MODELLING THE UK BUILT INFRASTRUCTURE MARKET USING GROSS FIXED CAPITAL FORMATION

Stephen Gruneberg[1]

University of Westminster, 35 Marylebone Road, London, GB, NW1 5LS

Built environment infrastructure includes roads, rail, airports, ports, water supply and water treatment. Most models of infrastructure markets use a national income approach to estimate the size of infrastructure markets. Such a top down approach uses a large aggregate to estimate the size of one of its components. Using a bottom-up approach, a combination of construction industry data and gross fixed capital formation, it is possible to find an approximation for infrastructure investment. This takes into account both new build infrastructure and work on existing structures. The proposed model uses official infrastructure data in construction statistics to calculate new build infrastructure and the ratio of repair and maintenance work to new build to estimate total work on existing infrastructure stock. This is then used in combination with gross fixed capital formation to estimate the size of the infrastructure market from gross fixed capital formation. Using this method, the UK data can be used as a benchmark model to estimate and compare infrastructure from gross fixed capital formation for different countries.

Keywords: built infrastructure, construction markets, construction statistics, gross fixed capital formation.

INTRODUCTION

The infrastructure market is both global and local in scope. Individual projects are commissioned and located in different countries and are therefore local (or national) in nature. However, the provision of new infrastructure is also a global market because both the project management skills and the capacity to undertake large projects are restricted to only a relatively few firms in the world that are capable of carrying out the work on such large scale, high risk, technologically advanced building and civil engineering schemes.

At the same time infrastructure is a major investment vehicle of private sector firms and funds with macroeconomic implications. Newell and Peng (2008) identify the financial role of infrastructure as part of investment portfolios, showing the risk and returns relative to other classes of investment including real estate. From the point of view of the economy as a whole, Yeaple and Golub (2007) conclude that infrastructure investment may account for international differences in total factor productivity and growth rates.

In one sense there are many markets but in another sense there is only one. On the demand side the markets are different as they vary in size, in clientele, in cultural context, in legal terms and in institutional terms. On the supply side the technical

[1] s.gruneberg@westminster.ac.uk

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skills and finance are mobile and move from one country to another. The proposed UK based benchmark model attempts to fill the gap for a method of making international comparisons of infrastructure markets.

It is not possible to identify infrastructure investment consistently in all economies as definitions and components vary. Econometric modelling is therefore needed to approximate annual infrastructure investment over time and to build predictive scenarios. The first stage sets out a proposed model. The second stage is to test the new model against alternative methods. This paper deals only with the first stage and describes a new approach based on construction industry data and gross fixed capital formation rather than gross domestic product as used by international bodies, such as the OECD (2006).

According to the OECD (ibid.) the major long run determinants of infrastructure are the value of infrastructure assets, the growth of gross domestic product (GDP) and population expansion. All other factors, including technology and governance, tend to have a far less significant influence on infrastructure investment.

However, the valuation of infrastructure assets is prone to error for many reasons, as are all built assets, since their valuation assumes a steady state. If all infrastructure values are aggregated this value would be in excess of their realisable worth since their value is stated at a given date. This hypothetical value could not be realised because the values would be reduced, if sellers actually competed in the market to offload their assets at the same time. Although there is a market place for infrastructure assets, their value depends on the willingness of the state to underpin the commercial risk and ensure a stream of future state revenues for the owners, regardless of whether they are in the public or private sectors.

Moreover, because of the size of GDP and the fact that it covers the whole economy, GDP tends to understate and smooth the volatility of predictions of infrastructure demand. While the approach adopted by the OECD is useful for long run predictions of infrastructure demand, the model used here to find infrastructure output (the proxy measure of infrastructure demand) is based on gross fixed capital formation (GFCF).

The next section of this paper analyses UK construction output data. This is followed by the benchmark model. In the subsequent section the benchmark model is applied to estimate infrastructure from GFCF. Finally, to complete the first stage in the development of a predictive model of construction output, attention is drawn to the limitations of the UK benchmark model and to further research required.

