Construction

Paul McCarthy

Gross fixed capital formation on construction (hereafter simply construction) is a major component of the expenditure on gross domestic product (GDP). The 2005 International Comparison Program (ICP) revealed that about two-thirds of the 146 participating economies had a construction share of GDP of between 9 and 18 percent. The average share of construction within GDP was 11.9 percent, but there were major variations around this average, ranging from a low of 1.6 percent in Nigeria to a high of 38.7 percent in Bhutan.

The purpose of this chapter is to provide the conceptual framework underlying the estimation of construction purchasing power parities (PPPs), explain the different pricing methods, and describe the methodology used in the 2005 ICP by the Eurostat–Organisation for Economic Co-operation and Development (OECD) and ICP regions. It concludes with a brief evaluation of the basket of construction components (BOCC) method used in the ICP regions, with some lessons learned for the 2011 ICP round.

The 1993 *System of National Accounts* (Commission of the European Communities et al., 1993) divides construction into three major components, which were used as basic headings in the 2005 ICP:

- *Dwellings* (residential buildings) are buildings used entirely or primarily as residences. Examples are detached and semidetached houses, apartments, houseboats, barges, mobile homes, and caravans used as principal residences of households. They include any associated structures, such as garages, and all permanent fixtures customarily installed in residences.
- *Nonresidential buildings* are buildings other than dwellings, including fixtures, facilities, and equipment that are integral parts of the structures and the costs of site clearance and preparation. They include stables, barns, warehouses, industrial buildings, commercial buildings, buildings for public entertainment, hotels, restaurants, schools, hospitals, churches, and stadiums.

- *Other structures* (civil engineering works) consist of structures other than buildings. They include highways, suburban roads, railways, airfield runways, bridges, tunnels, subways, waterways, harbors, dams, sewer systems, mines, pipelines, communication cables, transmission lines, power lines, and sports fields.

Conceptual Framework Underlying the Estimation of Construction PPPs

Many factors can affect comparisons of goods and services between countries, particularly when one must ensure that the products specified are comparable. Construction poses special problems because most construction outputs are unique, despite some superficial similarities. For example, no two office buildings are identical, nor are civil engineering projects such as bridges or dams because they have design features that cater to factors such as location or span. One example is China's Three Gorges Dam. Its construction made up a significant portion of the construction expenditures in China in 2005. However, no similar activity is under way in the world for comparison purposes. In addition, large projects such as these are rarely completed within a single accounting period, which makes pricing them even more difficult. Special techniques are thus needed to determine what is priced for comparison purposes for construction.

Any method of producing PPPs for construction is necessarily based on a series of compromises and approximations. For example, the type of dwelling specified has to take into account any variations in structure or components to accommodate local conditions such as the weather conditions in different parts of a region, perhaps requiring heating systems in colder areas and cooling systems in warmer areas. More than one specification could be used to overcome this problem in a region that is geographically diverse, but multiple specifications would require some countries to price more than one type of dwelling, which adds to the overall cost of data collection.

Two alternative pricing methods are available for comparing construction prices between countries. The first is so-called input pricing, and the second is output pricing, which is generally based on pricing models (such as of a bridge) that are comparable across countries.

Input pricing is based on recording the prices of all major material and labor inputs for a range of different types of construction projects and combining them using weights that reflect the relative importance of each input in each type of project. Project inputs are analyzed using the concept of an "average" or "typical" project of each type. For example, the inputs for an average office building may be based on a quantity surveyor's analysis of the inputs for different office buildings, ranging in height from only a few floors to many floors. The inputs include labor (such as concreters, electricians, and carpenters), as well as materials (such as cement, steel, and timber) and other inputs (such as hiring equipment). The main problem with comparing prices across countries by pricing inputs is that productivity differences are not measured because the amounts of labor required to assemble the various materials are assumed to be the same across countries. It could be assumed that productivity is some non-zero amount, but there is little point in doing so unless some means is available to impute different productivity levels for the countries being compared. In practice, it is not possible to systematically measure productivity using input pricing. The productivity issue can be partly overcome by obtaining contractors' rates rather than wage rates for particular parts of a project (such as the price for pouring a concrete slab of 100 square meters), but such an approach still does not solve the problem for those parts of construction projects that generally use salaried employees rather than contractors. Another problem is that overhead costs are not included. Overhead includes, for example, the costs of maintaining an office with the staff and resources needed to manage the construction activities. Without including overhead costs, it is assumed they are the same relative size across countries. Profit margins, an element of overhead, are also assumed to be the same across countries, but that is rarely an accurate assumption for the construction industry.

Applying the input pricing approach to the ICP involves collecting the prices of a range of inputs (materials, labor, and equipment) that are common to the countries being compared. Materials would include products such as cement, steel, and timber, but the detailed specifications would have to be meaningful in all the countries in the comparison. Labor would relate to the occupations engaged in building, and the basis of the comparison would be the compensation (wages plus other related costs) of those workers. The prices required for equipment relate to the cost of using the equipment, and so the usual approach is to collect details of the prices paid to hire the types of equipment commonly used in construction.

As stated earlier, the main disadvantage of using input prices for a comparison is that an assumption is made that labor productivity is identical across the countries being compared. This assumption is probably unlikely, however, especially in a region composed of countries at very different stages of economic development.

Output pricing involves specifying some typical kinds of projects within a country and then asking construction professionals to quote a price for building the whole project, much like they would tender for a project. In this way, the quoted prices relate to the construction outputs rather than the inputs, and so the effects of changes in productivity and profit margins are taken into account. However, it is a costly exercise to specify and then price the various models required to cover adequately the range of projects in the construction industry. Also, construction techniques tend to change fairly rapidly, and so it becomes necessary to respecify the models periodically to ensure they remain relevant.

