Teaching operations management using a ‘pseudo’-scientific approach?

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Abstract

The purpose of this paper is to explore a theory led approach to teaching operations and supply chain management that has emerged from the analysis of seminal operations management developments and case research. This research identified common operations construct relationships encompassing variation, uncertainty, buffering mechanisms and trade-offs which are used to provide a common basis for explaining these developments, linking established theory with current professional practice. The construct relationships are further shown to comprise three distinct but coordinated strategies that provide a useful framework for case evaluation.

Keywords: Teaching, Operations Theory, Supply Chain Management Theory

Introduction

Recent research (Doran et al., 2013) continues to show significant diversity in what is taught on Operations Management (OM) courses raising the ongoing question of what and how to teach. The OM book structure has clearly changed over the years with the introduction of chapters to reflect the breakthrough developments; these include operations strategy, supply chain management, total quality management, lean management and continual improvement. However, these chapters tend to emphasise the tools and techniques rather than the underlying shift in thinking that led to these seminal developments. As a consequence the systems thinking is not clearly represented resulting in these key developments being viewed as discrete and even unrelated? For example, the relationship between Kanban with Statistical Process Control (SPC) or at a more abstract level the relationship between the cumulative capability (sand cone) model (Ferdows and De Meyer, 1990) and Fishers supply chain model (1997) commonly used in text books. The lack of clear linkage between these systems developments and models is further confused by the inclusion of outdated cost models, such as the economic batch quantity which often still appears with a formula to apply.

This paper proposes a means of relating these system developments at a more abstract level, building on the laws (Hopp and Spearman, 1995; 1998) and principles (Hopp, 2008) that are centred on the deductive logic of queuing theory. However, such texts do not embrace the scope of OM topics and limit access to the less mathematically able. This paper, therefore, proposes a hybrid approach, arguably 'pseudo-scientific' to the purists, that utilises these deductive laws together with more empirical laws, initially proposed by Schmenner and Swink (1998).

The approach is illustrated in Figure 1. The outer layer of 6 laws are used as a basis for explaining key construct relationships which are used, in turn, to explain the relationship between both academic and practitioner led OM developments with established theoretical models, represented in the blue annulus. Having used the laws to explain these operational developments and associated theories the educational focus shifts to using the construct relationships to interpret and analyse case studies.

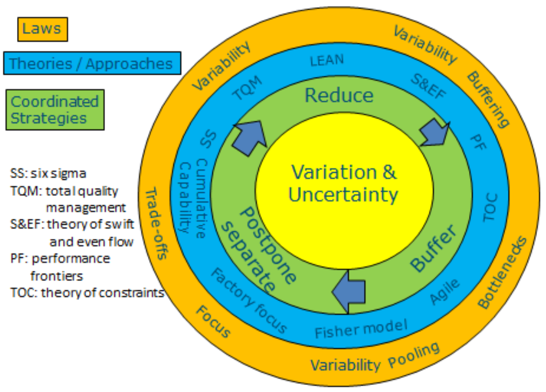

Figure 1 Linking operations laws to coordinated strategies

To support this process the construct relationships are interpreted as three coordinated strategies (green annulus) that centre on reducing, buffering and postponing / separating variation and uncertainty. The arrows represent the interplay between these strategies, hence coordination.

The paper structure is as follows: Firstly, an outline of the research that led to this teaching development and the subsequent action research. Secondly, the origin and definition of the six OM laws leads into using these laws to explain prominent OM developments, both academic and practitioner led. In each case the means of achieving the systems breakthrough is discussed with reference to the laws. Thirdly, the central importance of variation and uncertainty is developed through the use of three coordinated strategies which ~~is~~are illustrated through use of the Zara case. Finally, a discussion over the wider implications including interpreting established cost models and further evaluation.

Design/methodology/approach

The original case research (Stratton, 2008) investigated how key constructs (variation, uncertainty, buffering mechanisms and trade-offs) could be used to explain the performance of supply chains. The research involved 6 supply chain environments across a range of sectors over a 6 year period (Stratton and Warburton, 2006; Stratton 2012). The application of these findings within a teaching environment has been developed on the back of this case research using action research in the class room. This has involved feedback from the teaching team and students across UG and post grad and executive prost graduates over 4 years.

