Institution: University of Sheffield

Unit of Assessment: 19 - Business and Management Studies

Title of case study: Economic and environmental improvements in organisations through low carbon supply chain resource modelling

1. Summary of the impact

Research within Sheffield University Management School (SUMS) into supply chain management and carbon reduction has delivered economic and environmental impacts by helping businesses reduce their carbon footprint through lower-cost resource efficiencies. The supply chain management tool, SCEnAT, developed from SUMS research, has helped businesses change their operations to reduce CO_2 emissions, make cost savings of up to £250k per company and improve their business performance through, in one case, winning additional contracts worth £1.75m. The research has also been used by regional business organisations in developing and implementing growth strategies to support low carbon businesses in Yorkshire and Humber.

2. Underpinning research

Both globally and locally, external political, regulatory, institutional, economic and social drivers and pressures on organisations over the past five to ten years have created an imperative for combined low carbon, low cost operational and organisational solutions. In response, since 2005, research by a team in SUMS, led by Professor Lenny Koh, has tested theories and methodologies to develop a supply chain resource modelling system to enable organisations to maximise efficiency and to reduce the carbon footprint of entire supply chains.

Between 2005 and 2010, in response to research user needs and working with collaborators in Greece, Turkey, and Taiwan, the group undertook new research on green supply chain theory through the study of supply chains in Europe and Asia [R1, R2]. The group used systems theory to examine how decisions informed by a whole supply chain or intra-organisational approach could improve performance across the supply chain. They then focused specifically on low carbon supply chain management, the impact of environmental directives on intra-organisational decisions and established the need for a comprehensive decision support system for carbon management across the supply chain. This reflected a closer appreciation of real-world systems and a means of directly addressing research questions of user organisations. The group advanced theory by advocating a balanced whole supply chain system approach to improve both the understanding of, and decision making for, carbon accounting across global supply chains [R3]. The approach applied methodologies to identify areas of greatest risk and uncertainty in a supply chain (e.g. machine failure, quality issues, staffing problems) to the challenge of carbon reduction, identifying the most carbon-intensive parts of the supply chain. The research then advanced to focus on causality between such system interventions and supply chain practices [R4] to evaluate and optimise the effectiveness of the tools that the team might develop. Funding through the European Union and European Regional Development Fund enabled a feasibility study on energy efficiency in global supply chains linking China and Europe, disseminated at an international seminar in Beijing (2009).

In 2010, Professor Koh led a two-year research collaboration (RDA funded) between the Universities of Sheffield, Hull and York, which developed a decision support tool to enable organisations to identify areas of high carbon usage and select lowest-cost interventions to address them [R5]. This was the crucial point at which theory was brought to practice. The aim of the Low Carbon Supply Chain Project was to design a system that could integrate different techniques and methods of supply chain mapping and carbon accounting and suggest carbon reduction interventions that would reduce carbon footprint whilst improving operational efficiency. The SUMS element of the research developed methodologies for mapping entire supply chains, tracing each product component from cradle to grave, revealing materials and energy usage at each level of the supply chain, manufacturing processes and logistical operations within and between each company, including recycling and waste management [R6]. To supplement this, Dr Kuylenstierna (University of York) worked on the methodologies to calculate the carbon footprint of

each part of the supply chain and Professor Gibbs (University of Hull) worked directly with businesses to identify a range of practical interventions. The Sheffield team then developed software based on the relationships identified that, using data from any supply chain, can be applied to reveal the points of highest carbon consumption and interventions that have the most cost-efficient impact on the carbon footprint [R5].

University of Sheffield researchers included: Prof. Lenny Koh (2001- present); Prof. John Cullen (2005-present); Dr Andrea Genovese (2010- present); Dr Adolf Acquaye (2012-present); Dr Nasir Rana (Feb 2010-2012); Prof. Panayiotis Ketikidis (University's International Faculty in Greece, 1991- present); Prof Mehmet Demirbag (2003-present) and Dr Victor Shi (2008-2012).

3. References to the research

R1. Sevkli, M., Koh, S.C.L., Zaim, S., Demirbag, M., & Tatoglu, E. (2007). An application of data envelopment analytic hierarchy process for supplier selection: a case study of BEKO in Turkey. International Journal of Production Research, 45(9), 1973-2003. doi: 10.1080/00207540600957399

R2. Koh, S.C.L., Gunasekaran, A., & Tseng, C. S. (2012). Cross-tier ripple and indirect effects of directives WEEE and RoHS on Greening a supply chain. *International Journal of Production Economics*, 140(1), 305-317. doi: 10.1016/j.ijpe.2011.05.008