The output approach in the ICP is based on pricing models of complete construction projects. In practice, the models do not reflect a particular project in any country; rather, they are designed to embody a broad range of features typically found in buildings in the region, with the purpose of defining models that are comparable across countries. The objective is to obtain purchasers' prices that are consistent with the values in the national accounts. In practice, though, it is difficult to include the overhead, such as contractors' margins, because a subjective judgment is required, and it is difficult to ensure that the methods to estimate margins are consistently applied from one country to another. However, the overhead must be included to meet the requirements of an output price. The next section is an overview of the bills of quantities approach as used in the Eurostat-OECD comparison program. It is a form of output pricing.

Bills of Quantities

Historically, the ICP construction PPPs were based on a model-based technique known as the bills of quantities (BOQ) approach. It involved specifying in detail the components of various standard construction projects that covered the typical kinds of dwellings and a broad range of nonresidential buildings and civil engineering works (see box 13.1). The specifications were not based on actual projects; rather, in each case they were designed to reflect a hypothetical structure containing components representing the types of construction methods that were relatively common in the countries being compared and whose characteristics were roughly an average of those in the countries. The goal was for the models to be as representative as possible within each country and also to achieve comparability between countries. For example, the components underlying

BOX 13.1 Projects Specified for the BOQ Approach

The BOQ approach involved pricing detailed bills of quantities for a number of construction projects that were designed to be representative of such projects in the countries being compared. The projects were artificial in the sense that they did not necessarily exist in any country in the exact form specified—see chapter 6 of the *Eurostat-OECD Methodological Manual on Purchasing Power Parities* (Eurostat and OECD 2006) for more details.

The projects specified in the 2005 Eurostat–OECD PPP Programme were as follows (note that projects 5, 6, 7, and 12 were priced, where relevant, only by non-European OECD countries):

Residential buildings

01. European single-family house
02. Portuguese single-family house
03. Nordic single-family house
04. Apartment in a multi-apartment building
05. North American single-family house
06. Japanese single-family house
07. Australasian house

Nonresidential buildings

08. Agricultural shed
09. European factory building
10. Office building
11. Primary school
12. Japanese factory building

Civil engineering works

13. Asphalt road
14. Concrete road
15. Bridge
16. Concrete main sewer

excavating the site, pouring foundations, building walls, and other such activities were all specified in detail, taking into account the construction techniques used. In practice, though, the BOQ approach was based on obtaining costs for a large number of detailed components. Some included both materials and labor (such as a price for installed components rather than just the materials involved), but specific allowances were required for some overhead items such as project management and profits. The total price of each project was obtained by summing the costs of all the components—that is, the sum of the unit price times the number of units for each component. The PPPs were computed at the project level.

The BOQ is an output pricing approach when project overhead is included. The prices for a contractor to provide an individual finished component are the output prices for that component. For example, the price for supplying and installing a specific amount of a product (such as a brick wall that is 3 meters high and 300 square meters in total size) represents an output price for that particular element of a complete building project. However, when the (output) prices for all the components of a construction project are combined to provide a total price for the project, the outcome is a price somewhere between an input price and an output price because it excludes the overall project management costs and profits. Specifically adding allowances for this overhead to the aggregated prices for the components would result in an output price for the whole project.

The main problem with the BOQ approach is that it is very resource-intensive. Because the expertise required is not generally available in national statistical offices, the work must be contracted out. Pricing all the components in each project is costly because professional building analysts, such as quantity surveyors, must be employed, and the models themselves have to be respecified periodically, which is also an expensive exercise because of the expert resources required. In addition, although the BOQ approach may result in comparable prices for each model, the models themselves are not necessarily representative of construction projects in many of the countries being compared because of the compromises required to ensure they are comparable across countries.

After an extensive analysis of data covering several years, Eurostat found that about 40 percent of the number of items in the specifications for construction components accounted for 85–95 percent of the value of projects (Stapel 2002). Based on an analysis of the effects of using a "reduced list" of items in the bills of quantities, the study concluded that there was little difference in the average construction price level indexes for virtually all of the European Union countries when the pricing was based on a reduced list that contained about half the number of items in the full list. The study also concluded that "an appreciable amount of pricing effort contributes very little to the assessment of comparative levels. The number of items [priced] could be roughly halved and still one would catch about 90 percent of the project values." As a result, in 2001 Eurostat moved to a reduced list for pricing construction projects.

Alternative Pricing Methods

The ICP's Global Office investigated the possibility of using the "reduced product list" BOQ approach in the 2005 ICP, but it concluded that the cost would still be too high because of the number of models that would have to be specified in each region. Some alternatives were then examined. The countries in the Commonwealth of Independent States (CIS) collect input prices for a wide variety of construction components and then impute project prices using models specific to construction practices in the region. These countries use similar construction practices, which simplifies the modeling approach. This method contains many elements of an output pricing approach. However, because of the diversity of production practices many additional and more complex models would be required for this method to be used in the Africa, Asia-Pacific, South America, and Western Asia regions.

For these reasons, a completely new approach was adopted. It embodied some input pricing features, but was designed to approximate output prices as closely as possible. The method was based on pricing a relatively limited number of construction components designed to be as comparable as possible across countries. It became known as the basket of construction components approach.

Basket of Construction Components Approach

The BOCC approach, used in the 2005 ICP, involved collecting prices for a range of major construction components and basic inputs that were common across countries. The term *construction components* was used to describe specific physical outputs that are produced as intermediate steps in construction projects. A key element of this process was that the overall price estimated for each component was related to an installed component, including the costs of materials, labor, and equipment—that is, the price was closely related to an output price rather than to an input price.

