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THE USE OF THE UK BENCHMARK MODEL TO DEVELOP A STANDARD GLOBAL APPROACH TO CONSTRUCTION DATA

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Abstract

The human population of the world has grown rapidly in the last fifty years. The impact of the population explosion has also had a dramatic effect on the built environment. Yet it is difficult to find a source of statistical information on a global scale that combines the data that is available. Unless there is a measure of construction activity throughout the world there is no way of gauging the scale of the issues involved.

There is a need to know the location of activity, the types and quality of output, and the numbers and skills employed in the construction workforce. Only when these measures of the construction industry are found, policies to deal with construction problems, such as homelessness, migration, health and safety, training and skills, trade in materials, carbon emissions and many other issues can be assessed by the international community.

Setting these issues to one side, a benchmark model of construction based on the UK construction industry is considered. Such a model might be used to calculate the size and growth rate of the global construction industry and this can be used to compare to other estimates of global construction. It is suggested that the global construction industry, using the benchmark model as an international standard, can itself then be used as a benchmark to compare more detailed national construction statistics.

The benchmark model uses Gross Fixed Capital Formation (GFCF) taken from National Accounts. This is then applied to a breakdown of construction using UK Construction Statistics Annual (CSA). The model establishes the breakdown of construction for any country on the assumption that the breakdown in any country will be approximately similar to the breakdown in the UK and the UK breakdown represents a typical national construction industry.

In particular this paper deals with the issue of the most appropriate variable to use to relate GFCF available in every country's national income data to the detailed analysis of UK construction data for the sake of building the benchmark model. There are three options, namely: total GFCF, the total construction element in GFCF or all new work in the CSA. No statistically significant differences are found between any of the variables but for theoretical and operational reasons the preferred option is the total construction element in GFCF.

Keywords: global construction data, UK benchmark model, gross fixed capital formation, all new work.

INTRODUCTION

Construction appears in the Nomenclature Générale des Activités Économiques dans les Communautés Européennes (NACE), which is the agreed statistical classification of economic activities used by the EU. The UK version is the Standard Industrial Classification system, (currently SIC 2007). Both NACE and the SIC are consistent with ISIC, which is the International Standard Industrial Classification agreed at the United Nations for the purposes of global comparisons. In the SIC 92 (Office for National Statistics, 2011b) all activities were divided into sections and Section F covered construction, which appeared as a 2-digit classification: 45 Construction. In both NACE and the SIC, construction was further divided into 4 main 3-digit categories, namely 45.1 Site preparation, 45.2 Building of complete constructions or parts thereof; civil engineering, 45.3 Building installation, 45.4 Building completion, and 45.5 Renting of construction or demolition equipment with operator. Unfortunately, these categories are not particularly useful for the analysis of construction activities in terms of types of output, types of firms, and market sizes. The SIC 92 has been replaced by the SIC 2007 (Office for National Statistics, 2009) together with new 3 and 4-digit codes and descriptors. The 2 and 3-digit codes are shown in Table 1.

Table 1 *UK Standard Industrial Classification of UK Construction*

Section F Construction
41 Construction of buildings
41.1 Development of building projects
41.2 Construction of residential and non-residential buildings
42 Civil engineering
42.1 Construction of roads and railways
42.2 Construction of utility projects
42.9 Construction of other civil engineering projects
43 Specialised construction activities
43.1 Demolition and site preparation
43.2 Electrical, plumbing and other construction installation activities
43.9 Other specialised construction activities n.e.c.

In section F of the ISIC, (United Nations, 2008) there are only three main 2-digit codes within construction. They are 41 for the construction of buildings, 42 for civil engineering and 43 for specialized construction activities. Construction of buildings, which is also given a 4-digit classification, 4100, includes complete residential or non-residential buildings. Civil engineering is divided into three classifications, namely 421, the building of roads and railways, 422 the construction of utility projects, such as pipelines, communications, reservoirs, pumping stations and power plants and 429 which covers all other civil engineering projects, including refineries, harbours and outdoor sports facilities other than buildings.

Not only are definitions and classifications highly complex and variable even between the SIC, NACE and ISIC, they also change over time to reflect changes in technologies and output. There is no agreed method for estimating the size of construction industries in different parts of the world apart from the NACE and ISIC definitions given above. In any case construction data is not always available. As a result there is a need to estimate likely construction output in different countries. As Gruneberg (2008) has pointed out the OECD has modelled global infrastructure construction output using a top down approach based on an estimate of the value of existing structures, national income and the size of the global population. This data set can be used to assess the growth and size of construction markets throughout the world and gain a view of the scale of the challenge facing national and global organisations such as international development banks, the United Nations, the Organisation for Economic Co-operation and Development, the World Bank and the International Monetary Fund. However, it is not the only approach that can be adopted.

