FORECASTING THE NUMBER OF JOBS CREATED THROUGH CONSTRUCTION

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The construction sector is one of the largest single contributors to employment. A wide and varied set of metrics is used by official channels to predict the number of jobs that will be created for a given value of construction expenditure. These values tend to be shrouded in context specificity (ie, a peak workforce, or number of jobs created for one year) which meet the agenda of the organisation making the announcement. The research reported in this paper reviews the outcomes of five years of research into labour forecasting culminating in the development of the Labour Forecasting Tool (LFT). The research explores three approaches to deriving labour coefficients (the amount of labour per £m of construction value): i) a review of historic data produced by contractors; ii) a theoretical build-up of labour from bills of quantities and iii) an analysis of published UK national statistics. The shortfalls and advantages of each approach are discussed along with the results of a triangulation of the three methods to test the accuracy of the results. Encouragingly, the results point towards a strong agreement between the three approaches. However, whilst the labour coefficient can provide an estimate of the total labour demand in person-years this must be translated to a meaningful measure of the construction jobs created. To do so requires an understanding of the labour flow during a project. The LFT is capable of producing a month-by-month, trade-by trade forecast for a project by the use of a bespoke algorithm. Using the LFT, results are presented for eight typical projects within seven construction sectors. The significant impact of project duration on peak labour demand is shown. The conclusion can be drawn that any discussion of 'jobs created' must be clearly presented in the context in which it is reported.

Keywords: employment, labour forecasting, productivity

INTRODUCTION

In the current global economic climate, governments and developers are keen to predict the number of jobs created by their investments. Construction is one of the largest single sectors in the economy. Economically, the industry employs nearly 3 million people, outputs £100 billion worth of work per year and accounts for 8% of gross domestic product (HM Government, 2008). In these austere times the lack of

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growth in the construction industry is regularly cited as the cause of overall contraction in the economy (Office for National Statistics, 2012). However, at a more detailed level the question remains of how many jobs are created by construction expenditure for a given project.

There are a number of reasons why the number of jobs created by a given project might be required. One of the primary reasons is that those who are investing want to publicise the impact of their contribution. Therefore, public relation staff will issue press releases stating "X number of construction jobs created" by a particular new-build project. However, what is not immediately clear from such assertions is the rationale for calculating the number of jobs created and exactly what is meant by "a job". For instance, does it refer to the peak workforce and over what period of time will the jobs be created? A further reason for estimating the number of people employed is the increasing requirement from government at all levels to upskill the workforce. Planning requirements such as Section 106 Agreements under the Town and Country Planning Act 1990 allow local authorities to specify community benefits. Increasingly these are being used to ensure broader benefits such as increase in targeted recruitment and training. However, to be able to negotiate the training levels with developers, local authorities must first know the demand created by the project.

The aim of this research is to create a labour forecasting tool capable of forecasting on a project-by-project basis. This tool predicts at early planning stages when very little information is known about the project. The tool was originally commissioned by CITB-ConstructionSkills to inform the demands for training in its National Skills Academies for Construction (Forbes *et al.* 2009). The Academies focused on project-based training centres and therefore a need existed to forecast the demand for labour of all kinds, including professionals. Creating a fully evidence-based breakdown by month and by occupation is a vital starting point in developing realistic employment and skills plans for a project as well as determining requirements for targeted recruitment and training.

A secondary aim of the research presented in this paper is to compare the outputs of the Labour Forecasting Tool (LFT) with a selection of media reports of the number of jobs created by construction projects. Using articles publicising the number of jobs created in various projects and inputting these project parameters to the LFT estimates of the labour demand have been obtained. Using these it is possible to gain insight into the assumptions that are made in predicting the labour demand and the impact of these on the claims for the number of jobs created.

ESTIMATING THE LABOUR DEMAND IN CONSTRUCTION

Labour forecasting at an early stage of a project inception is a topic that has not received significant research attention in the literature. From a labour forecasting perspective Chan *et al.* (2006) developed a manpower planning model for Hong Kong. This model was designed with the aim of allowing government to compare where they might generate the most jobs from public investment. The tool split projects into 10 equal phases to determine the labour flow through the project and demand at each stage. Their approach calculates the average number of jobs created:

$$\text{Number of jobs created} = \frac{\text{Total labour requirements (in man-months)}}{\text{Project duration (in months)}}$$

Ball and Wood (1995) explored the issue of job creation from construction and reviewed the existing publications on the number of jobs per £1m of construction.

