INTERNATIONAL
COMPARISON OF COST FOR
THE CONSTRUCTION SECTOR
TOWARD A CONCEPTUAL MODEL FOR
PURCHASING POWER PARITY

Report Submitted to:
The World Bank Group
June 2002

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# INTERNATIONAL COMPARISON OF COST FOR THE CONSTRUCTION SECTOR

## TABLE OF CONTENTS

### INTRODUCTION AND BACKGROUND

- Goal and Objectives of this Research ......................................................... 2
- Basic Principles of PPP Calculations .......................................................... 3
- History of ICP and PPP ............................................................................... 3

### METHODOLOGIES RELEVANT TO THE CONSTRUCTION SECTOR

- Methodologies for Spatial and temporal Indices ........................................... 5
- Methodology for PPP Calculation for the Construction Sector .................... 5
- Methodology for Temporal Index Calculation for the Construction Sector .... 7
- Construction Sector Pricing Strategies ......................................................... 9
- Comparison of Standard Project Method and the Basket of Goods and Services Method .......................................................... 9
  - Standard Projects Method ........................................................................ 9
  - Basket of Goods approach ...................................................................... 10

### REVIEW OF CONSTRUCTION SECTOR LITERATURE


### CONCEPTUAL PPP MODEL FOR CONSTRUCTION SECTOR

- Construction Sector Background .................................................................. 12
- Levels of Estimation ..................................................................................... 13
- Design Considerations for Construction PPP System ................................... 14
- Conceptual Model ......................................................................................... 21
- Proposed Execution Plan ............................................................................. 23

### FUTURE RESEARCH NEEDS ........................................................................ 24

### REFERENCES ................................................................................................ 27
INTERNATIONAL COMPARISON OF COST FOR THE
CONSTRUCTION SECTOR

LIST OF FIGURES

Figure 1: Heading Levels for the Construction Sector ................................................................. 1
Figure 2: ICP Partners .................................................................................................................. 4
Figure 3: Sample BOQ .................................................................................................................. 6
Figure 4: Schematic View of the Standard Project Method .......................................................... 7
Figure 5: Construction Sector Influence Diagram ....................................................................... 13
Figure 6: Levels of Estimation for the Construction Sector ......................................................... 14
Figure 7: Cost Influences at Different Levels ............................................................................. 14
Figure 8: Price Collection Strategies .......................................................................................... 15
Figure 9: Comparability and Representativity as a Euclidean Plane .......................................... 16
Figure 10: Relationship between US Median Home Price and ENR Lumber Cost Index, 1997 to 2002 ........................................................................................................................................ 17
Figure 11: Variation in ENR Cost Indices and US Median Home Price, 1997-2002 ..................... 17
Figure 12: Construction Sector PPP calculations for Canada for 1996 ....................................... 18
Figure 13: Proposed BOCC Framework ....................................................................................... 21
Figure 14: Work Breakdown for a Residential Building ............................................................... 22
Figure 15: Cost Breakdown of a Construction Component ......................................................... 22
Figure 16: Component Contributions for Building Construction (Source RS Means Handbook for Estimating) .................................................................................................................. 23
INTERNATIONAL COMPARISON OF COST FOR THE CONSTRUCTION SECTOR

LIST OF TABLES

TABLE 1: Construction Sector Contributions To The GDP (From 1996 ICP Data-Real) N = 52 .... 2
TABLE 2: Temporal Index Methods................................................................................................................7
TABLE 3: Cost Indices Reported By ENR (Source ENR, March 22/29, 1999) ................................................8
**INTRODUCTION AND BACKGROUND**

Under the United Nations System of National Accounts (SNA) that is utilized by the International Comparison Program (ICP) the construction sector falls under the basic expenditure heading called Gross Fixed Capital Formation. The current breakdown provides three basic headings under which Purchasing Power Parity (PPP) calculations are done. Figure 1 shows the basic heading levels associated with the construction sector.

![ICP Expenditure Classification](Image)

**Figure 1: Heading Levels for the Construction Sector**

Construction sector expenditures play a crucial role in the national GDP calculations and their comparisons. Based on the 1996 ICP data provided by the World Bank on an average the construction sector contributes approximately 10.7% to the national GDP in real terms. Table 1 provides descriptive statistics of this contribution. Moreover, from a social perspective international aid provided to various nations often is in the form of constructed works. It should be clear from the foregoing that the construction sector is an important contributor to global economic growth. Accordingly, there is growing interest in cost comparisons for conducting construction activities between and among different countries. However, because of the nature of the output of the construction sector, the development of a comparison framework has proven very difficult. Stapel (2002) points out that relatively few examples of rigorous construction price comparisons exist, both from theoretical and practical points of view. The World Bank has convened an Expert Group to...
evaluate, amongst other things, the status of the methodological and calculation framework used by
the construction sector for the derivation of PPP.

Table 1: Construction Sector contributions to the GDP (From 1996 ICP Data-Real) N = 52

<table>
<thead>
<tr>
<th>CONSTRUCTION SECTOR</th>
<th>RESIDENTIAL BUILDINGS</th>
<th>NON-RESIDENTIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>10.7%</td>
<td>3.8%</td>
</tr>
<tr>
<td>Median</td>
<td>10.2%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>4.1%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Minimum</td>
<td>3.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Maximum</td>
<td>24.7%</td>
<td>9.2%</td>
</tr>
</tbody>
</table>

The Handbook of the International Comparison Program developed by the United Nations currently provides a framework for the PPP calculations for all basic heading levels. Implementation of the framework varies slightly by region. For example, in the 1996 comparison Organization for Economic Cooperation and Development (OECD) used a list of traded and non-traded goods and services that had approximately 4,000 items, including about 2,900 consumer goods and services; 800 pharmaceuticals; 186 capital goods; 50 motor vehicles; 34 government, education, and health services; and 20 construction projects (Vachris and Thomas 1999). Currently the calculations for the construction sector are handled by developing estimated costs for standard construction projects, for which bills of quantity and specifications have been developed. According to the EuroStat procedures, each bill of quantity requires price estimation for 10 to 20 chapters, each consisting of 100 to 1000 individual construction items (Stapel 2002). There is growing concern that the level of effort and resources represented by this process is prohibitive for expansion and continued application of construction sector comparison (Dubner and McKenzie 2002, Stapel 2002). Some partners of the ICP program have also cast their doubts on the accuracy of the data collected and credibility of the construction estimation process.

A methodological study is needed to deal with the following broad questions: What is the cost, in local currency units of each country, of constructing each of several different types of construction projects? Further, how can quality and level-of-service differences among countries be incorporated in these comparisons? The ICP needs to allow for pricing experts in each country to do the pricing in light of the materials and construction methods that are actually available, and in use, in their own country. This may mean that a standard design should be used for all countries, so as to achieve uniform quality of the final project between countries, while allowing for variation between countries in the specific materials and construction methods used in the pricing exercise to achieve this uniform quality. It may also be effective to use a construction cost indexing methodology for important construction materials and labor, similar to that employed for evaluating changes in construction cost over time for a given country. Hybrid systems could be considered as well.

