The cost drivers of infrastructure projects

Why project costs vary

Association for Consultancy and Engineering

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The cost drivers of infrastructure project

This document explores some of the cost drivers behind infrastructure construction projects.

Summary

- The drivers of construction costs are wide and various.
- Given the range of different factors involved, cost differences between developed countries are almost inevitable without some form of market intervention.
- Inaccurate cost estimation is a significant contributor to perceptions of whether a project is delivered on budget.
- Changes to project specifications part-way through can add up to 15% to project costs.
- The possibility that project costs are deliberately underestimated for reasons of political or commercial expediency should not be ignored.
- There is a need for an ongoing project to monitor construction costs and analyse the dynamics involved. This could be achieved through the establishment of a national construction research institute.

There are a wide range of cost drivers

Major infrastructure projects experience a wide range of cost drivers. These include:

- Materials costs.
- Labour costs.
- Design and development costs, including mid-programme changes to specifications.
- Costs of compliance with legal and regulatory requirements.
- Professional services (e.g. solicitors, accountants).
- Energy and utilities costs.
- Insurance.

Some of these cost drivers are controllable by project managers and promoters; others are entirely external.

Example: the impact of materials costs

Variations in materials costs from territory to territory can influence the cost of construction.

Gardiner and Theobald's International Construction Cost Survey[1] - an extract of which is printed below - highlights international differences in the cost of materials. For some materials the international variation is very large; structural steel, for instance, cost £483 per tonne in Ireland compared with £2,059 per tonne in Norway – around 320% greater. Likewise, the cost of aggregates ranged from £2 per tonne in Hungary to £49 per tonne in France – an increase of more than 2,300%.

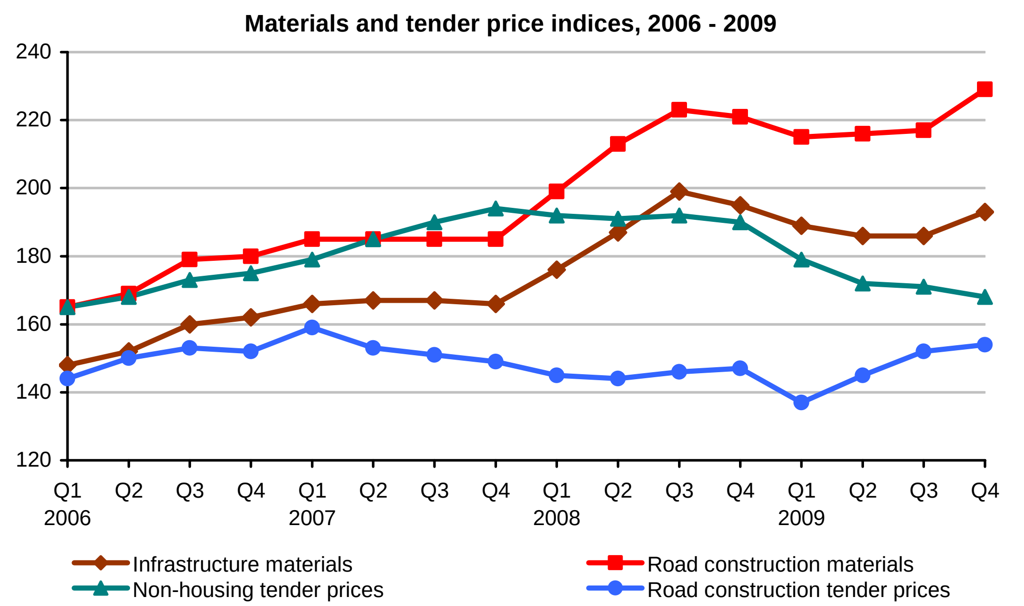
[1] Published February 2010.

Material	France	Germany (Berlin)	Ireland	Italy	Netherlands	Norway	Spain	Japan	USA (New York)	UK	UK rank in selection
Structural steel (£/tonne)	--	1,280	483	1,086	977	2,059	1,685	560	722	910	8
Concrete (£/m³)	113	61	58	82	78	95	73	84	86	60	9
Aggregate (£/tonne)	49	12	13	16	15	12	14	16	13	25	2
Concrete blocks (£/m²)	13	18	4	9	14	28	11	10	14	10	=7
Glass 6mm (£/m²)	39	16	35	28	31	42	36	11	60	25	9

Source: Gardiner and Theobald

In the comparison of ten developed economies above, material prices in the UK were among the lowest in the comparison sample, suggesting that – at present – the UK may not suffer from disproportionate material prices compared with other similar economies.