Interpreting OM developments

Some of the operations management developments that provide a teaching focus are discussed below with reference to the laws which provide the common foundation for teaching. Figure 2 identifies the main relationships typically covered in explain the systems based operations developments.

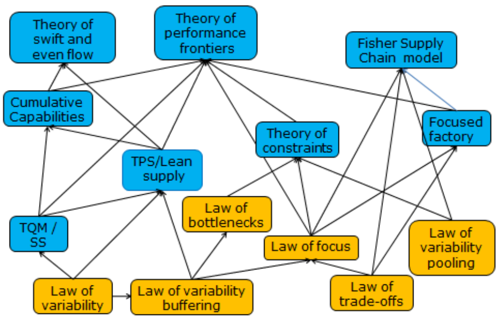

Figure 2 Some of the key relationships

Laws defined

The multi-case research identified 9 propositions and 3 coordinated strategies that explained the performance of the 6 case studies (Stratton, 2008). Subsequently these propositions have been rationalized to just 6 'laws' that are used to explain breakthrough developments and theory in OM at a more abstract level. In all cases the laws are not original, but there are some significant distinctions in the definitions which are briefly discussed.

- *Law of Trade-offs*: A delivery system cannot simultaneously provide the highest levels of performance (quality, delivery lead time, delivery reliability, flexibility and cost) (Skinner, 1969 modified).
- *Law of Focus*: A delivery system that is aligned to make the most of a limiting factor (e.g. order winning criteria or bottleneck) will be more productive. (Skinner, 1974; Hill, 1985;Goldratt, 1984 modified)

The law of focus is closely related to the work of Skinner and Hill, hence the reference to order winning criteria. However, the definition also embraces other limiting factors, such as bottleneck resources attributed to Goldratt.

- *Law of Variability*: Increasing variability always degrades the performance of a delivery system. (Hopp and Spearman, 1995 modified)
- *Law of Variability buffering*: Variability in a delivery system will be buffered by some combination of Inventory, Capacity and Time. (Hopp and Spearman, 1995 modified)
- *Law of Bottlenecks*: A resource with no buffer capacity dictates the delivery system throughput (and provides a focus for planning and control). (Goldratt, 1984 modified)

Although others have previously used the term 'law of bottlenecks' ~~previously~~ this definition is most closely attributed to Goldratt identifying a bottleneck is a limiting factor in the delivery system with no buffer capacity.

- *Law of Variability Pooling:* Combining sources of variability so they can share a common buffer reduces the total amount of buffering required. (Hopp, 2008 modified)

Focused Factory

The law of trade-offs and the law of focus are clearly allied to the emergence of operations strategy (Skinner, 1969) and the concept of the focused factory and a Plant Within a Plant (PWP) (Skinner, 1974). This was subsequently related to product-process alignment (Hayes and Wheelwright, 1979) and product profiling (Hill, 1985) identifying the need to focus and refocus trade-off choices around the limiting factor associated with the market characteristics. Hence, the importance attributed to structural and infrastructural choices concerning buffering and order winning criteria.

Although the concept of a focused factory appears simple it was profound at the time as it demanded a holistic systems perspective. In coming up with the focused factory concept Skinner was keenly aware of the tension between taking a strategic (systems) approach and the local performance measures and objectives that dominated plant management with each area being managed to achieve conflicting local objectives and measures. This productivity paradox (Skinner, 1986) was resolved through ensuring alignment within each PWP focusing on the key operations task or order winning criteria, viewed here as a limiting factors. This purely trade-off centred view of strategy was subsequently challenged and acknowledged (Skinner, 1992) through the growing ~~the~~ awareness of the Japanese led quality management approach (Deming 1982).

Quality Management - SPC

The importance of understanding variability in the product and process has long been acknowledged but took some time to emerge in the West. Again, the dominance of a local cost view required ~~resulted in~~ a paradigm shift in thinking that impacted many aspects of operations management practice (Deming, 1982). The emphasis this time being on reducing the variability and with it the trade-off implications referred to above. Central to this development was a management signalling tool that ~~to~~ replace dependence on inspection, ~~and with it~~ so enabling ~~e~~ a process of improvement. Statistical Process Control (SPC) and the experimental cycle Plan-Do-Study-Act (PDSA) (Shewhart, 1939) underpinned this~~at~~ capability, but it was to take many years for it to be acknowledged. This shift in thinking was notably embraced through targeting specific projects using the term six sigma (Klefsjo et al., 2001).