GOAL AND OBJECTIVES OF THIS RESEARCH

The goal of this research is to carefully study methods used for the comparison of construction costs within the context of the ICP program. The research team considered the current standard construction project method along with other state-of-the-art methods used for the development of spatial and temporal indices for construction. The objectives of the research project are to:

1) Conduct critical analysis of current methods used for comparison of construction costs;

2) Identify key issues and characteristics of the international construction cost comparison; and
3) Develop a modified or new preliminary conceptual model for the development of PPP for the construction sector.

**BASIC PRINCIPLES OF PPP CALCULATIONS**

The calculation of the purchasing power parity is straightforward in concept. The equation requires only the price for a given item in a given country (say country A), which might be thought of as the standard or numeraire, and the price of the same item in another country (say country B). The prices are obtained in the national currency of a given country at a given time, and thus the ratio allows for comparison of price levels between two different points in space at a given time (United Nations 1992). Then:

\[
PPP_{B/A} = \frac{p_B}{p_A}
\]

*Equation 1*

where:

- \(PPP_{B/A}\) = the Purchasing Power Parity for country B compared to country A;
- \(p_A\) = price for a given item in country A in the national currency of country A; and
- \(p_B\) = price for a given item in country B in the national currency of country B.

The underlying assumption of Equation 1 is that the price is applied to the same quantity of the same good. Given this assumption, the ratio represents the ratio of the national currency required in order to obtain equal value. This calculation is as straightforward as the concept for many of the goods in the ICP. For example, a ton of rice in one country can be reasonably equated to a ton of rice in another country. This is the so-called “a potato is a potato” theory (Heston 2002). Problems associated with quality variations or perceived value in a given pair of countries have been noted, but have generally been considered not too serious in most sectors of the ICP. This assumption may not hold in the construction sector, where the evident problem is how to establish equality of value.

It has been suggested that the calculation of the PPP is conceptually straightforward. Such a statement implies that more complexity accrues to the actual process of completing the calculation, and this of course is true. An important component of the calculation is that the ratio should relate the price of equal goods or services in the two nations being compared. Equality of value has been indicated by the concepts of comparability and representativity in the literature, and described for the construction sector in more detail later in this report (Stapel 2002, United Nations 1992, DISR 1999).

**HISTORY OF ICP AND PPP**

The ICP was established in 1968 as a joint venture of the United Nations and the International Comparison Unit of the University of Pennsylvania, with financial contributions from the Ford Foundation and the World Bank. In 1993, the World Bank assumed the role of global coordinator for the ICP program and PPP calculations (Biru 2002). The idea of PPP has been generally attributed in popular literature to Gustav Cassel dating back to his writings between 1912 and 1920 (Balassa 1964). Ever since, the Casselian PPP doctrine has received wide attention and is still being debated worldwide (Terborgh 1926, Papell 2002). Over the years regions dominated by industrialized countries have taken a lead in the ICP program and have attempted integration with national statistical collections. But there is growing concern amongst developing countries regarding the effort involved in the ICP program. The effort required seems to be more pronounced in the construction sector due the highly specialized nature of the industry and due to differences in data collection and pricing procedures adopted for the construction sector. This is the focus of this research and is discussed in more details in the following sections of the report.
Over the years the ICP has developed into an effort that is started at a regional level and is eventually compiled at a global level. Figure 2 shows the various agencies that participate in the PPP program at a global level. The research team feels that the regional characteristics of the program are an important consideration in the evaluation of any existing PPP methodology as well as important design criteria for a proposed methodology. Certain issues that present themselves during PPP calculations for the construction sector can be very well handled at the regional level. More details are provided in the section dedicated to the theoretical underpinnings for a proposed PPP model for the construction sector. Another related issue is that of devising a strategy that bridges or connects regions for the final calculations of the PPP at a global scale. A number of researchers working with the World Bank and other agencies are addressing this issue.

**Figure 2: ICP Partners**

**Methodologies Relevant to the Construction Sector**

In a very simplified form it can be stated that under the ICP three different methodologies exist. The first methodology is used for a majority of the basic headings. Under this methodology input prices for commodities form the core of the data collection and calculation. The second methodology is used for non-market services and is based on indirect pricing of commodities and services as indicators of the relevant service (Dean 2002). The third methodology is unique for the construction sector and uses a standard project method.
In general for most basic headings, the ICP utilizes a “basket of goods and services” (BGS) approach. This basket consists of a list of core commodities that are commonly found in a large number of countries in all regions of the world (United Nations 1992). Also included in the basket are goods and services that are more commonly available in a region. National statistical offices coordinate the collection of prices for the basket, which are then compiled at the regional level, and then eventually by the World Bank. In the basket-of-goods approach, the job of the statistician is to obtain the price for several standard items detailed in a list. The list of items (the “basket”) is developed via consensus opinions of experts, and the set of prices is then averaged (perhaps with weighting factors) or totaled. This is a simplification of the methodology and for a more detailed description the reader can refer to United Nations (1992). Based on a preliminary analysis, the research team found that this approach is not followed for non-market services such as health services, education, and general government services, and for the construction sector. The approach used for the construction sector is defined in the next section and for a description of the methodologies used for the non-market services the reader can refer to a recent article by Edwin Dean (Dean 2002).

In contrast to domestic price indices, PPP calculations are based on measuring relative price level differences for one time period across countries (United Nations 1992, Vachris and Thomas 1999). Therefore, the PPP is considered a spatial price index while domestic price indices are considered temporal indices. The item specifications entering into the calculations of parities at the basic heading level serve the same function as the price representatives in the building up of national temporal price indices, such as the consumer price indices, from category price changes (Vachris and Thomas 1999, United Nations 1992). Even though at a fundamental level there are significant differences between spatial and temporal indices, a significant overlap might exist in terms of data collection strategies. Heston points out that there seems to be a disconnect between collection of the price data for the ICP program and for temporal indices such as consumer and producers price indices at the national statistical offices (Heston 2002). Whereas most countries use significant resources to develop temporal price indices, little or none of these resources are used in parallel for the PPP data collection by countries and regions.

**Methodology for PPP Calculation for the Construction Sector**

The construction sector methodology used for the ICP is significantly different from that used for most other basic headings in that direct price or cost information is not used. Instead, the direct prices are masked within the total cost of the standard projects. The Handbook of International Comparison Program provides the following four reasons for this difference in approach:

1) The nature of construction projects performed in various countries is different one from another;

2) Each construction project is unique and it is hard to match projects across countries;

3) The cost of construction projects is influenced by random factors such as soil conditions, weather, culture, means and methods of construction etc.; and

4) From an operational perspective the technique devised by EuroStat was deemed to produce reasonable results (United Nations 1992).