UK CONSTRUCTION INDUSTRY INFRASTRUCTURE OUTPUT AND GROSS FIXED CAPITAL FORMATION

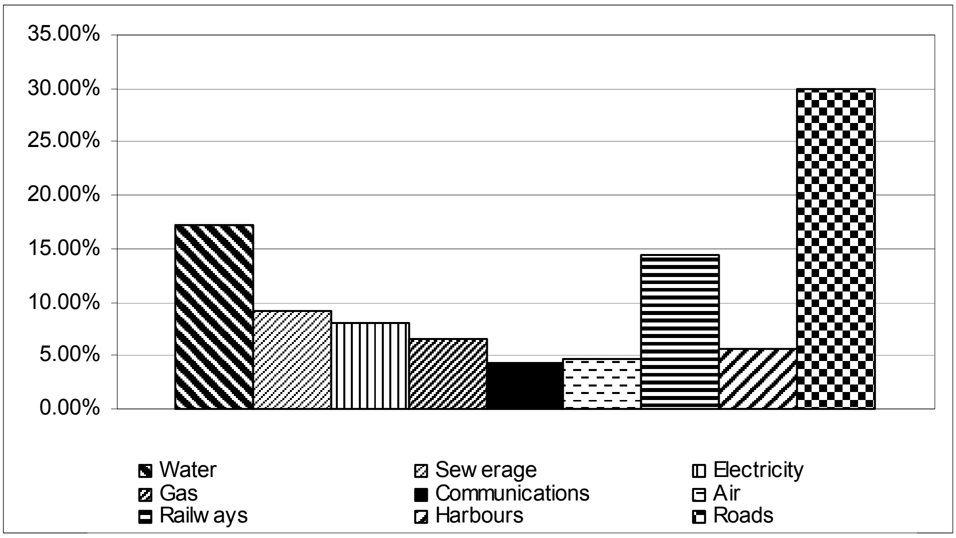
In the US the Congressional Budget Office, (CBO), (2007) describes the characteristics of infrastructure in terms of its capital intensity, its draw on public expenditure and the public sector management of facilities. Large amounts of infrastructure are needed to ensure both the public and private sectors can function smoothly. Infrastructure is a major component of government spending and private investment. Because of the strategic importance of infrastructure even where the facilities are in the private sector government retains a particular interest in the management of facilities due to the adverse and disproportionate economic consequences of infrastructure failure.

The CBO list of infrastructure facilities includes highways and roads, mass transit, rail, aviation, water transportation, water resources such as dams and levees, and water supply and waste-water treatment. The CBO also include energy facilities and telecommunications networks. This is similar to definitions used elsewhere.

The definition of infrastructure in quantitative terms depends on the structural types included in the list of construction outputs, which are deemed to have the characteristics of the basic built requirements necessary for society to function at whatever level of development that society has reached or aspires to reach. The UK benchmark model uses a list of categories found in official UK construction statistics published by the Department for Business, Enterprise and Regulatory Reform (DBERR) (2007) and shown in Figure 1.

Health facilities, schools, colleges and universities, military installations, prisons and many other types of buildings are excluded from the UK definition of infrastructure. However, other buildings are included: airports, railway stations, telephone exchanges, oil and gas pipelines. This demonstrates the difficulty of defining infrastructure and how that definition of infrastructure may vary from country to country.

Taking infrastructure as a whole, Figure 1 shows the average share of each type of infrastructure as a percentage of total infrastructure output in the UK from 1995 to 2005. The largest single sub-class of total infrastructure output is roads with 30 per cent, followed by water supply and treatment at approximately 17 per cent and railways at almost 15 per cent.