The importance of reducing variability in the product is identified as a first priority in the cumulative capability model (Ferdows and De Meyer, 1990) and remains a prominent theoretical model today (Ferdows and Thurnheer, 2011). Deming (1994) in his later years was to take this further emphasising the importance of variability and the systems perspective in his system of profound knowledge.

Lean - Toyota Production System - Kanban

Ohno’s (1988) development of the Toyota Production System (TPS), now commonly refer to as lean, building on Ford’s (1926) flow focus. This embraced the work of Shewhart and Deming in the reduction of product and process variability. However, he had to tackle the difficulty posed by the need to batch process, an issue Ford failed to address as he increased the range of cars he produced. The kanban management signalling tool was the answer (Ohno, 1988; p41), however, this is often overlooked.

'In reality practicing these rules [the six rules of kanban] mean nothing less than adopting the Toyota Production System as the management system of the whole company.' (Ohno, 1988:41)

Kanban has six functions that embrace control of material release and the systematic reduction of inventory to expose sources of variability. This involves the substitution of capacity for inventory buffering in enabling flow through the first of two ~~twin~~ pillars, ~~of~~ just in time (JIT). The second pillar, Judoka, centred on ~~and~~ exposing sources of variability (Judoka). The concept of an economic batch was replaced by a drive to minimise the batch size which in turn drove the need to reduce setup times (process variability) (Shingo, 1989). As with SPC and Ford's flow line, kanban provided a signalling mechanisms that displaced the influence of local efficiency measures, so shifting the management system from one oriented to local performance (push) to systems performance (pull) control.

The Cumulative Capability model effectively reflects the reduction of variability through improved product quality, then improved process dependability, enabling the reduction of overall buffering and specifically inventory in increasing speed. The theory of swift and even flow (Schmenner and Swink, 1998) similarly embraces these TPS and lean developments, but this theory lacks detail concerning the construct relationships provided through the use of these laws.

TOC – Buffer Management

The origins of the theory of constraints (TOC) is closely associated with the role of buffer capacity and bottlenecks, improving ~~enabling~~ flow in more complex make to order (MTO) environments. Such environments do not permit the solutions adopted by Ford or Ohno and the management signalling tool that is seminal to this development is buffer management (BM). The buffer is not a quantity of specific inventory between work areas, as with kanban, but an aggregated level of work, measured by the lead time between raw material release and the system pace setting drum. This is usually the master production schedule (MPS) due date, but is more commonly associated with ~~can also be~~ a bottleneck resource. The production application is termed Drum-Buffer-Rope, where the rope is the lead time offset and the buffer refers to the execution phase of managing the associated time to complete. The underlying distinction between kanban and BM is identified through the law of variability pooling. That is, through ~~In~~ BM the same buffer is used to protect multiple resources which makes it less sensitive to disruption. The use of ~~P~~pooled or aggregated buffers ~~(law of variability pooling)~~is shown to supports~~s~~ the management of variability, however, it is also shown that ~~but~~ this desensitises the management signal, effectively delaying the identity of sources of disruption when compared to kanban. The role of the law of variability pooling can be shown to have wider applications in project and distribution management. ~~However, BM can be used in a wider range of environments and has been developed further to support project and distribution management applications.~~

Goldratt was more overtly concerned with the damaging effect of local performance measures (Goldratt, 1983) which is clearly reflected in the throughput focus of the five steps of focusing (Goldratt, 1990). As with SPC and Kanban BM is shown to be key to displacing the local efficiency measures associated with MTO environments and is used in all the TOC applications.

Fisher's Supply Chain Model - Postponement

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Fishers model (1997) effectively embraces the laws of trade-off, focus and variability buffering in a supply chain context where postponed configuration can be used to decouple different levels of stability.~~ in a supply chain.~~ This can enable distinct operations strategies to be embraced around the decoupling point, often referred to as the order penetration point (OPP) (Olhagar, 2003).

Postponement is typically in terms of time, place and form (Bowersox and Closs, 1996) and the associated strategies encompass the interaction of customer data, operations management and product design (Van Hoek, 1998). This work emphasized the proactive involvement of marketing, design and supply chain operations in managing the impact of demand uncertainty driven trade-offs. Various authors (Zinn and Bowersox, 1988; Olhagar, 2003, Yang, et al., 2004) have identified how design can provide a means of demand aggregation via upstream standardization and in such cases the supply chain is effectively separated by decoupling inventory which limits the impact of demand variation and uncertainty on the supply chain as a whole.

