways and that adds further layers of complexity to the challenges of comparing industries or even specific industry characteristics across national boundaries.

Construction is not, in fact, a single industry; it is a group of economic activities that use a more or less common set of resources to produce built assets. Those activities are grouped together as an industry in the Standard Industrial Classification (SIC) but the differences in both process and product between, for example, small domestic repair and maintenance (R&M) and large infrastructure projects are very large. In contrast, the SIC definition for the car industry, for example, excludes R&M.

Construction in national accounts

Official data on construction activity can be confusing. Typically there are at least two main types of data: contractors' construction output and construction output in the national accounts. Brian Green's chapter describes in detail the measurement and presentation of contractors' construction output in the UK, only one country but illustrative of many; and the chapter illustrates how complicated that can be.

Construction in national accounts can be even more complicated. It can be presented as value added - the construction industry's contribution to construction output - or gross output - construction output including works and services bought in from other industries. Value added data is the basis of production and income versions of the national accounts; gross output is the basis of the expenditure version. And measures of construction activity can comprise all construction activity or only formal construction output, economic activity by firms registered to construction in the Standard Industrial Classification (SIC). This latter may include contracting firms' activities in addition to construction work (property development or building materials manufacture, for example). Construction in the national accounts should also include work by informal/ unregistered firms or individuals and capital works (new works and major improvements) by households but this is not always the case. Construction work undertaken in-house by organisations - direct labour or own account - is typically included as output by their industry; construction work undertaken by employees of a chemical products company is, therefore, chemical industry, not construction industry, output.

Construction professional services (architecture, engineering, project management) may be included as construction output or may be included as professional services. Partly this may be a result of how construction activity is defined in a country (see Meikle and Grillli, 1999) or just because the boundaries between construction and professional services are blurred. A number of procurement approaches - Design and Build or Public Private Partnerships, for example - include a range of works and services in their contract values and it is often difficult, if not impossible, to separate expenditures. Some procurement approaches include technological components - signalling in rail projects or wind turbines in alternative energy projects - and, again, their costs can be difficult to separate from construction work and may end up included as construction output.

The difficulties associated with the measurement of construction in the national accounts are important and deserving of further study.

The volume of output

One key difficulty lies in how we measure the quantity or *volume* of construction output. It is not necessarily an easy concept to grasp. Expressing output volume in terms of, say, floor area of residential construction does not provide a particularly useful quantity as, even if high-rise and other multi-unit residential construction is excluded, there is still considerable variety in the nature of the output as it includes everything from modest cottages for low-income families to lavish mansions for the well-to-do. Differences in the 'typical family home' between different regions adds greatly to the complexity – compare, for example the Nordic house and the Portuguese house that are part of the Eurostat-OECD price comparison exercise (Eurostat-OECD 2012). Comparing total floor area of housing in one place, or one time period, with that in another also ignores differences in scale, quality, complexity, materials and standard (quality) of fitout.

The heterogeneity of the industry's output leaves us with little alternative other than to express volume in terms of monetary value, yet this method has some obvious shortcomings. The amount paid for work done also offers little information or insight into the nature of the resultant output. For example: is one million dollars' worth of factory the same *amount* of construction as one million dollars' worth of prestige office? Both are 'non-residential construction' but the two products are physically very different, and the costs are markedly different. In Sydney in 2017 AUD1m. represented 500-1000m^2 of factory (depending on inclusions such as showrooms and offices) compared to around 200m^2 of fully fitted prestige office (Rawlinsons 2017).

The volume of output can be expressed in other ways; in *Measuring Construction* the idea of purchasing power parity (PPP) was described and construction-specific applications of the approach were explored. One example was based on the Big Mac Index; construction costs expressed in any national currency can be divided by the cost of a Big Mac hamburger in the same currency and thus the cost of construction can be expressed as the number of hamburgers per m^2 , or total cost can be measured in hamburgers, with the hamburger as an artificial unit of 'currency'. Buildings are not, however, constructed of hamburgers so the validity of this method is questionable[1] (see, for example, Croce *et al.* 1999).

The underlying purpose of PPPs is to eliminate price level differences between different locations. General PPPs are useful when a person is contemplating taking a job in another country where they will be paid in that country's currency. Simply converting the potential salary in a foreign currency to the equivalent in the home currency, using exchange rates, provides little insight into whether the potential salary is better than, or about the same as, the person's current salary in terms of how well they can live on the salary being offered compared to their present lifestyle. The important point is how much can the person buy in the new country with the new salary compared to what they can buy with their current salary in their home country, i.e. how will the purchasing power of the new salary compare to their current purchasing power?

'How much' the person can buy depends, of course, on what they buy. For someone relocating to another country the primary concerns will probably be living expenses: rent, food, energy, clothing and so on. General PPPs that are based on the costs of a large range of goods and services may be useful and the World Bank's general or GDP PPPs are computed using data on the cost of lots of items that are not relevant when simply comparing one salary with another, heavy machinery for example, as these PPPs are used to compare economic indicators on a larger scale, such as GDP per capita, but detailed PPPs are available for things like clothing, food and beverages, and housing.

