Targeting lean process improvement projects for maximum financial impact

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This empirical paper details a 12-month applied research project at a UK low-volume manufacturer of large vehicles. The industry problem from which this study originates was a concern over the subjective nature with which the firm′s existing lean intervention projects were being targeted (prioritised and selected). A structured literature review on this topic was unable to identify any objective decision support mechanism for doing so; one that encompassed financial as well as operational criteria. The resultant study was organised around an established seven-step action research framework. The main body of evidence was derived from extensive analysis of financial and operational data extracted from the firm′s enterprise resource planning system, along with two structured workshops that each involved multiple informants drawn from the firm′s production centres and its accountancy department. Supplementary primary research was provided in the guise of numerous unstructured interviews to validate data and from observation of shop floor practices. The main contribution of this article is identifying and addressing the gap highlighted above, by developing and testing a financially driven method for objectively targeting process improvement interventions within this large and geographically dispersed operation. This innovative method includes five new constituent techniques.

Keywords: process improvement; lean; targeting; cost analysis; action research

1. Introduction and research context

This paper details a case study of a 12-month action research (AR) project at a UK low-volume manufacturer of large vehicles, during which an effective new lean process improvement project targeting method was designed, implemented and assessed. In the interest of commercial confidentiality, this firm is referred to as VehicleCo for the remainder of this paper. This case firm is part of a large multi-national enterprise that is headquartered outside of the UK. VehicleCo′s UK operation is based upon six plants distributed throughout the country. These design, manufacture and support a variety of structures for the parent enterprise′s range of products and also fabricate the component parts that comprise these structures. At the time of the study reported upon in this paper, this company had a portfolio of more than 20 separate products/ size variants, which the firm terms ′contracts′. The structures for each contract are assembled on dedicated production lines in its final assembly area. On completion, these are shipped to another plant within the parent group for the integration of various systems and the kitting out of the vehicle interior.

VehicleCo had already amassed significant experience of implementing lean (Womack, Jones, and Roos 1990; Womack and Jones 1996) process improvement intervention projects within its business. There was an established and experienced internal lean process improvement team composed of manufacturing engineers, and they were working on a large ongoing project in concert with a team from a global management consulting firm. The focus of this project was waste reduction within the final assembly area, particularly labour waste reduction.

However, whilst significant waste and cost reduction performance had been reported under the aegis of the firm′s long-standing lean manufacturing programme throughout its existence, there was growing concern that existing techniques for targeting (prioritising and selecting) such intervention projects within the firm were subjective in nature. Two commonly heard metaphors that were aired in conjunction with this problem were: ′How do we know that we are not picking the low hanging fruit′? – and – ′Where should we intervene next to assure the maximum process improvement bang for our bucks′? This situation is clearly undesirable as it risks sub-optimal management decision-making. Senior management were therefore seeking a decision support method to target and hence evaluate the impact of such projects within their lean programme; one that was objective in nature and encompassed financial criteria such as cost reduction potential.

Existing literature provides no such guidance. The aim of this article is therefore to address this gap by developing a suitable targeting method. Doing so would make a valuable contribution to knowledge on the topical subject of lean thinking. It would also offer a practical contribution, it would greatly improve management decision-making and the future economic impact of the lean programme at VehicleCo. If the resultant method proved to be generalisable, it would likewise offer improved economic impact potential for all similar manufacturing firms adopting this method to support their indigenous lean initiatives.

The article starts by reviewing the literature on the targeting and evaluation of process improvement initiatives within the lean paradigm, including the evolving nature of the kaizen (continuous improvement) concept, and the role of value stream mapping (VSM) within this. The second section details the research methodology that was developed to realise the above research objective. This includes a discussion of the AR strategy and the detailed procedures that were used to collect, analyse and validate the data. This is followed by a discussion of the findings that were derived using this methodology. The paper concludes with a summary of its academic and practical contributions, methodological limitations and avenues for future research.

2. Literature review – targeting lean process improvement initiatives

2.1. The meaning of 'Lean'

'Lean' remains a topical subject with four papers within this journal alone in 2014 (see Lyonnet and Toscano 2014; Martinez-Jurado and Moyano-Fuentes 2014; Vinodh, Kumar, and Vimal 2014; Wong, Ignatius, and Soh 2014). A cursory bibliographic analysis using its four main synonyms of lean manufacturing, lean production, lean thinking and lean management reveals that the literature on lean is composed of an extremely large and growing body of material. It also reveals that a significant proportion of this is composed of contributions from practitioners and 'gurus', including many of its most influential and highly cited texts (see Womack, Jones, and Roos 1990; Womack and Jones 1996; Liker 2004; Dennis 2007).

The term lean itself was coined by the Massachusetts Institute of Technology researcher John Krafcik whilst working on the International Motor Vehicle Program, and entered the management lexicon via his 1988 article in the Sloan Management Review. Whilst coined by Krafcik, Schonberger notes that many people attribute the origins of the lean paradigm to the popular book by Womack, Jones, and Roos (1990), although he asserts that lean production-type initiatives were already well established in the US in the early 1980s albeit under different names such as 'Just-In-Time (JIT)', 'stockless production' and 'Zero Defects (ZD)' (2007, 406–408). Even though lean can therefore boast a lineage of over three decades, it suffers from an issue of interpretive viability (after Benders and van Veen 2001). Samuel (2011) suggests two related reasons for this issue. The first is a lack of common definition within the literature (Lewis 2000; New 2007; Shah and Ward 2007; Bayou and De Korvin 2008). The second reason is that as a concept, lean has evolved over time (Hines, Holweg, and Rich 2004; Papadopoulou and Ozbayrak 2005). To these a third reason might be added; a blurring of the boundaries between the lean paradigm and similar contemporary process-oriented operations paradigms such as the theory of constraints (TOC), agility and six sigma – further compounded by the emergence of hybrid paradigms such as leagility and lean-sigma.

To overcome this interpretive viability dilemma, authors have adopted numerous strategies to bound and communicate their interpretation of lean. One approach, such as that adopted by Dahlgaard and Dahlgaard-Park (2006), is simply to utilise Womack, Jones, and Roos (1990, 13) original characterisation:

> Lean production is 'lean' because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investments in tools, half the engineering hours to develop new products in half the time. Also, it requires keeping far less than half the needed inventory on site ....

A second strategy, adopted by authors such as Lewis (2000) and Melton (2005), has been to invoke Womack and Jones (1996) widely disseminated prescription of Five Lean Principles for achieving leanness in lieu of definition. Whilst a third, teleological approach, adopted by authors such as Feld (2000) and Shah and Ward (2007) has been to conceive leanness in terms of progress towards the implementation of its constituent tools and techniques.

2.2. Evolution of kaizen within the lean paradigm

Regardless of the conception and definition of lean (above), the concept of kaizen forms one of its integral components. Kaizen is a Japanese term for continuous improvement that was introduced by Imai (1986). It is the umbrella concept for the execution of process improvement within the lean paradigm, and is composed of an underlying management philosophy and supporting set of techniques and tools (Bicheno and Holweg 2008).

Kaizen is premised upon the continuous incremental improvement of all work processes by all of the firm's employees (Imai 1986, 1997), with these latter two features revealing its total quality control heritage. It is implemented by worker teams that have often been referred to as 'quality circles' (Karlsson and Ahlstrom 1996; Groover 2007). Such quality circles have been the subject of widespread analysis and publication since the early 1980s, when this technique first came to prominence in the west and was often considered to be one of the secrets of the success of Japanese manufacturing witnessed in that period (see for example Hayes 1981; Schonberger 1982; Lawler and Mohrman 1985). However, whilst quality circles were historically convened to address quality and productivity problems, contemporary circles have been used to address cost, safety, maintenance and other concerns, with the term 'Kaizen Circle' (KC) often being adopted to reflect this broader range (Dennis 2007; Groover 2007). A KC typically comprises 6–12 volunteers drawn from the same work area, who meet regularly to respond to improvement suggestions or specific problems encountered within that area. A lean programme will therefore comprise multiple KC teams; all working to resolve multiple concurrent problems. Each such KC is scheduled to meet periodically in company time, with each meeting lasting for at least an hour (Groover 2007). Typically, team members are trained in the use of problem solving tools such as the Seven Basic Quality Tools (Ishikawa 1985) and 5 Whys, and to use these within Deming's (1986) Plan–Do–Check–Act problem solving framework in order to systematically identify and redress the root cause of the problem symptoms being considered at that circle (Imai 1997; Bicheno and Holweg 2008).