R3. Ketikidis, P. H., Koh, S.C.L., Gunasekaran, A., Dimitriadis, N. and Kehajova, M. (2008) The Use of Information Systems for Logistics and Supply Chain Management in South East Europe: Current status and future direction, *OMEGA*, 36, pp. 592-599. doi: 10.1016/j.omega.2006.11.010

R4. Bayraktar, E., Demirbag, M., Koh, S.C.L. Ekrem Tatoglu and Halil Zaim (2009) A causal analysis of the impact of information systems and supply chain management practices on operational performance: Evidence from manufacturing SMEs in Turkey, *International Journal of Production Economics*, 122(1), pp. 133-149. doi: 10.1016/j.ijpe.2009.05.011

R5. Koh, S.C.L., Genovese, A., Acquaye, A.A., Barratt, P., Rana, N., Kuylenstierna, J. and Gibbs, D. (2012) Decarbonising Product Supply Chains: Design and development of an integrated evidence-based decision support system – the supply chain environmental analysis tool (SCEnAT), *International Journal of Production Research,* 51(7), pp. 2092-2109. doi: 10.1080/00207543.2012.705042

R6. Shi, G., Koh, S.C.L., Baldwin, J., and Cucchiella, F. (2012) Natural Resource Based Green Supply Chain Management, *Supply Chain Management: An International Journal*, 17(1), pp.54-67. doi: 10.1108/13598541211212203

Key Grants:

1. Yorkshire Forward (through Centre for Low Carbon Futures), 2009, Low Carbon Supply Chain Project, £824,595.
2. EU, 2008, Energy Efficiency and Conservation in Global Supply Chains: Linking China and Europe, €20,000.

4. Details of the impact

The research within SUMS into supply chain resource modelling has had economic and environmental impact, helping businesses adapt operations to achieve carbon-reduction targets, whilst reducing costs. It has also influenced regional and national business development strategy.

Process to impact:

The major output of the Low Carbon Supply Chain project led by SUMS was the Supply Chain Environment Analysis Tool (SCEnAT), launched in November 2011. SCEnAT has a web interface (www.scenat.com), making it easily and freely available for companies to use. Most recently, application of the software has been extended as a demonstration Cloud computing platform with Microsoft, which permits remote usage and the use of simulation data. The project team have worked with a business advisory group and with regional Chambers of Commerce to disseminate the research findings / tool to a wide network of SMEs. A practitioner report was produced and published on the Centre for Low Carbon Futures (downloaded 778 times between Dec 2011 and

Dec 2012). Six companies have used the tool to date. SUMS have also worked with Muntons PLC (a company which produces malt), to develop a 'spin off' carbon calculator specifically aimed at the agricultural sector which has been used by Muntons and their suppliers.

Impacts:

1. Assessment of carbon footprint

A key benefit for the organisations that have used SCEnAT has been the ability to identify, assess, and trace energy usage and carbon emissions at every step in their product's production process. This then provides the opportunity to select process and supply chain improvements that can deliver lower carbon, more resource efficient outcomes. User testimonials:

"*The SCEnAT model has proven to be a useful tool … [it] has allowed us to gain a better understanding of the emissions profile of our whole supply chain."* (Director of Operations at the steel producers, Sheffield Forgemasters International) [S1]

"The tool is a very practical and flexible system that Muntons has used to analyse and make real impacts on its supply chains." (Manufacturing and Sustainability Director, at the Suffolk-based malt producers, Muntons PLC) [S2]

"The direct benefit of using SCEnAT is that we are able to make informed decisions using empirical evidence. These decisions are based on us undertaking and benchmarking our current operating conditions against 'what if' scenarios." (Chairman and CEO, [text removed for publication]) [S3]

*"As an SME, we have not used any other decision support tools prior to SCEnAT. Using SCEnAT led us to identify transport and electricity as key 'carbon hotspots' in our supply chain. Consequently, we have implemented several operational changes to reduce emissions in these carbon intensive areas of the business." (*CEO, Brocklesby, a UK based recycling company) [S4]

2. Changes in organisational practice

Four companies have already implemented organisational changes after using SCEnAT to identify where interventions can deliver low carbon resource efficiencies. Brocklesby Ltd [S4], specialising in the reprocessing of used cooking oil and fatty acids, purchased six greener, more fuel efficient trucks and are targeting energy consumption through the installation of energy meters and an Anaerobic Digestion (AD) plant to generate renewable energy.

At Muntons, the growing of their raw materials was found to account for 60% of their global supply chain's carbon footprint. The manufacture and use of nitrogen fertiliser contributes the most to the cereal carbon footprint and SCEnAT showed, *inter alia*, that nitrogen fertiliser abatement could reduce that element of the footprint by around 50%. Consequently, Muntons shared their farming carbon calculator (developed with the SUMS team) with their grower suppliers and have worked with them to trial alternative fertilisers. They have also encouraged good practice by offering attractively priced 'low carbon' contracts to growers who adhere to certain criteria [S2, S5]. Further, they have introduced a range of operational changes to reduce water and energy usage, encourage green travel management, and improve the recycling of compostable waste [S2].