The objective of the BOCC approach was to provide simpler and less costly price comparisons for construction than was possible using the BOQ method. An important goal was to develop a technique that would enable construction to be priced in major locations within each country and that would result in comparable prices for similar components across countries that had different labor and equipment mixes because of their different levels of economic development.

Aggregation Levels: Definitions

The BOCC process was based on pricing two kinds of components: composite components and basic inputs. Annex A lists both for each construction basic heading (note that many of the composite components and basic inputs appear in more than one construction basic heading). For PPP estimation purposes, composite components and basic inputs were grouped into the systems shown in the tables in annex B. Most detailed was the *component* or *basic input*, followed by the *system* and, finally, the *basic heading*. These aggregation levels were defined by the developers of the BOCC system (see Walsh and Sawhney 2004b). Paraphrased, they are as follows:

- *Basic input item*. A construction material or form of labor that can be described in such a way that "like with like" can be priced across countries. The prices collected for basic inputs were, in effect, input prices.
- *Composite component*. A combination of materials assembled in their final intended location and clearly identifiable as having a simple purpose within a project—that is, it is one of the building blocks of a system. An example is a structural column. In the 2005 ICP, a composite component consisted of a combination of materials, labor, and equipment appropriate to the means and methods employed in a given country.
- *System*. A set of related components within a project that satisfy a given function. For example, the substructure system within a building is intended to denote that set of components that serve the purpose of supporting the building. It would not include the heating and ventilation equipment or nonstructural exterior covering. In the 2005 ICP, some of the basic and composite components appeared in more than one system. For example, concrete appeared in three systems for residential buildings, and sand appeared in five systems (see annex B). These multiple appearances provided an implied weighting of the different components as determined by the frequency with which they appeared in different systems.
- *Basic heading*. The entirety of the construction enterprise for each residential or nonresidential building and other construction.

Components and Basic Inputs

The BOCC method consisted of 22 composite components (such as a column footing or earthworks) and 12 basic input components, consisting of rent for four types of equipment (such as a backhoe or a centrifugal pump), six types of basic building materials (such as Portland cement or reinforcing steel), and both skilled and unskilled labor.

The price for each basic component was a price for a construction input. The collection form for Portland cement, a basic component, appears in annex C. The form provides detailed specifications and indicates that prices are collected for three different quantities. The collection form for skilled labor also appears in annex C. Again, it provides the specifications and captures compensation data for six different kinds of skilled labor. The prices of the basic components neither reflected any measure of productivity nor contained any margins for profit and overhead. Therefore, they were input prices.

The price for each composite component reflected both the cost of the materials and the cost of the labor and equipment used in assembling those materials to produce a particular output such as a column footing or a structural column. As a result, this price partially met the requirements of an output price because it reflected the effect of productivity differences between countries by providing the total cost of materials, labor, and equipment combined in the appropriate proportions in each country. However, it did not reflect profits and overhead.

The starting point for calculating the price for a composite *component* was to obtain the total cost of the materials, labor, and equipment relevant to that component. For example, the collection form for the component "interior painting" (see annex C) described the paintwork as covering 100 square meters, including a typical level of surface preparation for a new surface free from defects. Three coats were required—one mist coat and two full coats of emulsion paint on an interior surface—and they were to be applied in a new building without flooring so that no drip or spill protection was necessary, but window and door masking were needed. The price required was the total cost of the completed output, including the cost of the paint, the labor involved (both skilled and unskilled), and the hire of any equipment that may have been used. From the ICP viewpoint, the advantage of such a specification was that each country could include the types and amounts of labor and equipment typically used in the country, allowing productivity differences between countries to be taken into account. By recording the "price" as the total cost of a well-defined output, the process was similar to the "like with like" process adopted for pricing products in the ICP in which the price required is for a single product whose specifications are defined in detail. In each case, though, the prices entering into the total cost are required to be expressed in terms of the purchasers' prices—that is, the applicable taxes (minus subsidies), including any nondeductible value added taxes (VAT), are part of the price, as are the relevant trade and transport margins.

In theory, the BOCC approach enabled countries at different levels of economic development to combine labor and equipment in proportions that reflected their use within each country rather than use a one-size-fits-all approach. In practice, at the component level the proportions were taken into account by collecting details on the cost of each labor, material, and equipment (hire) input (i.e., the price times quantity of each) and summing them to obtain a total cost for the component (see the example in the preceding paragraph). As a result, the proportions of labor to materials would differ between countries, depending on the quantities of each that a country included in the total cost of each component.

Pricing Basis

The basis of the national accounts valuation of expenditures on GDP is the purchasers' prices, which are the amounts paid by the purchasers, excluding any deductible VAT, in order to take delivery of a unit of a good or service at the time and place required by the purchasers. The prices estimated for components using the BOCC approach were based on the direct costs to the construction company of materials, labor, and the hire of equipment, including product taxes such as nondeductible VAT, but excluding profit margins, project management costs, and fees for construction specialists such as architects and quantity surveyors. As a result, the component prices were not completely consistent with the national accounts expenditures on gross fixed capital formation, which were valued at the purchaser's price. In the BOQ approach, the contractors' margins were added to the prices estimated for each model. However, determining contractors' margins is difficult, even for construction industry professionals, because so many factors can influence them such as the state of the economy, level of activity in the construction industry, length of the project, and region in which a project is located. The uncertainties involved led to a decision that no specific allowance would be made for these margins in the BOCC approach, which is equivalent to assuming that the margins are proportional to the measured prices for each project in each country.