In stark contrast to the incremental improvement embodied by kaizen, the publication of Womack and Jones' seminal book on Lean Thinking in 1996 introduced the term 'kaikaku', a Japanese word meaning 'instant revolution' (Bicheno and Holweg 2008). The kaikaku concept aims to rapidly realise radical process improvement results, and is better known under a number of synonyms such as 'kaizen blitz', 'breakthrough kaizen', 'system kaizen', 'flow kaizen' or 'kaizen event' (see Womack and Jones 1996; Feld 2000; Melton 2005; Bicheno and Holweg 2008). This has resulted in the emergence of a lean process improvement typology, with the traditional KC approach described above now often labelled 'process kaizen' or 'point kaizen' to distinguish it from this more radical and increasingly prevalent improvement type. For example, Bicheno and Holweg (2008) suggest that the process kaizen is concerned with the elimination of localised waste and should be the responsibility of shop floor workers. By contrast, they suggest that the flow kaizen is concerned with the stimulation of swift and even flow of throughput (after Schmenner and Swink 1998) within the value stream, and should be the responsibility of senior management. We adopt this nomenclature for the remainder of our article.

2.3. Value stream mapping

To recap then, the process kaizen concept entails a response to localised improvement suggestions or problems by standing workplace quality circle or KC teams. By contrast, the flow kaizen concept entails the proactive design and implementation of discrete process improvement 'breakthrough' projects, and therefore suggests the need for temporary project teams and the targeting of such interventions. This targeting imperative is recognised by Nicholas (1998, 33), who states that '... an organization must be able to target its improvement and waste-elimination efforts. There must be some scheme for putting priorities on where to expend time, effort and resources [so that they contribute the greatest good]'. Put simply, some objective means of deciding where to start a lean programme within a firm, and once started, where to intervene next where multiple options present themselves? However, a structured literature review on this topic was unable to identify any decision support method for doing so.

Instead, this review highlighted the increasing prevalence of flow kaizen projects and the appearance of various VSM techniques since the latter part of the 1990s. Indeed, VSM has emerged as the de facto vehicle for implementing such projects and the most influential of these techniques, as evidenced by both the extent of its citation within the literature and implementation in practice, is Rother and Shook's (1998) Learning to See approach (see for example Seth and Gupta 2005; Abdulmalek and Rajgopal 2007; Serrano, Ochoa, and De Castro 2008; Lasa, De Castro, and Laburu 2009; Gurumurthy and Kodali 2011). By the same criteria, other influential VSM techniques and publications have been provided by Hines and Rich (1997), Tapping and Fabrizio (2001), Jones and Womack (2002) and Duggan (2002).

All of these VSM techniques share a number of common features. For example, they are all premised upon the actual mapping work being undertaken by a multifunctional project team drawn from the areas of the organisation believed to be transected by the value stream concerned. Quite clearly, the conception of the value stream to be mapped will have an important bearing on the composition of the team selected. Likewise, all of the cited VSM techniques stress the need for conceptual simplification. This is expressed in the guise of the mapping only a single, representative value stream rather than attempting to capture the complexity of routing of the organisation's complete product portfolio. These techniques also all share a discernibly similar project anatomy. This includes a planning phase during which the project team is formed, roles and responsibilities assigned and the project's terms of reference and focal value stream established. This phase is usually followed by a workshop to train the mapping team in general lean principles and the specific mapping tool to be deployed. Next, comes the 'current-state' mapping phase during which the current configuration and 'baseline' operational performance of the focal value stream is established collectively by the team, and described using a tool of prescriptive format and standard iconography. This is followed by a 'future-state' mapping phase during which they collectively visualise its idealised reconfiguration and consequential estimated operational performance level, using the map tool itself as a blueprint for this reconfiguration exercise. The penultimate phase is again a collective enterprise, and entails the team drawing up plans for a staged series of intervention projects to realise the future-state blueprint. The final phase is the implementation and monitoring of these interventions.

Whilst VSM has become the de facto vehicle for implementing flow kaizen projects, these techniques lack guidance for conceiving or objectively selecting, from the many alternatives that are typically available, the value stream that is to act as the focus for the mapping exercise itself. This selection will clearly have a profound bearing both on the risks of successful implementation and the potential performance improvement returns associated with the investment in the consequent lean intervention project. As indicated by the two metaphors cited during the Introduction to this paper, it is notable that the lack of an objective VSM targeting method has left many lean teams in practice open to the accusation of sub-optimal decision-making, including the 'cherry picking' of easy to implement interventions or the 'pet projects' of sponsoring managers. Of all the VSM authors, only Tapping and Fabrizio (2001, 13–15) address the issue of focal value stream selection. They suggest three selection methods. The first is subjective being merely to react to the most vocal external customer demand for improvement. The second is to undertake a product quantity analysis, which involves producing a Pareto chart that illustrates the distribution of production quantity by product. The authors propose that any product representing more than 20% of total production volume should be prioritised as a VSM candidate. If the analysis of volume is inconclusive, or if the variety of products and processes is complicated, Tapping and Fabrizio (Ibid.) suggest that a product routing analysis should then be undertaken and the selection based upon the desired pathway through existing resource centres.

In addition to this focal value stream selection issue, a review of the VSM literature reveals an exclusive focus on operational performance data. For example, Rother and Shook (1998) in their original description of the learning to see technique, and other authors who describe its general application such as Bicheno and Holweg (2008), stress the use of data such as process cycle time, changeover time, uptime and production lead time. In their application of this technique within an electronics manufacturing firm, Worley and Doolan (2006) highlight inventory, manufacturing lead time, quality, flexibility and customer satisfaction as focal measures; whilst Abdulmalek and Rajgopal (2007) in their VSM application within a steel mill stress the measurement of production lead time along with inventory at various stocking points within the entity. In all of the VSM techniques identified during the review exercise, there is a notable lack of a financial data. For example, inventory data is typically captured as a number of parts, and then sometimes converted into the 'daysworth' of consumption that this represents, but its monetary value is not recorded. Likewise, there is, for example, no evaluation of the additional revenue generated, costs reduced nor return on investment as an outcome of the project. There is consequently no financial dimension to either the [above] focal value stream selection criteria, the targeting of the associated improvement intervention projects, or the evaluation of the subsequent impact of such projects.

3. Methodology

3.1. Research objective

Given the characterisation of the literature in the previous section, the following research objective was established to guide this study:

> To design, implement and assess a targeting method for prioritizing and selecting a lean-type process improvement intervention project that yields the largest financial impact within a large and geographically dispersed manufacturing operation.

3.2. Research strategy

The case study was adopted as the basis for addressing the research objective detailed above because of our desire to conduct an empirical enquiry that sought to explain a contemporary phenomenon in a real-life context using multiple sources of evidence (Yin 2003). The case study can provide rich knowledge of a specific context (Meredith

1998; Yin 2003; Sousa and Voss 2008) and has a heritage within both operations management and logistics where it has been employed for research purposes that include exploration, theory building, theory testing and theory extension (Eisenhardt 1989; Ellram 1996; Voss, Tsikriktsis, and Frohlich 2002).

AR is a variant of case research (Coughlan and Coghlan 2009; Brown and Vondracek 2013) and similarly offers the advantage of yielding richness of insight over issues that actually matter to practitioners (Eden and Huxham 1996). The origins of AR are generally attributed to the work of the psychologist Kurt Lewin in the 1940s (Eden and Huxham 1996; Coughlan and Coghlan 2002; Hendry, Huang, and Stevenson 2013); and particularly Lewin (1946, 1947). However, since its inception, AR has evolved to encompass a number of related approaches such as action learning, action science, action enquiry and participatory AR (see Eden and Huxham 1996; Checkland and Holwell 1998). Given this evolution, within our paper we adopt the interpretation of AR suggested by Platts (1993, 9);

> … the researcher not only participates in the activity but seeks to direct and influence the way in which the activity is conducted. He imposes his conceptual frameworks on the tasks and interprets the events within these frameworks. He is not so much concerned with gaining a better understanding of current approaches to tasks as with changing those approaches and observing the effects.

An AR approach was therefore adopted because the researchers needed to actively participate with practitioners from VehicleCo to influence all the stages of the planned intervention project, observe its outcomes and also to consider the general implications of this study beyond this case firm (Gummesson 2000; Coughlan and Coghlan 2009; Hendry, Huang, and Stevenson 2013).