Decoupling inventory embraces the law of variability pooling and beyond this point in the supply chain capacity buffering is particularly applicable ~~necessary to~~in accommodating~~e~~ both the variety and the demand variability and uncertainty.

Coordinated strategies

The case research evidence was found to naturally support the idea of three strategies which effectively sub classifies the laws and approaches as shown in Figure 1.

- *Buffer the variation and uncertainty*
- *Reduce the variation and uncertainty*
- *Separate or postpone the variation and uncertainty*

However, it is clear these strategic directions are not alternatives but need to be coordinated with one often being more dominant. The laws help to identify the interplay between them with changes in any one resulting in a corresponding change in at least one of the others. Fisher (1997) originally identified the interplay between three ~~used the term~~ coordinated strategies within a ~~where he also identified three in the context of a~~ supply chain context and although ~~. T~~the terms used by Fisher were different ~~but~~ the intent was the same although only briefly covered ~~discussed~~ in this paper. The concept is developed further here to support case analysis around variability and uncertainty but also providing a more rounded interpretation of these seminal operations developments.

The OM developments discussed tend to be ~~above can be readily~~ more closely associated with one of these coordinated strategies. For example, focused factory and the fisher model are closely aligned with Separate/Postpone; TQM, SS and lean with Reduce; TOC with Buffer;~~,~~ and agile operations arguably with all three. However, the concept of coordination stresses the importance of the other two strategies in ensuring alignment. For example, the TPS is closely associated with reducing variability through Judoka but in order to enable this capacity buffering is actively used as a substitute for inventory. Similarly, although TOC applications initially focus on managing flow through strategic buffering, ongoing improvement comes through reducing sources of variability. In this way the ~~The~~ leading coordinating strategy effecitively ~~can be considered to~~ reflects the different environmental factors.

The coordinated strategies can similarly be used in case analysis when reflecting on past decisions or future proposals. Each strategy provides a direction for potential improvement that needs to be considered in relation to the other strategies as changing one will require at least one of the others to be realigned. This approach is used across several cases towards the end of the course some of which have been published with specific reference to coordinated strategies (Stratton and Warburton, 2006; Stratton, 2012).

Zara case analysis

Zara is a commonly used case in OM teaching that is interpreted here to illustrate the use of the construct relationships, laws and coordinated strategies.

Zara's business model can be shown to stem from their operations capability to respond rapidly to the market. This is turn is closely associated with the ability to postpone colour choice through the use of fabric as opposed to yarn dyeing. This ability to structurally separate colour from the fabric manufacture enables the focused factory (Skinner, 1974) concept to be embraced within and supply chain context. Hence, fabric manufacture is akin to a functional product and efficient supply (Fisher, 1997). This enables minimal variability and therefore buffering apart from the decoupling inventory that reflects the law of variability pooling (Fig.3). From this inventory pool fabric is selected twice weekly to be dyed, cut, assembled etc. and delivered around the world within 2 weeks. Short design and manufacturing cycles are enabled by the use of short setups and buffer capacity which is needed to accommodate demand uncertainty. This is summarized using the three coordinated strategies in Figure 4.

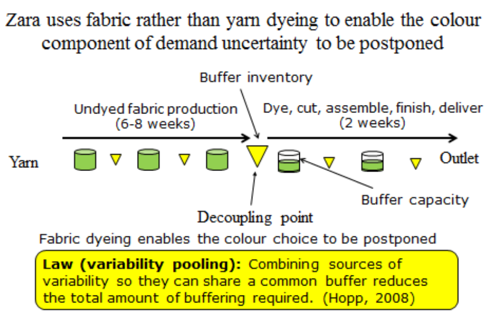

Figure 3 Illustrating the buffering mechanisms

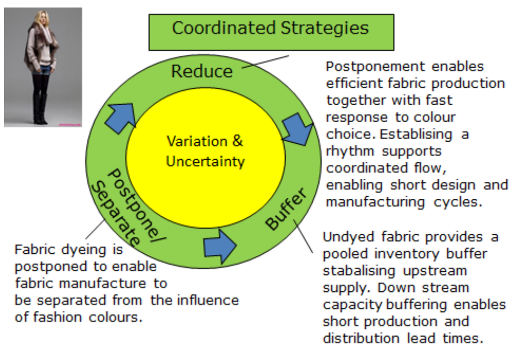

Figure 4 Using coordinated strategies in analysing the Zara case

Discussion

This approach to teaching OM raises many points of discussion, some of which are briefly explore below.

