Institution: University of Exeter

Unit of Assessment: 15 General Engineering

Title of case study: Agility Strategies and Supply Network Optimisation

1. Summary of the impact

Professor David Zhang's research into agility strategies and the analysis and optimisation of complex supply chain networks in the manufacturing sector has led to significant **economic impact**. Reductions have been made in inventory and cost of goods sold, amounting to an estimated £80M per annum for CIFUNSA**,** one of the world's largest engine block and head manufacturers. The entire senior management team has been trained in agility strategies and techniques at China's largest non-ferrous metals research and industry complex GRINM, leading to major corporate-level restructuring and growth. The senior management of solder-specialist COMPO has also been trained based on Zhang's research to help the company quadruple turnover in four years and become global market leader. Finally, these same strategy and analysis techniques have generated cost savings and performance improvements worth an estimated £375k for UK engineering solutions company J+S Ltd (http://www.jands.co.uk).

2. Underpinning research

Zhang, Chair of Manufacturing Systems at Exeter Engineering and Leader of the Materials and Manufacturing Group (MMG), joined the University in 2000. He served as Director of the Southwest Manufacturing Advisory Service (SWMAS) from 2001to 2009.

Zhang and his research group focus on both manufacturing strategy and supply chain optimisation in manufacturing industries, specialising in new combined agile / lean manufacturing strategies which have been applied to large multi-national companies and small to medium size enterprises.

Methodology and taxonomy for agility

Zhang's seminal early work [1,2] and its developments in methodology for agile manufacturing implementation were the first relating the theoretical concept of agility to practical implementations. The methodology has been applied in industry and, with the support of several hundred UK companies, led to the development of a classification theory for agile manufacturing strategies in 2006 [3]. Contrary to existing holistic concepts of agility, Zhang's work demonstrated the existence of three distinct agility strategies and identified the characteristics, business cases for and ways of delivering these strategies.

For Barnstable-based SME J+S, in 2006, Zhang researched drivers for agility and the required strategic capabilities, then developed an agility strategy based on his agility theory. He identified methods, tools and best practices to be implemented, and aided implementation of these into practice. This included an adaptive resource and skills scheduling and planning tool based on his work on dynamically integrated systems [4].

A Knowledge Transfer Partnership with J+S (2004 – 2006) started with tailoring of the tools and methods, development of the strategy, and the implementation of the identified tools and techniques in a chosen business area. Zhang has worked with J+S through further collaborative projects in new agility strategies and optimisation with a team of MPhil/PhD researchers until 2008.

Analysis and improvement of supply chains

Zhang has developed tools and methodologies to analyse complex supply chains configurations. These use problem solving methods such as swarm intelligence, multi-agent and ant-colony optimisation that mimic the behaviour of social insects [4-6] and which can then be directly applied to manufacturing strategies.

Following research by Zhang's student Luis Moncayo-Martinez (PhD 2008), the pair worked with CIFUNSA to address the problem of supply chain (SC) configuration and safety stock placement. They formulated it using an early ant-colony algorithm with the total supply chain cost (inventory and production cost) and lead time as factors [5,6]. In doing this Zhang and his student solved a real-world supply chain problem for one of the largest foundries in the world.

3. References to the research

1. Sharifi H, Zhang Z. (2001). Agile manufacturing in practice: application of a methodology. *International Journal of Operations and Production Management*, **21** (5/6), 772–794.

2. Zhang Z, Sharifi H. (2000). A methodology for achieving agility in manufacturing organisations. *International Journal of Operations and Production Management*, **20** (4), 496–512.

3. Zhang, DZ. (2011). Towards theory building in agile manufacturing strategy: case studies of an agility taxonomy. *International Journal of Production Economics*, **131**, 303-312. **

4. Zhang, DZ, Anosike A and Lim, MK. (2007). Dynamically Integrated Manufacturing Systems (DIMS) – A Multiagent Approach, IE*EE Trans on Systems, Man and Cybernetics, Part A: Systems and Humans*, **37**(5), 824-850. **

5. Moncayo-Martinez LA, Zhang DZ. (2013). Optimising safety stock placement and lead time in an assembly supply chain using bi-objective MAX–MIN ant system. *International Journal of Production Economics*. **145** (1), 18–28.

6. Moncayo-Martinez LA, Zhang DZ. (2011). Multi-objective ant colony optimisation: A meta-heuristic approach to supply chain design. *International Journal of Production Economics*, **131**(1), 407–420. **

** Papers that best indicate quality of underpinning research.

4. Details of the impact

The impact described is strongly economic, with Zhang's research having direct effect on efficiency of manufacturing operations with significant and directly measurable financial performance improvements in four companies.

