

<b>Institution:</b> Cardiff University		
<b>Unit of Assessment:</b> Business and Management Studies (17)		
<b>Title of case study:</b> Driving innovative procurement for infrastructure supply chains in the UK and internationally		
<b>Period when the underpinning research was undertaken:</b> 2004 – 2017		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Jonathan Gosling	Professor	03/01/2006 – present
Mohamed M. Naim	Professor	01/10/1987 – present
Wessam Abouarghoub	Senior Lecturer	03/06/2013 – present
Denis Towill	Professor	01/01/1966 – 29/08/2015
<b>Period when the claimed impact occurred:</b> 2013 – 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<b>1. Summary of the impact</b> (indicative maximum 100 words) <p>Major infrastructure projects are often in the public eye. Due to their complexity, they can encounter unforeseen problems that lead to them running over time and over budget. Cardiff research on the effectiveness of construction supply chain systems improved the procurement of infrastructure projects in the UK, the organisational practices of major engineering organisations, and the drafting of contract forms. It transformed Highways England's procurement practices, enhanced supplier relationships at the Mace Group, reduced transaction costs for Costain, and shaped contracting models for the New Engineering Contract.</p>		
<b>2. Underpinning research</b> (indicative maximum 500 words) <p>Public spending on major infrastructure projects consumes vast amounts of taxpayers' money and shapes our cities and transport systems. The Road Investment Strategy, for example, accounted for over £15B of spending between 2015 – 2020. The supply chains for such projects involve a complex network of regulators, government clients, engineering contractors, subcontractors and consultants. Cardiff research focuses on appropriate overall supply chain strategy and its consequences for a project and associated governance (which in this case includes: contract forms, incentivisation systems, risk and reward allocation arrangements, and relational types).</p>		
<b>2.1 Rethinking procurement and supply chain approaches in construction</b> <p>The Cardiff team completed a suite of Engineering and Physical Sciences Research Council (EPSRC) research grants, culminating in the award of a £3.6M EPSRC Innovative Manufacturing Research Centre <b>[G3.1]</b> that included a project on mass customised collaborative logistics for sustainable manufacture <b>[G3.1]</b>. Previous research in the field assumed that lessons from other environments (manufacturing, automotive, retail) could simply be transposed into complex construction environments. The Cardiff researchers, uniquely applying an operations and supply chain management lens to the area, challenged this assumption and showed that the industrial approach needs to be adapted and contextualised if it is to work for the construction sector <b>[3.1]</b>. They <b>[3.2]</b>:</p> <ul style="list-style-type: none"> <li>revealed the extent to which mass customisation approaches (i.e. using standardization to meet individual requirements) are relevant to the construction sector;</li> <li>adapted supply chain principles, taken from the mainstream operations management discipline, but applied to construction engineering in a novel way.</li> </ul> <p>The team also focused on 'engineer-to-order' (ETO) situations – a supply chain structure where unique solutions requiring innovative engineering work are developed 'to order' rather than mass produced <b>[3.3]</b>. They developed guidance for designing supply chains operating in these structures.</p>		

## 2.2 Applied research

The team strategically built on their fundamental research through funded projects **[G3.2]** co-produced with Highways England, Costain, their supply chains, and the New Engineering Contract group. These formed the basis for industry guides **[G3.3]** translating the research findings for a broader research user group. The first guide gave specific guidance on appropriate contracts, while the second gave broader recommendations on procurement in major projects. The empirical research also enabled the research team to expand understanding of essential ETO definitions and structures to cover different phases of engineering designs, also explaining risk and uncertainty profiles, and appropriate governance arrangements **[3.3, 3.4]**. Combined, these provide:

- a model of procurement excellence, anchoring contract strategy in a set of principles;
- an 'order entry' point model for understanding readiness and engineering uncertainty early in the procurement cycle;
- a basis for considering early engagement of relevant parties, including internal teams and relevant external parties;
- a classification of contract choices, the associated relational and innovation investments needed, and an evaluation of the performance implications of different options to inform procurement strategies.