Whilst this approach was deemed the most appropriate to address the research reported upon within this paper, AR is not without its criticisms. In concert with the case study with which it shares common methodological characteristics, these criticisms concern methodological rigour and chiefly originate from a positivistic world view, revolving around the validity of generalising to a wider population from a [case] 'sample size of one' and the lack of repeatability of such studies (Eden and Huxham 1996; Checkland and Holwell 1998; Coughlan and Coghlan 2002). Premised upon such a world view, Gummesson (2000), for example, asserts that case-based research can generate hypotheses but not test them. This deems such research insufficient for either generating or testing theory. By contrast Eden and Huxham (1996, 80) recognise that each AR intervention is highly situational, making AR an unsuitable vehicle for theory testing. However, they argue that AR will generate

> … an emergent theory, in which the theory develops from a synthesis of that which emerges from the data and that which emerges from the use in practice of the body of theory which informed the intervention and research intent.

They likewise recognise that tools, techniques, methods or models can form the basis of such theory. To support this latter view and counter the concerns raised above, authors have stressed the importance of deliberate research design that considers the wider implications of the research and effective roles and relationships within AR project teams (Coughlan and Coghlan 2002; Hendry, Huang, and Stevenson 2013). It is to these issues that we now turn.

3.3. Research design, data collection and analysis

Drawing upon Lewin's (1946) work, numerous authors have categorised the steps involved in the design of an effective AR study, which is typically premised upon iterative intervention/ reflection cycles. Perhaps, one of the most influential of these techniques is the work of Coughlan and Coghlan (2002), which was used as the framework for the design of our study.

Due to its instrumental role within this study, the following provides a brief summary of Coughlan and Coghlan's guidance on the purpose of each of these steps. Table 1 details the main fieldwork-related activity that was undertaken during each of these steps, and hence illustrates how this guidance was translated into practice during this first AR cycle at VehicleCo.

According to Coughlan and Coghlan (2002), the first step of an AR cycle is a pre-step entitled Context and Purpose. The aim of this is to clearly establish and articulate the rationale for the proposed action by addressing the question of why this project is necessary or desirable from the perspective of the organisation. Likewise, to also consider the rationale for undertaking the research by addressing the questions: why is this project worth studying, why is AR an appropriate methodology for it, and what is its expected contribution to knowledge? For the VehicleCo project, this step therefore entailed the research objective developed earlier, along with the concomitant practical terms of reference such as roles and responsibilities, resource availability and time frames. A steering group was then formed that included the heads of VehicleCo's engineering, manufacturing and accountancy departments. Because of the nature of the research objective, the project was 'championed' by the head of finance. His role was to act as the main point of contact between the steering group and project team that was subsequently formed to deliver the project's research

Table 1. Steps and activities in the VehicleCo AR cycle.

Step	Fieldwork activities
1. Context and purpose	• Establish the project's research objective and practical terms of reference. • Form the project steering group. • Form the project team. • Initiate company-specific document collection.
2. Data gathering	• Project team workshop to establish a block diagram of the high-level structural features and KPIs of VehicleCo's operation. • Follow-up interviews with attendees and shop floor staff to validate and elaborate upon the efficacy of this block diagram. • Data mining of time series data from the ERP system to deepen insight into the firm's operational and financial performance. • Ongoing observation of shop floor practices. • Ongoing unstructured interviews with shop floor staff.
3. Data feedback	• Miscellaneous ongoing feedback sessions to the project champion at the end of each pre-planned monthly 2–3 day fieldwork event.
4. Data analysis	• Analysis of numerous trends and relationships within the mined ERP time series data to establish what the data inferred about the working principles, practices and subsequent performance within the firm. • Synthesis of four new key constructs: Profit & Loss Improvement Sensitivity Analysis, Inventory Trend Analysis, Inventory-Working Capital Analysis and Inventory Provision Analysis.
5. Action planning	• Construct a progress report and supporting presentation. • Formal presentation to the steering group.
6. Implementation	• Project team workshop to design the format of a new process improvement targeting mechanism, subsequently entitled Big Picture Financial Map, and populate this with requisite data for VehicleCo. • Develop a business case and supporting presentation for the intervention project suggested by the BPFM targeting mechanism.
7. Evaluation	• Formal presentation to the steering group. • Decision to execute the next AR cycle (design and implement the intervention project identified by the BPFM).

objective. This project team contained three of the authors of this article, who were acting as facilitators and were all experienced action researchers. It also contained a group of six mid-level managers drawn from and representing the key fabrication and final assembly work centres found within VehicleCo's UK operation. Once the project team was formed, they were tasked with collecting background information such as company structure, hierarchy and promotional literature, and hence initiating company-specific (secondary) document collection.

The second step in the framework is entitled Data Gathering. For the action researcher, data generation is derived via active involvement in the day-to-day organisational processes and interventions relating to the AR project. This involves the collection of 'hard data' such as operational statistics and financial accounts, and also involves the collection of 'soft data' gathered via observation, discussion and interviewing. Drawing upon the previously collected background information, this step was initiated at VehicleCo with the full project team engaging in a highly interactive one-day workshop. The purpose of this was to provide the newly formed team with a common understanding and overview of the whole of VehicleCo's UK operation and the nature of the management control information used within it, as none of the team members currently had that requisite knowledge due to the functional nature of their roles. The workshop entailed the collective production of a simple block diagram to highlight its main high-level structural features and the main key performance indicators (KPIs) used within the operation. The practitioners were tasked with bringing along copies of relevant supporting evidence such as work centre performance management documentation, with the event itself involving free flowing discussion. In the weeks following this workshop, the researchers conducted a number of follow-up semi-structured interviews with the attendees and salient shop floor staff. The purpose of these interviews was to clarify and validate a number of details raised during the workshop event, and also to collect further information on the most influential KPIs in use within the firm.

This information was subsequently added into the block diagram drafted during the workshop, then circulated to the team members for their information and further confirmatory feedback. In order to deepen their insight into the firm's current working principles and practices in addition to quantifying the firm's resulting operational and financial performance, the project team next undertook a large-scale data mining exercise of data for the previous 7 months. This was conducted with the active participation of the VehicleCo accountancy department and involved obtaining data such as the physical location and value of all work in progress (WIP) per contract, monthly operating expenses and sales revenue per contract. This time series was extracted from the firm's enterprise resource planning (ERP) system into a series of Excel spreadsheets for subsequent analysis.

Data Feedback, the third step in the AR cycle, involves the researcher feeding back the gathered data to the client organisation with the view to making this data available for analysis. Research is rarely conducted in a neat linear–sequential manner, and this project was no exception. During the VehicleCo study the data gathering and feedback steps were conducted as a series of iterative mini-cycles. This took the form of pre-planned monthly 2–3 day fieldwork events conducted over a 6month period, with each such event culminating in an informal feedback session to the project champion. An agenda was agreed in advance of each event, and each involved the full-time participation of all nominated project team members. The fieldwork event itself typically comprised a number of formally minuted meetings as well as structured and unstructured fieldwork activity. During the course of both this step and the analysis step that followed, ongoing observation of shop floor practices and unstructured interviews with shop floor staff was afforded by the richness of access and location of the project team's office space at a central location within the operation. The observation was supplemented by digital photography to evidence salient practices. Each fieldwork event culminated in minuted supplementary data collection tasks to be completed by the practitioners in advance of the next scheduled whole-team event. As a consequence of these procedures, the evidence base of our project was significant. It amounted to over 50 h of interviews, 20 h of observation and hundreds of pages of company-specific documents, digital photographs and ERP data extracts.

Data Analysis involves the identification of issues and subsequent focus for action. Importantly, Coughlan and Coghlan (2002) assert that the criteria and tools for analysis should be directly linked to the purpose of the research and the aim of the interventions. Of critical importance is the requirement for such data analysis to be a collaborative exercise, involving both the researchers and members of the client organisation. During the VehicleCo study this step was a significant undertaking, being conducted over a further 6-month period. As per the above, this took the form of monthly 2–3 day collaborative fieldwork events undertaken at VehicleCo's premises, with each such event culminating in feedback to the project champion. The analysis stage of an AR project typically entails the coding and content analysis of interview data (see Lavikka, Smeds, and Jaatinen 2009; Brown and Vondracek 2013). However, because of the nature of the research objective, the analytical focus at VehicleCo was on the hard data extracted from the firm's ERP system to establish what it could further infer about the working principles and practices deployed by the firm, and the resulting performance levels attained. Therefore, during this period, this time series data was first smoothed using a standard 30-day month in order to facilitate inter-month comparisons. It was then manipulated at the factory, work centre, department, resource (a machine or group of like machines) and item level. The exercise was approached with an open mind and no preconceived ideas regarding the specific relationships to explore, although particular attention was paid to inventory relationships as these would provide insight into how the firm was deploying its capacity. This resulted in the identification of numerous trends and relationships that had not previously been explored within the firm such as sales and WIP, sales and working inventory (WIP + finished goods) and factory hours worked and WIP. The product of this exercise was the synthesis of four new constructs that were believed to be salient for the targeting of the consequent improvement intervention; a Profit & Loss (P&L) Improvement Sensitivity Analysis, Inventory Trend Analysis, Inventory-Working Capital Analysis and Inventory Provision Analysis.