The problem has been addressed in another way by using a representative basket of typical inputs to construction projects (including items of labour, plant and materials). The basic approach involves the pricing of a set of inputs that are considered to be reasonably representative of construction so that the basket that is priced becomes, in effect, a unit of construction currency. The cost of construction can then be expressed as the number of baskets per m^2, or total project cost can be expressed as a number of baskets. Unlike the Big Mac such a basket consists of real inputs to the construction process and are thus more representative of the industry's output. The construction component of the ICP uses a variant of this approach and that exercise is described in some detail in *Measuring Construction* (see Chapter 4) and later in this book (see Chapter 9). Another variant is discussed by Langston in Chapters 8 and 9 of *Measuring Construction* and a practical application described by Emmett and Langston in Chapter 10 here.

Alternatively, the cost of baskets priced in different locations can be compared and PPP factors calculated that can be used to compare construction costs recorded in different currencies. It is important to understand that the construction-specific PPPs so derived should only be used when measuring and comparing volumes of construction output; they are not exchange rates and they should not be used when construction in one country is to be paid for using funds from another, e.g. where a client in the US wishes to build a facility in another country and will be funding the project using US money. In such situations the use of current exchange rates to express costs in the same currency is appropriate. If the US client is choosing between potential locations in several other countries, then bringing all costs to a common base (most likely the client's national currency if the money to build will be sourced from the client's own country) is perfectly logical. If, however, the purpose is to answer the theoretical question: 'Is it more expensive to build in Country A, B or C?', then the use of construction-specific PPPs is appropriate as the question then relates to the volume or amount of construction that a client can buy for a given amount of local currency.

Construction PPPs (CPPPs) are derived using cost data associated only with items relevant to the construction industry, usually a mix of materials, labour and equipment, weighted to reflect a typical mix of the cost of resources or inputs. Such a mix might be 55% materials, 40% labour and 5% equipment, but this varies according to location and the type of construction. Where labour is cheap and abundant, and many materials are imported, the cost of the labour and equipment components may shrink while materials cost rise although percentages may not vary much because the prices and quantities of labour in different countries tend to cancel each other out (i.e. lots of cheap but relatively inefficient workers in poorer countries may make up much the same proportion of total costs as a smaller number of expensive but highly skilled workers in richer countries).

Where labour is more expensive, most materials are largely locally produced, and more capital is invested in equipment, the mix will vary to reflect these differences. Similarly, the construction of civil engineering projects, such as highways and dams, will mostly use large quantities of basic materials (e.g. steel and concrete) while utilizing more plant and machinery than is usual in the construction of buildings.

Temporal indices are also about volumes - they normalize, or bring to a common base, values over time (they deflate or convert current to constant prices) and allow volume comparisons to be made. Both temporal and spatial price indices convert values in nominal or current prices (prices of the day) to real or constant prices.

The diversity of output

Construction activity is typically divided into three broad categories: residential, non-residential, and engineering construction; high-rise residential, due to its scale, may be included with non-residential. Within these categories there is great diversity in the projects (products) that are built. Few buildings are truly identical. Even when standard designs are repeated there are variations due to differences in local regulations, site, climate, availability of materials, influence of adjacent structures and more. Engineering construction is perhaps even more diverse. It covers a disparate set of project types ranging from dams and power generation plants to railway lines, tunnels and bridges and much more.

Within this diversity, when looking to make comparisons between countries (say) it is necessary to find items (whether products, materials, components or whole projects) that are similar enough to be compared in a rational way yet are sufficiently representative of ‘typical’ construction in the countries being compared. This lies at the very heart of any method for comparing, for example, projects across countries.

There are other divisions of total construction output; for example, the construction of new buildings, improvement of existing buildings (i.e. additions, major renovation and refurbishment), and routine repair and maintenance (R&M) of existing buildings. They involve construction activity, but each has its own characteristics and how such activity is recorded varies. A good deal of R&M is done by owners as DIY projects and may well never be recorded beyond the purchase of materials and components.

The complexity of output

Any sort of measurement of the construction industry, particularly where some sort of comparative exercise is being undertaken, tends to rely on data that is for 'average' conditions or 'standard' or 'typical' projects. Buildings are, however, seldom standard products and they vary in many ways; apart from the more obvious differences in type/function, scale/size and location, differences in the complexity of buildings affects both the cost and the time required to build them. Such differences are a key concern in comparative studies.