The Cardiff researchers also reviewed the Mace group's supply practices and analysed two large supplier performance datasets. Applying relational models and learning curve approaches, they categorised suppliers according to relationship types and supplier development initiatives – strategic partners, preferred, approved, and alternate suppliers. Their findings, published in a series of papers outlining evidence-based practices for strategic partnerships **[3.5, 3.6]**, showed that:

- supplier development approaches need to be matched to relational forms and sustained over time to make a consistent impact;
- there is a significant difference between the volatility of performance between different supplier categories;
- the higher the level of partnership in the relational category, the better the improvement in performance during the lifetime of a project;
- investment in supplier development must be tailored to suit supplier category – for example, suppliers in the approved category perform less well on the 'close out' of projects, suggesting a need to raise performance on close out issues.

This body of work, strategically co-created with user input, provided the evidence base needed to underpin and drive improvements across the UK's infrastructure supply chain.

## 3. References to the research (indicative maximum of six references)

**[3.1] Gosling, J., and Naim, M. (2009)** Engineer-to-order supply chain management: a literature review and research agenda. *International Journal of Production Economics*, 122 (2), 741-754. <https://doi.org/10.1016/j.ijpe.2009.07.002>

**[3.2] Gosling, J., Towill, D. R., Naim, M. M., and Dainty, A. R. (2015)** Principles for the design and operation of engineer-to-order supply chains in the construction sector. *Production Planning & Control*, 26 (3), 203-218. <https://doi.org/10.1080/09537287.2014.880816>

**[3.3] Gosling, J., Hewlett, B., and Naim, M. M. (2017)** Extending customer order penetration concepts to engineering designs, *International Journal of Operations & Production Management*, 37 (4), 402-422. <https://doi.org/10.1108/IJOPM-07-2015-0453>

**[3.4] Gosling, J., Hewlett, B., and Naim, M. M. (2020)** Relational Investments and Contractual Choices for Diverse Engineering Designs, *IEEE Transactions on Engineering Management*, early cite, <https://doi.org/10.1109/TEM.2020.2981611>

**[3.5] Gosling, J., Naim, M., Towill, D., Abouarghoub, W., and Moone, B. (2015) Supplier development initiatives and their impact on the consistency of project performance. *Construction Management and Economics*, 33 (5-6), 390-403. <https://doi.org/10.1080/01446193.2015.1028956>**

**[3.6] Gosling, J., Naim, M., Abouarghoub, W., and Moone, B. (2019) Constructing supplier learning curves to evaluate relational gain in engineering projects. *Computers & Industrial Engineering*, 131, 502-514. <https://doi.org/10.1016/j.cie.2018.05.008>.**

#### **Selected grants:**

**[G3.1] Naim, M. *The Cardiff Innovative Manufacturing Centre*, EPSRC (GR/S75505/01, EP/C515404/1) (2004-2007), £3.6M (including *Mass customised Collaborative Logistics for Sustainable Manufacture* £589K, 2004-2007)**

**[G3.2] Rowsellwright Ltd, with Cardiff University as academic partner, *Procurement Capability Review* Office of Road and Rail and Highways England, £9,088 (out of total of ~ £150,000), 2017**

**[G3.3] Gosling, J., Kumar, M., Lethbridge, S., Naim, M. *Engineering to order construction supply chains*. Highways England in partnership with Costain, £34,000, 23/10/14-30/11/16. MoU 543974**

#### **4. Details of the impact (indicative maximum 750 words)**

The beneficiaries of this research cover the wider infrastructure supply chain of major infrastructure projects, including regulators (the Office of Road and Rail), Government clients (Highways England, Crossrail), contract bodies and law firms (NEC, Pinsent Masons), as well as major engineering contractors and their supply chains (Costain and Mace).

##### **4.1 Impact on the drafting of contract forms**

Standard contract forms, for instance those developed by the New Engineering Contract (NEC) group, have been widely adopted across construction and engineering sectors. Cardiff's principles for good procurement practice have shaped the upgraded version of the suite of contracts (currently NEC4).

[Text redacted]

Examples of how the NEC4 suite is being used in the industry include:

- [Text redacted] They confirmed that the Cardiff principles, as evident in the new contract forms, "*guided our commercial and procurement teams, leading to a greater use of NEC across projects*" **[5.2]**.
- [Text redacted] For example, Sydney Water adopted NEC4 contracts as its standard contract model for delivering up to AU\$4billion (£2.2B) of construction works and services between 2020 and 2030. Its new NEC4-based model, which involves replacing its traditional, transaction-based supply chain with three regional delivery consortia, is expected to lead to 5-10% annual programme savings **[5.3]**.