[text removed for publication] have invested in pollution prevention initiatives and installed a new range of machinery and equipment to reduce their energy consumption. For example, in February 2013 they completed a technology upgrade project focused on improving their coal-based energy supply system [S3].

Sheffield Forgemasters use large quantities of energy and natural resources in their manufacturing processes and produce substantial emissions to air and water as well as generating waste. Using SCEnAT, they introduced a range of initiatives to improve these areas, including, (1) deploying waste segregation facilities to encourage and improve recycling; (2) installing a desorber unit in the Forge in 2011 enabling them to recycle and reuse an average of 4500 litres of oil per week (accounting for approximately 50% of the usage); and (3) replacing cold air burners in the melt shop with new high velocity burners in 2012 reducing gas consumption by 40% [S1, S6].

3. Environmental and commercial impact

The businesses that have used SCEnAT have benefitted from a reduction in their carbon footprint and supply chain cost savings due to interventions recommended by the model. Examples:

[text removed for publication] has seen a £0.8million reduction in costs and a 35% reduction in CO_2 emission [S3].

Sheffield Forgemasters' Director of Operations believes that the work has helped them to introduce initiatives that have contributed to a reduction in their CO_2 emissions to 38% below the Government's 1990 benchmark. This in turn is helping them reduce their "green" taxes which currently cost the company £1.25million per annum [S1].

Muntons PLC have used SCEnAT to identify carbon hotspots, verify their carbon footprint and develop an alternate model for cereal carbon footprinting, which have saved the company an estimated £37,000 to £50,000 in consultancy fees. In addition, the company have stated that the low carbon supply chain work has contributed to them winning new contracts worth £1.75m [S2]. Muntons were the top manufacturing company in the 2011 Sunday Times Green Competition, a position they attribute to their work with SCEnAT [S2].

Brocklesby estimate that the changes that they have made to their supply chain after using SCEnAT has resulted in direct costs savings and benefits totalling approximately £250,000 [S4].

4. Regional policy impact

Engagement with umbrella organisations to maximise the reach of research forms part of SUMS' impact strategy and as part of this the SCEnAT team have worked with the Sheffield City Region Local Enterprise Partnership (LEP) and the Sheffield Chamber of Commerce to reach a wider range of businesses. Professor Koh represents the University of Sheffield on the LEP's Low Carbon Sector Group and chairs the Low Carbon Skills Working Group which aims to assist local businesses, especially SMEs, to develop skills that enable them to identify and exploit green opportunities and technology [S7]. SCEnAT has been included in the LEP's Strategy Document 2013 [S8]. In a recent letter, the Chairman of the LEP's Low Carbon Sector explained: *'we have used [*Koh's*] research to design our low carbon strategy to maximise supply chain opportunities for our region which is worth 1.4% of £120 billion [the value of the Low Carbon Sector in the UK].'* [S7]. The research has also informed and influenced the Sheffield Chamber of Commerce and Industry's strategy to stimulate business and industry investment in decision making that exploits carbon reduction and efficiency improvement across the supply chain. The chamber is committed to helping local businesses reduce emissions and has promoted the SUMS research and SCEnAT to its members [S9]. National prominence has also been given to Koh's research through its reference and inclusion in the TSBs Integrated Transport Report 2013 [S10].

5. Sources to corroborate the impact

S1. Statement from the Director of Operations, Sheffield Forgemasters International Ltd corroborating the impact described at Sheffield Forgemasters.

S2. Statement from the Manufacturing and Sustainability Director, Muntons plc. corroborating the impact described at Muntons.

S3. Letter from the CEO, [text removed for publication]

S4. Statement from the Managing Director, Brocklesby Ltd outlining the impact at Brocklesby

S5. Muntons Environment Statement 2013 confirming changes made at Muntons.

S6. Sheffield Forgemasters International Environment Strategy Annual Progress Report 2011/12 confirming changes made at Sheffield Forgemasters.

S7. Letter from the Chairman of Sheffield City Region LEP Low Carbon Sector stating how SCEnAT and the underlying research is relevant to their plans for the City Region.

S8. Sheffield City Region Local Enterprise Partnership (LEP) Strategy Document 2013 (pp.13)

S9. Sheffield Chamber of Commerce and Industry, 'Save £ and reduce CO_2 with SCEnAT!', July 2012: https://www.scci.org.uk/2012/07/save-and-reduce-co2-with-scenat/ [19/07/13]

S10. Technology Strategy Board, Integrated Transport Report. July 2013. (pp.110-113).