

Construction Output Price Indices: Methodology [November 2014]

Executive Summary

This document describes the production and use of output price indices for construction, a separate report addresses construction input cost indices. Official construction price indices have been published since the 1960s, originally by the Ministry of Public Building and Works and subsequently by the Department of the Environment and the Property Services Agency and successor government departments and agencies. In recent years, indices have been produced by the Building Cost Information Service (BCIS) of the Royal Institution of Chartered Surveyors and Carillion, a major contracting company, and published by the Department for Business, Innovation and Skills. In 2013, the contract for production of the construction cost and price indices was awarded to AECOM, a construction consultancy firm, and part of that contract was to investigate and, if appropriate, develop alternative approaches to the production of the indices. The rationale behind the request for a new approach were concerns that both the methods and the data used were no longer appropriate due to sample size issues, number of revisions to published data and the transparency of the methodology.

This document relates to construction output price indices produced from data provided by AECOM and ONS to be published in the construction output statistics release. The first figures using the new approach will be published in December 2014 (Q3).

The key users of construction cost and price indices are the ONS to deflate construction output and new orders current price data and the construction industry, industry analysts, and public and private sector [client] organisations. Principal uses include:

- Deflating construction output
- National accounting purposes
- Pricing contracts
- Estimating activities
- Evaluating proposals
- Monitoring changes over time
- Operating cost reference systems
- Producing financial models for projects
- Updating estimated costs to current prices
- Analysing variations in projects
- Updating variation of price contracts
- Forecasting

Introduction

Issues with the previous methodology used to produce the construction price and cost indices (PCIs) have been identified in reviews by the Department of Enterprise and Regulatory Reform (BERR)^{1,2} and its successor, the Department for Business, Innovation and Skills (BIS)³, and in an assessment by the UK Statistics Authority^{4,5}. While some issues have been addressed, there remain concerns relating to sample sizes, revisions, coverage and transparency.

The previous methodology used to derive output price indices was predominantly based on tender price indices modelled to sector output in previous quarters. In turn tender price indices (TPIs) were derived from indexing Bills of Quantities (BoQ) against a base schedule of rates.

¹ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/16480/Davis_Langdon_report_-_BERR_final_revised_260310.doc

² https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/16481/BIS-response-to-Davis-Langdon-report.doc

³ <https://www.gov.uk/government/publications/uses-of-construction-prices-and-cost-indices-results-of-bis-consultation>

⁴ <http://www.statisticsauthority.gov.uk/assessment/assessment/assessment-reports/assessment-report-95---construction-price-and-cost-indices.pdf>

⁵ <http://www.statisticsauthority.gov.uk/assessment/assessment/assessment-reports/confirmation-of-designation-letters/letter-of-confirmation-as-national-statistics---assessment-report-95-and-169.pdf>

In the previous suite of indices there were four TPIs:

- Tender Price Index of Public Sector Building Non Housing (PUBSEC)
- Tender Price Index of Road Construction (ROADCON)
- Tender Price Index for Social Housing (TPISH) and
- Tender Price Index for All Construction (ALLCON)

In terms of deriving the TPIs, PUBSEC and ROADCON have suffered from a declining sample over a number of years, more specifically the number of projects submitted quarterly for indexing has steadily declined. In addition, any issues highlighted in the constituent components of ALLCON (i.e. PUBSEC and ROADCON specifically) was likely to have a corresponding impact on the representivity of the ALLCON series.

The decline in the number of BoQ for indexing is largely the result of a move away from more traditional procurement routes, where the use of BoQ was commonplace, towards alternative procurement routes i.e. design & build, public/private partnership (PPP) where the use of BoQ on projects is much less common. In our opinion the declining trend in sample sizes was likely to continue in future, this drew into question the representivity of the indices and the future of its supporting methodology.

In addition, the following index series were provided to ONS as output price indices and used directly in their estimation of construction deflators:

- Private housing OPI
- Public housing R&M OPI
- Private housing R&M OPI
- Public-private non-housing R&M OPI

The series above were based on the results of a quarterly survey of service providers. Again the trends in most sample sizes were declining, some to levels where the representivity of the results were drawn into question.

Derivation of Output Price Indices

Since AECOM were awarded the contract for the development and production of the PCI we have spent the past fifteen months reviewing the previous approach and suggesting methodological improvements for both the construction input cost series and the construction output price series.

Our approach to the PCI now includes direct price observation within the input cost series and a secondary data approach in the derivation of the output price series, essentially the inverse of the previous approach which used secondary data to derive the input cost series and direct price observation to estimate the tender price indices which subsequently informed the output price series.

Input costs are the prices paid by contractors to their suppliers, not the prices charged to their customers which is what is required for output price estimation (see separate methodology document for a description of the methodology used to derive the input cost series). However, it is possible with adjustments to input costs to derive estimates of output prices. More specifically, adjustment from costs to prices can involve using markups as additions to input costs. Our aim therefore was to identify a series of markups that best reflected supplier's profit margin, productivity and overhead which are then applied to the input costs paid by contractors to arrive at the price contractors charge to their clients, i.e. the output price.