They found that these varied by up to 100% and that there was a need to develop new estimates using site-based information. Proverbs et el (1999) developed an approach designed for estimating labour at the inception stage. This created a measure of labour hours based on the floor area of a building and was restricted to a concrete framed high rise structures using productivity rates for each task. More recently, Anumba *et al.* (2006) considered the problem of supply and demand in construction labour market planning. They concluded that the GIS approach which they developed should be used in conjunction with other labour forecasting approaches and that there was a particular need to look at the sub-regional level. Such sub-regional data did not exist in 2005 and it is at this level that our Labour Forecasting Tool contributes.

In an approach that is designed to provide quick estimates of the number of jobs per year created from construction the former Regional Development Agency, One North East (2010) published guidance. For new build projects they recommended coefficients from between 10.6 and 21.0 jobs per £m output per year at 2009 prices. Personal correspondence in 2012 with Scottish Enterprise suggested a similar approach. They currently use one job per £75,000 of expenditure. This value is derived by assessing the turnover per employee in the construction industry from national statistics. This equates to 13.3 jobs per £m construction and is therefore comparable with the outputs from One North East.

Overall there is a need to explore how labour can be forecast at an early stage of a project when very little is known about the project except an outline budget. The research presented attempts to create a forecast with a rigorous, evidence-based approach and develop a tool which can forecast labour demand initially for the UK.

THE LABOUR FORECASTING TOOL

The Labour Forecasting Tool was initially developed in 2008 for CITB-ConstructionSkills. CITB-ConstructionSkills are the industry training board and the Sector Skills Council for Construction in the UK. The tool was developed to create project-based forecasts. It can be used to forecast the labour demand on a month-by-month basis broken down by each of 26 occupations shown in Table 1. To create this forecast the tool needs to know a) the project type; b) the project value and price ruling date (exclusive of any land or site preparation costs); c) the location (by UK region); and d) start date & end date/duration.

Land costs and site preparation costs are excluded from the forecast as preliminary investigation led to the conclusion that these tended to be site specific. Examples of site preparation costs include extensive earthworks or contaminated land restoration.

For the project types, the level of granularity is maintained at a high level. The types are defined by the seven sectors used by the Office for National Statistics (Office for National Statistics (2010). This produces high-level forecasts at a sector level and ongoing work is seeking to improve the granularity of these to improve the forecasts of specific building types. Forecasting at this level maintains consistency with the data which is available. The seven sectors are:

- Housing
- Infrastructure
- Public non-residential
- Private industrial
- Private commercial
- Housing repair and maintenance

- Non-housing repair and maintenance.

For each of the forecasts produced, it is possible to select which of the 26 occupations are required. These occupations are defined by the 26 Standard Occupational Classifications (SOCs) produced by CITB-ConstructionSkills. In producing a forecast using these occupations a picture is obtained of the total labour involved in a project including both site and non-site based staff.

Table 1: List of Standard Occupational Classifications

Senior, executive and business process managers (SOC01)	Plant operatives (SOC14)
Construction managers (SOC02)	Plant mechanics/fitters (SOC15)
Non construction professional, technical, IT, and other office based staff (excl. managers) (SOC03)	Steel erectors/structural (SOC16)
Wood trades and interior fit-out (SOC04)	Labourers nec (SOC17)
Bricklayers (SOC05)	Electrical trades and installation (SOC18)
Building envelope specialists (SOC06)	Plumbing and heating, ventilation, and air conditioning trades (SOC19)
Painters and decorators (SOC07)	Logistics (SOC20)
Plasterers and dry liners (SOC08)	Civil engineering operatives not elsewhere classified (SOC21)
Roofers (SOC09)	Non–construction operatives (SOC22)
Floorers (SOC10)	Civil engineers (SOC23)
Glaziers (SOC11)	Other construction professionals and technical staff (SOC24)
Specialist building operatives not elsewhere classified (SOC12)	Architects (SOC25)
Scaffolders (SOC13)	Surveyors (SOC26)

Sources of data

The aim of the LFT is to predict the labour demand at an early stage when there is little known about the specific characteristics of the project. For instance, it may not be known whether the housing project is timber framed or non-timber framed. Therefore, the data which underlies the tool is taken as an average across all of the sub-sectors within each of the seven sectors as data is not available at a sufficiently detailed level to allow a more detailed analysis to be undertaken. It is not the aim of this paper to outline the analysis undertaken in detail; the processes is summarised here for completeness along with the shortfalls and benefits of each approach. Please refer to Forbes *et al.* (2009) for more details.