However, price inflation continues to be a factor. Data from BCIS indicates an almost continuous rise in materials prices, with sharper increases observed throughout 2008. Tender prices, while broadly tracking the growth in materials prices through 2006, have since experience decline. This indicates that, while material prices are an important factor of construction costs, there are likely to be other factors that carry similar weight.



Source: BCIS. 1995 = 100

Higher UK costs may be inevitable

It is valid to consider whether the cost of infrastructure in the UK should really be at similar levels to comparable countries.

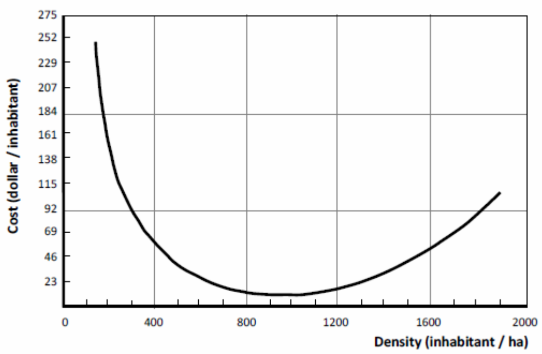
The UK is one of the most densely populated countries in Europe. Approximately 90% of the population is classified as urban[2], with only the Netherlands and Belgium recording higher population densities in Europe.

Country	Population density (inhabitants per km^2)
Netherlands	485.3
Belgium	350.4
United Kingdom	250.8
Germany	229.9
Italy	201.2
Switzerland	188.8
Czech Republic	133.8
Denmark	126.7
Portugal	115.2
Slovakia	110.1

Source: Eurostat. Data as of 2007

The above table lists the ten most densely populated European nations. By comparison, France ranks twelfth (100.9 inhabitants per km^2) and the Republic of Ireland rank eighteenth (63.7 inhabitants per km^2).

Such factors of urbanisation and density may be significant. Neumann's[3] study of water infrastructure in Venezuela suggests that the relationship between cost and density is parabolic, with initial efficiency gains as population density increases. In this model, the optimum population density beyond which per capita infrastructure costs begin to increase again is around 1,000 inhabitants per hectare (or 10 inhabitants per km^2).



[2] CIA World Factbook, data as of 2008.

[3] In Danko C, Mendes S, Ramos L, Lourenço J and Bentes I (2009). *Infrastructure costs and urban sprawl.* Presented at the 45th ISOCARP Congress 2009.

However, this scenario may assume an under-developed infrastructure subject to growing demand. Developed countries and areas with pre-existing infrastructure may be subject to a different mechanism. For example, Schiller[4] notes that, at the neighbourhood level, residential density is directly linked to expenditures on neighbourhood infrastructure, with higher densities generally corresponding to lower per-capita costs.

While the magnitude of the effect observed may not be applicable to the UK, the Venezuela example does illustrate that higher population densities do not always result in lower per-capita infrastructure costs.

A different dynamic is observable when population densities of urban areas decline. Schiller[5] observes that, in urban areas with existing infrastructure capacity, decreasing population densities in residential areas is strongly linked to rising additional costs from network underutilisation. Fixed networks with a duty to supply generally experience rising per-capita costs as population densities decline; this is largely because physical capacity cannot be easily scaled back to respond to declining demand.

However, Schiller concludes that, in scenarios of population decline or stagnation, costs "can be stabilised if the potentials of current stock are grasped in time."[6]

Given that the urban profile of the UK is largely fixed, albeit varying from locality to locality as areas grow and decline, it may be that little can be done to alter the part of the cost base attributable to population density factors.

Variation and rework add significantly to project costs

Repeating parts of a project can add significantly to the total cost. Repetitions can be triggered by a wide range of factors including change orders issued by clients, poorly-executed work by suppliers, and climate or weather effects.

The effect of repeating work has been estimated by a British research team to add 10-15% to a project's costs[7]. A similar study of roadwork projects in the USA found the range of impact of change orders on project costs to be 0.01% to 15%[8].

A study of projects in South Africa found that variation orders were responsible for 79% of cost overruns and 68% of time overruns, and that changes in specifications and scope were the most common sources of variations[9].