This document contains the following sections:

- About the output
 - o Relevance
 - o Sources of data
 - o Timeliness
- How the output is created
- Concepts and definitions

About the Output

Relevance

Output price indices should reflect, as accurately as possible, the price contractors charge to clients for a construction project at a particular moment in time.

OECD⁶ guidance indicates that the difference between an Output Price Index (OPI) and an Input Cost Index (ICI) can be attributed to three elements: supplier's profit margin, productivity and overhead. AECOM in conjunction with the ONS have developed a series of markups which estimate the three elements described. The markup is subsequently applied to the cost of materials, products, equipment hire and labour, included within the ICI to derive an output price index. This approach is based on the assumption that the output price contractors charge to clients reflects a markup over the cost faced by contractors.

The aim is to produce different output price trends for the diverse types of construction work (market based not construction projects related). The approach aims to model profit margins, productivity and overheads as a unique markup based on economic theory, rather than direct price observation. The method has the following advantages:

- Provides linkages to national accounts and other relevant statistics (i.e. better alignment with the standard industrial classification)
- Facilitates data collection through the use of published data (uses existing data sources that have been subject to quality review)
- Provides a transparent and replicable methodology throughout the different sectors of the construction industry
- Allows for the measurement of changes over time in markups in the construction industry

Sources of Data

All of the data used to derive the OPI are published collections available through official sources. Broadly speaking the data sources used include:

- Construction input costs
- Construction employment (employees & self-employed)
- Average weekly earnings in construction
- Value of work in the construction industry (at current prices)

Timeliness and Punctuality

Results are published at quarterly intervals, as follows:

- 1Q (January – March) is published in June
- 2Q (April – June) is published in September
- 3Q (July – September) is published in December
- 4Q (October – December) is published in March

As a result of the data collection method used there is limited need for provisional data with minimal amendments/revisions to previously published series. However, there are elements which might be subject to revision and which could therefore result in amendments/revisions to the indices as previously published:

- Construction Output <http://www.ons.gov.uk/ons/rel/construction/output-in-the-construction-industry/august-2014/stb-construction-august-2014.html#tab-Output-in-the-Construction-Industry---August-2014>
- Value of work in the construction industry at current prices <http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-332700>
- Average Construction Earnings <http://ons.gov.uk/ons/taxonomy/index.html?nscl=Earnings>
- Average Regional Earnings <http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Earnings+by+Region>
- Construction Employment <http://www.ons.gov.uk/ons/taxonomy/index.html?nscl=Building+and+Construction+Employment>

⁶ OECD (2002), Sources and Methods Construction Price Indices <http://www.oecd.org/industry/business-stats/2372435.pdf>
www.aecom.com

How the Output is Created

The theoretical assumptions upon which the OPI methodology is based follows the approach outlined by the ONS in their consultation response, which itself references Macallan (2008)⁷, Martins (1996)⁸, Phelps & Winter (1970)⁹ and Rotemberg & Woodford (1992)¹⁰. The approach is based on deriving an implied markup term that estimates profit margins, productivity and overheads in construction. The ONS consultation response can be found in the BIS response to the consultation.¹¹

Following Macallan (2008) it is noted that a “...method of estimating the markup is to make an assumption about how businesses combine inputs to produce output...” through their production function. If “businesses have a ‘Cobb-Douglas’ production function... the markup will be proportional to the inverse of their labour share¹²”.

This implies that the markup for any given unit of output can be expressed as a function of the amount of nominal GDP that accrues to workers in the form of compensation of employees and the elasticity of output with respect to the labour input. Furthermore, with a Cobb-Douglas production function, the elasticity of output with respect to labour is shown to be a constant and has no impact on the change in the markup. The Cobb-Douglas function provides the benchmark production framework for any given unit of output (y), which has as inputs: labour (h), fixed capital (k), consumption of intermediate goods (x) and their respective elasticity (α, β, γ). Mathematically this can be expressed as (1):

$$y = f(h, k, x) = h^{\alpha} k^{\beta} x^{\gamma}; \quad (1)$$

It is also assumed that each firm’s objective is to maximise profits, subject to the constraints of the production function and the demand it faces for its products (represented in this case by any construction project). A firm’s profit is equal to the revenue from its output less the costs of the inputs, which are represented by quantities of deployed labour, capital and intermediate goods, multiplied by their respective unit costs.

It is noted that the profit maximisation is subject to the firm’s ability to produce (algebraically: $[y = f(h, k, x)]$; (2)) and the request of products from the market, being a function of market prices (algebraically: $[y = g(P)]$; (3)). The equation (4) can be solved when the function is differentiable, through a Lagrange function.