Source: DBERR, (2006) Construction Statistics Annual, Table 2.8c

Figure 1: The average composition of UK infrastructure 1995 to 2005

The relative size of different components of infrastructure in the UK differs widely from the global infrastructure market as estimated by the OECD (2006). Table 1 shows the OECD prediction of total global spending on infrastructure in selected sectors. In 2000-10, infrastructure spending is estimated to be 2.84 per cent of world GDP. In 2010-20, it is predicted to be 2.49 per cent and between 2020 and 2030 it is expected to be 1.79 per cent of GDP. Clearly there are differences in the composition of infrastructure priorities at the global level compared to the UK. Both water and telecoms are seen as significantly larger than roads. This difference between global and UK percentages highlights a distinction between the relatively wealthy European economies and the less developed economies in many parts of the world. It may also reflect the pace of public sector growth compared to the ability of the private sector to move into new lucrative markets, such as telecommunications.

Table 1: Average annual world infrastructure expenditure (additions and renewal) for selected sectors, 2000-30, in $bn and as a percentage of world GDP

Type of infrastructure	2000-10	Approximate % of world GDP	2010-20	Approximate % of world GDP	2020-30	Approximate % of world GDP
Road	220	0.38	245	0.32	292	0.29
Rail	49	0.09	54	0.07	58	0.06
Telecoms[1]	654	1.14	646	0.85	171	0.17
Electricity[2]	127	0.22	180	0.24	241	0.24
Water [1, 3]	576	1.01	772	1.01	1 037	1.03

Source: OECD, (2006) Infrastructure to 2030, Paris, p.29

1. Estimates apply to the years 2005, 2015 and 2025.
2. Transmission and distribution only.
3. Only OECD countries, Russia, China, India and Brazil are considered here.

THE UK BENCHMARK MODEL

The aim of the UK construction benchmark model is to estimate the size of the built infrastructure market from GFCF. Not all GFCF is construction and not all construction is included in GFCF because GFCF only includes new build not repair and maintenance (R&M). GFCF represents the value of new capital produced before allowance has been made for depreciation of assets.

Repair and maintenance although an important component of construction output is akin to capital consumption or depreciation in the same way as plant needs to be maintained in order to continue production. Such repair and maintenance, though essential, does not in itself increase the productive capacity of the economy. At best it only maintains current capacity. Increases in capacity are achieved through net investment. Net investment, which is the investment in additional capacity for the economy as a whole, is included in the aggregates of new build shown in GFCF, though some new build only replaces demolished buildings or structures and should therefore, strictly speaking not be included in GFCF, though it happens to suit our purposes. Meanwhile, R&M is a real output of construction and therefore is an important component of total market size, although R&M is excluded from GFCF.