When price levels are compared in different countries, the errors introduced by assuming margins are proportional to the measured prices may be significant. The project management overhead will always be an extra amount that should be added to the other construction costs actually priced. However, profit margins may be negative in some extreme circumstances, such as when demand for construction has fallen markedly because of the economic situation (e.g., following the collapse of a property price bubble). An extreme case could be two countries with their economies at opposite ends of the economic cycle in the ICP benchmark year. For example, in a country that has suffered a collapse in property prices it is likely that profit margins in the construction industry would be low, perhaps even negative (i.e., construction companies would be operating at a loss) if businesses wanted to keep skilled workers on their payroll in the expectation of a forthcoming turnaround in construction activity. Companies operating in another country that is experiencing buoyant conditions in the construction industry would be making a profit, perhaps even a higher level than usual if demand were sufficiently strong. Clearly, assuming that profit margins are a fixed share of other construction costs would not provide an accurate price comparison between these two countries. However, because of the difficulty in objectively measuring the profitability of construction businesses in different countries, it was not possible to obtain the data needed to adjust the price levels for overhead. The lack of data precluded even a subjective assessment of the likely impacts of such differences on the 2005 ICP price levels for construction.

In addition to the requirements just noted, the prices for construction were required to be the national average prices, which meant that they should be the prices observed in various regions in a country and weighted together, using the relative quantities of construction activity in each region as weights. Ideally, the annual average prices for 2005 were required, but to minimize collection costs each national statistical office was allowed to provide prices as of mid-2005, provided that inflation was low in the country concerned.

Estimating Construction PPPs

Eight systems were identified for each of residential and nonresidential buildings: site work, substructure, superstructure, exterior shell, interior partitions, interior/exterior finishes, mechanical and plumbing, and electrical (see annex B for details of the components allocated to each system). Civil engineering works consisted of six systems: site work, substructure, electrical equipment, superstructure, underground utility, and mechanical equipment. Various components were "reused" in different combinations within each system in each type of project. For example, the basic component, Portland cement, was used in six of the eight systems for residential buildings. Another basic component, aggregate base, was part of the site work system in residential and nonresidential buildings and in civil engineering works, and was also a component of the substructure system in all three types of projects.

The first step in estimating PPPs took place at the system level within a basic heading. As noted, the three tables in annex B show the systems used for each basic heading and the mixture of composite and basic components making up each system. Each composite and basic component was treated as a product, and the first estimation of PPPs was at the system level. The site work system for residential and nonresidential buildings contained 10 prices/costs that formed the first stage of estimation of the PPPs. The PPP for site work for each country was based on aggregation of the relative prices of the 10 items in the site work system. Thus the basic heading PPP emerged from the aggregation of the system PPPs.

No weights were applied to the different composite or basic components making up each system. However, some of the composite and basic components appeared in more than one system.

Their frequency of appearance was an implied form of weighting. As one could see, sand and labor were used more frequently than other components. The problem was that the estimation of PPPs included combining complex components that reflected output prices with basic components that were essentially input prices.

The Country Product Dummy (CPD) regression method was used to obtain a PPP at the system level. The outcome of the BOCC approach was that the costs of each construction component could be compared directly between countries.

Weights

The original goal of the BOCC approach was to use different weights in each country for aggregating the basic and composite components to systems to reflect the relative importance of each within each construction system in each country. Annex B shows that the components of the systems for residential and nonresidential construction are essentially the same except for a single item of equipment hire. However, each component and system within the basic heading was to receive different weights relevant to residential and nonresidential construction, respectively.

The BOCC approach was designed to use weights at three separate levels known as the W1, W2, and W3 weights. The W1 weights were the expenditure aggregates for the three basic headings making up construction—that is, gross fixed capital formation on residential buildings, nonresidential buildings, and civil engineering works. The W2 weights were intended to be used in aggregating the system PPPs to the basic heading. The W3 weights were intended to weight together the component PPPs in order to obtain the system PPPs underlying each of the three basic headings.

In practice, the W1 weights were provided by all countries. However, their quality varied because some countries did not compile estimates of expenditures on GDP (including construction) as a regular part of their national accounts. In such cases, special procedures were adopted to estimate values for these basic headings (see chapter 3 for details).

The process intended to obtain W2 weights was to employ a construction expert to advise on the shares that each of the systems would have within each of the three basic headings within gross fixed capital formation on construction. The idea was to use bills of quantity from past investigations into construction projects (e.g., for estimating the weights for time series price indexes of construction). However, an insufficient number of countries had access to these types of data to make the approach viable, and so regional average weights were used for all countries within each region other than Western Asia. There, subregional weights were used, one set for Gulf countries and another set for the remaining countries within the region.

The original purpose of the W3 weights was to aggregate relative prices for the basic and composite components up to the system level. They were designed to take into account the potentially diverse shares of the components of construction in different countries (even within a single region). But as occurred for the W2 weights, it proved impossible to derive the W3 weights, and so component PPPs were aggregated to those for systems without weights using the CPD method.

The inability of countries to provide the data required to apply the W2 and W3 weights was the major shortcoming of the BOCC approach. Other significant shortcomings were as follows:

- Expert consultants were required for the data collection and validation, which increased the data collection costs and moved the work out of the national statistical office.

- The BOCC comparison was essentially a comparison of basic components. The extra cost of obtaining the composite component costs was not justified because they were weighted equally with basic components in the PPP estimation process.
- Because of the mixture of input and output prices, the goal of including productivity in the measurement was not met.
- Because profit and overhead margins were not included for either the composite or basic components, the PPPs were not consistent with the price structures in the national accounts expenditures for construction.