At the seven sector level three sources of data are used to populate the LFT. The first of these and the most comprehensive is the analysis of Office for National Statistics (ONS) data. Data is published for the number of each occupation employed in each year and the total output (£m) from each sector. This data is used to create 26 occupational labour coefficients (person-years/£m) for each of the sectors. One of the difficulties in using national data is that the aggregation process provides an average across the sectors. However, at the stage the LFT is designed to be used this is not a problem and is far outweighed by the breadth of the data available for the analysis. The labour coefficient in each SOC is each industrial sector was established by

solving a large set of simultaneous equations. As data in from the ONS is published annually a continuous updating process can be undertaken.

Although the data from the ONS is the most complete and comprehensive two additional sources of data were analysed to verify the initial analysis. The first of these was a review of actual data from contractors on historic projects. This is the richest and most reliable source of data and would be the data of choice for use in forecasting. However this presented challenges in obtaining the data in the required format for the range of projects and trades. Where this data is available it is a very rich source which provides the exact labour data for a project. However, there were particular issues in relation to contractors who sub-contracted all or part of the works as labour records were rarely kept. The final source of data to determine labour coefficients was to create a theoretical build-up of labour by assigning the labour requirements to bills of quantities. This is similar to the approach used by Proverbs *et al.* (1999). Whilst this proved effective it was time consuming and therefore not feasible on a large number of bills. Attempts were made to automate the process but a lack of consistency in the production of bills of quantities rendered this ineffective.

However, following the two additional analyses there emerged sufficient data that the values arising from the ONS analysis could be triangulated. The results showed that there was a degree of uniformity between the outputs from the various analyses and thereby providing considerable confidence in the results.

Factors affecting the labour forecast

There is a multitude of factors which might affect the labour requirements for a construction project. The assumptions which are made regarding labour productivity (Horner and Duff, 2001) and the construction method are amongst a few. At the stage the LFT is designed to be used it is not necessary to take account of all of the differing factors and indeed likely to be impossible. However, the LFT does take account of two factors in determining the labour demand:

a) the different points at which each trade arrives on and leaves site (for instance finishing trades will start and finish on site later than ground works) and

b) the labour flow throughout the project (the shape of the "s-curve").

By taking account of these it is possible to translate the overall labour demand from a labour coefficient (person-years/£m) to a number of people in each month. However, both factors can have a significant impact on the peak labour demand and their interaction affects the peak. For instance, if the assumption is made that a particular trade is on site for the entire duration the peak will be lower than for the same labour profile that is only on site for say 75% of the project.

The Labour Forecasting Tool takes account of these factors by best-fitting s-curves and lead and lag times for each occupation in each sector. These have been fitted to historic data from contractors. Fitting data in this manner overcomes some of the limitations of models which split a project into a number of equal periods such as Chan *et al.*'s (2006) model for Hong Kong.

FORECASTS OF EMPLOYMENT ARISING FROM CONSTRUCTION

The media regularly run reports from developers, government agencies and other organisations providing headline-grabbing figures of the number of jobs that will be created by a particular new development. This section outlines outputs from the

Labour Forecasting Tool for projects which have hit the headlines. Table 2 outlines the characteristics of eight projects representing a range of sectors, regions and values. All have been featured in recent news articles from different sources. The sources of these are provided.

Table 2: The projects

Project	Type	Description	Location	Value	Duration	Source
1	Housing	Conversion of existing building to student accommodation	East Midlands	£30m	2 years	http://bit.ly/Ia1aBm
2	Commercial	Construction of new office accommodation	Scotland	£34m	20 months	http://bit.ly/IlmfEw
3	Public non-residential	Construction of University Arts Building	Wales	£40m	2 years	http://bit.ly/I31Qod
4	Commercial	New retail development	West Midlands	£150m	33 months	http://bit.ly/Jvysw7
5	Infrastructure	New road construction	Scotland	£320m	2 years	http://bit.ly/I6EuAn
6	Industrial	Pharmaceutical factory	North West/Scotland	£350m	6 years	http://bit.ly/JvfYN6
7	Infrastructure	New road construction	Scotland	£445m	3 years	http://bit.ly/JvfWF8
8	Infrastructure	Large infrastructure project to form new logistic park	South East	£647m	3 years	http://bit.ly/I31P3A

Each of the eight projects was input to the LFT and a labour profile created for the project. Sufficient information was available from each of the articles to assess the input parameters for the LFT. The assumptions which were made related to the project values. In none of the cases was it explicitly stated whether the value included land costs. Given the nature of the articles, it was assumed that land costs were excluded from the figures. It was not clear whether site preparation costs were included. However, it was assumed that the total jobs presented would relate to value which was presented and so site preparation costs would therefore be reflected in the overall labour demand. The impact of site preparation costs would be to produce a separate peak, or at the very least a rise in labour at an early stage in the project. This would reduce the overall peak labour demand but the effect of this is not likely to be significant as has been tested in preliminary forecasting work.