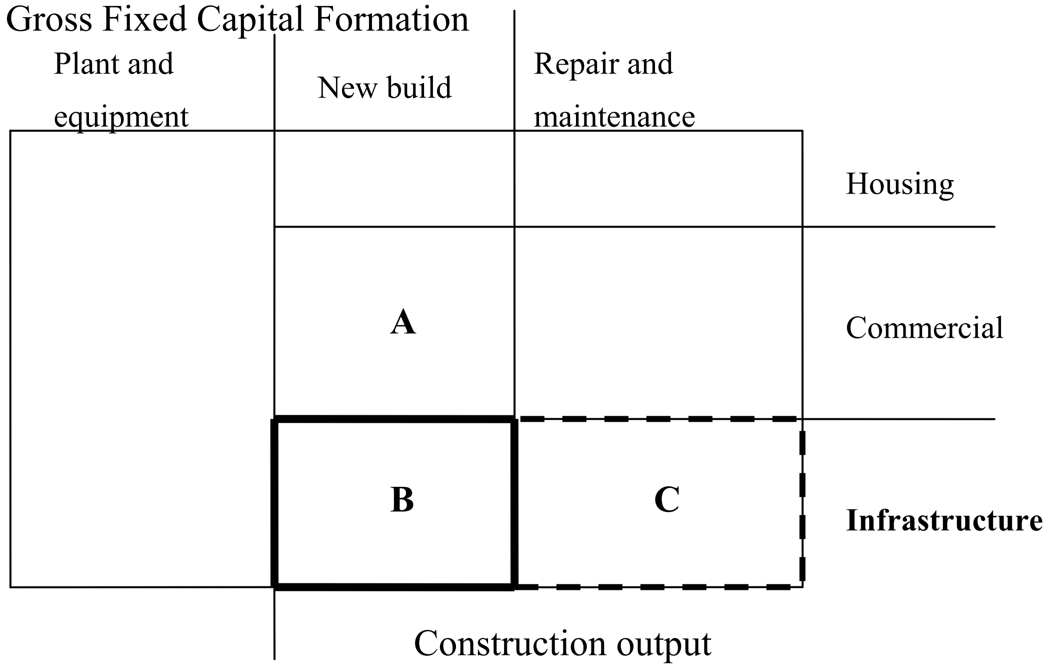


Figure 2: Gross Fixed Capital Formation and Construction Output

Figure 2 illustrates the schema of GFCF and total construction output. In the tables of GFCF in the UK National Income Accounts new build construction consists of two categories of work, namely housing and other constructions. "Other constructions" is shown as rectangles A and B in Figure 2. The proportion of GFCF that is attributable to the building of new infrastructure is the area of rectangle B. Total construction infrastructure spending is represented by B + C, namely new build infrastructure (NB) and infrastructure repair and maintenance respectively. Building repair and maintenance is not part of GFCF but it is part of total construction output.

The average ratio of all construction R&M to all UK construction work from 1997 to 2005 was 0.46. This ratio is used in the benchmark model as the ratio of infrastructure R&M to all infrastructure work. As infrastructure new build is part of the GFCF and represents 0.54 of the total infrastructure market, in the model new build is multiplied by 1.85 to find total infrastructure investment, (1.85 is the inverse of 0.54).

The UK benchmark model uses the composition of UK infrastructure output to estimate infrastructure investment from the GFCF data in different countries. The model is based on:

- UK new build infrastructure as a share of GFCF, and
- UK infrastructure new build and repair and maintenance as a share of UK construction output.

Unfortunately the definitions used in official statistics are not consistent across the different sets of publications. One of the difficulties is that the value of infrastructure is not given as such in the National Income Accounts. Instead, the National Income Accounts give sub-divisions of construction output as "dwellings excluding land" and "other buildings and structures". The series, other buildings and structures, includes infrastructure and buildings which are not infrastructure. To estimate the value of infrastructure in other buildings and structure 'other non-housing excluding infrastructure new build output' given in Table 2.8, Construction Statistics Annual (2007) is deducted from "other constructions" in the National Income Accounts. Ideally the residual could be used as an estimate of infrastructure.

Taking an average of this residual from 1998 to 2006, the percentage of new build infrastructure to gross fixed capital formation was 11.95 per cent. If R&M is included in total infrastructure, the percentage increases to 21.93. This calculation implies that 47.75 per cent of construction output is concerned with infrastructure but, according to construction output data, all infrastructure, (including R&M), was only on average 15.13 per cent of output between 1998 and 2006. Indeed, since 1998 infrastructure declined as a percentage of construction output and by 2006 it was only 10.12 per cent. The construction output data is more consistent with the international data given in Table 1.

An alternative model is required, which is derived from construction statistics alone and then used in conjunction with GFCF. Figure 3 describes the model. All the percentages are relative to GFCF. Only that part of construction that is new build comes within GFCF. New build construction is almost 50 per cent of GFCF, and construction repair and maintenance is equivalent to approximately 40 per cent of GFCF. This implies that the value of construction industry output is approximately equivalent to 90 per cent of GFCF. To estimate all infrastructure construction from GFCF combine new build and R&M infrastructure, approximately 4.1 per cent of GFCF. This is the preferred approach for benchmarking UK infrastructure, as it is consistent with the construction data and international figures such as those given in Table 1.