Data Validation

The procedures adopted for validating construction prices were similar to those used for other parts of the ICP. The first step was to check the consistency of prices collected for similar products in different localities within a country. The next step was to compare similar products in different countries, an exercise undertaken by the ICP's regional offices. Countries were grouped in two ways for this part of the exercise, first by subregion and second by the similarity of construction techniques. Countries were consulted on any apparent inconsistencies, and any revisions to prices as a result of this stage were incorporated into the process. In some regions, a final stage was to convene a small group of construction experts who examined the relative prices within each country and compared prices across countries. Based on their experience in the construction industry, they flagged any prices that appeared to be implausible, and the regional office then followed up these queries with the countries involved if time permitted.

Linking Regions

The 2005 ICP was conducted in six regions: five geographic regions—Africa, Asia-Pacific, CIS, South America, and Western Asia—plus the Eurostat-OECD "region." The results for each of these regions were obtained independently of those for each of the other regions. The final step in the 2005 ICP was to amalgamate the results for the countries in each region into a set of worldwide results that would enable any pair of countries to be compared, no matter in which region their initial results were compiled.

Chapter 8 in this volume is an overview of the process followed to calibrate the regional PPPs to a global level and enable the comparison of countries in different regions. As described in that chapter, a global list of products was established for household consumption. Two to four countries—so-called Ring countries—from each region priced this global list in addition to the products in their regional comparison. The PPPs from the global list were used to estimate regional linking factors to combine the regional PPPs. This process was followed for the household consumption basic headings. The BOCC methodology described earlier was followed by the Africa, Asia-Pacific, Western Asia, and South America regions. Therefore, the same data were used to compute the linking factors. The four Ring countries from the Eurostat-OECD region provided the BOCC data as well as the BOQ data. The Russian Federation priced both the BOQ and its regional specifications, and thus was used as the linking country to bring the CIS region into the global set of PPPs.

Some Interesting Comparisons

The ICP provides several ways in which to compare the effects of construction in different countries. The real expenditure on construction, expressed in international dollars with the United States as the base, indicates which countries contribute the most to construction activity worldwide. The GDPs of the world's 10 largest economies are shown in table 13.1, together with their real expenditures on construction. It is no surprise to see that the world's three largest economies—the United States, China, and Japan—also have the largest real expenditures on construction for the 2005 reference year. However, construction activity in China, the world's second-largest economy, is almost double that in the world's largest economy (United States), with real expenditures in international dollars of $2,623,761 million and $1,341,500 million, respectively. Japan is a distant third with $497,295 million, followed closely by India with $496,908 million.

Four countries outside the 10 largest economies have real expenditures on construction that are higher than some of those included in the latter group. They are the Republic of Korea ($254,042 million), Indonesia ($203,274 million), Spain ($191,726 million), and Canada ($157,426 million). Together, they contribute an additional 9.1 percent of the world's construction activity.

The most prominent aspect of table 13.1 is the extremely large share of worldwide construction activity contributed by China (29.8 percent of the total, compared with a 9.7 percent share of world GDP). When measured by adjusting to a common currency using exchange rates, China's share of worldwide construction activity is only 11.7 percent, while that of the United States is 25.3 percent (the corresponding shares of world GDP are 5.1 percent and 27.9 percent). The reason for the large difference is that these shares are not adjusted for the effect of the differences in price levels between China and the United States. It emphasizes the importance of compiling PPPs, which adjust for both differences in exchange rates and price levels between countries.

TABLE 13.1 GDPs and Real Expenditures on Construction, World's 10 Largest Economies

Country	GDP (international $ millions)	GDP, share of world (%)	Construction expenditure (international $ millions)	Construction expenditure, share of world (%)
United States	12,376,100	22.5	1,341,500	15.2
China	5,333,230	9.7	2,623,761	29.8
Japan	3,870,282	7.0	497,295	5.6
Germany	2,514,783	4.6	212,933	2.4
India	2,340,997	4.3	496,908	5.6
United Kingdom	1,901,710	3.5	141,765	1.6
France	1,862,193	3.4	216,964	2.5
Russian Federation	1,697,541	3.1	146,408	1.7
Italy	1,626,326	3.0	188,984	2.1
Brazil	1,583,162	2.9	144,515	1.6
Total, top 10	35,106,324	63.9	6,011,033	68.2
World	54,975,662	100.0	8,818,601	100.0

Source: ICP 2005.

TABLE 13.2 Per Capita Real Expenditures on Construction and GDPs: 10 Countries/Economy

Country/ Economies	GDP (international $)	GDP index (world = 100.0)	Construction (international $)	Construction index (world = 100.0)
Qatar	68,696	765.8	18,850	1,309.9
Kuwait	44,947	501.0	11,692	812.5
Luxembourg	70,014	780.4	9,153	636.1
Macao SAR, China	37,256	415.3	9,138	635.0
Iceland	35,630	397.2	7,894	548.6
Bahrain	27,236	303.6	6,922	481.0
Singapore	41,479	462.4	6,815	473.6
Ireland	38,058	424.2	6,696	465.3
Korea, Rep.	21,342	237.9	5,277	366.7
Brunei Darussalam	47,465	529.1	4,910	341.2
World	8,971	100.0	1,439	100.0

Source: ICP 2005.

A very different picture is observed when per capita real expenditures on construction are compared. Table 13.2 shows these expenditures for the 10 countries with the largest per capita real construction expenditures worldwide, together with their real expenditures on GDP.

Table 13.2 presents a completely different perspective on construction activity. The top 10 countries classified on the basis of their per capita real expenditures on construction do not include any of the world's 10 largest economies. In each case, their per capita real expenditures are several times as large as the world average, and the largest (Qatar, index = 1,309.9) is more than 12 times the world average.