The Action Planning step entails translating the insight gained during the previous step into a practical intervention plan, and it is again important that this be a collaborative exercise. At VehicleCo, this step was initiated by the project team preparing a progress report and supporting presentation that encapsulated the above insight and suggested project next steps. A team presentation was made to the steering group, who subsequently gave their approval for the project to progress.

Implementation involves the client organisation enacting the above planned actions. A second whole-project team workshop was consequently convened at VehicleCo. The purpose of this was to collaboratively design the new process improvement targeting mechanism itself. Taking the block diagram developed during the data gathering stage as a starting point, the format of this new mechanism was duly innovated and subsequently labelled a Big Picture Financial Map (BPFM) by the team. Drawing upon the previously collected data, and again with the active involvement of the accountancy department, this BPFM was then populated with the salient data from a representative month within the firm's commercial operation. Its subsequent analysis suggested the logical point of process improvement intervention within VehicleCo's dispersed UK operation. Based upon this insight, this step culminated in the development of the business case and supporting presentation for this suggested intervention project.

The seventh, Evaluation step, entails assessing both the intended and unintended intervention outcomes with regard to the stated purpose for the AR project. The project steering group is the ultimate arbiter of this evaluation exercise. During the VehicleCo project, this step started with the formal presentation of the above business case to the steering group in order to seek approval to plan and execute the intervention project. After due consideration and a significant question and answer session with the project team, the steering group assessed that this new BPFM mechanism and the intervention project that it suggested indeed had the potential to yield a significant financial impact within the firm. They consequently approved this intervention, hence initiating the second intervention/reflection AR cycle at the firm. The detailed characterisation of this 12-month project is outside the research objective reported upon within this paper. However, during the Evaluation step of this second AR cycle, the financial impact of the targeted intervention was independently valued by the VehicleCo accountancy department to be worth at least £850K per annum to the firm. This impact therefore validated the steering group's assessment decision.

The final step in Coughlan and Coghlan's (2002) AR cycle is entitled Monitor. This is categorised as a 'metastep' by the authors, as monitoring should ideally occur during each of the previous steps. This step is the preserve of the researchers, who in addition to a concern for evaluating the practical outcomes (above), also have a concern for reflecting upon the efficacy of the process by which these outcomes are achieved. Because of the inherent nature of this step, it is omitted from Table 1. However, to support reflective practice, a journal containing ideas, thoughts and observations was maintained by the researchers. This was supplemented by a comprehensive project file that contained copies of all company documentation, agendas, minutes and correspondence collected during the project. The insight provided by this exercise was utilised to good effect in the subsequent AR cycle.

3.4. Data validity

As indicated earlier, AR is a variant of case study research and the validity of the data collected during AR can be evaluated against the criteria applied to case research (Brown and Vondracek 2013). Because of the nature of such research, the issues of validity and reliability are highly related. Yin (2003) suggests four tests of validity in addition to the tactics required to realise them, and these offer a yardstick by which our VehicleCo study can be evaluated: construct validity, internal validity, reliability and external validity.

Construct validity necessitates establishing the correct operational measures for the phenomenon being studied. In accord with the tactics suggested by Yin, we used multiple sources to establish 'chains of evidence'. All the collected data was reviewed for accuracy by the source informants and practitioners on the project team, with the steering group presentations forming a further plausibility test. Importantly, we also employed methodological triangulation to generate complementary data (after Denzin 1970). Drawing upon the discussion in the previous sub-section, Table 2 summarises the instruments that we used per step in the VehicleCo AR cycle, with the workshops and ERP data mining exercise being, respectively, deconstructed into the categories 'interviews' and 'company-specific document collection'.

The internal validity of our study was underpinned by the degree of collaboration and research access that was afforded the researchers, along with the nature and extent of dialogue with the project champion. This was enhanced via the application of time series data analysis. Yin's third test (reliability) refers to an ability to demonstrate that the operations of a study can be repeated with the same results, and it is to address this criterion we have detailed the research design, data collection and analysis procedures within this article. Yin's fourth and final test of external validity refers to the domain in which the study's findings can be generalised. Our study suffered the inherent limitation of being a single, AR case and therefore details one particular application. We will return to this limitation in the Conclusion of our paper, where we outline planned future directions of research for increasing the external validity of this study.

3.5. Confidentiality

Under the terms of a strict confidentiality agreement, a 4-year moratorium on publication has been observed for this study. Other measures have also been applied within this paper to assure the anonymity of the firm whilst simultaneously maintaining the integrity of the findings. These measures include the use of the alias VehicleCo for the case firm, and the disguise of all terminology that could be used to identify it. This includes all specifics regarding the firm's product portfolio, the industry sector within which it operates, its geographic location and all reference to its annual turnover and scale of employment. Lastly, all financial and operational data has been disguised by means of a constant modifying factor.

Table 2. Data collection instruments used during the VehicleCo AR cycle.

AR cycle step	Interviews[a]	Observation[b]	Company-specific document collection	Reflective journal and project file
1. Context and purpose			✓	✓
2. Data gathering	✓	✓	✓	✓
3. Data feedback				✓
4. Data analysis	✓	✓	✓	✓
5. Action planning				✓
6. Implementation	✓			✓
7. Evaluation				✓

[a]Includes unstructured and semi-structured interviews.
[b]Includes digital photographs.

4. Discussion

As indicated in the previous section, the initial steps of the AR cycle at VehicleCo involved forming the project team and establishing among them a common, high-level understanding of the structure of the firm's UK operation. The main deliverable was the high-level block diagram that distinguished between the final assembly and fabrication parts of the business, and also identified the main plants, work centres and inventory holding points within each of these. Likewise, the main production lines (assets that are dedicated to specific customer contracts) were identified within the final assembly area. Whilst the format of the diagram was unremarkable, the process used by the project team to produce it rapidly established that comprehensive cost data was readily available within VehicleCo, and at factory, work centre, department, and resource level. Operational performance measurements were found to also reflect this trend. However, information on lead times through various parts of the operation was difficult to establish, although cycle time and quality/scrap information at individual resource level was again readily available.

During the course of the initial project team workshop and the interviews that followed it, a concerted effort was made to establish the main KPIs that were used for management control purposes within the operation. A large number of different metrics were duly identified, and the most influential of these were annotated onto the block diagram to act as an aide-memoire. These metrics were found to be almost universally of a unit cost type and included controllable overhead rate, controllable wrap rate and direct labour rate. Measurements influence behaviour (Hrebiniak and Joyce 1984; Neely, Gregory, and Platts 1995) therefore unsurprisingly the follow-up interview evidence and subsequent secondary analysis of the operational performance data established that for many managers such unit cost measures were being interpreted as 'make as much as you can in the time available', a culture of local optimisation.

Following the data feedback step, the team turned to the data analysis of the financial and operational data contained in the firm's ERP system. Data was extracted, smoothed and then combined in 'interesting' ways to establish whether any trends or relationships could be discerned that would cast insight into the working principles and practices that were in common currency within the firm. Whereas a number of such relationships were explored, only two are presented here due to space constraints, but suffice to illustrate the general findings.

The first of these is the relationship between sales revenue and WIP (Figure 1). The data on both of the axes has been smoothed, and plotted over a representative 7-month period. WIP equates to manufacturing lead time, so the following chart illustrates a relatively long average lead time of 80 days plus, although this is not unusual for the industry concerned. The most interesting feature of the diagram is that during the period May– July, WIP and hence lead time grows in an inverse relationship to the sales velocity. It seems that more material is being released to the floor as orders decline. This suggests that perhaps the plant is being kept busy for the sake of being busy, in an attempt to maintain utilisation figures and unit costs.