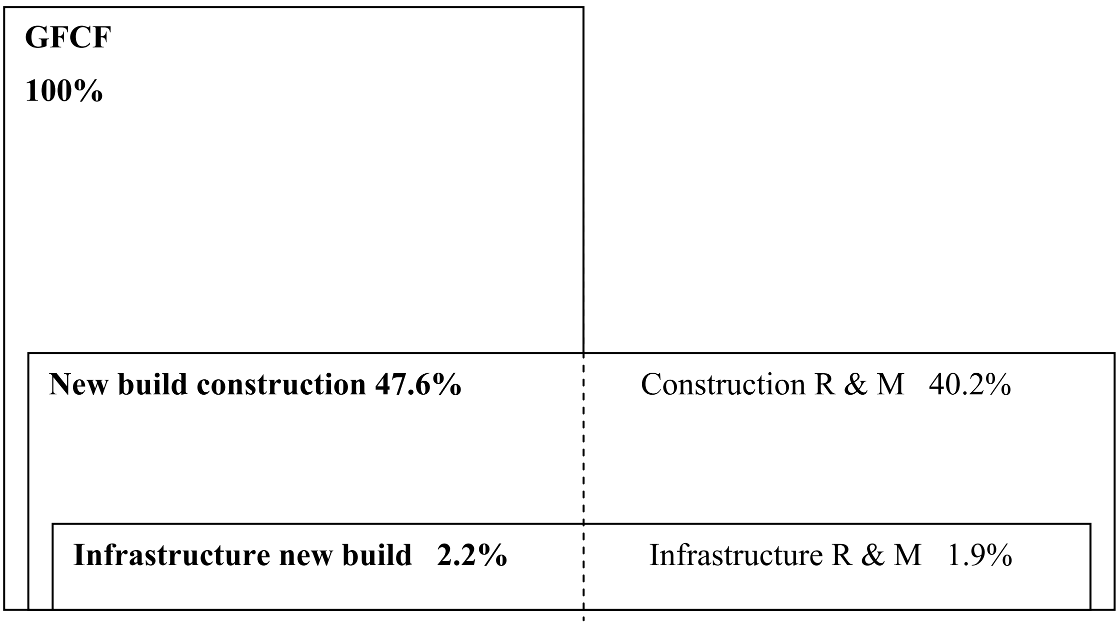


Figure 3 Construction as a percentage of GFCF

In more detail the first model, given below in Equation 1, estimates infrastructure new build and repair and maintenance on the basis of the ratios found in the UK, using the UK National Income Accounts (NIA) and the UK Construction Statistics Annual (CSA).

Let R = P – Q

where R = estimate of new build infrastructure

P = other buildings and structures, and

Q = non-housing construction less infrastructure

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

where I = total new build and repair and maintenance infrastructure

GFCF = gross fixed capital formation

NB = new build

R&M = repair and maintenance, and

n = number of years

This equation estimates infrastructure from GFCF using an estimate of infrastructure new build (R) derived from other buildings and structures (Source: Table 9.3, NIA) and non-housing construction less infrastructure (Source: Table 2.8, CSA), and the ratio of UK repair and maintenance to new build.

Unfortunately, as the definitions of new build infrastructure construction in CSA data and the NIA data are different, only the CSA is used in the second model. Data for the benchmark model is taken directly from contractors' output rather than from calculations based on capital acquisitions and disposals. The equation in the proposed benchmark model therefore uses construction data from the CSA only in combination with GFCF. This simplifies the equation to:

Let INB = infrastructure new build, (Source: Table 2.8, CSA), and

IR&M = infrastructure repair and maintenance = (R&M/NB).INB

$I = aGFCF + abGFCF$ (Equation 2)

where $a = \Sigma\{INB/GFCF\}/n$, that is the average annual ratio of INB/GFCF

and $b = \Sigma\{R\&M/NB\}/n$, that is the average annual ratio of R&M/NB,

Thus;

$I = a(GFCF + bGFCF)$ (Equation 3)

Thus, for example, using Equation 3, the average ratio of infrastructure to GFCF from 1998 to 2005 is 0.04077 or 4.08 per cent.

