

<p>Institution: University of Cambridge</p>
<p>Unit of Assessment: UoA15</p>
<p>Title of case study: Strategic design of global manufacturing networks</p>
<p>1. Summary of the impact (indicative maximum 100 words) The results of research at the University of Cambridge Department of Engineering (DoEng) on global manufacturing networks were disseminated to industry through publications, events, training and consultancy. During 2008-13 more than 20 multinational corporations applied the findings to transform their global networks, determining the ideal location and roles of plants around the world, and achieving beneficial trade-offs of access to markets and resources, innovation and risk, while minimising cost. Corporations including Rolls-Royce, GSK, BAE Systems, and Caterpillar report impacts in terms of cost savings (measured in tens of millions GBP per annum), improved competitive differentiation and shifts in capital expenditure allocation (measured in hundreds of millions GBP per annum). GBP 2,158,181 revenue has also been directly generated in consultancy and training spin-offs.</p>
<p>2. Underpinning research (indicative maximum 500 words) Professor Sir Michael Gregory (now Head of Manufacturing and Management) joined the Department of Engineering (DoEng) at the University of Cambridge as Lecturer in 1979 and was promoted to Professor in 1995. His research explored how companies can leverage their international production networks for competitive advantage. Gregory was the PI for the EPSRC grant 'Manufacturing Mobility' (1994-98) [a]; this work led to his key 1998 paper in the <i>Journal of Operations Management</i> [1] which set out new structured knowledge about international manufacturing networks by analysing the networks, classifying configurations and identifying capabilities. The research led a shift in academic thinking from "plant-level" towards "factory network-level" optimisation, with an important output being a typology of network-level characteristics to be used as the basis of strategic analysis. Two main network dimensions (geographic dispersion and coordination) were used as a framework to explain four network configurations (regionally-focused, global-exporting, multi-domestic and globally-coordinated). Key findings included a possible strategic evolution path between the configurations, with the emergence of a fifth hybrid "glocal" model.</p> <p>Gregory won further EPSRC grants to continue this work: 'Developing International Manufacturing Capabilities' (1997-2000) [b], which focussed on the needs of four sectors (automotive component supply, telecoms and electronics, aerospace equipment and capital plant); 'Global Manufacturing Virtual Networks' (2000-03) [c], which identified key drivers of the increasingly fragmented and interdependent global structure of firm-networks (and was reviewed as 'internationally leading' in quality, practice and planning, and 'outstanding' in communication of outputs, potential benefits to society, and overall); and 'Mergers and Acquisitions – Achieving Manufacturing Synergy' (2005-08) [d], which explored how multi-national manufacturing companies can achieve synergies following cross-border mergers and acquisitions.</p> <p>Gregory published the results of this further research – presenting a new understanding of the nature of global manufacturing networks, in terms of their structure, drivers and constraints, and supporting their strategic analysis, design and transformation – in two further seminal papers in the <i>International Journal of Operations and Production Management</i> in 2003 [2] and 2008.[3] His co-authors included members of the core team which he built in the DoEng from 1994 onwards, particularly Dr Yongjiang Shi (research student 1994-98, Research Associate from 1999, appointed Lecturer in the DoEng in 2006; Co-Investigator in the final grant mentioned above) and Research Associates Dr Jagjit Srari and Dr Tomas Harrington.</p> <p>From 1994 to the present, the team (working in the DoEng's Centre for International Manufacturing) has evolved a network design methodology in which new theoretical approaches from research were tested and applied in companies, not only to disseminate the latest results, but also to inform further research. Alongside this close coupling of research, development, testing and application (described further in section 4), the team has continued to extend the underpinning models. Since 2008, the intra-firm network model has been extended to the inter-firm supply</p>

network context by exploring how companies should design their global supply networks to enhance competitive capabilities; the network configuration and capability approach has also been extended into research in engineering and service networks, and from mature sectors to emerging technologies. Enabling processes in the areas of network risk and resilience, and the design of sustainable supply chains, have also been published.

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

[1] *Shi Y and Gregory MJ (1998) "International manufacturing networks - to develop global competitive capabilities", *Journal of Operations Management*, Vol 16, pp 195-214. doi: 10.1016/S0272-6963(97)00038-7

[2] *Colotla I, Shi Y and Gregory MJ (2003) "Operation and performance of international manufacturing networks", *International Journal of Operations and Production Management*, Vol 23, No 10, pp 1184-1206. doi: 10.1108/01443570310496625

[3] *Srai JS and Gregory MJ (2008). "A supply network configuration perspective on international supply chain development", *International Journal of Operations and Production Management*, Vol 28 No 5, pp 386-411. doi: 10.1108/01443570810867178

*All three research outputs represent the quality of the research.