A further assumption was made in relation to the price ruling date. None of the articles stated the date for the value given. In the absence of this data it was assumed that the price ruling date was the date of publication. However, there has been very little fluctuation in tender price indices in the last four years, so this is likely to have little impact.

The Labour Forecasting Tool was run twice for each project. Figure 1 shows an example output for project 6 for all 26 occupations.

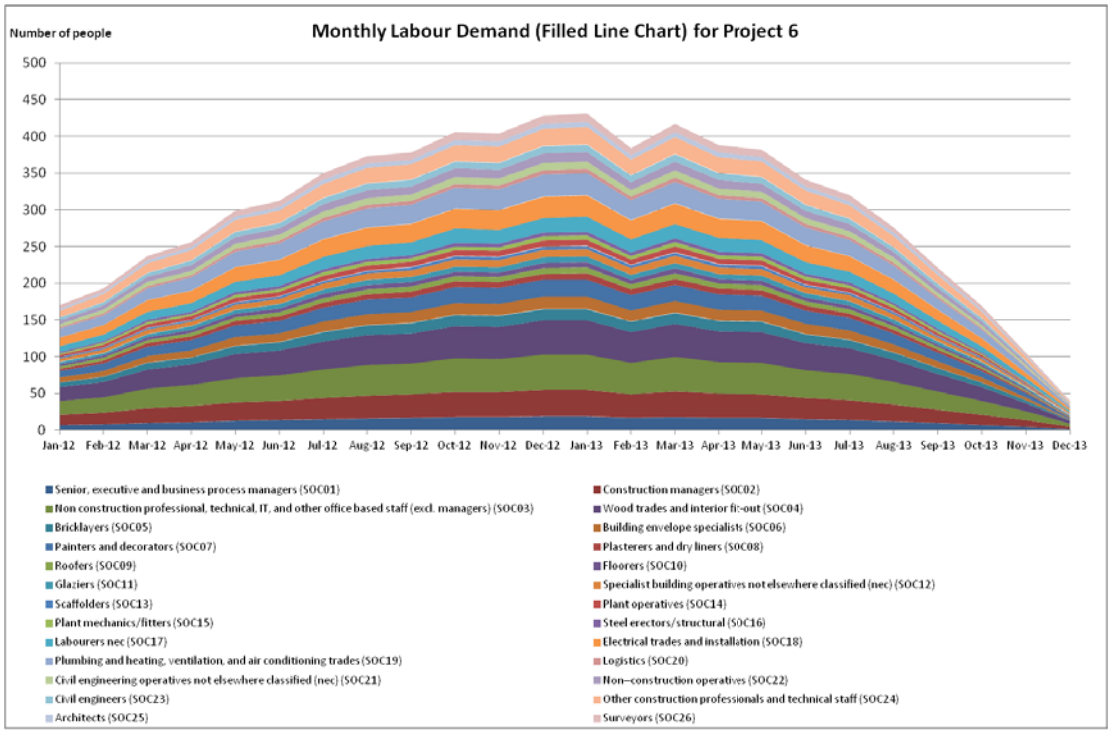

Figure 1: Labour forecast for Project 6 (total labour on the project)

An initial forecast was produced for the 19 of the 26 SOCs which are site-based. The outputs from the tool for this are shown in Table 3 for both the peak workforce (which may only last for one month) and the average workforce over the whole project. This average workforce uses Chan *et al.*'s (2006) conversion to number of jobs. The number of jobs created by the project as published is also shown. For project 2, which is split between Scotland and the North West, an average of the outputs for the two regions was used. This implies the assumption that the project is equally split between the two regions. It should be noted that there is a 5% difference in tender price indices between these regions.