Supply chain optimisation in engine block casting: CIFUNSA

CIFUNSA (http://www.cifunsa.com.mx) is one of the world's largest producers of gray iron blocks and heads (200,000 tonnes annually, and even in 2006 had sales of approximately $1bn) for automotive giants GM, Ford, Chrysler, as well as Toyota, Nissan, John Deere etc.

Zhang's research into ant-colony optimisation of safety stock placement and lead time in an assembly supply chain was applied to model CIFUNSA's highest demand engine block supply chain in **2009**. The results were then adopted by CIFUNSA, leading to on-hand inventory reduction of 20% between **2009** and **2011**. In the same period, the cost of goods sold (CoGS) was reduced by 10% (a). The foundry process in this business is very labour-intensive, so a small reduction in CoGS represents a significant enhancement to the company's earnings of an estimated $100M per annum).

Agile business strategy for R&D and manufacturing: GRINM

Beijing General Research Institute for Non-Ferrous Metals (GRINM) started in the 1950's as a Chinese national research institute providing research and development support for the non-ferrous metal industry (http://www.grinm.com). Over the last 12 years, GRINM has been transformed from a state-funded research organization to an R&D and manufacturing enterprise

operating in the global market. Business agility is an important factor for their success.

In **2008**, based on his research, Zhang was invited to help GRINM develop an agile business strategy. The deputy general manager of subsidiary company COMPO visited Zhang at the University of Exeter in **2009**, spending eight months learning about manufacturing strategies, systems and management, developing expertise in Zhang's agile and lean enterprise theory. This led to Zhang visiting GRINM in **2010** to work on a strategy building process and train 82 senior directors and managers (b).

GRINM have continued to apply Zhang's agile process, assisted from **2012** by Rolan Berger (international business strategy consultants) who are tasked to implement the strategy, with continuing hands on support through personal visits by Zhang. GRINM estimate Zhang's agile process coupled with other factors have contributed to turnover rising by over 30% from RMB 33bn (~£3.4 bn) since **2010**, during a period of decline in the global market for metal products.

Agile business strategy development: COMPO

Beijing COMPO Advanced Technology Co. Ltd was established by GRINM as a subsidiary in 2005 (http://www.composolder.com), COMPO is a high-tech enterprise specialising in R&D, production, trade and services for tin-based solders and non-ferrous new materials.

By **2009** the company realized that its size required an agile and lean process for managing its strategies, operations, marketing and systems, and the consequent development of its top management. This resulted in COMPO's deputy general manager studying at Exeter. On his return to China in **2010** he applied his training to formulate and implement a business strategy, with Zhang's direct assistance. Since then the company has grown its revenue by over 50% annually, with a total increase of sales by 400%, and profits by 300% (c).

Business strategy: J+S Ltd

Implementation of Zhang's strategy and analysis techniques to J+S Ltd (http://www.jands.co.uk) has resulted in a direct reductions of stock and work-in-progress levels by £200k (approximately 2% of turnover), production lead-time by 15%, and average days late on contracts by 2.8 days. The company's turnover went up from £9.9m in 2004 when the collaboration first started to £12.8m in **2012** with profit increased fivefold. According to the company's operations director (d), on a visit to the university in **2010** for further collaboration:

"*we have done extremely well since the scheme thanks to the system that has been put in place during the collaboration, a recent example is that we have won a 10 year contract worth over £10m due to the system, that is why I am here to seek further collaboration*".

During the implementation of this strategy 23 company staff including project managers, engineers, and shop floor supervisors and operators were trained in the agile and lean techniques.

Impact via Knowledge Transfer Projects

Mr Volata, a KTP Associate with J+S, was subsequently employed in **2007** by the company to manage and implement Zhang's research in the company's Aberdeen site. Volata joined Knox D'Arcy in **2008**, and later KPMG in **2009** as an operational strategy consultant helping other UK companies to achieve competitiveness, using the agile and lean strategies developed by Zhang at Exeter. Since **2009**, Volata has used the agile methodology developed by Zhang and himself to assist international and UK companies, including Zurich Financial Services, BP, Heineken UK, Londis, Budgens, Anglo American, Unilever and Thomas Cook.

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

a) Letter (2011) from Research and Development Manager CIFUNSA. PDF supplied.
b) Letter (2013) from Director, Beijing General Research Institute for Non-Ferrous metals. PDF supplied.
c) Letter (2013) from CEO and General Manager, Beijing COMPO Advanced Technology Co., Ltd. PDF supplied.
d) Quote (2010) from J+S Operations Director.