Application of the UK benchmark data to the UK

Using 4.08% of GFCF in the model to estimate total infrastructure from GFCF, Table 2 shows the benchmark value of infrastructure in 2006. The value of GDP using the output measure was £1,299,622, (NIA, 2007, Table 1.2) Total infrastructure is approximately 4.08 per cent of GFCF and 0.74 per cent of GDP. In a further application of the model, using equation 3 to find annual total infrastructure, the rate of growth of infrastructure output in the benchmark model could be based on the geometric mean of the annual percentage changes in GFCF over any given period.

Table 2: Estimate of 2006 infrastructure

Variable	Benchmark model
GDP	£1,299,622m
GFCF	£234,751m
Infrastructure	£9,578m
Infrastructure./GFCF	4.08%
Infrastructure./GDP	0.74%

One use of the benchmark data is to set out the relative importance of infrastructure compared to GFCF and GDP. It is not the purpose of a benchmark model to predict infrastructure internationally but only to make international comparisons. This benchmark model of the UK can, however, serve to show a reasonable figure for infrastructure in different countries relative to the UK data. Nor would it be possible to predict UK infrastructure on the basis of GFCF or GDP data alone. This is confirmed using data from 1998 to 2006 at current prices in Table 3.

Table 3: Regression results

	Std. Error	R2	T	Sig t	F	Sig F	Df
GDP	2082.88	0.45	2.23	2.45	4.93	5.99	6
GFCF	806.86	0.08	0.72	2.45	0.52	5.99	6

It is customary when comparing time series analysis to use annual changes in variables, known as first differences. Using first differences to test the significance of the reliability of the model to associate infrastructure with GFCF or GDP for any given year, the following results were found, $\alpha = 0.05$. According to Table 3 both the t test and the F test show the relationships between GFCF and GDP as not statistically significant. Much longer time series would be required. The results in this table are due to a peak of infrastructure construction activity in 2002 caused by the exceptionally large Channel Tunnel rail link project in the South East of England. In the following years infrastructure activity in the UK actually declined. This demonstrates the volatility of the infrastructure market due to large discrete individual projects and the difficulty in relying on time series modelling to make accurate predictions, where changes in government policy can significantly affect total investment in infrastructure.

CONCLUSION

Just as it is not possible to predict the future based on past performance, it is not possible to predict infrastructure markets in different countries based on the ratios existing in another. Benchmark models are a form of metaphor and just as metaphors can often lead to inappropriate comparisons, benchmark models may not always be applicable. Using the island economy of the UK as a benchmark to compare to land-locked countries such as Switzerland, Belarus or Zambia, or as a benchmark to be compared to Peru, Zimbabwe or Bangladesh with their very different degrees of development may be stretching the principle of benchmarking. This has not been tested here. Future empirical research will demonstrate the usefulness or otherwise of this approach.

Nevertheless, using past performance to estimate likely future outcomes can be useful for decision making purposes. Similarly, using the UK benchmark model may be a useful indicator of the size of markets relative to their GFCF.

As GFCF is widely used to compare economies more generally, this model is a useful tool for estimating the size of construction markets in particular in different countries. As with any model or estimation, the model works best when used in conjunction with judgement and more immediate information. The model only provides an indicative approximation of the size of the construction market.

It therefore has to be treated with a degree of caution. Definitions of infrastructure vary between countries. Changes in government, political motives and policy decisions can intervene to alter expectations based on the model. Unexpected changes in the economy also tend to make patterns of growth deviate from their long run trends.

Most importantly, there has been no attempt to test this benchmark model and it remains to be seen if comparisons and predictions can be made using this approach. Although models of global infrastructure have been devised, there are few, if any, detailed breakdowns and comparisons of international infrastructure based on macroeconomic models. It is therefore only possible to compare the results of the benchmark model to national data where this is available. As it is difficult to access this data the benchmark model offers one approach in the absence of a globally uniform set of construction output statistics.

Just as more research is needed to test the appropriateness of benchmark model for international comparisons, more research using longer time series will help to establish the reliability of GFCF. It would also be useful to carry out further work to develop a bottom-up predictive model based on auto regressive integrated moving averages (ARIMA). This benchmark model proposed here is only a starting point.

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