Table 3: A comparison of the site-based jobs created

Project	Number of jobs created as advertised	Total Jobs Created		Site-based Jobs Created	
		LFT Forecast - Peak (% difference)	LFT Forecast - average (% difference)	LFT Forecast - Peak (% difference)	LFT Forecast - average (% difference)
1	200	431 (116%)	303 (52%)	276 (38%)	174 (-13%)
2	250	1290 (416%)	593 (137%)	834 (234%)	359 (44%)
3	350	361 (3%)	158 (-55%)	232 (-34%)	100 (-71%)
4	450	2127 (373%)	1463 (225%)	1359 (202%)	934 (108%)
5	500	1947 (289%)	1378 (176%)	1243 (149%)	879 (76%)
6	300	587 (96%)	438 (46%)	376 (25%)	280 (-7%)
7	350	1873 (435%)	1302 (272%)	1173(235%)	831 (137%)
8	700	2554 (265%)	1806 (158%)	1631 (133%)	1153 (65%)

Table 3 also shows the results for the second run of the tool for all 26 occupations. This produces an estimate of the total number of people involved in the project including both the site and non-site based staff. Table 4 explores the impact of

spreading the construction spends equally over each year of construction. From this and the number of jobs advertised by the developer the jobs per average spend per year can be seen. The table shows that there is a marked difference in the number of jobs which have been forecast. For comparison the number of jobs created using industry wide averages proposed by Scottish Enterprise have been included. These multiply the average spend by the coefficient of 13.3 jobs/£m. The total number of jobs per average spend of output is shown alongside. These show no correlation between the number of jobs advertised and the outputs from the LFT.

Table 4: An approximation of coefficients used in published articles

Project	Project value (£m)	Duration (years)	Average spend (£m)/year	Number of jobs created as advertised	Jobs/average spend/year (as advertised)	Number of jobs created using industry-wide average	Jobs/average spend/year (LFT outputs)	
							Total	Site
1	30	2	15	200	13.33	200	20.20	9.80
2	34	1.67	20	250	12.25	272	29.65	17.95
3	40	2	20	350	17.50	266	7.90	5.00
4	150	2.75	55	450	8.25	727	26.60	16.98
5	320	2	160	500	3.13	2133	8.61	5.49
6	350	6	58	300	5.14	777	7.55	4.83
7	445	3	148	350	2.36	1977	8.80	5.61
8	647	3	216	700	3.25	2875	8.36	5.34

DISCUSSION

The Labour Forecasting Tool is a unique tool which offers the opportunity to forecast the labour demand on a project at a very early stage in the UK. There are limitations associated with the use of the tool as it uses average outputs from historic projects and applies them to a new project. However, at an early planning stage it is not practical to produce a detailed build-up of labour that will be subject to much change. The LFT offers a quick estimate of the labour demand

The results presented in Table 3 shows that on the whole the Labour Forecasting Tool produces higher estimates of the number of jobs created from new-build construction work than those published.

There are a number of reasons why this might be the case. Whilst a developer wishes to promote their credentials by generating a large number of jobs from a new-build construction they may also wish this to be downplayed. Increasingly planning requirements are being placed on contractors to train a proportion of their workforce. Developers therefore may have a vested interest in keeping published figures as low as possible.

One of the key items that ought to be noted in the outputs is the differences between the peak and the average workforces. The peak workforce is dependent upon the lead and lag times for each occupation and the shape of the s-curve that has been derived for each occupation. The data presented in Table 3 shows some marked differences between the peak and the average workforces produced by the LFT. In some cases

these result in a reduction of 50% from peak to average. However, it should be noted that at some point in the peak month or months the number of people employed on the site will be equal or close to the peak workforce. However, it is unlikely that this will be sustained for more than handful of weeks. The project duration taken from Table 2 will also have an impact on the peak. A longer project than anticipated will have a lower peak; a shorter project will have a higher peak. It is clear from Table 2 that most of the projects have had their duration rounded to a yearly period. Therefore the exact peak labour demand may vary.

One particular sector forecast which should be used with caution is the infrastructure sector. This is a particularly broad sector ranging from tunnelling, highways, water treatment etc. Therefore it is difficult without greater degrees of granularity to produce detailed forecasts. This applies to projects 1, 3 and 7. However, the LFT outputs for these projects are not at the extremes of the divergence from the advertised number of jobs.