Lessons Learned from Using the BOCC in ICP 2005

The underlying principle of the BOCC was that the construction costs of residential and nonresidential buildings and civil engineering works could be compared by pricing the major components of the construction of each. The set of 34 components identified for pricing included 12 that were basic input items such as building materials, labor, and the rental costs for four types of equipment. The data collection form for each basic item captured the average purchaser's cost for different quantities, such as three different quantities of Portland cement (annex C). The costs of skilled labor were obtained for six different occupations, ranging from bricklayers to machine operators, and aggregated into a single "skilled labor" category (annex C).

The 22 composite components included parts of the construction process such as earthworks, a column footing, or an interior wall. The data to be collected for each composite component included materials, labor, and equipment. However, the main objective was to obtain the total cost of each component, which was the comparison variable—that is, the equivalent of the price for a single product. Meanwhile, there was considerable overlap between the composite components and basic items. For example, a column footing is a composite component, but the total cost included concrete (which is also a composite component), reinforcing steel, and different kinds of skilled and unskilled labor, which were basic components that were also priced separately. The difference was that the concrete etc. in the composite component was included as a total cost, whereas an average price was captured for each basic item.

The idea of pricing composite components was based on the premise that it would be easier to calculate the cost of components than the cost of an entire project. In addition, it was assumed that the components were fundamental parts of construction projects that were comparable across countries. The total cost of a component would then capture the relative trade-offs between countries of labor versus capital. In other words, the component costs reflected the relative contributions of labor, equipment, and materials in each country. Although the costs of the composite components were assumed to be more easily obtained than the data on the bills of quantities, in practice the input of experts was still required for data collection.

The component costs were based on the purchasers' prices of the material, labor, and rental of equipment. These costs did not include any profit margin or overhead expenses for architects and other construction experts. The comparison based on costs assumes that the profit margins and overhead costs are proportional to the overall costs across countries.

The basic and composite components were combined into different sets of systems for residential and nonresidential dwellings and civil engineering works. Four composite components (aggregate base, earthwork, exterior sidewalk, and concrete) and six basic items (aggregate, Portland cement, sand, backhoe (hire), unskilled labor, and skilled labor) were combined in the site work system. The comparison variable for each composite item was the total cost, and the average price was used for basic components. The composite component costs included the combined total cost of materials, labor, and equipment. For example, the total cost of labor in the composite component would be correlated with the average input costs of the different types of workers. Some additional points follow:

- Each system for PPP estimation was to be treated like a basic heading, which meant there would be no weights applied to the composite component costs and basic item prices within each system.
- The basic input items were not independent—for example, concrete includes cement, sand, and aggregates, all of which were also included as basic components.
- The sidewalk composite component also includes concrete (which is made up of cement, sand, and aggregate).
- If the total cost were provided for every composite component and average prices for every basic item, 24 variables would be priced for the site work system.
- Even though there were no explicit quantity weights within any system, the components were implicitly weighted because the "price" was the total cost of each of the separate elements. For example, the composite components made up only four of the 24 items. Sand was priced for three different components (two composite components and in its own right as a basic component), and so it effectively was three of the 24 items. Concrete, which reflects the prices of sand, cement, and aggregates, could be said to make up almost half of the variables being compared. Skilled labor, with its six different types, had twice the weight of the other composite components.
- A review of the other systems in annex B shows a similar pattern. The basic component—sand—appears in six of the eight systems, and skilled and unskilled labor are in seven of the eight systems. One could say, then, that the most important things to price for residential housing were sand and labor.

Once the PPPs for each system were computed, the next step was to weight these to the residential PPP. These system weights, or W2 weights, were to be determined for each country individually. Regions and countries were advised to use construction experts to obtain the system weights for each country as a whole, taking into account differences in the construction inputs in different areas in the country. In practice, it was difficult for most countries to furnish the system weights. As a result, system weights were determined for each region for the residential and non-residential and civil engineering basic headings. In effect, all countries within a region received the same weights for aggregation at this level.

Summary

The introduction of the BOCC approach in the 2005 ICP round was an attempt to produce robust comparisons of construction prices for all participating countries at an affordable cost. The data collection worked well. The regional linking was considered to be a much better process than that used in previous ICP rounds. However, the main problem with the BOCC approach was the inability of countries to provide the information required to produce the W2 and W3 weights, which were a critical part of the overall approach. In addition, the BOCC approach was intended to be sufficiently straightforward that pricing could be undertaken by staff in national statistical offices. However, in practice it proved necessary to use construction experts to collect the price data required for the BOCC approach.

Last but not least, the method called for pricing both the composite and basic components of construction. Although the composite components provided an output price reflecting productivity differences between countries, the prices still did not reflect profit and margin differences between countries. The basic component prices were, in effect, input prices, which did not capture productivity differences or profits and overhead. Mixing input with output prices reduced the attempt to partially measure output prices.

On the positive side, detailed specifications were developed for the basic and composite components that could be used as building blocks for future data collection for the ICP or for producer price indexes at the national level.

Possible alternative approaches are being investigated in the early stages of the 2011 ICP round to determine whether a potentially better method is available for comparing gross fixed capital formation on construction that could be introduced in that round.