This indicates a responsibility on the client to scope out a project thoroughly before going to market, as well as an onus on designers, contractors and suppliers to take a 'right first time' mentality to delivery.

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[4] Schiller G (2007). *Demographic change and infrastructural cost – a calculation tool for regional planning.* Dresden: Leibniz Institute of Ecological and Regional Development.

[5] Ibid. 4

[6] Ibid. 4

[7] Sun M, Sexton M, Aouad G, Fleming A and Senaratne S (2005). *Managing changes in construction projects.* Bristol: University of the West of England. Accessed from http://www.bne.uwe.ac.uk/cprc/publications/mcd.pdf

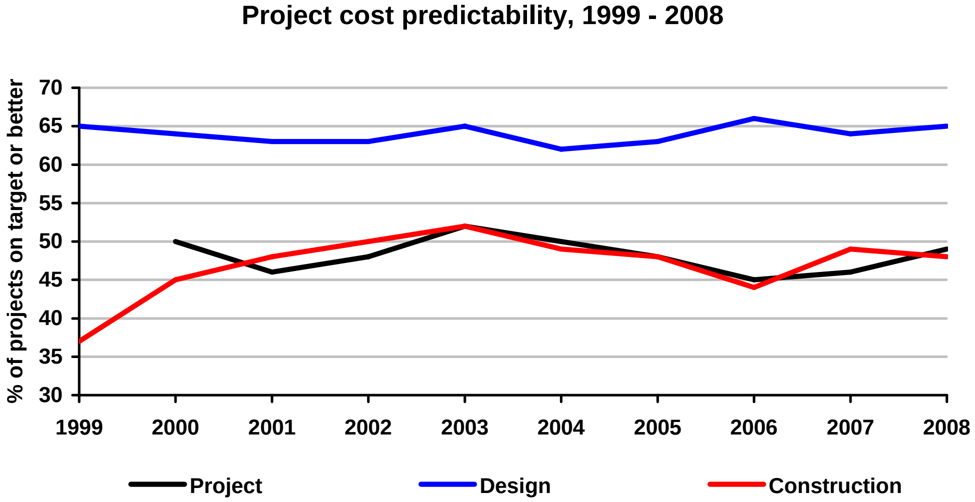
[8] Serag E, Oloufa A, Malone L and Radwan E (2010). *Model for quantifying the impact of change orders on project cost for US roadwork construction.* Journal of Construction Engineering and Management, vol 136, no 9, pp 1015-1027.

[9] Oladapo A (2007). *A quantitative assessment of the cost and time impact of variation orders on construction projects.* Journal of Engineering, Design and Technology, vol 5, no 1, pp 35-48.

Inaccurate cost estimation is a significant reason for escalating costs

The accuracy and quality of estimation of project costs is a major determinant of whether projects are delivered on budget. Underestimation of costs at the outset leads to unrealistic expectations, and thus the perception that the project has cost more than it should.

In the UK, cost predictability has not improved significantly in the past decade. Research by Consulting Excellence[10] in 2008 found that 49% of projects were delivered to expectation or better. However, this particular indicator has fluctuated around the fifty per cent level since measurements began in 2000. In general, design costs tend to be more predictable than construction costs.



Source: Constructing Excellence

Professor Bent Flyvbjerg of the University of Oxford[11] notes that, in infrastructure projects, underestimation of costs is much more common than overestimation, and the rate of underestimation has not declined in almost a century of major infrastructure projects.

Reasons for inaccurate estimation vary

Reasons for inaccurate cost estimation include:

- Internal factors, e.g. construction risks, project management risks etc.
- External economic factors, e.g. changes in materials prices, inflation, legislative changes etc.
- Flawed estimating.
- Optimism bias, i.e. over-emphasis of the potential benefits of a project, or excessively discounting the downside risks.
- Changes to project specifications part-way through delivery.

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[10] Constructing Excellence (2008). *UK industry performance report.* London: Constructing Excellence.

[11] Flyvbjerg, B (2009). *Survival of the unfittest: why the worst infrastructure gets built, and what we can do about it.* Oxford Review of Economic Policy, vol. 25, no. 3, pp. 344-367.

- Deliberate underestimation.

Underestimation may not always be inadvertent

Despite the evident technical difficulties of making accurate cost estimations, the possibility that underestimation of costs can happen deliberately should not be discounted.

