Institution: University of Birmingham

Unit of Assessment: UOA 19 - Business and Management Studies

Title of case study: Adoption of new management tools within global engineering networks

1. Summary of the impact

Key findings from Dr Zhang's research at Birmingham Business School into global engineering networks (GEN) have been adopted by some of the largest manufacturing firms in the UK, leading to measureable improvements in the effectiveness and efficiency of their engineering functions. The programme of research combines engineering, technology and process management and wider insights from organisation studies to develop decision-making tools for firms. One important route for disseminating GEN research findings to industrial audiences has been the High Performance Engineering Forum; member companies of the Forum have achieved tangible benefits from application of the approach including reduced engineering expenses, improved communication, support for novel working approaches and the introduction of innovative business initiatives. Users cite the benefits of these tools in support of the formation and implementation of global engineering strategies and improved communication between operations at different stages of the engineering value chain. There is also evidence of wider impact in terms of the increased awareness of the need to combine engineering and technology-related expertise with innovation management capabilities and knowledge of the changing international landscape. The research focuses on emerging competitors, growing markets and potential collaborations, particularly in, from, or with China. These have significant implications for current manufacturing business models in the UK. The GEN framework has also been adopted as an essential input for the Excellence Engineering Education System in China co-developed by the Chinese Academy of Engineering, Cambridge University and Tsinghua University, and intended to provide a novel framework for Chinese engineering education.

2. Underpinning research

GEN research has focused on global collaborative engineering networks and has evolved through close partnership with industry. GEN research at the Birmingham Business School (BBS) began in June 2009, when Dr Zhang was appointed as a Lecturer at BBS. The Birmingham research has been focused on further developing the GEN theories into practical tools which can be directly used by managers to design and optimize their global engineering operations [1].

At the same time, the GEN theories have been further developed into the Engineering Value Chain (EVC) model through applications in different industry sectors (described below) and industrial settings [2], including engineering design, manufacturing and services provision (related to the 'servitisation' agenda for British manufacturers).

Zhang is the academic co-ordinator of the EU FP7 funded of a multidisciplinary research platform for international engineering network collaborations which has been established to undertake GEN research and industrial applications in high value engineering, advanced manufacturing and innovation. This project builds on leading expertise in Europe and China along the whole engineering value chain from research, design, development and production, to delivery, service, support, recycling and disposal. The project has seven founding institutions, including seven leading engineering universities in the Europe and China as well as a wide range of academic and industrial partners. (Overall EU support is €839k from 2012 to 2016. Grant No. PIRSES-GA-2011-295130. Project website www.birmingham.ac.uk/hven)

Key GEN findings from Zhang's research are:

- Engineering and technology management: GEN offers advanced methods to analyse and guide the emergence of new combinations of technologies and novel engineering capabilities.
- Engineering design and innovation: GEN can contribute to the development of global technological platforms and open innovation systems along the engineering value chain.
- International manufacturing and engineering: there is scope to develop novel business models incorporating advanced manufacturing capabilities, innovative operations structures and value chain integration.
- Service engineering and engineering services: the transformation of manufacturing towards service-centred operations and service innovation, and the emergence of service sciences in

international engineering operations, can be facilitated by GEN methodologies.

In addition to the above themed research areas supported by industrial collaborations with UK-based engineering organisations, the GEN approach has been further developed into models to address particular business challenges through international collaborations. For example, the GEN framework has been developed into a risk management model through a series of application projects with Danish firms [3]. The EVC model has been further developed into value network analysis methods for complex maritime engineering networks in Norway [4] and China [5].