ANNEX A

Construction Components Included in Basic Headings for Residential and Nonresidential Buildings and Civil Engineering Works, ICP 2005

Construction components	Residential buildings	Nonresidential buildings	Civil engineering works
Composite components			
Column footing	x	x	
Culvert			x
Drilled shaft			x
Earthwork	x	x	x
Electrical service point	x	x	
Exterior painting	x	x	
Exterior wall cement plaster	x	x	
Interior ceiling plaster	x	x	
Interior painting	x	x	
Interior wall ceiling plaster	x	x	
Roadway lane			x
Round bridge pier			x
Structural column (round)	x	x	
Structural column (square)	x	x	
Round bridge pier			x
Aluminum frame (window)	x	x	
Bridge T-beam			x
Bridge spread footing			x
Concrete airfield pavement			x
Exterior sidewalk	x	x	
Masonry interior wall	x	x	
Concrete	x	x	x
Basic inputs			
Equipment hire			
Backhoe	x	x	x
Vibratory plate compactor		x	x
Centrifugal pump			x
Sand filter			x

(continued)

Construction components	Residential buildings	Nonresidential buildings	Civil engineering works
Materials			
Portland cement	x	x	x
Aggregate	x	x	x
Sand	x	x	x
Reinforcing steel	x	x	x
Structural steel	x	x	x
Plywood	x	x	x
Labor			
Unskilled	x	x	x
Skilled	x	x	x

Source: World Bank 2007.

ANNEX B

Components of Systems: Residential and Nonresidential Buildings and Civil Engineering Works, ICP 2005

1. Components of systems for residential buildings

System	Component	System	Component
Site work	Aggregate base	Exterior shell	Aluminum frame window
	Earthwork		*Sand*
	Exterior sidewalk		*Portland cement*
	Concrete		*Unskilled labor*
	Aggregate		*Skilled labor*
	Portland cement	Interior partitions	Masonry interior wall
	Sand		*Portland cement*
	Backhoe		*Sand*
	Unskilled labor		*Plywood*
	Skilled labor		*Unskilled labor*
Substructure	Aggregate base		*Skilled labor*
	Column footing	Interior/exterior finishes	Exterior wall cement plaster
	Concrete		Interior ceiling plaster
	Aggregate		Interior wall plaster
	Portland cement		*Exterior paint*
	Reinforcing steel		*Interior paint*
	Sand		*Portland cement*
	Backhoe		*Sand*
	Plywood		*Plywood*
Superstructure	Structural column round		*Unskilled labor*
	Structural column square		*Skilled labor*
	Concrete	Mechanical and plumbing	*Unskilled labor*
	Aggregate		*Skilled labor*
	Portland cement	Electrical	Electrical service point
	Reinforcing steel		*Unskilled labor*
	Sand		*Skilled labor*
	Structural steel		
	Plywood		
	Unskilled labor		
	Skilled labor		

(*continued*)

2. Components of systems for nonresidential buildings

System	Component	System	Component
Site work	Aggregate base	Exterior shell	Aluminum frame window
	Earthwork		*Sand*
	Exterior sidewalk		*Portland cement*
	Concrete		*Unskilled labor*
	Aggregate		*Skilled labor*
	Portland cement	Interior partitions	Masonry interior wall
	Sand		*Portland cement*
	Backhoe		*Sand*
	Unskilled labor		*Plywood*
	Skilled labor		*Unskilled labor*
Substructure	Aggregate base		*Skilled labor*
	Column footing	Interior/exterior finishes	Exterior wall cement plaster
	Concrete		Interior ceiling plaster
	Aggregate		Interior wall plaster
	Portland cement		*Exterior paint*
	Reinforcing steel		*Interior paint*
	Sand		*Portland cement*
	Backhoe		*Sand*
	Plywood		*Plywood*
Superstructure	Structural column round		*Unskilled labor*
	Structural column square		*Skilled labor*
	Concrete	Mechanical and plumbing	*Vibratory plate compactor*
	Aggregate		*Unskilled labor*
	Portland cement		*Skilled labor*
	Reinforcing steel	Electrical	Electrical service point
	Sand		*Unskilled labor*
	Structural steel		*Skilled labor*
	Plywood		
	Unskilled labor		
	Skilled labor		

3. Components of systems for civil engineering works

System	Component	System	Component
Site work	Concrete	Superstructure	Roadway lane
	Aggregate base		Bridge T beam
	Earthwork		Concrete airfield pavement
	Portland cement		Concrete
	Aggregate		*Aggregate*
	Backhoe		*Plywood*
	Sand		*Portland cement*
	Unskilled labor		*Reinforcing steel*
	Skilled labor		*Sand*
Substructure	Round bridge pier		*Structural steel*
	Bridge spread footings		*Unskilled labor*
	Aggregate base		*Skilled labor*
	Concrete	Underground utility	Culvert
	Aggregate		Drilled shaft
	Portland cement		Concrete
	Reinforcing steel		*Backhoe*
	Sand		*Portland cement*
	Backhoe		*Sand*
	Plywood		*Sand filter*
	Unskilled labor		*Unskilled labor*
	Skilled labor		*Skilled labor*
Electrical equipment	Electrical service point	Mechanical equipment	*Vibratory plate compactor*
	Unskilled labor		*Centrifugal pump*
	Skilled labor		*Portland cement*
			Unskilled labor
			Skilled labor

Source: World Bank 2007.
Note: Basic inputs are shown in italics.

ANNEX C

Collection Forms: Portland Cement, Skilled Labor, and Interior Painting, ICP 2005

1. Portland cement

150200.0.23 Portland Cement

Observation ☐ (Auto Calc)

Source Information:

- Date of price collection (dd/mm/yyyy):
- Country:
- Describe source of price:
  - ☐ Material supply
  - ☐ Informal or temporary sales location
  - ☐ Average, Price Index data collection
  - ☐ General contractor
  - ☐ Specialty contractor
  - ☐ Other: ( )
- Price is for year:
  - ☐ 2005
  - ☐ 2006

Details:

Cement to be priced shall be ordinary Portland cement that is used for typical concrete work in a variety of residential, nonresidential, and civil works projects. Cement used for these purposes is generally categorized into the following categories:

- Type I – for use when the special properties specified for any other type are not required
- Type IA – air-entraining cement for the same uses as Type I, where air-entrapment is desired
- Type II – for general use, more especially when moderate sulfate resistance or moderate heat of hydration is desired
- Type IIA – air-entraining cement for the same uses as Type II, where air-entrapment is desired
- Type III – for use when high early strength is desired
- Type IIIA – air-entraining cement for the same uses as Type III, where air-entrapment is desired
- Type IV – for use when a low heat of hydration is desired
- Type V – for use when high sulfate resistance is desired

Even though the roman numerals-based designation of the types may be prevalent in only certain regions of the world, the general categorization is applicable worldwide. Whichever type of cement is most commonly used in the country should be priced.