Tilley *et al.* (1997) created a project performance index based on the number of requests for information (RFIs) generated during construction. As it would be expected that the construction of larger and/or more complex projects might lead to a greater number of RFIs some sort of correction was required to account for differences in scale and complexity. The performance index they produced is:

$$PI_1 = \frac{N_c}{CV \times D}$$

where: N_c = number of *information clarification* type RFIs
CV = estimated final contract value (\$100,000's)
D = initial project duration (months)

The factor CV x D, the product of construction cost and time, was used as a measure of complexity to offset the expected increase in incidence of RFIs in larger/more complex projects. Best and Langston (2001) used a similar factor in their performance index for projects. More recently, Langston (2016) investigated that index further and then derived a construction complexity index based on time, cost and floor area that could be reduced to the ratio of the cost squared to the floor area squared.

Statutory/regulatory requirements

Building codes and other regulations (e.g. workplace health and safety legislation) vary considerably from country to country and these naturally have an effect on the design and construction of buildings. These varying requirements can affect both time and cost. Such provisions may result in physical differences between buildings or through different mandated work practices.

Fire safety requirements relating to building materials are an example of the way that physical differences in buildings are created by differing codes and regulations. Façades on high-rise buildings have been the subject of much scrutiny since the tragedy of London's Grenfell Tower with the belief that the fire spread quickly due to the nature of the external cladding (Davey 2017). In Australia, AS5113 sets strict standards in regard to the assessment and classification of external walls of buildings according to their tendency to spread fire. These standards are more demanding than those current in other parts of the world, even in developed countries such as the UK and US and these stricter controls can have a significant impact on building costs (Ervine 2018).

Site safety requirements vary from place to place as does the degree of enforcement of such regulations. In Australia, for example, all electrical tools have to be checked and tagged every three months by a licensed technician, sub-contractors are required to supply copies of the certificate of currency for their workers' compensation insurance every month and most sites with 20 or more people on site will have a full-time safety officer. All of these requirements add to the cost of construction through increased administration costs and/or additional salaries. These are just a few of the quite stringent safety regulations in Australia that add to building costs there, but which do not necessarily apply in other places.

The quality of output

Differences in the quality of buildings add to the difficulty of measurement of output, particularly when the aim is compare industry characteristics such as productivity or efficiency between producers, whether at project, firm, regional or national level. The quality of construction output can be considered in a number of ways including assessment of compliance with codes and regulations, surveying standards of workmanship, or assessment against recognized standards such as star ratings for hotels or office space which will reflect attributes such as the quality of materials and finishes specified for different projects.

While compliance might be taken as a given, codes can vary considerably between different jurisdictions and these differences can affect cost and productivity. Similarly, the diligence with which compliance is assessed and enforced varies from place to place. Informal construction, and DIY building work, typically will not be subject to any sort of compliance assessment.

In the past, assessment of workmanship was largely a subjective exercise; Flanagan *et al.* (1986: 4) suggested there was 'no recognized method of quality assessment' for buildings. McKim *et al.* (2000) identified several more objective measures including estimated cost of rework and repairs, and number of requests for rework and repairs. Brown and Adams (2000) considered 'delivered quality' and assessed that as a function of the number of building defects recorded at the handover of completed buildings.

Sodangi *et al.* (2010) surveyed Malaysian construction clients to obtain their views on contractors' quality performance based on the clients' assessment of the buildings that contractors had completed for them. The parameters addressed included building performance, building reliability, compliance with design standards and specification, durability of buildings, serviceability and aesthetics. As the survey sought client opinions it must be concluded that this sort of measurement is largely subjective. Furthermore, it is hard to see how a client's opinions on the aesthetics of a completed building somehow reflect the quality performance of the contractor. What this study highlights more than anything is how difficult it is to measure construction quality objectively.

Singapore, however, introduced the Construction Quality Assessment System (CONQAS) in 1989 (BCA n.d.) and this has been used and refined over a long period with the 9th edition published in 2017 (BCA 2017). Standards of workmanship are assessed against benchmarks with a view to reducing the degree of subjectivity involved. Variations of the CONQAS approach are used in a number of other countries including China and Malaysia but there is certainly no internationally agreed standard for measuring construction quality in any of its varied manifestations.

Conclusion

In this chapter just some of the factors that complicate the measurement of construction have been reviewed. What is clear is that while measurement is often subject to many complications there are serious efforts being made to find methods that address issues such as variations in quality and complexity that will eventually lead to better measurement and thus to more robust comparisons. Understanding a problem is usually an important first step towards solving that problem and while some of the chapters that follow do offer some possible paths towards better understanding through new methodologies, often the value lies as much in the exploration and analysis of the problems as much as in any potential solution that is put forward.

There are more topics that have not been addressed in this book or its companion volume; these include further investigation of the value of informal construction in developing countries, the performance of construction firms (performance in terms of economic performance rather than the more common measures such as timely completion of projects and completion within budget), and, as indicated earlier, comparative studies of what is included in or excluded from national construction statistics. And more work is needed on some, if not all, of the topics that have been addressed.

Endnotes

[1] '…. it should be obvious that in countries where food production is not based on wheat, sesame seeds, beef, dairy products, dill pickles and potatoes 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, it is not any sort of a 'standard commodity' (Croce *et al.* 1999:21)

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