The methodology that is in current use is called the “standard building models” or “standard projects” method (SPM) (United Nations 1992, Stapel 2002). In this method, around 20 standard construction projects are identified for the three basic headings for the construction sector, i.e. for
residential buildings, non-residential buildings, and civil engineering works (Figure 1). A complete set of construction drawings, construction specifications, and bills of quantity (BOQ) for each of the standard projects is prepared. The BOQ is the most important document, and lists basic work items that constitute the standard project. This approach, also referred to as the BOQ approach, was pioneered by EuroStat (United Nations 1992) Under the standard projects approach, services of government and professional quantity surveyors, architects, or civil engineers are used to price the BOQ items. This methodology has been in existence since the early 1970s, although minor refinements have been made (Stapel 2002).

The EuroStat survey collects prices for about 15 bills of quantity, each containing 10 to 20 chapters with 100 to 1000 construction items in each chapter. Figure 3 shows a portion of a BOQ from a construction project, and is provided simply to demonstrate the kind of information conveyed on a BOQ.

<table>
<thead>
<tr>
<th>S.no.</th>
<th>Particulars</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Unit</th>
<th>Item Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Supplying laying in position &amp; curing complete at all elevations as per specifications design mix cement concrete of grade M20 as per drawings and direction of engineer in-charge (excluding cost of cement).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) From 0.0 m to 5.00 m.</td>
<td>300</td>
<td>690</td>
<td>Cum</td>
<td>207000</td>
</tr>
<tr>
<td></td>
<td>(b) From 5.00 m to 10.00 m.</td>
<td>50</td>
<td>711</td>
<td>Cum</td>
<td>35550</td>
</tr>
<tr>
<td></td>
<td>(c) From 10.00 m to 15.00 m.</td>
<td>1300</td>
<td>730</td>
<td>Cum</td>
<td>949000</td>
</tr>
<tr>
<td></td>
<td>(d) From 15.00 m to 20.00 m.</td>
<td>100</td>
<td>749</td>
<td>Cum</td>
<td>749900</td>
</tr>
<tr>
<td></td>
<td>(e) From 20.00 m to 25.00 m.</td>
<td>500</td>
<td>768</td>
<td>Cum</td>
<td>384000</td>
</tr>
<tr>
<td></td>
<td>(f) From 25.00 m to 30.00 m.</td>
<td>500</td>
<td>787</td>
<td>Cum</td>
<td>396109</td>
</tr>
<tr>
<td></td>
<td>(g) From 30.00 m to 35.00 m.</td>
<td>520</td>
<td>825</td>
<td>Cum</td>
<td>429000</td>
</tr>
<tr>
<td>10</td>
<td>Reinforcement steel work in high yield strength (HYSD). Deformed bars of all dia with cutting, bending &amp; placing in position at all locations with cost of all labor material complete as</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3: Sample BOQ

Figure 4 provides a schematic view of the process used for the standard construction project method. In this method, as shown in the figure, the key link between the survey coordinators and national statistical agencies conducting the survey for a given nation are the voluminous construction project documents.

There seems to be little evidence available that points to the fact that the standard projects method was adopted for the construction sector after a careful analysis of the drawbacks of the basket of goods or services approach for the construction sector. More literature search and review is needed to confirm this. EuroStat has recently undertaken some preliminary efforts to evaluate the basket of goods and services approach and also to carefully evaluate the validity of the standard projects approach (Stapel 2002). Stapel (2002) also shows that a 50 percent reduction in the number of construction items included in the BOQ of standard projects had no negative influence on the overall quality of the PPP calculations.

Clearly a need to evaluate the basket of goods and services approach for the construction sector exists. In addition a careful study of the temporal index calculation methods for possible applications in spatial calculations for the construction sector also exists.
Methodology for Temporal Index Calculation for the Construction Sector

A number of methodologies exist for temporal index calculations for the construction sector. Table 2 shows a list of methods divided in two broad categories.

Table 2: Temporal Index Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior Breakdown Method</td>
<td></td>
</tr>
<tr>
<td>• Standard Factors Method</td>
<td>Factors such as labor and material are priced</td>
</tr>
<tr>
<td>• Component Cost Method</td>
<td>Standard construction components are priced</td>
</tr>
<tr>
<td>Subsequent Breakdown Method</td>
<td></td>
</tr>
<tr>
<td>• Quoted Price Method</td>
<td>Standard construction output product is priced, based on actual submitted quotes</td>
</tr>
<tr>
<td>• Schedule of Price Method</td>
<td>Same as above but with all project components</td>
</tr>
<tr>
<td>• Matched Models Method</td>
<td>Unit prices are obtained from actual submitted quotes on matched projects</td>
</tr>
<tr>
<td>• Building Volume or Area Method</td>
<td>Obtain prices for on a per area or per volume basis from actual projects</td>
</tr>
<tr>
<td>• Hedonic Method</td>
<td>Regression techniques are used to predict prices based on past projects</td>
</tr>
</tbody>
</table>
A detailed review of these methodologies is provided in a document developed by EuroStat and the OECD (2001). The document, titled “Sources and Methods: Construction Price Indices,” divides these methods into two categories—Prior Breakdown Methods and Subsequent Breakdown Methods. The basis of the Prior Breakdown Methods is a set of carefully specified factors or components that allow the estimation of the total input or output costs of a selected construction project. Subsequent Breakdown Methods involve the use of samples of either actually completed or fictitious construction projects. The estimation process for these methods starts from a completed project and progresses in reverse to determine the prices of factors or components that have been identified for index calculation purposes (OECD and EuroStat 2001). A detailed description of these methods is available in the above-mentioned document (OECD and EuroStat 2001).

In addition to these, there are other price indices developed by construction industry participants. Of particular interest in the North American context are the indices developed or reported by the Engineering New Record (ENR). These are summarized in Table 3.

Table 3: Cost Indices Reported by ENR (Source ENR, March 22/29, 1999)

<table>
<thead>
<tr>
<th>Name of the Cost Index</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENR Construction Cost Index (CCI)</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>ENR Building Cost Index (BCI)</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>ENR Material Cost Index (MCI)</td>
<td>Basket of Goods</td>
</tr>
<tr>
<td>The Austin Company Index</td>
<td>Standard Project</td>
</tr>
<tr>
<td>E. H. Boeckh Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>Bureau of Reclamation General Property Index</td>
<td>Building Volume or Area</td>
</tr>
<tr>
<td>Chemical Engineering Magazine Index</td>
<td>Schedule of Prices</td>
</tr>
<tr>
<td>Factory Mutual Engineering Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>FruCon Index</td>
<td>Matched Model</td>
</tr>
<tr>
<td>Handy Whitman Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>Marshall and Swift Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>RS Means Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>Nelson-Farrar Refinery Index</td>
<td>Basket of Goods and Services</td>
</tr>
<tr>
<td>Smith, Hinchman and Grylls Inc. Index</td>
<td>Schedule of Prices</td>
</tr>
</tbody>
</table>
CONSTRUCTION SECTOR PRICING STRATEGIES

Three pricing strategies can be adopted for the construction sector in the PPP calculations (OECD and EuroStat 2001). These strategies differ primarily in the source of the pricing data. The three strategies include:

1) Input Strategy: In this strategy prices of the input to the construction sector are used. For a given construction project input factors in terms of material, labor, and equipment are obtained. These factors are then priced in order to determine construction indices that are generally temporal indices.