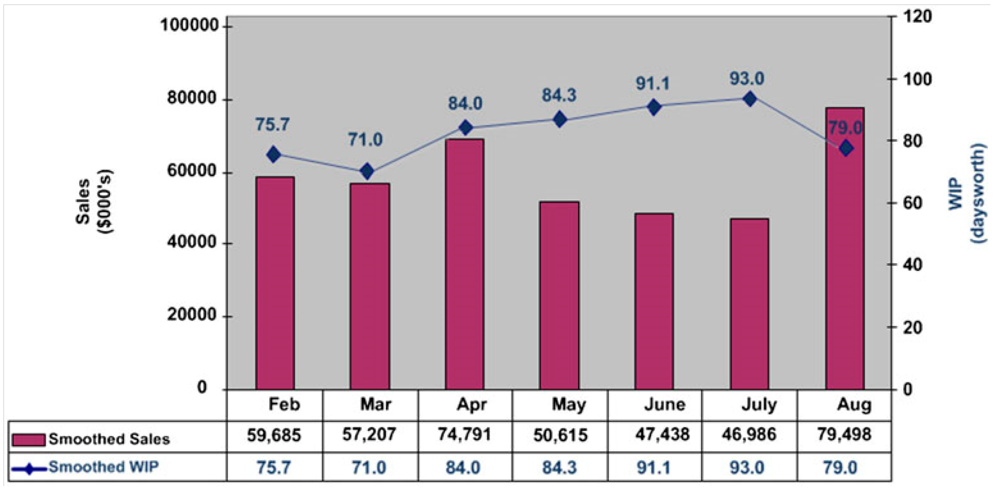


Figure 1. Relationship between sales and work in progress.

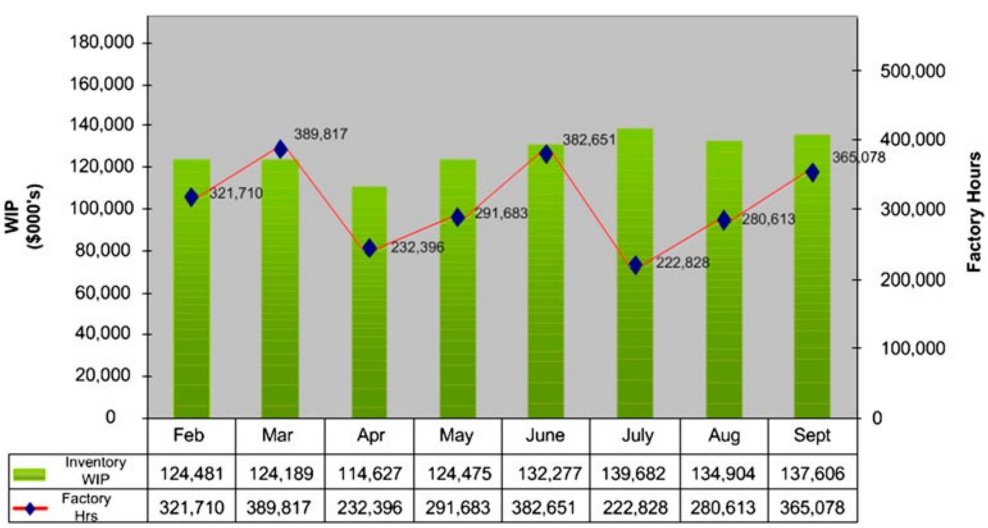


Figure 2. Relationship between factory hours worked and work in progress.

The second exploratory relationships are illustrated in Figure 2. This chart reports upon the same 7-month period and illustrates the relationship between total factory hours worked and the total WIP value. Both April and July are notable holiday periods within the locale of the plant, and it is interesting that the chart seems to indicate extra hours worked and the building of WIP in the months adjacent to each of these two periods. This reinforces the pattern that emerged in the previous figure. These two examples, taken in conjunction with the wider accompanying trends and relationships explored during this part of the study, clearly indicated that the VehicleCo operation was working to conventional mass production principles and practices whose lineage could be traced to scientific management (Taylor 1911), such as the importance of local rationality and scale-derived efficiency.

Having gained this insight, the project team now turned to establishing a greater depth of understanding of the effects of these working practices on the current financial and operational performance of the firm. Whilst more extensive analysis was performed as indicated earlier, four new constructs provided particular insight. These were a P&L Improvement Sensitivity Analysis, Inventory Trend Analysis, Inventory-Working Capital Analysis and Inventory Provisions Analysis.

Figure 3 illustrates the P&L Improvement Sensitivity Analysis, which represents an important innovation for the targeting and development of a business case for a lean-type process improvement intervention. The lefthand side of the figure illustrates a conventional P&L statement for the previous 12-month period up to that census month to date. The data used for the production of this statement were extracted directly from the firm's accounting system and utilised its conventional cost category labels. The only unconventional category is 'throughput', which is a throughput accounting (TA) construct defined as sell price − material cost (Goldratt and Cox 1984; Corbett 1997). This P&L statement therefore summarises the real money that the company generated in terms of sales in that period. It also summarises

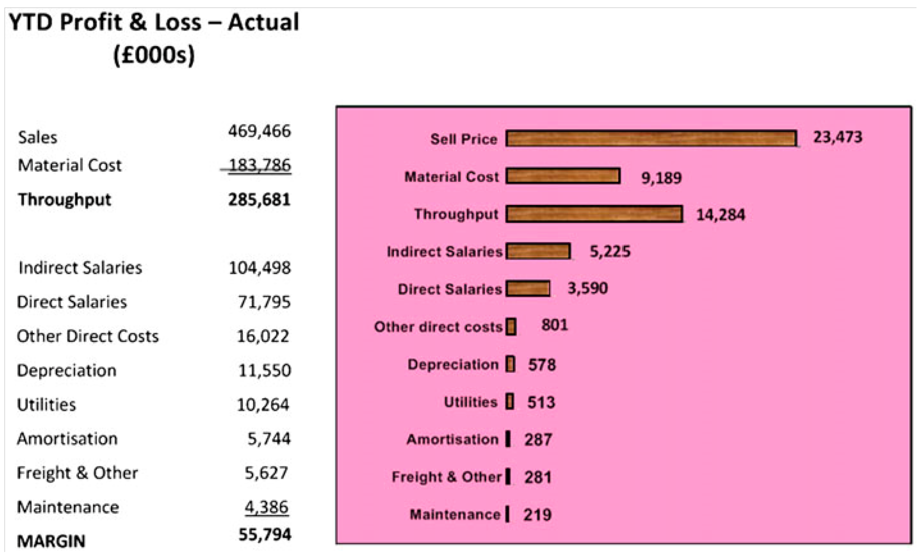


Figure 3. Profit & loss improvement sensitivity analysis (5%).

the real money it spent to realise that revenue. The righthand side of the figure forms the sensitivity analysis. It illustrates the financial impact of a 5% improvement in each of the respective cost categories. The reason for selecting 5% was that this figure was considered a modest improvement goal by the firm, yet it still revealed a significant impact on the bottom line. The cost categories are arranged in a descending order of impact of this 5% improvement.

Figure 3 therefore illustrates that the initiative that would yield the largest financial impact to the firm would be an across-the-board increase in the sales price of its product offerings. This was deemed impractical by senior management given the state of the market at that point in time, which was highly competitive and in a period of slow recovery from recession. In any case, VehicleCo received a transfer price from the parent enterprise and did not set the end price of its product offerings to the final customer. The second largest financial impact would be delivered via an across-the-board reduction in the cost of materials. Again, this would entail negotiation with external stakeholders, and was deemed impractical due to the nature and number of contracts concerned. However, the third largest opportunity lay entirely within the internal control of the firm itself. This was the potential offered via a programme for increasing throughput, because a 5% improvement would add £14.28 million to the bottom line. This is nearly 273% larger an impact than the 'next best' opportunity, the targeting of indirect salaries. In fact, the throughput improvement opportunity represented 162% of the bottom line impact of the combined reduction of both indirect and direct salaries.