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

1. Zhang, Y. and Gregory, M. 2013. "Towards a Strategic View of Engineering Operations", Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, vol. 227, no. 6. DOI: 10.1177/0954405413478524
2. Zhang, Y. and Gregory, M. 2011. "Managing Global Network Operations along the Engineering Value Chain". International Journal of Operations and Production Management, vol. 31, issue 7, pp. 736-764. DOI: 10.1108/01443571111144832
3. Hansen, N., Zhang, Y. and Ahmed-Kristensen, S. 2013. "Viewing Engineering Off-shoring in a Network Perspective: Addressing and Managing Risks", Journal of Manufacturing Technology Management, vol. 24, issue 2, pp.154-173. DOI: 10.1108/17410381311292287
4. He, T., Zhang, Y. and Xu, X. 2012. "On Service Supply Chain Operations Management: A Service Value Perspective". International Journal of Product Development, vol. 17, issue 3/4, pp. 277-295. DOI: 10.1504/IJPD.2012.052104
5. Engelseth, P. and Zhang, Y. 2012. "Engineering Roles in Global Maritime Construction Value Network", *International Journal of Product Development,* vol. 17, issue 3/4, pp. 254-276. DOI: 10.1504/IJPD.2012.052104

4. Details of the impact

The insights, frameworks, tools and approaches developed under the GEN research programme have had an impact in a number of ways across a variety of industry contexts. The particular relevance for practitioners lies in the way the approach links plant-level and supply-chain level performance measures of effectiveness and efficiency – which have long been used to assess improvements arising from new technology, process configurations or supply chain structures – with broader changes in the global manufacturing landscape. This landscape has been dramatically changed in the recent decades driven by globalization, emerging markets, new competitors and changing technologies. For the UK this has meant many well-established engineering and manufacturing sectors are shifting operations to lower-cost locations, including emerging BRIC economies (Brazil, Russia, India and China). At the same time, manufacturers in emerging economies are trying to upgrade their technical and operational capabilities through joint-ventures, international acquisitions or other forms of cross-border collaborations. These trends give rise to a number of opportunities and threats for UK firms. There is greater scope to exploit high value engineering capabilities, but greater risks of losing key competitive assets. Understanding the complex dynamics of global value networks and developing capabilities for systematic engagement with such networks present major challenges to UK firms.

GEN research findings have been used to provide practical guidance to UK manufacturers looking to develop novel approaches to enhancing industrial performance in high value engineering, advanced manufacturing and innovation areas. GEN's direct contributions to industry have taken place through three main forms of engagement, all of which have improved the effectiveness of practices in the industry, thus achieving commercial and economic benefits.

One of the leading companies Zhang has worked with has been Rolls-Royce. The company's Head of Supplier Engineering has written to confirm this collaboration and said that he is ".. *very confident in the industrial value of your research for enhancing the performance of engineering operations on a global scale*" and that he expects to see "..*benefits and tangible improvements gained from your research in introducing a systematic approach to global engineering networks*." [s1]

1. Extending awareness of GEN across the engineering industry

There is an increasing awareness of the importance and value of GEN approaches to the engineering industry, as evidenced by a series of invited presentations to industrialists and policymakers. The GEN research findings have been disseminated to a wide range of industrial audiences through the High Performance Engineering (HPE) Forum, of which Zhang has been a member since 2008. The HPE forum provides a platform for sharing experiences and supporting GEN research. Two major engineering meetings were held at the Royal Academy of Engineering and the Institute of Mechanical Engineers in London with participation of senior engineering managers to steer GEN research, validate the findings, and assess the implications of the research findings in their businesses.

The Forum has 12 core members including major engineering companies from a wide range of industrial sectors including aerospace, defence, automotives, electrics and electronics. The Forum organisers have confirmed that *"around 60% of the member companies have directly benefited from GEN frameworks and methods through various engagement activities. Recently applications, with our facilitation, include global engineering strategy review and engineering network restructuring guided by decision making tools originated from GEN. These application projects helped to improve the effectiveness and efficiency of the companies' engineering operations on a global scale. Tangible improvements have been observed in many different areas, e.g. reducing engineering expenses, improving communication, supporting novel working approaches, introducing innovative business initiatives, etc*." [s 2]