2) Output Strategy: Under this strategy the price of construction products is used to determine the price indices relevant to the construction sector. This allows inclusion of factors such as overhead, profit, and taxes etc.

3) Seller’s Price Strategy: This pricing strategy uses the prices of construction output paid by the purchaser or final owner of the output of the construction activity.

Comparisons and discussions of the basket-of-goods and standard project approaches often describe the implications of the difference between input prices in the former and output prices in the latter. In other words, the basket-of-goods approach will typically capture the prices that contractors will pay for a series of items, and hence measures input prices to the construction process. The standard projects approach, however, will typically include other cost categories, such as VAT, overhead, and profit, and therefore represents better the output price to the ultimate consumer.

COMPARISON OF STANDARD PROJECT METHOD AND THE BASKET OF GOODS AND SERVICES METHOD

As previously related, the two most important approaches are the SPM and BGS. It is important to recognize that there are important implications for the accuracy and the utility of the method that arise from the selection of these two approaches. In this section the authors will review the strengths and weaknesses of each.

Standard Projects Method

The reader will recall that the SPM requires cost estimates for one or more rigidly defined construction projects. Simply stated, the idea is to retain national and regional experts to develop a detailed item-by-item cost estimate for these projects. The experts are provided with bills of quantity, drawings, and specifications to facilitate the estimation process. The measurement of the prices under this approach is completed at the output level, as the final cost is more representative of the price that the construction users/buyers actually pay to purchase a constructed facility. This approach inherently introduces some advantages and disadvantages.

The most important advantages include the direct inclusion of productivity differences and the implications of the equipment/labor trade-off into a calculation. Because the project cost reflects the labor to actually install a given quantity of material, labor productivity differences are accounted for. In addition, if equipment is commonly used to replace labor in a given country these cost implications are also automatically captured. Because of the detailed documentation and the bills of quantity provided, this approach is intrinsically comparable but not necessarily representative. For certain types of projects (for example semiconductor manufacturing plants) since the construction technology is controlled by the final quality standards to a large degree this method is extremely applicable.
This method suffers, however, from a number of disadvantages. Perhaps the most important to
the current discussion is the sheer complexity of the data collection process (Dubner and McKenzie
2002, Stapel 2002). Literally thousands of highly specialized, construction-specific items have to be
priced. To develop installed costs for these items further requires detailed knowledge of the means
and methods to put those items in place, the labor, equipment and other resources needed, and the
typical order of events in a construction project. This specialized knowledge is not widely distributed
but resides only with highly experienced construction professionals. As a consequence tapping these
skills is expensive and difficult.

Another important challenge arises from the wide variety in construction tolerances and
acceptable quality that exists between nations. The current standard projects approach relies on
highly detailed information about the materials and quality requirements in order to ensure
comparability at the expense of representativity (Stapel 2002). It is hard to imagine a project which
would contain only materials and products that are relevant or appropriate for every country. One
way to circumvent this deficiency is to produce the standard project documents in such a way as to
define materials and products flexibly, to allow for variations in usage without disturbing the
mathematical basis for comparison. But no scientific or mathematical research has been done to
enable such flexible specification. Another approach is to account for differences using a hedonic
approach as practiced by some countries for their domestic statistics. Again to date there is no
authoritative and comprehensive research to support the necessary regression analyses.

Another challenge pertains to the size and nature of the standard construction projects that are
used by the ICP program. Ideally the standard projects selected would reflect the range of projects
undertaken by the construction sector in a given economy and in any economy. It is not clear that
the current slate of projects has this characteristic. For example Stapel (2002) points out a mismatch
between the typical project sizes by total installed cost in the U.K. compared to the standard projects.

It is interesting to note that the standard projects approach does not appear to be the most
common method for temporal comparisons within countries or regions, where the basket of goods
approach seems to be more commonly used. Furthermore, the other sectors of the ICP seem to rely
heavily on the basket of goods and services methodology rather than a standard level of effort
approach. Out of the 60 OECD and EU member countries, over 50% of the countries use the
goods- and services-based approaches for their domestic temporal price indices in the construction
sector (OECD and EuroStat 1999). A similar percentage appears to hold in North America (Table 3).

Basket of Goods approach

The basket of goods and services approach is widely used as a means for temporal comparison
of prices in many countries. Such use makes the method appealing, at least at first blush, as it carries
the suggestion that temporal comparisons already available might be fit within the framework of
spatial comparison and augment the utility of both types of comparison. The BGS approach requires
only that one monitor the prices for goods and/or services included in the basket, and compare them
to prices at some other time (or, in the case of PPP, at some other place). Because of this simplicity
of concept, the required data are relatively simpler to obtain, perhaps even potentially possible
without the aid of construction-specific experts. The items included may be unambiguous (a ton of
steel is a ton of steel) if commonly used international or regional specifications are used to identify
the items. As a result, comparability is likely to be high for the BGS approach.

However, this method has its own challenges as well. First (and probably most important), the
BGS method usually does not capture productivity very well. Even in cases where the basket includes
labor items, in most instances the cost of a fixed number of hours of labor is reported. So, for
example, a basket might call for the cost of 600 hours of skilled labor, without concern for the
amount of construction work likely to be put in place during those 600 hours. This problem degrades the comparability of the basket when more productive labor is compared to less productive labor. In a similar vein, this approach removes the labor/equipment tradeoff from the result, because the degree to which some of the tasks the requested labor might conduct would be simplified by equipment is not considered in the basket.

An even larger challenge may arise from representativity concerns. A fixed basket of goods would have to consist of very ubiquitous items and labor classifications, in just the right mix, in order for an index based on the BGS to be representative. Existing baskets in common use seem to concentrate on structural elements (concrete and steel principally), which may be appropriate. However, the authors are unaware of research literature presenting convincing evidence that any existing temporal baskets are appropriate for spatial comparison.

**REVIEW OF CONSTRUCTION SECTOR LITERATURE**


These authors present material that appears to be ancillary to some workbooks they allude to in the paper. The paper consists mostly of a very elementary treatment of the sources of variation in construction estimates. The discussion is at a very basic level, for example providing much less detail and much less sophistication in analysis compared to Oberlender and Trost (2001), although the ultimate conclusions in terms of range of variation are similar to Oberlender and Trost’s. As an example, the authors refer to statements from the 1982 Business Round Table as comments on “modern management systems.” The references are by and large from secondary literature (magazines or minor journals). In addition to the dated nature of the specific comments, the paper adopts a very condescending tone toward construction estimation as a profession and estimating procedures as a whole.