~~The six laws have proved to be sufficient to explain the OM developments and associated theories. The underlying constructs provide a means of interpreting these developments at a more abstract level which helps clarify the conflict tension between the local and systems perspective. As discussed above, this tension was in many cases identified by the originator of these OM developments but this perspective is often missing, resulting in viewing these approaches in isolation.~~

~~The different approaches identified above can be allied with one of the three coordinated strategies which emphasise a particular direction for improvement. This direction is influenced by the inherent level of variability in the environment as evident in the case of TPS/lean and TOC.~~

Management signalling tools

Three of the seminal developments discussed above (TQM, TPS and TOC) are closely associated with management signalling tools (SPC, Kanban and BM respectively) which are used to replace the default control provided by local efficiency measures. These controls are centred on managing and systematically reducing variability in the product, process and demand with each tool being specifically designed to meet the needs of different environments. This needs to be acknowledged in their selection and potential integration.

Redefining the batch size conflict

As discussed in the introduction one of the anomalies in the teaching of OM is the traditional representation of the batch quantity model. This cost model is widely acknowledged to be inconsistent with a systems approach although it is still commonly used. Figure 5 offers an alternative interpretation which refers to buffer inventory and buffer capacity rather than cost. This is clearly allied with the laws of variability buffering, trade-off and focus. The systems approach advocated by TPS /lean and TOC is to reduce the batch size utilising buffer capacity but not to the point where a bottleneck is created (law of bottlenecks). Further batch reduction would require set-up time reduction (reducing process variability).

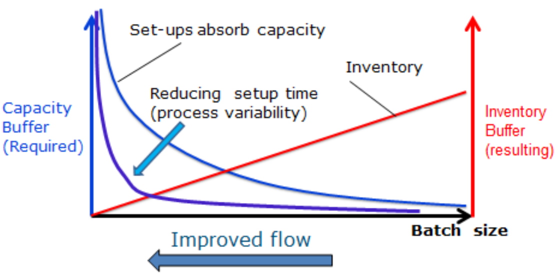

Figure 5 Reinterpreting the batch size trade-off model

Theory of Performance Frontiers

The theory of performance Frontiers (Schmenner and Swink, 1998) effectively embraces strategic positioning and the continual improvement strategies discussed above. However, the theory can be very effectively enhanced through reference to the laws. In this way the operating frontier can be moved towards the asset frontier by both reducing variability and more effectively managing the variability through strategic buffering.

Flow and resource efficiency

It has recently been suggested that lean stresses flow efficiency as opposed to resource efficiency in a trade-off relationship (Modig and Ahlstrom, 2012). It is proposed that this relationship can be developed further by using these laws to clarify that resource efficiency is not a valid alternative to flow. Flow embraces the need to buffer variability with capacity but this process itself exposes the sources of variation in support of continual improvement. All the breakthrough developments embrace this conflict by providing means of practically adopting a systems approach that replaces the local efficiency centred paradigm.

Teaching experience

This model has been developed in the teaching of undergraduates and post graduates OM over the past four years. Input to the models development has involved feedback from students and staff through team teaching. The main focus however has been in teaching OM to the MBA cohort where this systems interpretation proves to be most readily appreciated by students with managerial experience.

Conclusion

This teaching framework is still under development and does not claim to be comprehensive in covering all relevant OM content. However, it does provide a means of viewing seminal OM developments more hostically. The interpretation of some of these developments shows that the laws can be used to explore the common systems perspective enabling deeper and more integrated understanding. This has proved to be particularly fruitful in teaching ~~in depth if necessary, as in the case of~~ MBA and ~~or~~ specialist OM modules. The three coordinated strategies provide a novel approach to case analysis that effectively demonstrates the interplay between the theories and approaches. The framework has been refined to a point where it is considered worth sharing here but it still remains under development and is in the process of being more formally evaluated.

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