Grants

[a] EPSRC GR/K41472, 1994-98 (PI M Gregory), 'Manufacturing Mobility' <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=GR/K41472/01> GBP162k

[b] EPSRC GR/K86107, 1997-2000 (PI M Gregory), 'Developing International Manufacturing Capabilities' <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=GR/K86107/01> GBP413k

[c] EPSRC GR/R10950, 2000-03 (PI M Gregory), 'Global Manufacturing Virtual Networks: a New Architecture For Manufacturing Systems' <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=GR/R10950/01> GBP408k

[d] EPSRC EP/C541588, 2005-08 (PI M Gregory, Co-I Y Shi), 'Mergers and Acquisitions - Achieving Manufacturing Synergy' <http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/C541588/1> GBP457k

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

During the assessment period the team developed, tested and applied the research results in projects for over 20 multinational corporations, through a toolkit titled "Manufacturing Footprint Strategy", providing a structured approach for companies to address four questions: a) why is it necessary to evolve the global production network? b) what strategic elements form the basis of distinctive market position? c) where should plants be located, and how many plants should there be in each role? and d) how best can the transition be achieved and monitored?

These manufacturing footprint strategy projects – each involving at least 12 months of intense collaboration and a senior cross-functional team – applied the research across a wide range of sectors from construction equipment, aerospace and transport, to chemicals, packaging, white goods and toys. Companies which have used the research in the assessment period to set strategy and to make major budgeting and expenditure allocation decisions, benefitting as a result from cost savings and improved competitive differentiation, include Beiersdorf, Bombardier, Caterpillar, Electrolux, Grundfos, Huntsman, Invensys, LEGO, Rolls-Royce, Schneider Electric, Sealed Air, Shell and Wavin. In addition, projects relating to supply network design, engineering and service networks have been undertaken in the same period with BAE Systems, GKN, GSK, Huawei, LEGO, Rolls Royce and Unilever.

The research has been disseminated through publication, events, training and consultancy. In 2007, the DoEng published a best practice guide, *Making the Right Things in the Right Places – a structured approach to developing and exploiting manufacturing footprint strategy*. [4] Key events include Practitioner Forums (structured programmes of workshops and analysis aimed at defining best practice and sharing experiences, based on members of the research team working closely with company executives) and Annual Symposia (aimed at leading academics and industrialists in the area of global manufacturing, providing a focal point for a community of practitioners to share experiences in this field, and to help align academic research with industry needs). 7 such events relating to this research have been held in 2008-13 with a total of 331 delegates.

The main vehicle for training and consultancy has been DoEng's wholly-owned subsidiary Institute

for Manufacturing Education and Consulting Services Limited (ECS), which has generated GBP 2,158,181 in consultancy, training, publication and events revenue based on the research between Jan 2008 and July 2013.

The specific outcomes of the collaborative projects with companies are often commercially highly sensitive, particularly when they concern strategic investments or major budget reallocations and their impact on costs and employment. However, the following companies have provided summaries of the impact on their businesses during the period 2008-13:

- **Sealed Air** (a USD8bn-turnover global leader in food safety and security, facilities hygiene, and product protection) applied the research in a major strategic programme during the period 2004-11 involving 120 senior managers across multiple business divisions, and culminating in a Board decision on radical transformation of its global production network. The VP of Global Manufacturing described the project at the Annual Symposium in 2009, defining the aim of the company's Global Manufacturing Strategy (GMS) to expand global production capabilities in developing markets around the world, and to re-align existing production into manufacturing centres of excellence within an optimised network, in order to significantly improve operating efficiencies and lower overall costs without compromising service, quality or EHS. The company reported a series of updates in Press Releases over the period 2008-11, where it announced that the overall project involved capital expenditure of USD220m [5] and delivered repeating savings of USD55m per annum.[6]
- **Rolls-Royce** has been working with ECS since 2011 to apply the research on managing complex global supply networks, to build thought leadership within the company and thereby sustainable supply-chain competitive advantage. Work in the assessment period has included development of 'Do-Buy' tools for prioritising investment in new manufacturing process technologies; piloting of global supply network capability development tools; and development of new concepts in the areas of internationalisation and industry structure mapping and reconfiguration. Rolls-Royce's Director of Corporate Planning comments that the work "*has resulted in innovative strategy tools – linked to original research – that have been embedded as part of our on-going strategic processes. These are helping to guide significant investments of around GBP250m in our supply chain that will generate tangible business value (over GBP750m) over the life of the investments, and which will contribute to competitive differentiation.*"[7]
- **GlaxoSmithKline (GSK)** has applied the research on managing global supply networks. Work in the assessment period included a global packaging strategy model (used to underpin GSK manufacturing's move to a regional/hub model and to support development of growth markets); a supply network capability framework (used to assess different network configurations and the required capabilities at different sites); and a framework for assessing the dynamic reconfiguration of networks (underpinning the supply of novel products and the creation of new business models for diagnostics supply). The SVP Head of Network Strategy, Global Manufacturing and Supply, commented: "*Our work has resulted in a range of new strategy tools with very practical application. These tools have helped in important decision-making areas in our supply chain that have enabled GSK to drive business performance in manufacturing and supply chain, and commercially. We estimate that this work has underpinned investment decisions affecting more than GBP50m of investment, and supported the development of our new product capability supporting revenue in excess of GBP500m.*"[8]
- **Caterpillar** has worked with ECS throughout 2008-13. The research on optimising global manufacturing networks has underpinned an enterprise-wide strategic process of aligning manufacturing networks with projected sales, generating improved return on production-related assets and increased enterprise synergies. The Manager of Global Production Network Planning comments: "*We are one of the world's largest manufacturers, with sales approaching USD50bn, and the main reason for starting this process was to secure the long-term optimisation of our production network*". Since 2008 this approach has been used in all business divisions and serves to guide and align all Caterpillar's investment regarding the future footprint. This process guides Caterpillar's annual multi-billion-USD capital spend through coordinated investments across the vertically integrated company.[9]