As stated, the paper alludes to some workbooks that were apparently delivered with the paper. The workbooks themselves are not presented, nor is the design process used to develop the workbooks. Based on what is presented, it can be concluded that these authors have developed some simple standard projects, and have developed a work breakdown structure for costing them, which may be loosely based on the 16 Construction Specification Institute (CSI) divisions. CSI is commonly used for developing work breakdowns in the North American construction industry. The authors provide no evidence that their proposed workbooks would provide an effective basis for construction cost comparisons.


This author applied the EuroStat methodology for the PPP calculations for the construction industry in Commonwealth of Independent States (CIS) and Mongolia. The author has developed a modified standard project-based method through a series of regional expert group meetings. The key modification is that in the calculations proposed by the author an explicit contribution of indirect construction costs including social contribution, depreciation, profit, VAT, design fee and other overhead costs is included. An example standard project partially showing the proposed calculations is provided in the paper. No indication is however provided relating to the estimation of the indirect construction cost contributions. It includes a BOQ with approximately 100 line items. The paper indirectly points out the advantages of a region-specific framework for improving representativity and comparability.
The author provides an excellent overview of the PPP calculation framework for the construction industry as adopted by EuroStat. The paper provides the current state of the standard project-based PPP calculation approach for the construction industry. The paper finds via simulation that the number of line items in the BOQ can be halved, without negatively affecting the overall quality of the PPP calculations. The author proposed a test basket of goods for the construction industry consisting of six materials and a fixed quantity of three types of construction labor. The preliminary findings give some reason for optimism but are ultimately inconclusive. The structures of the basket of goods that the author proposes result in input prices and inherently exclude productivity implication from the calculations.


These authors review extensively several generic methods originally provided in a report titled “Sources and Methods: Construction Price Indices” published by the OECD. They perform a qualitative analysis of these methods using criteria such as comparability of prices, availability of data, and cost of data collection. These authors point out the need to balance the cost benefits of a short list of items to price against the accuracy benefits accruing to procedures which require more data.

**Conceptual PPP Model for Construction Sector**

**Construction Sector Background**

That the construction sector has been difficult to incorporate into the ICP should not be surprising; the complexity of the construction industry has made it a difficult industry to fit into almost every standardized econometric system. The construction industry consists of a vast array of contractors, subcontractors, and suppliers. The construction industry supply chain is considered one of the most complex by some supply chain pundits. There are no formalized industry structures that represent all of its stakeholders. Its primary output is a series of projects, each resulting in a unique constructed facility. The industry is typified by temporary, contract-driven relationships between the participants of a given project, and this condition makes characterization and collection of national statistics very difficult to satisfactorily achieve.

Nonetheless, the industry is striking in the degree of customization and flexibility that it offers to the construction consumer. Very few products are as targeted to the wishes of a particular consumer as the construction project. Furthermore, construction buyers are notorious for changing their desires even while the project is underway, even regarding portions already put-in-place. The result is that it becomes very difficult to compare one project to another. The external influences that are at work on the constructed product are correspondingly unique, and exist primarily at the project level. Figure 5 depicts the transformation process. In general terms, the economic activity of the construction sector is related to conversion of materials, labor, and equipment into the unique constructed facility. Variations in these inputs, and in the common means and methods used to orchestrate and install them, exist between regions of the world, between nations, and even internally within nations (Thomas 2002).

The cost of a construction project is directly influenced by the selection of means and methods of putting materials in place, the materials themselves, and the labor and equipment rates in use at that time and place. However, there are a number of indirect influences that affect these choices. A
number of these indirect factors are represented on Figure 5, termed “indirect” here because they will modify the selection of materials, equipment, labor, or methods, but will not appear on a bill of quantity themselves.

![Figure 5: Construction Sector Influence Diagram](image)

**LEVELS OF ESTIMATION**

Somewhat unique to the construction sector is the issue of the level at which PPP calculations can be performed for the construction sector output. Figure 6 shows a hierarchical view of the construction sector, highlighting the various levels at which cost data collection (and the resulting PPP calculations) can be performed. At the top level is the construction project, which can be broken down into construction components. Each construction component is in turn derived from a number construction work items. Underlying these work items at the lowest level of the hierarchy are the input factors, consisting of construction materials, construction labor, and construction equipment.

The standard projects approach is really based upon the highest level of the hierarchy shown in this figure. At this level the complexity of the price estimation is the highest, requiring consideration of hundreds of individual construction components. If the focus is shifted to the single construction component, or even a group of construction components, the complexity of the estimation is reduced. Estimation of PPP at this level requires careful selection of construction components. At any level below the construction component level, the estimation process is significantly less complex. However, the accuracy of the PPP estimate may suffer. This aspect is described with the help of some example calculations in the section titled “Design Considerations.”

In Figure 7, factors that get incorporated in the PPP estimates at the various levels of the construction sector are outlined. Estimation of the PPP at the construction industry level is a difficult task. The output of the construction sector is so complex and varied that devising a strategy that can measure prices at the topmost level of the hierarchy is probably impossible or nearly so. Complex issues such as culture, climate, demand and supply etc. need to be included in the estimate at this level. Estimation of the PPP at the construction project level allows a best balance in terms of the incorporation of factors that influence the construction output. This advantage is offset, however, by the relative difficulty of price estimation for a construction project. Calculation of PPP at the
construction work item level, even though a simple task, allows incorporation of only basic factors that impact the construction output. In between the construction work item and the construction project is the construction component level, at which level a unique combination of relative pricing ease and incorporation of an important set of factors influencing the construction output can be captured. The authors envision that this level of PPP calculation affords the maximum potential in terms of arriving at a PPP calculation methodology for the construction sector which is acceptably accurate and constitutes an acceptable level of effort to complete.

**Figure 6: Levels of Estimation for the Construction Sector**

**Figure 7: Cost Influences at Different Levels**

**DESIGN CONSIDERATIONS FOR CONSTRUCTION PPP SYSTEM**

In order to represent any meaningful comparison of prices for construction, the treatment of the sector in the ICP must be mindful of several important realities. These are the characteristics of the construction industry (principally its project-based pricing structure), comparability and
representativity considerations, and the need to create a system that can feasibly be deployed in the participating nations and yield reasonably meaningful results. The project influences on the sector have been previously described. In this section, the other considerations will be expanded as a basis for the presentation of a conceptual model for construction cost comparison.

The concepts of comparability and representativity were briefly described previously in this report. These concepts represent a very significant challenge to the successful development of a system for construction cost comparison. “Comparability” of goods or services is required in order to achieve a ratio of related items. Identical items are obviously comparable. “Representativity” of goods or services addresses the issue of perceived value. Items that are generally available and in generally the same demand are considered representative. The two characteristics can be conceptualized as axes in a Euclidean plane, depicting the degree to which a given good or service exhibits each of the two characteristics. These characteristics are somewhat problematic in construction, as there are significant regional differences between construction materials, means, and methods, and between the acceptable level of finishes and tolerances in the final product. For example, lumber is the primary structural component used for residential construction in North America, but is less frequently used in many parts of the world, including Latin America.

