Institution: Lancaster University

Unit of Assessment: 19, Business and Management Studies

Title of case study: Improving Make-To-Order Manufacturing Planning: The Lancaster 'Workload Control' Approach.

1. Summary of the impact

Over 25 years, research by Hendry and Stevenson has explored the specific challenges faced by Make-to-Order (MTO) manufacturing companies and developed a novel Workload Control (WLC) approach, which has been most notably implemented in PDS Engineering. This led to significant increases in successful bids and reductions in lead times for PDS, with a knock on effect through their supply chain that includes large aerospace companies like Rolls-Royce. Publication of this stream of research led to international collaborations including in the Netherlands and Belgium, where an EU project involving 10 firms and further consultancy work has also led to reductions in lead times, typically of over 50%. The WLC approach is now ready for commercialisation in the UK.

2. Underpinning research

WLC enables customised MTO manufacturers to operate lean manufacturing principles, providing a novel means of reducing work-in-progress inventory when methods used in standardised production do not apply. Better control of this inventory along with capacities enables companies to set more realistic, yet competitive, delivery dates and therefore bid more successfully for new orders. The WLC approach was developed through a combination of: theoretical analysis and simulation; prototyping of software based on simulation results; implementation and testing of software in manufacturing firms; and conceptual and software refinement towards commercialisation of the software. Each of these stages was conducted in close collaboration with industrial partners. In addition, there have been joint research initiatives with Dutch and Portuguese universities, and knowledge transfer meetings with consultants and software companies.

<u>Development of the WLC approach:</u>
The WLC approach has its origins in research conducted by Lancaster's Professor Brian Kingsman (Lancaster employee until 2003) in the late 1980s (e.g. Kingsman *et al*., 1989). It included the doctoral research (1985–1989) of Linda Hendry (e.g. Hendry & Kingsman, 1993). The focus of the research was on the specific challenges faced by the MTO sector, e.g. coping with variable production specifications, capacity needs and set-up requirements. Such low-volume/high-variety, customised manufacturing is increasingly important in developed economies, as more standardised, high-volume manufacturing is being sourced from developing countries. Given that customised products cannot be supplied from stock, this research demonstrated the importance of gaining control of workloads from the moment a new customer enquiry is received.

Developing a software prototype and enhancing WLC theory:
Early research focused on theoretical aspects of WLC and on developing a software prototype with an industrial collaborator. The research findings revealed potential but also shortcomings in the theory underpinning the software, which were later addressed through computerised simulation modelling in collaboration with, and using data from, industrial collaborators (most notably Pilkington Optronics). This externally-funded [by the ACME Directorate of SERC, as was] work was conducted with support from two research assistants, Worden and Wilson, and developed the approach by improving coordination between manufacturing planning and the firms' salespeople (e.g. Kingsman *et al.*, 1993 & 1996). This manufacturing-marketing link is a distinctive feature of the Lancaster WLC approach, and was shaped by the marketing-related work of Lancaster's Emeritus Professor Alan Mercer (e.g. Kingsman & Mercer, 1998).

Engaged research with industry:
Exploration of the organisational context was continued by the case- and action-research-oriented doctoral work of Mark Stevenson (2002-2006) and Yuan Huang (2006-2010). The emphasis in recent years – with Stevenson and Hendry now both members of staff – has been to continue with

an engaged research approach and to develop an increasingly sophisticated understanding of the context-specific requirements for the successful implementation of WLC in MTO companies (e.g. Stevenson *et al.*, 2011). This has led to the development of an implementation strategy for WLC.

The work in Lancaster has directly informed and shaped further theoretical and empirical research, most notably in Portugal and the Netherlands, and case study research has been conducted in collaboration with these research teams (e.g. Hendry *et al*., 2008; Stevenson & Silva, 2008). More recently, considerable further collaboration has involved academics around the world, including Fredendall (Clemson University, USA), Melnyk (Michigan State University, USA), Huang (University of Hong Kong), and Land (University of Groningen, the Netherlands). International collaboration is epitomised by the doctoral research of Thürer (2008-2011), based at the University of Coimbra, Portugal, but co-supervised by Stevenson. The research investigated the performance of WLC approaches through simulation and explored how a number of implementation challenges identified in Hendry *et al*. (2008) and Stevenson & Silva (2008) could be accommodated through a redesign of the approach (e.g. Thürer *et al.*, 2010, 2011). This collaborative work demonstrated that considerable performance improvements can be achieved in MTO companies specifically through Lancaster's WLC approach, providing benefits akin to lean manufacturing (Thürer *et al.*, 2012).