Having obtained this preliminary financial insight, the second task was to analyse the firm's total inventory holdings over the last 6 months of the period reported upon above (Figure 4). Further data was extracted from the firm's ERP system for each of the raw material (RM), WIP and finished goods (FG) categories of inventory. As per the daysworth figures presented in the earlier diagrams, this data was then smoothed using a standard 30-day month to establish an average 'daysworth of sales coverage' figure

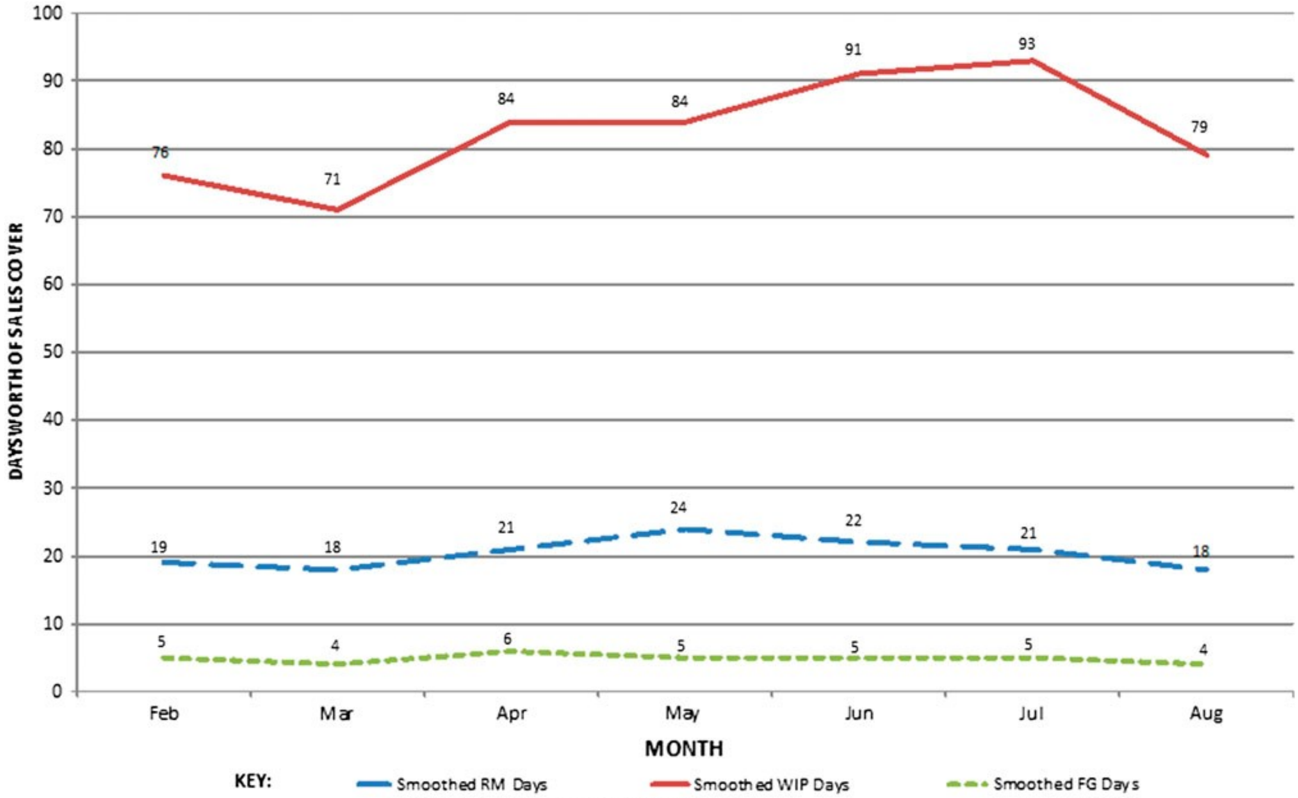
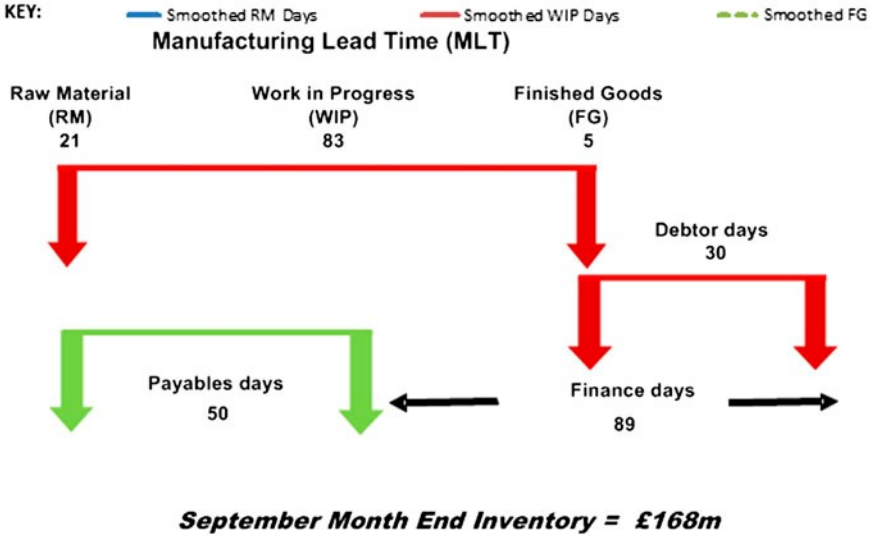


Figure 4. Inventory trend analysis.



for each inventory category for each of the 6 months concerned. By the way of illustration, the equation used to establish the ‘RM daysworth of sales coverage’ figure for February was: (raw material value at end of February/raw material cost of sale for March) × 30 days. Figure 4 illustrates relatively stable inventory coverage for each of the three inventory categories over the 6-month period reported upon. The following average sales coverage figures were also established: RM (21 daysworth), WIP (83 daysworth) and FG (5 daysworth). It is notable that the FG figure is a function of spare parts rather than whole bodywork or auxiliary structures, as the value and nature of these products ensured their rapid distribution to the downstream customer. The levels of WIP witnessed seemed to be a structural feature of the industry within which the firm operates, which is typified by penalty clauses for late delivery. However, the working practices established earlier were also a likely contributory factor.

After establishing the above average inventory coverage figures, it was possible to utilise them to gain further insight into the working capital implications of the current state of the VehicleCo operation (Figure 5). Inventory equates to manufacturing lead time (MLT), as indicated earlier. Therefore, when the average RM, WIP

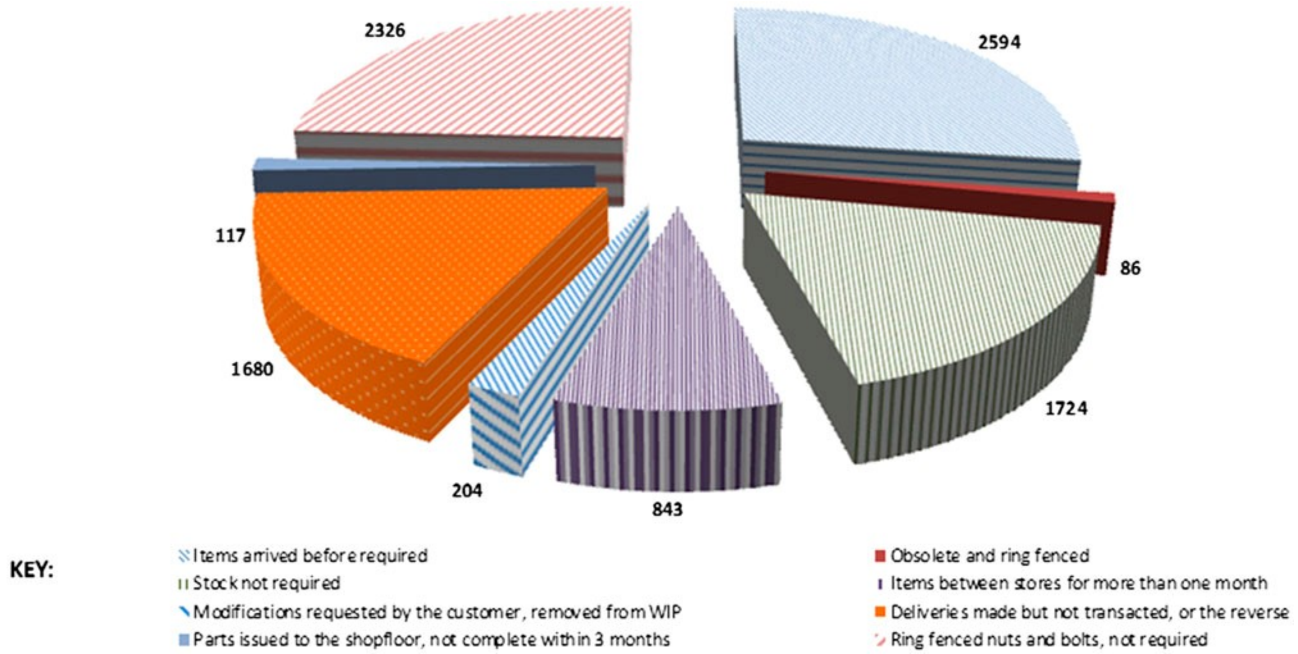


Figure 5. Inventory-working capital analysis.

and FG inventory coverage figures are added together, they yielded a derived MLT of 109 days. A check was made with production staff to validate the reliability of this figure as an approximate to the actual average MLT witnessed in reality. Based upon a standard 30-day term for debtors to pay for their FG, this then equates to a 139-day manufacturing-to-cash lead time, from receipt of the RM by VehicleCo in order to start the production process through to receipt of payment from the customer for the resulting FG. Payable terms and conditions for

Figure 6. Inventory provisions analysis (£000s).

goods received by VehicleCo were 50 days. It was established that September was a representative month and that the September month-end inventory valuation figure was £168 million. The firm was therefore being called upon to finance this value of inventory for 89 days. This is clearly a significant financial burden.