As an illustrative example, let us imagine that one intends to compare residential construction prices, and one part of the comparison involves the cost of the heating, ventilating, and air conditioning equipment. Three strategies (Figure 8) for the required costs seem possible. First, one could rigidly specify a given manufacturer, model number, and size for a given air conditioner, and require each participating country to provide a price for that exact unit. The results, as they cover identical items, would be comparable. However, this unit may be totally irrelevant in cold regions, or even in temperate regions where no equipment is specified. The prices reported for countries heavily influenced by such climates would be very artificial, and the ratio would as a result suffer from representativity deficiencies. Alternatively, one could produce a more flexible requirement, perhaps asking participating countries to provide a cost for the most common HVAC equipment used. Setting aside for the moment countries where no equipment is a common condition in homes, the resulting ratios would have the advantage of covering representative items in both the numerator and the denominator. However, one might very well question the comparability implied by a ratio of the cost of an electric air conditioner to the cost of a natural gas furnace, which is a very possible outcome from such a strategy. The relationships between representativity and comparability for these two strategies are shown on Figure 9.

<table>
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<tr>
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<th>Cost of identical items</th>
<th>Cost for the same item, but with local modifications</th>
<th>Cost of a typical item</th>
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<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Representativeness</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

Note: intensity of fill color represents degree to which indicated strategy achieves the characteristic.

*Figure 8: Price Collection Strategies*

One might choose to adopt a strategy somewhere in the middle by specifying items, but allowing the participant some latitude to substitute for local conditions. In this particular example, one might require that the respondents report prices for air conditioners, but allow variations in the manufacturer and the size of the unit reported to allow for some climatic variability. The result could be a ratio which is not highly comparable, and not highly representative, but somewhere in the middle on both characteristics (near the center of the plot of Figure 9). Of course, the ideal condition
would be to select items for pricing that are so widely used as to be highly representative and highly comparable, which would therefore be represented on Figure 9 in the region called the ideal condition. The reality of the industry, however, is that there are very few items that are so pervasive as to fit into this region. In general, the authors would expect that the longer the list of items requiring pricing, the more opportunity for problems with comparability and representativity to arise.

![Figure 9: Comparability and Representativity as a Euclidean Plane](image)

This argument should not be taken to imply that the authors believe that a very short list of materials or simply-specified services is likely to lead to effective cost comparison either. Construction cost indices in current use demonstrate rather easily that the basket of goods and services approach, by itself, is unlikely to predict construction output. Because the authors had easy access to them, in this case the ENR cost indices are used, but other indices could be used to demonstrate a similar point. The output price in this case is the cost of a home in the United States, here sensed by the median new home price reported by the US Census Bureau. Again, US data was chosen only because it was readily available to the authors. Figure 10 shows the US median home price (USMHP) and the ENR Lumber Cost Index (LCI) over the period 1997 to 2002. The LCI is a weighted cost index including both dimensional lumber and sheathing, and so represents the cost of the largest single structural component of the typical home.

Figure 10 demonstrates that the output price to the consumer may not be tightly coupled to the component costs of the materials from which the construction project is composed. In this case, the component material cost for lumber fluctuates somewhat but generally decreases over this time period, while the median home price conversely increases steadily. A cost estimate for the construction of the home would require the measurement of the quantity of component items, pricing those items, and determining the labor and equipment charges necessary to place the components into their required location and connect them to the whole. Land costs, profits, taxes, regulatory impacts, and pricing considerations would then modify the construction cost to develop the sales price for the home. Clearly, the input price of a single material cannot fully capture the total.

Carrying this analysis a little further, one can also identify ENR indices that incorporate more components of the total cost. ENR also produces a weighted Material Cost Index (MCI) and a Building Cost Index, which includes weighted contributions from cement, steel, lumber, and skilled labor. All of these indices are reported monthly. Figure 11 depicts the variation of these indices and
the US Median Home Price over the period 1997-2002. Because these indices cover a wide range of absolute values, they have all been normalized in Figure 11 in order to allow direct observation of the relative variation of each.

![Graph showing the relationship between US Median Home Price and ENR Lumber Cost Index, 1997 to 2002.](image)

**Figure 10: Relationship between US Median Home Price and ENR Lumber Cost Index, 1997 to 2002**

![Graph showing the variation in ENR Cost Indices and US Median Home Price, 1997-2002.](image)

**Figure 11: Variation in ENR Cost Indices and US Median Home Price, 1997-2002**

This analysis points out that there are significant differences in result for different kinds of cost indices. Index values which measure primarily the cost of commodities required for the construction process (such as the LCI or MCI) will have the advantages of being relatively easier to measure. Such costs are not based on estimates, but on actual costs for physical goods. The primary disadvantages
are that the indices do not include the labor productivity or the labor/equipment tradeoff, and from the analysis above these indices may not track very well with the actual cost to the consumer of the constructed facility (presumably the best measurement of the resulting GDP growth). Indices that include some labor content (such as the BCI) track the construction cost to the consumer somewhat better, but can be more complicated to measure. The BCI does capture labor, but as it includes only a set number of hours, rather than the labor or equipment needed to install a given quantity of some construction product, it does not really capture the productivity or labor/equipment tradeoff. Because labor and equipment are such important components of the construction enterprise, it seems clear that construction cost comparisons should incorporate them.

Carrying the preliminary analysis further, the author’s compiled monthly lumber pricing data for 1996 published by ENR for 20 major U.S. cities and two Canadian cities. Information published by ENR includes pricing information for 13 lumber items generally used in building construction in the U.S. and Canada. The motive behind this analysis was to assume a simple basket of construction materials and perform a comparison of pricing levels between Canada and U.S. using readily available data. The two-city average price in Canadian dollars was divided by 20-city average price in U.S. dollars for all the 13 construction materials as well for the entire basket to obtain a test PPP value for the construction sector. These calculations were performed on a monthly basis.

Figure 12 shows a plot of monthly PPP values calculated using the above approach alongside PPP calculations performed for Canada by the World Bank for 1996. Monthly PPP values calculated using 2”x8” common dimensional lumber that showed the maximum monthly price variation and monthly PPP values calculated using roofing insulation that showed the least amount of price variation are plotted. Also shown on the plot are the PPP calculations for Canada at the GDP level, construction sector level, and for residential construction and non-residential construction provided by the World Bank for 1996. This simple analysis shows that a basket of goods primarily comprised of one type of material used for construction projects does not yield a good estimate of the PPP.
Contributions of other construction materials and the influence of productivity are critical in the development of a PPP estimate. Another issue brought forth by this analysis is the price collection strategy. As can be seen from the plot, material prices show significant seasonal variations and as such should be considered in the design of the PPP calculation methodology. Dubner and McKenzie (2002) also raise this issue of national annual prices by arguing that the use of mid-year prices as annual averages might not be appropriate.