Quality and Packaging:

- Package size (kg):
- Package type (paper sack, cloth sack, etc.):
- Volume effects:
  - Price for single package:
  - Discount for larger quantities:

Source:

- Domestic:

  Manufacturer:
- Imported:

  Country of origin:

  Manufacturer:

Product Characteristics:

Percent volcanic ash:

Fineness:

Compressive strength (MPa):

Type (I, II, III, IV, V, IA, IIA, IIIA):

Soundness:

Specific gravity:

Pricing Information:

Material costs *(in national currency)*

Type	Quantity (column 1)	Units of measure	Unit cost (column 2)	Extended material costs (column 1 × column 2)
Ordinary Portland cement	10.000	Cubic meters		0.00
Ordinary Portland cement	100.000	Cubic meters		0.00
Ordinary Portland cement	200.000	Cubic meters		0.00

Comments (*if any*):

2. Skilled labor

150200.0.29 Skilled Labor

Observation

☐ (Auto Calc)

Source Information:

- Date of price collection (dd/mm/yyyy):
- Country:
- Describe source of price:
  - ☐ General contractor
  - ☐ Specialty contractor
  - ☐ Average, Price Index data collection
  - ☐ Other: ( )
- Price is for year:
  - ☐ 2005 ☐ 2006

Details:

Provide details of the compensation of employees for the following six kinds of skilled workers:

- Bricklayer
- Plumber
- Carpenter
- Structural steel worker
- Electrician
- Machine operator

A **skilled worker** is one that has had training in one of these trades. The training may consist of an apprenticeship, on-the-job training, or training in a technical college or similar institution.

Compensation of employees includes wages and salaries (before deductions for social contributions such as health or retirement benefits, income taxes, or trade union dues) *plus* social contributions made by the employers, *plus* in-kind benefits such as meals or housing.

You may report one of the following:

- Rates per hour for regular hours (i.e., excluding overtime)
- Rates per day (specify the regular number, excluding overtime, of hours worked per day)
- Rates per week (specify the regular number, excluding overtime, of hours worked per week).

Depending on the choice to report rates per hour or per day or per week, you will need to impute rates for social security contributions and income in kind and record them in the table below.

The rates should refer to skilled labor employed on a construction project near a major urban center.

(*continued*)

Pricing Information:

Compensation of employees *(in national currency)*

	Compensation of employees	Complete one of these columns numbered 1 to 3: Rate per hour (1)	Rate per day (2)	Regular hours worked per day	Rate per week (3)	Regular hours worked per week
Bricklayer	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	
Plumber	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	
Carpenter	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	
Structural steel worker	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	
Electrician	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	
Machine operator	Wages					
	Social security contributions paid by employers					
	Income in kind					
	Total	0.00	0.00		0.00	

Comments (*if any*):

3. Interior painting

150200.0.17 Interior Painting

Observation ☐ (Auto Calc)

Source Information:

- Date of price collection (dd/mm/yyyy):
- Country:
- Describe source of price:
  - ☐ Architect
  - ☐ Engineer
  - ☐ Average, Price Index data collection
  - ☐ General contractor
  - ☐ Specialty contractor
  - ☐ Other: ( )
- Price is for year:
  - ☐ 2005
  - ☐ 2006

Quantity and Details:

This component is intended for collection of pricing data for one mist coat and two full coats of emulsion paint on interior surface in a residential building or nonresidential building. The SPD (structured production description) is for painting as a finishing/decoration item. Assume that the surface to be painted is a plastered or rendered surface. For purposes of this pricing, assume that the painting is being provided on the first floor of a residential or nonresidential building (e.g., office building). The price is to be provided for 100 square meters of painting, including an allowance for a typical level of surface preparation (filling, patching, etc.). The plastered surfaces are to be perfectly smooth, free from defect, and ready for decorations. Assume new construction, without flooring installed, so drip/spill protection is not needed. Assume that window/door masking is required.

Product Characteristics:

- Paint Type:

Pricing Information:

Material costs *(in national currency)*

Type	Quantity (column 1)	Units of measure	Unit cost (column 2)	Extended material costs (column 1 × column 2)
Interior emulsion paint				0.00
				0.00
				0.00
				0.00
				0.00
				0.00
				0.00
TOTAL COST OF MATERIALS *(in national currency)*				**0.00 (a)**

Labor costs *(in national currency)*

Type	Number of hours required (column 1)	Rate per hour (column 2)	Extended labor costs (column 1 × column 2)
Unskilled labor			0.00
Skilled labor (list by type):			
			0.00
			0.00
			0.00
			0.00
TOTAL COST OF LABOR *(in national currency)*			**0.00 (b)**

(*continued*)

Equipment costs *(in national currency)*

Type	Number of hours required (column 1)	Rate per hour (column 2)	Extended labor costs (column 1 × column 2)
			0.00
			0.00
			0.00
			0.00
			0.00
			0.00
TOTAL COST OF EQUIPMENT *(in national currency)*			**0.00 (c)**
Total price for interior painting *(in national currency—sum of a, b, and c)*:			

Comments (*if any*):

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