The fourth and last of the new constructs produced during this stage of the study was an inventory provisions analysis (Figure 6). Initial comments made by a number of staff during the confirmatory feedback interviews in the data gathering step had suggested that write-off costs were not significant within the firm. This new construct was therefore made in order to substantiate these claims, and the results were surprising. The accountancy department again assisted with the provision of the necessary data. It was subsequently found that there were eight inventory provision categories in operation, and that £3.4 million had been written off in the first 9 months of the year to date. This data, taken in conjunction with the follow-up interviews with the accountants and managers in the operational areas concerned, reinforced the fact that inventory was relatively slow moving and that engineering changes were relatively frequent due to the nature of the product portfolio. These figures therefore suggested further evidence that resource centres throughout the firm were optimising the organisation of their work to respond to the unit cost nature of their prevailing KPIs, scheduling batch sizes to maximise machine utilisation rather than flow rates, and hence exposing the surplus stock to the risk of obsolescence due to engineering changes.

In summary then, the analysis of the financial and operational data yielded by the four key new constructs developed during this step of the AR cycle clearly indicates that the most logical course of action for this firm, given its current level of performance, would be to increase throughput. To achieve this, it would be necessary for VehicleCo to reduce its MLT in order to improve the flow of work through the production process. Reference to Figures 5 and 6 reveals that WIP represents by far the largest component of the MLT within this case operation. Unlike RM and FG, which are generally a reflection of the variability of supply and demand (respectively), the amount of WIP a firm holds is a function of its policies and the way that it deploys its capacity. The amount of WIP is therefore entirely within the control of the firm. The data therefore suggest that the focus for the intervention should be the systematic reduction of MLT via the reduction of WIP. This course of action would yield a number of benefits. Of immediate impact would be the reduction in production lead time, which would be a function of the amount of WIP (daysworth) reduced. It would similarly reduce working capital requirements and concomitant inventory management costs. The increased inventory turns that would result from this exercise would likewise reduce the exposure to risk, and hence write-off costs, that are associated with engineering changes. Lastly, improved throughput could also reasonably be expected to translate into improved due date performance. A WIP reduction initiative of this sort therefore promises more than unfocused waste reduction of the type characteristic of many lean initiatives (Bicheno and Holweg 2008). It instead offers both genuine cost reductions to the producer and improved utility to the downstream customer.

After presenting the previous findings to the steering group, the project entered the Implementation step of the study. It was during this step that the new mechanism was to be designed to help identify and target the most appropriate location for this WIP reduction intervention within VehicleCo's large and geographically dispersed manufacturing operation. 'Appropriate' in this context was interpreted to mean the potential for the largest financial impact within the firm. Consequently, to inform this exercise additional analysis was undertaken again in concert with the VehicleCo accountancy department, and a second whole-project team workshop was convened. First, the format of this new mechanism was developed and agreed upon. It was then populated with data for a representative (commercially typical) month. This new mechanism came to be named a BPFM and it took the guise of a new form of a high-level schematic representation of the financial current state of the whole case operation at a representative point in time (Figure 7).

An important feature of this BPFM is that it embodies the three TA measures of throughput, inventory and operating expense, proposed by Goldratt and Cox (1984) as part of their TOC. According to these authors, the goal of any private sector organisation is to make money, and they introduce the concept of TA to assist managers in making decisions that attain this. TA is premised upon three metrics that differ in definition to the more conventional usage of the terms (Corbett 1997): 'Throughput' is the rate at which the system generates money through sales. This is the volume of sales expressed in terms of money rather than units, and products only become throughput when they are actually sold. The second measure is 'inventory', which is defined as the money invested by the system in things that it intends to sell. Within TA, this measure encompasses equipment and facilities in addition to the conventional inventory categories of raw material, WIP and finished goods. However, in the case of the latter categories, it equates to the direct material cost and excludes any notion of value added during the production process. The final TA measure is 'Operating Expense', (OE) which is defined as the money that the system spends to convert inventory into throughput. The TA conception of operating expense adopts a marginal costing approach and notably excludes all overhead allocations (Boyd and Gupta 2004). Goldratt and Cox (1984) argue that all management decisions should be based upon these three criteria alone, with the aim being to increase throughput whilst simultaneously decreasing inventory and operating expense. Such a decision is classified as 'productive' as it will contribute to the organisation achieving the goal.

The BPFM distinguishes between the raw material, fabrication and final assembly areas of the VehicleCo manufacturing operation. Within the final assembly area, all of the main product line contracts (value streams) are identified along with the total throughput associated with each in the period concerned. This captures the real money flowing into the firm's bank account. Within the fabrication area, all of the firm's main machining work centres are identified, along with the major material work flows between these centres and the final assembly areas. Each such centre is represented as a box, with its monthly OE displayed at the bottom. This is the sum of the fixed costs that are incurred in running the centre for that period, regardless of its production volume, and it excludes any overhead allocations as indicated above. The BPFM also captures the WIP inventory material and utility cost valuation that is tied up at each major stock point in the system. However, absolute inventory value doesn't tell us much about whether this is too much, or too little, for the demands placed upon it. Each such value is consequently converted into a daysworth of sales coverage figure to cast further insight into this issue, using the calculation detailed earlier.

The analytical work conducted to produce the BPFM yielded three notable findings. The first of these was the triangulation of the average MLT figure established during the earlier data gathering step. A second finding was that nearly half (47%) of the firm's total labour was to be found in the upstream fabrication work centres as compared to 53% in the final assembly area. This was important because it meant that the firm's established internal lean initiative, which was focusing on labour cost reduction in final assembly, was in fact currently targeting only approximately 50% of its potential scope. When considered in conjunction with the insight gained via the P&L Improvement Sensitivity Analysis (Figure 4), this also meant that a company-wide improvement in throughput offered an impact potential of nearly 600%