An alternative bottom up approach, devised by Gruneberg (2008), makes use of construction data and estimates construction output as a ratio of construction to gross fixed capital formation (GFCF). To begin the discussion of appropriate statistics for construction, the UK database of construction is used and the ratio of UK construction to UK GFCF can then be applied to other economies. Clearly, where this fails to produce data that resembles available construction data and information, modifications can be made to the results for any given country.

Of course the estimates will vary depending on the method used and the appropriateness of the model, when it is applied to particular countries. Nevertheless, it is important to begin the process of assessing economic activities that have an impact on the environment. Few activities can have the effect both locally and globally that the construction sector has on the environment.

Indeed, the capacity of the global construction industry is challenged by the growth of the world population and expectations regarding standards of living in different countries. Thus, as the population of the world approaches 7bn people, according to the US Census Bureau (2011), it is expected to continue growing to over 9bn by 2050, albeit at a declining rate of increase. Indeed the rate of growth in population is on a downward path from a high of 2.2 per cent per annum in the 1960s to less than 0.5 per cent by 2050. It is currently estimated by the Bureau to be growing at just over 1 per cent.

Not only are the absolute numbers of people increasing but at the same time the expectations of the populations in many ountries appear to be rising, as the so-called BRIC countries, (Brazil, Russia, India and China), increase their domestic consumption, making further demands on the environment and resources in line with their growing levels of income. The question then arises as to whether or not construction has the capacity to deliver and what effect delivering sufficient buildings and infrastructure will have on global resources and the environment.

In looking at national income data the construction industry is often seen as being approximately 5 to 8 per cent of the economy. This, however, only estimates the value added activities on site. Taken as a final good, including all the material and labour inputs, construction activity contributes between 15 to 20 per cent of the annual output of economies. As a consequence of using value added by industrial sector as the basis for aggregating national data, the impact of construction activity is often undervalued and overlooked.

DEFINITIONS AND PROCEDURES USED IN THE BENCHMARK MODEL

It is therefore important to discuss ways of deriving reasonable estimates of construction outputs. The most readily available international economic data is provided by the United Nations and other international organisations. This data includes the National Income accounts of all members of the UN, given in a common format agreed globally. In these sets of national income accounts is a chapter headed gross fixed capital formation (GFCF). Within the CFCF is construction output. This component of GFCF is itself broken down into two components and these can be used to model a breakdown of construction data into different categories based on the pattern of output in a benchmark country or international average. In the absence of an international average breakdown of construction output by type, it is suggested that the UK construction data be used as a benchmark until a more appropriate standard is found. Of course any country might be used as a standard for this purpose until work can be carried out to find a more suitable international norm, if such as thing could be arrived at.

The actual method involves taking UK construction output data as an example. Each category of output in the data, such as housing, infrastructure, commercial and repair and maintenance are used to establish its percentage of total output by using the mean ratio for a given number of years. Table 2.8 in Construction Statistics Annual provides new build construction output only. Thus infrastructure forms a percentage of UK construction output and within infrastructure the different components can be estimated. Using UK Construction Statistics Annual the average distribution of unfrastructure can be calulated as illustrated in Table 2.

Table 2 *Average UK Infrastructure by Type of Infrastructure 1997-2008*

Type of infrastructure	***Percentage of infrastructure***
Water	15.50
Sewerage	10.82
Electricity	8.39
Gas	4.00
Communications	6.62
Air	4.83
Railways	15.93
Harbours	5.36
Roads	28.54
Total infrastructure	100.00

Based on data taken from Table 2.8d, Construction Statistics Annual, ONS (2010)

Table 2.8 in Construction Statistics Annual provides new build construction output only. The estimates for new build therefore need to be grossed up to find the total value of construction output or an estimate of the total value of all output including repair and maintenance for any given component of construction output where this is not given in the data. This is done using Table 2.2 to find the average ratio of new build to total output. For example, between 1997 and 2008 this was 0.56 of total construction output. The inverse of 0.56 is 1.79 and this inverse can be used to estimate total construction output or the total including repair and maintenance for any element within the data set.

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This percentage of total construction output is then used as the coefficient of the value of the construction element in annual GFCF to estimate the value of housing or infrastructure or other component in any given country. The same method is used to establish coefficients for all components of construction output for each year.

DISCUSSION

This modelling of the construction industry based, as it is, on existing international data and the UK is of course to some extent an arbitrary method based on a number of assumption. However, it is invariably necessary to make a number of assumptions in order to make an operational assessment to form the basis of rational decision making at an international level. The assumptions are that the same pattern of construction output exists in every country, when clearly it does not. One obvious case would be where the UK as an island, depends on ports and harbours for much of its trade. Ports and harbours do not feature as highly in land locked countries or countries with land borders with its neighbours.