- **Wavin** (a leading supplier of plastic pipe systems with over 40 plants across Europe) and ECS worked together in 2009/10 to apply the research on optimising global manufacturing networks, resulting in a strategy covering development of clear plant roles and guidelines for ongoing investment. One particular area of focus was optimising the trade-off between exploiting low-cost labour and investing in automation in legacy high-cost country plants. The project resulted in an advanced analysis tool, based on the research, which was used to guide decisions on production location and investment programmes. Wavin's Executive Director of Supply Chain Operations described the project's impact in 2012: *"This was a major strategic thrust aimed at developing and implementing the right supply and manufacturing footprint to achieve operational and service leadership within the Wavin Group. As a result, we are running an investment program of EUR8-10m per year for 3-5 years to implement the desired footprint as designed. The estimated repeating annual cost-savings achieved to date are EUR3-5m."*[10]
- **Electrolux** (a EUR12bn-turnover global leader in household appliances selling more than 40 million products to customers in 150+ markets every year) conducted a collaborative programme with ECS in 2012-13, applying the research on optimising global manufacturing networks through strategy workshops with senior managers across 4 global product lines, with results being aggregated to form an enterprise-level global footprint strategy for the board. The outcome will guide investment in the future footprint over the next 3-5 years, expected to be in the order of 3.5 Bsek (EUR400m), where the targeted cost savings are in the order of 1.3 to 1.6 Bsek (EUR180m) annually. The SVP of Global Manufacturing Operations at Electrolux comments: *"This project forms a major part of our corporate business strategy and will help to guide the optimisation of our footprint of over 45 plants around the world. This will drive structural changes in terms of cost reduction and responsiveness to customers which will underpin our future competitive differentiation."*[11]
- **BAE Systems** used the network configuration and capability tools in 2010-11 to analyse the current and future role of the Engineering Function of the Military Air and Information (MAI) Business Units, in order to determine their potential role as part of an evolving network over the next ten years. The network design tools developed by the DoEng provide a structured approach to developing industrial capability, showing how the proactive reconfiguration of the network can shape future engineering and industrial capability across the design-build-service-support operation.

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

[4] Making the Right Things in the Right Places – a structured approach to developing and exploiting manufacturing footprint strategy, University of Cambridge Institute of Manufacturing, ISBN 978-1902546612, 2007,

http://www.ifm.eng.cam.ac.uk/uploads/Resources/Reports/footprint_strategy.pdf

[5] Sealed Air Corporation 4th quarter and year end results 2008

<http://ir.sealedair.com/phoenix.zhtml?c=104693&p=irol-newsArticle&ID=1248071>

[6] Sealed Air Corporation 4th quarter and year end results 2010

<http://ir.sealedair.com/phoenix.zhtml?c=104693&p=irol-newsArticle&ID=1518900>

[7] Statement from Director of Corporate Planning, Rolls-Royce

[8] Statement from Vice President (Investigational Material Supply), GSK

[9] Statement from Vice President (Advanced Components and Systems Division), Caterpillar

[10] Statement from Executive Director, Wavin

[11] Statement from Senior Vice President (Global Manufacturing Operations), Electrolux