3. References to the research

Over 30 papers have been published in peer-reviewed, international journals by Lancaster researchers, including with international research collaborators. For example:

1. Hendry, L.C., Kingsman, B.G. and Cheung, P. (1998) 'The effect of Workload Control (WLC) on performance in make-to-order companies', *Journal of Operations Management*, 16: 63-75 (FT listed journal). Simulation study using data collected from a make-to-order company.
2. Hendry, L.C., Land M.J., Stevenson, M. and Gaalman, G.J. (2008) 'Investigating implementation issues for Workload Control (WLC): A comparative case study analysis', *International Journal of Production Economics*, 112(1): 452-469. Comparative analysis of two implementations providing research questions later investigated via joint work with Thürer.
3. Stevenson, M. and Silva, C. (2008), 'Theoretical development of a Workload Control methodology: Evidence from two case studies'. *International Journal of Production Research*, 46(11): 3107–3131. Comparative analysis of two implementations, leading to theoretical developments later tested through joint work with Thürer.
4. Stevenson, M., Huang, Y., Hendry, L.C., and Soepenberg, G.D. (2011) 'The theory and practice of Workload Control: A research agenda and implementation strategy', *International Journal of Production Economics*, 131(2): 689-700. Interviews with 41 high-variety manufacturers exploring the steps needed for WLC to be implemented.
5. Thürer, M., Stevenson, M., Silva, C., Land, M.J., and Fredendall, L. (2012), 'Workload Control (WLC) and order release: A lean solution for make-to-order companies', *Production and Operations Management,* 21(5): 939-953 (FT listed journal). Simulations showing Lancaster's WLC approach can provide high-variety companies with benefits akin to a lean implementation.
6. Hendry L.C., Huang Y., and Stevenson M., (2013), 'Workload Control: Successful implementation taking a contingency-based view of production planning & control', *International Journal of Operations & Production Management,* 33(10): 69-103. Describes the action research project with PDS Engineering, highlighting its impact and how this was achieved.

4. Details of the impact

The central impact achieved by firms adopting the WLC approach is an increased awareness of, and control over, the flow of work through the production process from tendering/ bidding onwards. Collaborations with industry and with international researchers in the USA, Europe and China have generated successive cycles of problem formulation, theory-building, research design and problem-solving. As such, management practice has been influenced in the early stages as well as the later stages of the research programme.

Specifically, adoption of the WLC approach has had a **significant** impact on companies as it

makes it much easier for managers and shop-floor staff to work on the right jobs at the right time, thereby reducing lead times, and allows the sales/marketing function to confidently quote delivery lead times for new orders. It also informs decision-making on where extra capacity is needed as the order mix changes over time. Apart from improving delivery performance, the approach has been demonstrated to reduce the amount of reactive 'fire-fighting', which in turn means an organisation can devote more attention to quality improvements and innovation. This iterative research process has resulted in a WLC software package that is mature and ready for commercialisation in the UK.

Regional impact - PDS Engineering:
In recent years clear-cut and **significant** industrial impact has been made through longitudinal, in-depth collaboration with PDS Engineering, a small precision engineering company in the North West of England. PDS produce a wide range of complex, high-specification components, mostly on a MTO basis, and often to short and changing lead times.

Implementing Lancaster's WLC system led to increased clarity of production and capacity planning, giving PDS a much better understanding of shop-floor priorities, of how and when to adjust capacity, and of what delivery lead times they can confidently quote to prospective customers. The Operations Director at PDS has stated that '*the LUMS WLC system has improved our performance at PDS significantly ... therefore contributing to our profitability*'. Specific evidence of the impact on quantitative performance improvements since 2009, as published in Hendry *et al.* (2013), includes:

- 64% increase in order-winning performance (% of tenders converted into definite orders)
- 50% reduction in manufacturing lead times, due to reduced work-in-progress
- 11% reduction in delivery lead times (total time from order confirmation to delivery)
- 27% reduction in the mean tardiness of deliveries to customers

Further information about this case, including evidence from employees is available in the brochure 'Workload Control at PDS Engineering'.

Impact on PDS supply chain:
In addition to the impact on the competitiveness of PDS Engineering, their improved performance has had an impact on the supply chain in which they operate. The impact has been felt by key customers – such as Unison Engine Components (formerly Smiths Aerospace Components) – and, in turn, by one of Unison's key customers, Rolls-Royce. An independent supply chain consultant working for Unison corroborates that Lancaster's WLC system has made PDS '*fit for purpose*' to supply leading aerospace companies. In particular, the consultant confirms that WLC has led to improved on-time delivery performance, and that: '*the adoption of the Workload Control system was fundamental to the improvement seen at PDS Engineering, and I often use this as an example of best practice in industry*'. Among a set of ten suppliers participating in a supplier development initiative run by the consultant, PDS were one of only two firms that continued to make considerable progress in spite of the recent financial crisis.