A second assumption is that buildings in one country are equivalent to buildings in another. For example, residential buildings in the UK need to withstand weather conditions ranging from relatively mild winters to relatively mild summers compared to seasonal variations in Russia. Buildings therefore need to be constructed to withstand greater or lesser variations in climate in different countries and need to be built to different standards to meet those requirements. Similarly North African countries do not require buildings to withstand the winter conditions experienced by those of Northern Europe.

Gruneberg's benchmark model is based on the combination of the GFCF of the national income accounts of each country and the ratios of construction to GFCF in the UK. In this model Equation 1 shows construction new build (NB) and repair and maintenance (R&M) as a ratio of GFCF, based on the ratio of new build to GFCF and repair and maintenance to GFCF in the UK. The data is taken from the UK National Income Accounts and the Construction Statistics Annual.

$$I = (\Sigma\{RNB/GFCF\}/n)(GFCF + [\Sigma\{R\&M/NB\}/n]GFCF) \qquad \text{(Equation 1)}$$

where I = total new build and repair and maintenance
n = number of years

Having established the ratio of total construction output to GFCF, it is then possible to estimate the component parts of the output of construction in terms of the different types of buildings and output of construction, such as housing, commercial and infrastructure. For example,

let INB = infrastructure new build, and
IR&M = infrastructure repair and maintenance = (R&M/NB).INB

Then,

$$I = aGFCF + abGFCF \qquad \text{(Equation 2)}$$

where a = Σ{INB/GFCF}/n, that is the average annual ratio of INB/GFCF
and b = Σ{R&M/NB}/n, that is the average annual ratio of R&M/NB.

The reduced version of the equation for infrastructure becomes:

$$I = a(GFCF + bGFCF) \qquad \text{(Equation 3)}$$

Using this method, Gruneberg (2008) found the average ratio of infrastructure to GFCF from 1998 to 2005 was 4.08 per cent.

In order to improve on the model given in Gruneberg (2008) a modification of the model involves replacing GFCF with one of three options, namely the construction element of

GFCF alone or all new work as given in Table 2.1, Construction Statistics Annual (Office for National Statistics, 2011a). The original benchmark model used total GFCF but GFCF includes non-construction investment, namely plant and machinery. A revised version of the UK benchmark model should therefore be based on the built element only of GFCF.

Revised version of the benchmark model

In order to demonstrate that this produces a significantly different result, it would be necessary to show that annual changes in the built component of GFCF are significantly differently from annual changes in GFCF as a whole.

When this test was carried out on UK national income accounts data, the following results were found, using Excel:

Table 3 *New construction as a component of GFCF and total GFCF***.**
Analysis by type of asset at current prices £m

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
New dwellings, excl land	21664	22516	23928	25222	25700	27394	29806	34499	38462	44298	47489	53331	55767	50292	39558
Other buildings and structures	31843	32825	35455	40274	42934	43175	44932	47562	52295	50530	56709	60454	68755	76973	68869
Total construction	53507	55341	59383	65496	68634	70569	74738	82061	90757	94828	104198	113785	124522	127261	108427
GFCF	117448	126291	133776	155997	161722	167172	171782	180551	186700	200415	209758	227234	249517	240361	205063

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Components may not sum to totals due to rounding.

Table 4 *Regression Statistics of new construction as a component of GFCF and total GFCF.*

Multiple R	0.982134151
R Square	0.964587491
Adjusted R Square	0.961863452
Standard Error	4867.985874
Observations	15

ANOVA

	df	SS	MS	F	Significance F
Regression	1	8391254685	8391254685	354.101922	8.18E-11
Residual	13	308064724.1	23697286.47		
Total	14	8699319409			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-24616.02559	6023.36836	-4.086754142	0.001284642	-37628.7	-11603.3
GFCF	0.608222727	0.032322021	18.81759607	8.18305E-11	0.538395	0.67805

From Table 4 the differences in the two variables GFCF and the total construction element were found to be significantly different (t = 18.8, with 14df). This would indicate a preference for the construction element of GFCF rather than total GFCF.

Turning now to the first differences of these two time series, given in Table 5, namely the construction element in GFCF and GFCF itself, a similar result is found in Table 6. Even when comparing annual changes in these variables, significant difference between the behaviour of the two variables can be identified (t = 6.63 with 13df).