Under the EC-HVEN platform, co-ordinated by Zhang, there have also been a series of industry and policy focused workshops, seminars and invited talks to international audiences. Most recent workshops include: the global engineering design workshop in Denmark with industrial participants from six companies in March 2013; an engineering services workshop in Harbin with industrial participants from six companies in April 2013; and the manufacturing services and business model innovation workshop in Hangzhou with industrial participants from five companies in April 2013. International activities have included invited talks for industrialists at the Global Manufacturing Conference in Hangzhou 2010 and at the Manufacturing Service Out-sourcing Conference in Shanghai 2011; and for policymakers, an invited seminar focusing on the Industrial Upgrading and Strategic Development in Guangzhou 2012 and an invited talk at the Global Engineering Workshop in Washington 2012.

2. Application of GEN decision-making tools

Extensive impact has been achieved by providing decision-making tools for the formation and implementation of global engineering strategies. These tools include practical frameworks such as structured working sheets for data collection and performance analysis, combined with knowledge of new and emerging (technological, industrial, market) opportunities. They are normally used by companies with support of academic researchers, industrial fellows or consultants.

A typical toolset on engineering value chain analysis covers topics such as engineering value chain mapping, key success factors assessment, comparative analysis of value creation mechanisms and the development and selection of network design archetypes. These draw on BBS research findings presented in nine in-depth case studies and applied projects in the aerospace, automotives, defence and electrics and electronics industry sectors.

In such projects long-term performance measures of (1) effectiveness (how closely an organisation's output meets its goal and/or customer requirements) and (2) efficiency (how economically the organisation's resources are utilised when producing the required output or providing a given level of customer satisfaction) provide some validation of the added value. A commonly cited measure put forward by corporate partners in the GEN network is cost savings resulting from process or supply chain consolidation, standardisation and integration leading to economies of scale or scope at the level of a particular plant or corporate division. Other users cite the benefits of clarifying cost-benefit trade-offs between different structures and configurations as part of re-location or foreign direct investment (FDI) projects, or to analyse the relative merits of joint-ventures and M&A propositions.

3. Improving communication between managers in the engineering value chain

GEN has also contributed to a significant improvement in communication between managers working at different stages of the engineering value chain. Zhang's research at BBS led to the development of the key principles and practical mechanisms to influence behaviour in the workplace. Part of the value of the GEN framework was to connect high-level visions of a company's engineering network with the detailed processes and procedures managers were familiar with, but which varied by department.

The GEN configuration framework ensured the consistency of the key organisational and strategic elements in network design and operations, which have been used to guide companies to optimise their engineering networks or design new networks to support their businesses or their customers better.

The improvement of communications has been achieved in practical terms through involving engineering managers from different parts of the business. In a GEN application workshop, for example, participating managers spend two to three days to understand the similarities and differences between their departmental approaches, resolve process barriers and develop strategies and action plans to optimise their engineering networks, or to design new engineering networks for future success. Their effective interaction at such workshops is facilitated by the structured guidance from the GEN approach. This focuses discussion on a shared assessment of whole-system network configuration and value creation (i.e. how the total is more than a sum of the parts) and trade-offs between various options.

4. GEN in Excellence Engineering Education System in China

The GEN framework has also been adopted as an essential input for the Excellence Engineering Education System in China co-developed by the Chinese Academy of Engineering, Cambridge University and Tsinghua University, and intended to provide a novel framework for Chinese engineering education. This will contribute to China's engineering education policies and strategic plans for the coming 20-30 years through the Chinese Academy of Engineering and the Ministry of Education. The Project Leader has confirmed that Zhang's research on GEN and EC-HVEN has made a major contribution to this work, particularly in helping to shape the theoretical foundations and in identifying emerging trends in theory and in practice. [s3]

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

[s1] – Corroborating statement from Head of Supplier Engineering, Rolls-Royce, Derby dated 29th September 2013

[s2] – Corroborating statement from Director of High Performance Engineering Forum dated 25th October 2013

[s3] – Corroborating statement from Project Leader of the Engineering Education Project, Institute of Engineering Education at Tsinghua University and Chinese Academy of Engineering dated 25th October 2013