Flyvbjerg[12] notes that, in situations with high political and organisational pressure, the underestimation of costs and overestimation of benefits is caused by non-intentional technical error or optimisation bias.

Such situations can arise from pressure to 'make the numbers look good' in order to secure funding, for example when available funding is limited and competition high. Flyvbjerg's report[13] quoted a transport planner with a local transport authority in the UK, who commented:

- "You will often as a planner know the real costs. You know that the budget is too low but it is difficult to pass such a message to the counsellors [politicians] and the private actors. They know that high costs reduce the chances of national funding."

Another interviewee explained that:

- "The system encourages people to focus on the benefits… the project promoters know that their project is up against other projects and competing for scarce resources."

Optimism bias can be driven by pressure to obtain private investment. At the initial public offering for the Channel Tunnel, Eurotunnel advised investors that a reasonable allowance for unforeseen impacts on construction costs would be 10%. In the event, costs overran by 80% for construction and 140% for financing.[14]

A recent case in the United States[15] illustrates the difficulties that poor cost estimation can cause. The high speed rail committee of Palo Alto City Council, California, has created a draft resolution of no confidence in the California High Speed Rail Authority and its proposed $42bn scheme. The resolution makes several observations regarding the cost estimates of the programme:

- "The Authority prior to the 2008 election estimated the cost of the system at $33.6 billion. Shortly after, it increased to $42.6 billion citing inflation as the cause for the increase (but we've had little or no inflation in recent years). Many observers believe the Authority is significantly underestimating the cost."
- "The Authority's cost estimates do not include the cost of necessary land acquisitions. We have repeatedly asked the Authority to tell us what properties would have to be taken in Palo Alto and what would be the estimated cost for such properties. The Authority has stated that it's too early in the process to have such information but we have been advised to the contrary. The Authority's concern, of course, is that land acquisition will significantly increase the cost of the project."
- "Business plan. There isn't one. Not a meaningful one."

[12] Ibid. 11
[13] Ibid. 11
[14] Ibid. 11
[15] *Palo Alto: no confidence in the California High Speed Rail Authority*. Rail-News.com, 3 September 2010.

While ACE makes no suggestion of dishonesty or wrongdoing in the above example, it does help to illustrate the risks and difficulties that can lie in the process of bringing a large infrastructure project to fruition.

The need for ongoing evaluation of costs

As this report indicates, the drivers of costs in construction are wide and various, and the evidence base is disparate and complex. A sound grasp of the cost base of construction and its multiple drivers is essential for several reasons:

- Understanding the true cost of construction allows for greater accountability through greater transparency;
- Expectations can be managed through reducing instances of costs overrunning due to unforeseen or ignored factors;
- Public resources can be allocated to projects on a sounder basis, as a more accurate picture of economic viability will be available; and
- Private sector investors may invest more readily as the cost risks are more quantifiable.

To help overcome such barriers, a National Construction Research Institute could be established. This could be a virtual organisation formed by coordinating the existing work streams of organisations such as:

- Leading university construction departments;
- Industry representative bodies such as the professional institutions, trade bodies and the Construction Industry Council;
- BRE;
- Constructing Excellence;
- The National Audit Office; and
- The Office for Government Commerce.

The aim of the new Institute would be to ensure that research into construction processes – including technical, commercial, societal and environmental factors – are coordinated and complementary.

The Institute could enable research organisations to share resources and data, thus increasing transparency and enabling larger scale research to be conducted.

Findings of the Institute's work could be used by, for example, Infrastructure UK and major construction clients to inform strategic planning, programme management and project delivery.

There would be some additional costs in setting up and maintaining the virtual centre, but the majority of work would be funded through existing construction research funding streams. The key benefits would be to bring together disparate sources of funding and achieve economies of scale, particularly in the current climate where research funding is under pressure.

As a predominantly virtual organisation, it would differ from existing construction research institutes such as those in operation in Canada[16] and the USA[17]. The UK's Institute could be modelled to a degree on earlier initiatives such as the Knowledge Transfer Networks.

Such an arrangement could also help to overcome concerns about commercial sensitivity by putting formal structures in place that could address data security issues effectively.

[16] http://www.nrc-cnrc.gc.ca/eng/index.html
[17] http://content.constructioninst.org/