##### **4.2 Impact on the public procurement of infrastructure projects**

The series of guides produced by the researchers, which include easy-to-read principles for appropriate contracts and models, have been an important pathway to impact informing better procurement of major projects.

When Highways England (HE, formerly the Highways Agency) became a Government owned company in 2015, it benefitted from research support when introducing its new operating model for procurement and supply chain management. The industry guides, which "*were instrumental in transforming HE procurement practices from 2015-2019*", informed the key areas of change in this transformation. Lucia Fullalove, the Highways England Lean Practitioner who commissioned the research confirmed that, as well as encouraging the use of NEC4 forms, it led to "*a reduction in non-conformance outcomes (as in M1 project), less rework and fewer disputes in the supply chain*" **[5.2]**. In addition, she stated that the research informed Highways England's sector-guiding Supply Chain Strategy 2015 and Procurement Plan 2019 **[5.2]**, which "*led to a more structured approach to the generation and capturing of efficiencies and innovations in procurement*" **[5.2]**.

**a. Road Investment Strategy**

In 2017 the researchers worked with the Office of Road and Rail (ORR), the statutory body that oversees and regulates transport infrastructure in the UK, to shape its road investment strategy (worth £15.2B between 2015 and 2020). They carried out a capability review [5.4], co-written with Steve Rowsell and David Orr (former Institution of Civil Engineers' president), offering specific analysis and recommendations for ORR and Highways England procurement. This assessment of procurement capability informed the:

- [text redacted];
- [text redacted];
- [text redacted].

An independent report [5.5] published by Highways England and referencing the ORR review [5.4], evaluated the reforms and changes undertaken across Highways England over the period 2014-2018 and concluded that there has been an *"improved procurement process"*, *"a more collaborative and less bureaucratic approach to procurement"*; and *"relationships with its suppliers had improved"*, leading to efficiencies and innovation.

**4.3 Impact on the organisational practices of major engineering organisations and their supply chains**

The underpinning research directly influenced two of the UK's largest engineering groups (both with a turnover of approx. £1.5B) and their supply chains.

**a. Mace**

Through long-standing collaboration with Mace's Centre of Supply Chain Excellence (known as the Mace Business School), the Cardiff team informed Mace's approach to supply chain relationships and supplier development initiatives. In providing an evidence base for the value of long-term strategic partners, the research changed company practices.

Brian Moone, Mace's Supply Chain Director, confirmed [5.6] that the collaboration has:

- enabled greater use of long-term strategic partners – *"our spend with long-term strategic partners has increased by 38%, which is c.400 suppliers"*;
- contributed to positive dialogue with clients, *"leading to greater success of tenders. Most notably we have grown our share of the market and secured over £1.6bn of projects in 2019, based on our supply chain excellence"*;
- changed company culture – *"The supply chain at Mace is no longer considered an 'island' or a commodity, but a strategic area to be managed in a holistic way, allowing the supply chain to invest in long-term relationships more effectively."*

In an online article on Mace's partnership with Cardiff, Moone further noted that the research *"helped us inform our teams and our supply chain partners that collaboration is key to success and we reflected this in Mace Business School's training modules"* [5.7].

**b. Costain**

Costain and its supply chain partners are also benefitting from adopting principles from Cardiff's research on long-term strategic partners, as well as from Cardiff's co-production approach to research. [Text redacted].

As noted by [text redacted], Cardiff research on supply chains and governance provided the reliable evidence agencies and groups needed to improve procurement of major infrastructure projects, transform practices, and shape contracting models.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

[5.1] [Text redacted]

[5.2] Testimonial: Lucia Fullalove, Lean Practitioner at Highways England (2009 – 2018)

[5.3] NEC in Action case study (from the NEC website)

[5.4] Highways England – Procurement Capability Review (December 2017)

[5.5] Ipsos MORI and Risk Solutions report: Evaluation of Roads Reform (2019)

**[5.6]** Testimonial: Brian Moone, Supply Chain Director, Mace

**[5.7]** Brian Moone, 'How can we use research to deliver project success?' Mace website (27/11/19)

**[5.8]** [Text redacted]