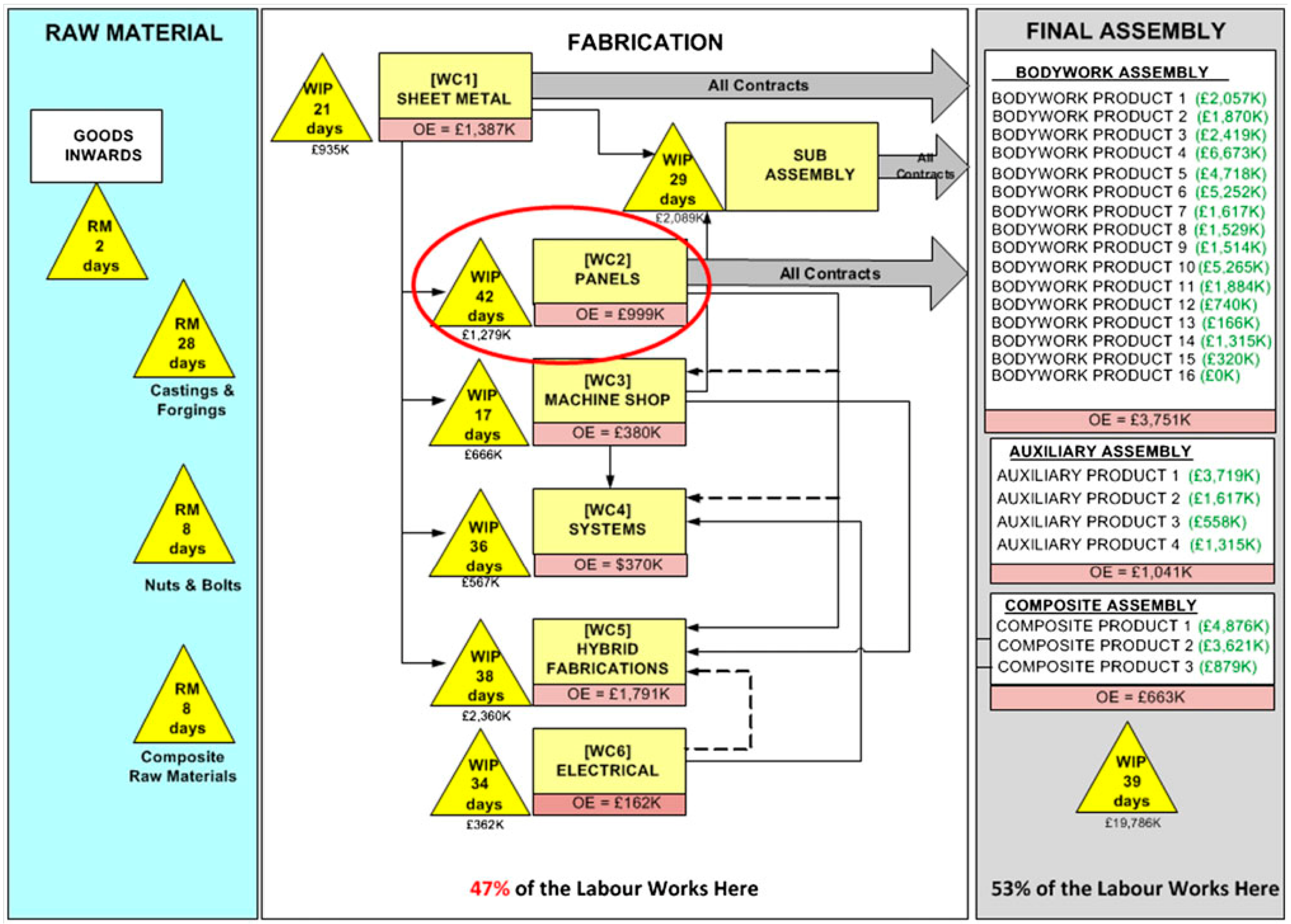


Figure 7. Big picture financial map of VehicleCo's UK operation.

more than this established programme of labour cost reduction, and not 300% as originally estimated.

The third finding was the identification of the most appropriate location to intervene within the complex case operation. Figure 7 reveals that the fabrication work centre that has the highest WIP in terms of absolute inventory value is WC5-Hybrid Fabrications. It also has the highest OE. However, the BPFM likewise revealed that the centre that was carrying the highest inventory in terms of daysworth of sales coverage was WC2, where the individual bodywork and auxiliary panels were produced. In addition, this centre represented the third highest operating expense figure. Unlike WC5 which was perceived as an exemplary centre and was actually producing 'early' approximately 60% of the time, WC2 was considered an operational 'problem child'. It was suffering from high rework and scrap rates and long lead times. It was also suffering from poor delivery schedule adherence, being late approximately 60% of the time. This was evaluated to be causing on average six jig stoppages per week within the final assembly area. Hence, WC2 was already causing much disruption to the production schedules of its downstream final assembly customer.

This comparative performance requires brief explanation. Whilst Figure 7 illustrates that WC2 feeds WC5, this workflow represents a relatively small number of parts. The products of these two work centres are produced in response to independent demands from the final assembly lines. WC5's early performance profile merely represents another form of poor delivery schedule adherence. For example, final assembly demands 50 of WC5's component X products to be assembled into its final composite structures. However, 100 component Xs are produced as a consequence of the local batching rules and efficiency metrics within WC5. This is recorded on the company's performance measurement system as '50 × early'. This is consequently a sequencing, batching and performance measurement issue.

Returning to WC2's issue and during the period on the run up to the presentation of the study's results to the steering group, the firm's order book took a significant uplift as the market started to recover. When the firm modelled the implications of this new order book, they found that within the immediate months ahead, they would be encountering a serious operational problem within WC2. In accord with conventional mass production practice, the traditional response to more demand had been to push more work into the system; therefore, tying up more working capital, producing more WIP and consequently more risk of obsolescence and damages (but not more throughput). The problem was poised to become acute over the coming period as, apart from the cost and working capital implications, the uplift in the order book meant that if current working practices were followed, there was not going to be enough physical space within WC2 to accommodate all of the panels that were forecast to be produced and moved around this centre. Consequently, WC2-Panels was identified as the most appropriate location for the planned process improvement intervention.

These recommendations were accepted by the steering group, stimulating the second AR cycle within the firm. The resultant 12-month process improvement project within WC2 is detailed in Darlington et al. (2015). This intervention took the form of a Drum Buffer Rope (DBR) type of pull system (after Goldratt and Cox 1984) and was implemented with significant operational and financial success. It resulted in a 23-day (56%) MLT/ WIP reduction that was independently valued by the VehicleCo accountancy department to be worth at least £850K per annum. The improved throughput translated into an increase in WC2′s inventory turns from 9.1 to 21.2 per annum, and the improved lead time and reliability resulted in jig stoppages in final assembly falling to less than one per week. As a consequence of this economic impact, the WC2 DBR project was nominated by VehicleCo for the parent enterprise′s annual worldwide process improvement competition that year, where it won the first prize.

5. Conclusions

The industrial problem that formed the context for this AR study was the need for an objective method for targeting (prioritising and selecting) lean intervention projects within the case firm; one that encompassed financial as well as operational criteria. However, a structured literature review on this topic was unable to identify any decision support mechanism for doing so. Instead, it established that the kaizen technique that forms the medium for process improvement within the lean paradigm has evolved over the last three decades. In its original conception, kaizen entailed continuous incremental improvement in response to localised suggestions or workplace problems by standing quality or KC teams. This has become known as process kaizen. By contrast, the more contemporary flow kaizen type entails the proactive design and implementation of discrete lean process improvement projects. It is this latter type of kaizen that is practised at VehicleCo and which necessitates a supporting targeting device. Flow kaizen seems to be becoming increasingly prevalent, and this in turn appears to be driven by the influence of various popular VSM techniques that have emerged since the latter half of the 1990s. Indeed, VSM has emerged as the de facto vehicle for implementing flow kaizen-type projects. However, mirroring the gap identified above, existing VSM techniques lack guidance for conceiving or objectively selecting the value stream that is to form the focus for the mapping exercise. They likewise reveal an exclusive focus on operational performance criteria, and contain no direct financial dimension. This clearly has implications for both the risks and returns associated with the resultant improvement projects.

The development of the resulting targeting method at VehicleCo involved the main body of evidence being derived from extensive analysis of financial and operational data extracted from the firm′s ERP system, along with two structured workshops that involved multiple informants drawn from the firm′s production work centres and accountancy department. During this exercise, a number of previously unexplored trends and relationships in the data were investigated. These were used to establish that the firm was operating according to conventional mass production principles, such as the importance of local rationality and scale-derived efficiency. Four key constructs were then developed to deepen the team′s understanding of the effects of these practices on the financial and operational performance of the firm. This analysis suggested that the most logical course of action for the firm was to increase throughput via a targeted WIP reduction initiative. A new targeting mechanism named a BPFM was subsequently developed that drew upon the information derived during the preceding stages of study, and this was used to identify which of the work centres within VehicleCo′s six UK plants offered the greatest financial potential for the initiative identified. The resultant intervention yielded a very significant financial and operational impact at the case firm, and as a consequence, it was awarded the first prize at the subsequent annual worldwide process improvement project competition that was held by the parent enterprise. This impact validated the efficacy of the new targeting method and hence heralded achievement of the research objective stated above.

As a consequence, it is possible to conclude that this paper makes notable contributions to both the academic and the practitioner. The academic contribution of this paper resides in its addressing of the gap highlighted above, by offering a financially driven method for objectively prioritising and selecting a process improvement intervention that was proven effective within the case manufacturing environment. It is important to stress that this new targeting method is not presented as a substitute for the existing VSM techniques discussed in this paper. It is instead presented as a complementary method to be conducted as precursor to the deployment of such techniques. This new method itself features a number of innovative constituent techniques that include four new constructs for deepening the understanding of the working principles and financial performance of the focal case firm, and also a new technique for mapping the financial current state of the focal firm.

The practical contribution of this study for the future economic impact of the lean programme at VehicleCo is self-evident. If this targeting method proves to be generalisable, it could likewise offer improved economic impact potential for the firms adopting it to support their indigenous lean process improvement programmes. However, the limitations of the new method's external validity need to be recognised as it was derived from a single AR case. As VehicleCo was purposively selected, it is possible to conclude with a degree of confidence that the external validity of our results will extend to similar contexts (Silverman 2000). Therefore, the new targeting method is likely to prove effective in other large, multi-site manufacturing operations. Conversely, the more different a new context to that of our source AR case, the more unreliable will be the transferability of our results. Adopting Yin's (2003) advice to apply replication logic to increase external validity, future research will be conducted in a similar, large manufacturing operation. To improve empirical generalisation, future research will also be conducted in a variety of new contexts (Lavikka, Smeds, and Jaatinen 2009). Foremost amongst these contextual selection criteria will be scale, manufacturing process technology and operational complexity. In each such replication study, Platt's (1993) three criteria for assessment will be considered: feasibility (could the new method be followed); usability (how easily could the method be followed); and utility (did the method derive the expected outcomes)?

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