Incorporation of productivity is an important advantage of the standard project approach. For the sake of argument, let us assume for the moment that a project can be imagined that is representative and comparable. Even in this happy circumstance, the challenges for PPP calculation are not over. Many authors have pointed out that there can be a very wide range in cost estimates, and that these estimates can compare very poorly to the actual cost of the construction project at the end of the day. The Construction Industry Institute reported that a range of as much as $-50\%$ to $+100\%$ compared to the actual project cost can exist on early estimates of industrial projects, and even well done detailed estimates can range through $25\%$ (CII 1996, 1998). Oberlender and Trost (2001) evaluated factors that influence construction cost estimates. They found the following factors to be the most significant in determining the accuracy (measured by a comparison to the actual total installed cost) of a cost estimate. The factors are listed in order from most important to least important based upon Oberlender and Trost’s survey results:

- Degree to which basic process design is available to estimating team
- Team experience and availability of cost information
- Time allowed to prepare the estimate
- Degree to which site requirements (such as utility supply, design criteria) are described to the estimating team
- The bidding and labor climate
- The degree to which the estimating team is aligned with the project type and the owner
- The owner’s input on cost constraints
- Methods used for contingency selection and estimate review
- The degree to which a formalized estimating process is used by the estimating team
- The impact of taxes, government requirements, and change orders
- The use of technologies in the anticipated project process or estimating process

Of these items, it appears that all but the first are outside the control of the ICP. These issues cumulatively account for $75\%$ of the variations from the final total installed cost in Oberlender and Trost’s database. This means that a good deal of the potential scatter in construction cost estimates can be expected to actually exist in estimates produced for the ICP.

Aside from these influences, there is also the dependency of the accuracy of the estimate on the effort expended to produce the estimate (Curran, 1989). Sinclair, et al (2002) suggested a Pareto function to describe this relationship. Remer and Buchanan (2000) worked from a database of
estimates, costs to produce the estimates, and actual construction costs for a number of projects. They found an exponential relationship between the project cost and the cost to produce the estimate, with variable coefficients depending on the desired accuracy. Remer and Buchanan indicated as much as 50% variation between estimated and actual construction cost, down to as little as 5%, depending on the level of effort expended as measured by the cost of the estimate preparation process.

That the accuracy of the estimate is related to the effort expended is perhaps intuitive. Nonetheless, the implications for comparison of construction costs are significant. Wealthier nations are likely to be willing and/or able to devote the effort required to obtain accurate estimates for a standard project. Less wealthy nations may not be willing or able to do so, and as a consequence may develop less accurate estimates. The result is that significant fluctuations may result in subsequent iterations of the ICP, which fluctuations would be detrimental to confidence in the process and its results. The most effective way to address this concern, in the judgment of the authors, is to reduce the effort required for all participants. Such reduction would tend to have a normalizing effect on the level of effort dependency, and could be accomplished by reducing the scope of the estimating effort and the complexity of the projects estimated.

In spite of these problems, the standard project approach does allow for the inclusion of productivity and the labor/equipment tradeoff in the PPP calculation. The basket-of-goods approach, at least as commonly conducted with physical components, cannot capture these items. On the other hand, the advantage of the shorter list of items to price, and the ability to capture these prices more easily, cannot be overstated in terms of actually conducting the required comparisons.

What seems clear from the foregoing analyses is that the final system must have several important characteristics. These are:

- A relatively short list of items, in order to minimize the effort required to collect the data;
- Incorporation of productivity and the labor/equipment tradeoff into the result
- Items on the list should be representative of construction work performed in each country, meaning that they should be things that actually occur routinely rather than items with artificial pricing due to scarcity of use or lack of demand
- Items on the list should be comparable between countries, meaning that they should be as equivalent in objective and perceived value as possible in every country that participates

There are several obvious tensions in this list of characteristics. For example, the first item could be used to argue for a short list, while the remaining items lend themselves naturally to arguments for a long list. These two pressures are difficult to resolve using the polar extremes of the current standard project approach and the baskets-of-goods commonly used commercially in some countries for temporal price comparisons.

It therefore seems that a compromise must be reached that will allow the publication of a shorter list than the current EuroStat method, but will still maintain credibility on the other three dimensions of success. It is the authors’ belief that a revision to the basket-of-goods concept would serve such a compromise. The revised basket would require some expansion of the goods, in order to include items that adequately capture productivity and labor/equipment tradeoffs. Specifically, the researchers recommend the development of a “basket-of-construction-components” for use in the
PPP calculations for the construction sector. The use of the basket of construction components will probably result in a methodology that

**CONCEPTUAL MODEL**

The fundamental basis of the conceptual model proposed in this study is centered upon the idea of a construction component. As such the methodology proposed herein is called the Basket of Construction Components (BOCC). A construction component is a production unit or good measured at the level of its cost installed in a construction project. In a hierarchical setting a construction component falls between a construction project and a construction work item (Figure 6). A construction component is at an advanced stage of the production process thereby allowing inclusion of more than the rudimentary factors without introducing undue calculation complexity. The BOCC would capture estimates of installed components in the field. Pricing of the construction components here is intended to include the price of the good itself, the cost of the labor or equipment required to install it, and appropriate markups (taxes, fees, profit, etc.) A fixed contingency requirement should also be stated in the description of the BOCC. BOCC items would be chosen based on their ubiquity in construction worldwide, so that they would be inherently representative and inherently comparable. Based on the current ICP framework it seems three distinct BOCC might be needed for the proposed methodology. Figure 13 elucidates this point graphically.

![Figure 13: Proposed BOCC Framework](image)

Figure 14 shows a sample work breakdown for a typical residential building in its simplest form. At the lowest level of this breakdown, two construction components have been identified—one for the substructure and one for the superstructure of the residential building. Concrete footing as a component is present in a majority of residential buildings worldwide including one using wood framing for the superstructure as in the U.S. and one with masonry superstructure as in Asia and Latin America. Inclusion of such a component in the BOCC will allow a relatively accurate PPP calculation. On the other hand the reinforced concrete elevated slab component might not be so universally used. In North America, where superstructure of a residential building is built using wood framing, a reinforced concrete slab in the upper storey of the building will be absent. This process of evaluating the existing standard projects for their components, and assessing the ubiquity of the various components within a given region, could be used to establish the BOCC.
Figure 14: Work Breakdown for a Residential Building

Figure 15 provides a sample cost breakdown of the concrete footing component. Once a quantity (generally in cubic meters) is noted for the component, fairly detailed construction drawings and specifications for the component can be developed. The authors, based on their construction experience, believe that variation in construction specification will be minimal, as for example the concrete footing component is universally recognized and entails very few regional and local modifications.