Table 4 shows that the variations in the number of jobs advertised do not vary in proportion to the project values. This is not unexpected as the sources of the articles vary, as do the reasons for publication. However, in effect they are all making the same claims and ought therefore to provide relatively consistent results. There is no consistency with the average spend per year. All of the projects, except 8 produce jobs per average spend that are below that proposed by Scottish Enterprise and 8 is within the range suggested by One North East. Using the industry wide figures proposed by Scottish Enterprise creates a forecast number of jobs that is greater than advertised in all the projects except 8. These figures are more closely aligned with the values forecast by the LFT.

CONCLUSIONS

The culmination of five years of research is a Labour Forecasting Tool which can generate an indication of the likely labour demand on a project at a stage when only minimal information is known about the project. It can act as a useful tool in workforce planning and in influencing employment and skills plans. There are obvious limitations to the tool given the stage at which it is designed to be used. It cannot be used to accurately plan and programme a specific project but instead provide guidance to the skills needs when no other information is available. The tool is fully functioning and usable at the seven sector level and current work is exploring how it can be populated with additional data at a greater degree of granularity. This work is focussing primarily on the infrastructure sector and the application to tunnelling, and energy generation projects.

The data underlying the tool is derived from a range of sources and its reliability has been tested by triangulating the outputs from national statistical data, actual out turn data from sites and theoretical approach from bills of quantities. All of the data sets were independent of each other and converge towards the same values. This would lead to the conclusion that a degree of accuracy can confidently be placed in the results of the tool. The research presented in this paper has compared the LFT outputs with the forecasts from the developers in the press and also the approaches proposed by Scottish Enterprise. The LFT outputs are aligned with the values from Scottish Enterprise even though they are divergent from the developers' articles. This would suggest that the LFT is an appropriate tool for government agencies and departments to use to predict the labour demand from construction projects.

The comparisons that have been undertaken between the numbers of jobs created as published by developers and as forecast by the LFT have highlighted some marked differences that exist. In most cases the total number of jobs predicted in the news articles is an underestimate compared to the LFT for both the peak and the average workforce values. Whilst it is difficult to draw any particular conclusions about the causes of this without obtaining further background information and data pertaining to the project it is vital that any figures relating to "jobs created" are treated very carefully. The context for which the numbers are presented ought to be clearly stated. It should be clear whether the total of people employed relates to a peak or average workforce. It has been shown that the impact of this can be substantial and can have an impact on training levels and the development of employment and skills plans.

REFERENCES

Anumba, C E H, Dainty, A, Ison, S and Sergeant, A (2006) Understanding structural and cultural impediments to ICT system integration: A GIS-based case study. Engineering, Construction and Architectural Management, 13(6), 616-33.

Ball, M and Wood, A (1995) How many jobs does construction expenditure generate? Construction Management and Economics, **13**(4), 307-18.

Chan, A P C, Chiang, Y H, Mak, S W K, Choy, L H T and M.W.Wong, J (2006) Forecasting the demand for construction skills in Hong Kong. Construction Innovation: Information, Process, Management, **6**(1), 3-19.

Forbes, D, El-Haram, M, Horner, M, Hatton, D and Evans, A (2009) Estimating the labour demand for housing construction. In: Dainty, a R J (Ed.), Procs 25th Annual ARCOM Conference, 7-9 September 2009, Albert Hall, Nottingham. Association of Researchers in Construction Management, **1**, 655-63.

Horner, M and Duff, R (2001) "More for Less: A contractor's guide to improving productivity in construction". London: CIRIA.

HM Government (2008) Strategy for Sustainable Construction. [Available online from: http://www.berr.gov.uk/files/file46535.pdf], accessed 10 June 2008

Office for National Statistics (2008) Construction Statistics Annual (No. 9). Basingstoke: Palgrave Macmillan.

Office for National Statistics (2010) Construction Statistics - Chapter 17 - Appendices, No. 11 [available online from: http://www.ons.gov.uk/ons/rel/construction/construction-statistics/no--11--2010-edition/chapter-17---appendices.pdf]. Accessed 24 August 2011

Office for National Statistics (2012) Gross Domestic Product: Preliminary Estimate, Q1 2012 [Available online from: http://www.ons.gov.uk/ons/dcp171778_263578.pdf], accessed 30 April 2012.

One North East (2010) Combined Indicators Technical Note: Single Programme – Jobs [available online from: www.onenortheast.gov.uk/object/download.cfm?lib=liDownload&id= 16401], accessed 19 December 2011

Proverbs, D G Holt, G D, Olomolaiye, P O (1999) A method for estimating labour requirements and costs for international construction projects at inception. Building and Environment, **34** (1) pp 43-48