Table 5 *Annual change in total new construction in GFCF and total GFCF £m*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Change in TNC	1834	4042	6113	3138	1935	4169	7323	8696	4071	9370	9587	10737	2743	-18838
Change in GFCF	8843	7485	22221	5725	5450	4610	8769	6149	13715	9343	17476	22283	-9156	-35298

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Note: First differences of current data have been used

Table 6 *Regression Statistics of first differences in new construction as a component of GFCF and total GFCF.*

Multiple R	0.886365165
R Square	0.785643206
Adjusted R Square	0.767780139
Standard Error	3474.466789
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	530940288.1	530940288.1	43.98143057	2.42318E-05
Residual	12	144863033.7	12071919.47		
Total	13	675803321.7			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1140.056718	1018.996455	1.118803419	0.285120118	-1080.14583	3360.259265
Change in GFCF	0.444663653	0.067049718	6.631849709	2.42318E-05	0.298574867	0.590752439

Turning to the use of construction output data rather than the value of construction in the GFCF, Table 7 gives the indices of the current values of UK annual total construction new build and GFCF respectively. Again, from Table 8, these two time series are significantly different (t = 7.35 with 14df). Therefore the output of the model will depend to some extent on which of these two time series is selected in the model.

Table 7 *Indices of annual total new work and total GFCF*

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
All new work	45	47	50	55	60	63	67	76	85	96	100	109	118	114	93
GFCF	56	60	64	74	77	80	82	86	89	96	100	108	119	115	98

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Table 2.1, Construction output, Construction Statistics Annual, 2006, for years 1995 to 1998, and Construction Statistics Annual, 2010, for years 1999 to 2009
This table is based on an index of UK construction at current prices, 2005 = 100 and an index of UK GFCF at current prices, 2005 = 100.

Table 8 *Regression Statistics based on annual total new work (Table 2.1, Construction Statistics Annual) and total GFCF.*

Multiple R	0.904494901
R Square	0.818111026
Adjusted R Square	0.802953611
Standard Error	3.511944344
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	665.7058407	665.7058407	53.97431233	8.89339E-06
Residual	12	148.0050369	12.33375308		
Total	13	813.7108776			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.354344218	1.029987925	0.344027546	0.736778825	-1.889806684	2.59849512
Change in GFCF	1.044403955	0.142159193	7.346721196	8.89339E-06	0.734665683	1.354142228

Table 9 *Indices of annual differences in total new work and total GFCF*

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Change in all new work	2	3	4	5	3	4	9	8	12	4	9	9	-3	-21
Change in GFCF	4	4	11	3	3	2	4	3	7	4	8	11	-4	-17

Sources of data
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2004 for years 1995 - 1997
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2007 for years 1998 - 2000
Table 9.3 Gross fixed capital formation at current purchasers' prices, United Kingdom National Accounts Blue Book 2010 for years 2001 - 2009
Table 2.1, Construction output, Construction Statistics Annual, 2006, for years 1995 to 1998, and Construction Statistics Annual, 2010, for years 1999 to 2009
This table is based on an index of UK construction at current prices, 2005 = 100 and an index of UK GFCF at current prices, 2005 = 100.

Table 10 *Regression Statistics based on first differences of annual total new work (Table 2.1, Construction Statistics Annual) and GFCF new construction.*

Multiple R	0.906646947
R Square	0.822008686
Adjusted R Square	0.807176077
Standard Error	3.474112213
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	668.8774096	668.8774096	55.41902039	7.79397E-06
Residual	12	144.833468	12.06945567		
Total	13	813.7108776			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.432338423	1.066273497	-0.405466725	0.692270322	-2.755548796	1.890871951
GFCF constr.	1.036626928	0.139249314	7.444395233	7.79397E-06	0.733228737	1.34002512

Finally, the difference between the first differences of the indices of new work and the construction component in GFCF in Table 10 are also significant with t = 7.44 with 13df. Again this reinforces the need to select the time series rationally.

The rationale for selecting the construction component of GFCF is that it appears in the national income accounts of all countries. As it appears in all national income accounts, it can be most easily applied to any country in the world and combined with UK construction data using coefficients to represent the proportion of total annual output in any one year attributable to any particular variable. In this way national construction data can be estimated to find output and other aspects of the construction sector within each country. This would only provide an approximate model of any country or region's construction sector. Local knowledge and contingent factors would also need to be taken into account.

CONCLUSION

We reject the null hypotheses that there are no significant differences between the GFCF and the construction component of GFCF and construction output all new work in the Construction Statistics Annual. We also reject the null hypotheses that there is no significant difference between annual changes in total GFCF, the annual changes in the construction component of GFCF and indeed the total new work found in Construction Statistics Annual.

The use of the construction component of GFCF is suggested as the most practical time series to use in the benchmark model to link with national accounts data and this should be used in conjunction with the construction data found in Construction Statistics Annual to form the benchmark model. This method for establishing the link between individual countries and the benchmark model could be applied to any country.

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