Figure 15: Cost Breakdown of a Construction Component

Another important point brought forward by this figure is that cost of labor is a direct cost i.e. it is directly related to the quantity of work specified for the component. This inherently allows the inclusion of labor productivity in the cost calculations. A country where labor productivity is relatively high will use a lower labor factor in the calculations. Also included in the scheme is the equipment cost. This allows the calculation to directly capture the labor/equipment tradeoff. In a country where construction is equipment intensive, the construction equipment factor will be higher as compared to a country where labor is more often used.
From a conceptual point of view it will be important to develop a system that can be used to identify component contributions towards final construction output in order to establish weightings for the contents of the BOCC. A number of resources exist in this regard. Figure 16 shows a typical component contribution for building construction projects in North America. This information has been produced by R.S. Means based on their historical database for such projects in North America, and provides percentage contribution of various components towards final project cost. Using the BOQ from standard projects already available through ICP together with information similar to Figure 16 for other regions or nations, a similar construction component contribution listing can be developed for various regions of the world.

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Figure 16: Component Contributions for Building Construction (Source: RS Means Handbook for Estimating)

PROPOSED EXECUTION PLAN

The obvious question which then arises is what these “components” might be. To address this question, the authors propose that the existing standard project definitions form a reasonable starting point for developing the BOCC. The process envisioned would be as follows:

1) Obtain the standard projects currently used by ICP for the PPP calculations

2) Break these projects down to the component level, by which is meant to imply the smallest installed production unit. A work-breakdown structure approach to this process would likely be a reasonable approach to the componentizing of the standard projects.

3) Identify those components, which are common across all or nearly all of the standard projects. This is expected to result in a relatively short list. Probably the most
effective means of completing this step will be to begin at the regional level for purposes of identifying common elements first. Once done at the regional level, identification of elements of global commonality should be more straightforward.

4) Review the list of components which arises, and if considered necessary shorten or reorder at a higher level of aggregation.

5) Develop a set of documents, which describes in sufficient detail the desired quantity, configuration, and quality of each component.

6) Conduct test data collection using the resulting BOCC, seeking to identify data availability in participating countries as well as the statistical relationship between the resulting PPP ratios and other relative measures of the construction economies.

7) Finalize the BOCC based on this process, and roll out for routine data collection.

An example component might be a quantity of finished concrete floor. Concrete is ubiquitous in construction throughout the world, so that issues of comparability and representativity for the material itself should be minor. Design documents can be used to augment this characteristic by specification of standard measures of quality, such as 28-day strength and slump. Some elements of craftsmanship can be introduced by requiring the estimate for a somewhat oddly shaped area, for example an “L” shaped slab-on-grade floor of given dimensions resulting in the desired total floor area. Productivity differences between countries would be captured in much the same way as in the standard project approach, because the cost requested would be all-in, counting whatever labor is needed to install that set amount of slab-on-grade floor. Labor/equipment tradeoffs would also be inherently included, because standard practices for elements of the process could be priced using whatever method is commonly used in each country. In developed countries, activities such as mixing and finishing that are typically accomplished with equipment could be costed as such, and the converse would be true when labor is more common than equipment. Examples of additional components that are likely to be ubiquitous and candidates for inclusion include an elevated concrete slab (such as a second floor), a given length of trench of a specified width and depth, or hoisting of a given weight to a given height.

The authors envision a list of 10 to 20 components, with an expectation that these components would require collection of no more than 100 underlying unit prices. Estimation errors should be reduced by virtue of using relatively simple components with little complexity associated with them, so that estimation should be relatively easy. As a result, the accuracy of the estimate relative to actual installed costs should be enhanced. Furthermore, these simple items on this relatively short list should require much less specialized knowledge to complete, allowing more widespread participation.

**Future Research Needs**

The authors obviously believe that the construction-component-based approach holds promise for providing a workable and effective construction cost comparison system. Clearly, there is more work to do in order to realize this potential. The path forward described in the last section represents, in the judgment of the authors, a reasonable and realistic means of addressing the practical concerns of development of the system. However, it is important to remember that several agencies have attempted to develop systems in the past (notably the World Bank, EuroStat, OECD, and the Australian Bureau of Statistics). Each of these efforts shows evidence of the particular point-of-view of the lead agency. In order to develop a truly useful method, the authors believe that a coordinated effort involving a wide range of points-of-view will be the most effective. A cooperative
program involving experts in construction and economics/econometrics, as well as input from the major regional groups, will have the highest probability of success. The authors believe the growth of the system from the regions outward is a management mechanism which would organically foster just this sort of cooperative approach.

Aside from the purely practical issues raised by the development and deployment of a PPP system for construction, a number of related issues were pointed out during the course of this research. These issues are somewhat ancillary to the development of the system per se, both in terms of their immediacy and in terms of the research perspective. These issues are listed below as candidates for future research.

- Development of a test procedure that can with some certainty test the accuracy of the PPP calculations is needed. Currently recognized problems with the existing construction PPP system revolve mostly around the level of effort required to produce the desired result, rather than around the accuracy and appropriateness of the result. Overall PPP values are often compared in the literature to long-term average currency exchange rates or other economic measures as a means of assessing whether or not the PPP value is correct. It is not clear that this sort of approach is appropriate to the GDP subdivisions in general, or to the construction sector in particular. The authors have shown herein that different approaches will likely yield different results. In order for real confidence to accrue to the construction PPP values in the future, there must be some method of determining whether the results of any proposed system are reasonable and correct.

- Research in the area of hedonic methods for PPP calculations in the construction sector is needed. Numerous efforts, especially for the housing sector, have been reported in popular literature (e.g. Bailey et al. 1963, Wallace 1996). Regression and other econometric techniques have been used by various countries to develop temporal indices (OECD and EuroStat 2001). The authors believe that hedonic methods show promise as a means to improve comparability and representativity of the results.

- Another area that needs investigation is the use of artificial neural networks and other evolutionary computing techniques in the calculation of price indices. Past attempts in this area have remained inconclusive (Williams 1994), but the authors believe that this technique could be very powerful.

- Use of mathematical simulation has proven to be extremely beneficial in a number of application areas ranging from predicting service level of bank tellers to forecasting of debt for developing countries (Kumar et al. 1993). Recently EuroStat has used simulation as a way to test and validate some initial attempts at revising the construction sector PPP calculation approach (Stapel 2002). The authors believe that simulation can play a key role in the development, validation and testing of the BOCC approach. The BOCC approach, like the standard project approach, will require preparation of construction cost estimates, albeit with a shorter list of items fitting into a simpler whole. Still, it should be possible to assess the probable range of values for the necessary construction cost inputs (material, labor, and equipment). Simulation tools could then be used to evaluate the most likely value and the range of values for the PPP, taking into account offsetting errors.

- Current approaches to the construction pricing problem internationally should be surveyed. The utility of the overall PPP has been validated by many years of
application and use. A number of potential uses for construction PPPs can be imagined, particularly for international construction projects involving contractors and subcontractors from multiple nations. This kind of construction happens frequently right now, and the companies involved must have developed some solutions to the purchasing power parity issue for development of their own bids. The authors are aware of some such practices which rely on currency exchange rates, but believe there are other approaches in current use. A detailed review of completed international/multinational projects for purposes of assessing the approach taken to this problem could be useful in pointing out new approaches to the PPP calculation.
REFERENCES


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