Commercialising WLC in the UK:
In order to extend the **reach** of this approach further, Lancaster staff have developed a WLC software package that is ready for commercialisation in the UK. It provides a solution tailored to the needs of MTO companies that is better aligned with their production environment than typical, alternative commercial Enterprise Resource Planning (ERP) packages. The Operations Director of PDS Engineering, for example, confirmed that '*The alternatives ... were lacking the production and capacity planning that was so essential to us yet they had lots of other functions which we wouldn't have used*'. The Access Group, a provider of ERP software to the midmarket in the UK and Ireland, has audited Lancaster's WLC software and visited PDS Engineering to observe its use. The Supply Chain Divisional Manager of the Access Group has confirmed that '*there appear to be no other solutions which provide its specific functionality*'. He went on to describe the software as '*a unique solution which has been shown to work well … and has many other potential areas of application*.'

Adoption of WLC approach in Europe and China:
The **reach** of the industrial impact has not, however, been restricted to PDS and its supply chain,

nor indeed to the UK. The combination of the underpinning research and the exemplary impact of its implementation at PDS have resulted in the uptake of similar projects internationally.

Europe:
Through an EU-funded project in the Netherlands, ten companies, including Corus Perfo B.V. and Lapack B.V., have collaborated with researchers from the University of Groningen to implement WLC. Improvements claimed by Corus Perfo B.V. include increased transparency, leading to more predictable lead times. Meanwhile, Lapack B.V. highlighted that WLC provides '*a very simple means to maintain our guarantees for delivery within 24 hours*'. A firm of consultants, Langhout & Cazemier, provided a piece of production planning and control software known as Elance® to support the EU project. As is evidenced by researchers at the University of Groningen, this software incorporates many of Lancaster's WLC ideas and has since been implemented in a large number of other Dutch companies. WLC ideas have also been adopted by consultants in Belgium (Sirris) and by two companies working with the University of Coimbra in Portugal, including Navarra S.A. Navarra S.A. highlighted improved production-marketing integration and reduced work-in-progress, cutting costs and increasing profits, while a representative of Sirris states that: '*By applying the principles of WLC, we have been able to reduce the lead times at several companies, often by a factor of 50%*'. The representative of Sirris also confirms that meetings with Lancaster staff inspired this WLC knowledge transfer, stating that the '*work of the University of Lancaster has been of great importance for our own thinking*' and describing Lancaster's researchers as having '*set themselves apart as a world leading group in the field of WLC*'.

China:
After reading papers by Lancaster academics (e.g. Kingsman, 2000; Stevenson, 2006), researchers from the Guangdong University of Technology, China have implemented WLC in several mould manufacturing companies, including Greatoo Inc, with funding from the National Natural Science Foundation of China. Greatoo Inc benefitted from production-marketing integration and reduced work-in-process, but also from shorter lead times due to reduced waiting times prior to final order assembly and a better matching of workloads to capacities.

5. Sources to corroborate the impact

Testimonials:
1. Operations Director, PDS Engineering – to corroborate the **significance** of the impact in PDS Engineering, including its contribution to increased profitability through reduced manufacturing lead times and improved order-winning performance.
2. Managing Director (and Independent Consultant), UK Supply Chain Associates Limited – to corroborate **reach** into PDS's supply chain and the **significance** of the impact in PDS.
3. Associate Professor of Operations Management, University of Groningen – to corroborate **reach** into European firms (including Corus Perfo B.V. and Lapack B.V.), where benefits include more reliable delivery dates.
4. Senior Researcher and Consultant, Sirris – to corroborate **reach** into European firms via consultancy projects, where lead times have been reduced through WLC implementations.
5. Supply Chain Divisional Manager, Access Group UK Ltd – to corroborate that the Lancaster WLC software provides a **unique solution** and has potential for further impact in the future.

Publicly available sources:
1. Sirris website – includes reference to Lancaster WLC software and screen shots. http://www.sirris.be/newsitem.aspx?id=2070&langtype=2060&lastmod=2008-05-13
2. University of Groningen website – includes reference to joint paper with Stevenson. http://www.rug.nl/research/publicationofthemonth/land
3. Workload Control website maintained by Thürer (former doctoral student) – includes a Microsoft Excel©-based WLC system that can be downloaded and implemented by practitioners; a link to the 'Workload Control at PDS' brochure; and a simulation model for researchers. It is unknown how many practitioners have downloaded/implemented this software. www.workloadcontrol.com