I.e. Maximise profits yields to maximizing: $\pi = Py - Wh - rPk - qx$; (4)

In addition to maximising profits, the firms are subject to a cost minimisation constraint, subject to their production function. The solution to this problem implies the firm’s cost function (C) is a function of the unit labour costs (W), the unit capital costs (rP), the unit intermediate goods costs (q) and the output produced (y), algebraically: $C(W, rP, q, y)$ (5). This equation also needs to be solved through the application of the first order conditions which lead to the marginal cost equation (6).

$$MC = \frac{\partial C(W, rP, q, y)}{\partial y} = \frac{\partial C(W, rP, q)}{\partial y}; \quad (6)$$

Intuitively, this means that the marginal cost of production equates to the sum of the marginal costs of each individual input. The total differential can be substituted into the marginal cost equation; through an algebraic simplification the terms yield to the output price shown to equate to the marginal cost multiplied by a markup (7).

$$P = MC \cdot A \quad (7)$$

The markup (denoted by the letter “A” in equation 7) can be rewritten in terms of the labour share (s), and the elasticity of output with respect to labour input (α). The labour share equates to the proportion of the value of output that is distributed to labour in the form of labour compensation, while the elasticity (α) can be thought of as the responsiveness of output with respect to a change in labour which can be written as (8):

⁷ Macallan, C (2008), “The cyclicity of markups and profit margins for the United Kingdom: some new evidence,” *Bank of England Working Paper No. 351*

⁸ Martins, J (1996), “Markup pricing. Market structure and the business cycle,” *OECD Economic Studies No. 27*

⁹ Phelps, E S and Winter (1970), SG, “Optimal price policy under atomistic competition,” *Microeconomic foundations of employment and inflation theory*

¹⁰ Rotemberg, J and Woodford, M (1992), “Oligopolistic pricing and the effects of aggregate demand on economic activity,” *Journal of Political Economy*

¹¹ [BIS response to the PCI methodology consultation](#)

¹² Macallan, C, (2008) “The cyclicity of markups and profit margins for the United Kingdom: some new evidence,” *Bank of England Working Paper No. 351*

$$\alpha = \frac{dy}{dh} \cdot \frac{h}{y}; \quad (8)$$

The latter can be rearranged in terms of the elasticity of output with respect to labour input (9):

$$f_h(h, k, x) \cdot \frac{h}{y} = \frac{dy}{dh} \cdot \frac{h}{y} = \alpha; \quad (9)$$

Thus (10):

$$A = \frac{hf_h(h, k, x)}{y} \cdot \frac{Py}{Wh} \rightarrow A = f_h(h, k, x) \cdot \frac{h}{y} \cdot \frac{Py}{Wh} = \frac{\alpha}{s}; \quad (10)$$

From the Cobb-Douglas assumption made at the start of this note (1), the elasticity of output with respect to labour is a constant (α). Therefore the markup (A) is inversely proportional to the labour share (11):

$$A = \frac{\alpha}{s}; \quad (11)$$

As we are scaling the inverse labour share by a constant factor (α), the change in the markup will solely equate to the change in the labour share (12) and (13).

$$A_t = \frac{\alpha}{S_t}; \quad (12) \Rightarrow a_t = \ln(\alpha) + \ln\left(\frac{1}{S_t}\right); \quad (13)$$

Here S_t is defined as the labour share and α equates to the elasticity of output with respect to labour input. In line with the project requirements all data used in the calculations are derived from official data sources. The results are subsequently adjusted to smooth the effect of seasonality using an ARIMA model, specifically a 5-term *Henderson* filter.

Having calculated the markup (A) for the construction industry, it is subsequently applied to the different construction input cost series (ICI) as a multiplier to obtain output price series by type of work.

Regional Output Prices

It is assumed that, on average, the cost of materials, machinery and equipment is broadly comparable across regions. Similarly, the regulatory system and the market structure are consistent throughout the country, allowing for profit margins, productivity and overheads to vary with a comparable trend across different locations. *Ceteris paribus*, the main factor accounting for price variation across regions is represented by differences in the cost of labour.

These assumptions are adopted to create regional input costs by sector and types of work, the regional input costs are then inflated by the markup, as described in the previous section, to produce regional OPI.

Concepts and Definitions

Construction output price indices are produced for:

Type of work/sector

- New Work
 - Public housing
 - Private housing
 - Infrastructure
 - Public non housing
 - Private industrial
 - Private commercial
- Repair and Maintenance Work
 - Public housing
 - Private housing
 - Non-housing
- All Construction

Region	
Yorkshire and the Humber	East Midlands
East of England	London
South East	South West
Wales	West Midlands
North West	Scotland
North East	

Reliability

Assessing the revision between the first published estimate and the final estimate provides an indication of reliability. Revisions are monitored on a quarterly basis.

Other information

Future changes

One area within the current approach where we believe there might be scope for further improvement is in the derivation of sector specific markup terms and we will be investigating the options for deriving these going forward.