A Practical Approach to Achieving Agility – a Theory of Constraints Perspective

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Agility has been put forward as a possible solution for manufacturers to compete in today’s dynamic environment. The literature is abundant when it comes to identifying the characteristics of agility and positing that the possession of these characteristics can provide a sustainable competitive advantage. However, there has been little contribution by theorists in providing a practical approach to achieving agility. This paper documents an action research project that was aimed at identifying the practical steps needed to become an agile manufacturer. Through the implementation of the Theory of constraints (TOC) a flexible manufacturing system known as drum-buffer-rope (DBR) is created that possesses the characteristics of speed, responsiveness and adaptability. What is being posited is that the TOC perspective can be used as a practical approach to becoming an agile manufacturer.

Keywords: Agility, TOC, Flexibility, Manufacturing, Strategy

INTRODUCTION

The push towards a new paradigm of manufacturing has come from the dynamic forces present in today’s global markets. Stalk (1998) identified response time as the single most important criteria for achieving a competitive advantage. Huang and Mak (1999) argued that the manufacturing environment is characterised by rapid changes, with these changes ultimately reflected in products and manufacturing processes. These rapid changes have rendered strategic planning alone inefficient due to a kaleidoscope of opportunities, threats, constraints and imponderables that occur in real time (Meredith and Francis, 2000). Brown and Bessant (2003) describe today’s manufacturing environment as a new competitive landscape that is characterised by ongoing and heightened levels of competition, which demands flexibility, delivery speed and innovation. One of the greatest challenges facing businesses in today’s dynamic global competition is how to achieve and sustain a competitive advantage (Teece et al, 1997). The era of mass production is coming to an end with the changing nature of markets. Gagnon (1999) put forward that strategic management has moved from a market based to a resource based view of competition. Consumers are looking for customisation as opposed to standardisation and as such businesses need to have the capacity to produce customised products with the cost and efficiency of mass production.

Teece et al (1997) argued that to attain and sustain competitive advantage firms could use a dynamic capabilities approach. By dynamic they refer to the capacity to renew competencies so as to achieve congruence with the changing business environment. The term capabilities is defined as the key role of strategic management in appropriately adapting, integrating and reconfiguring internal and external organisational skills, resources and functional competencies to meet the requirements of the changing environment. The ability to adapt both the internal resources of a business and its behaviour in the market place can be achieved through the adoption of agile principles. While the literature has identified what agility is and its characteristics it has not addressed, with any great detail, the question of how to become an agile manufacturer. It is posited that through the adoption of the theory of constraints as a method of production and the resource-based view as a method of identifying strengths and weaknesses that an agile strategy can be achieved. A review of the literature followed by a case study of an SME that has achieved agility through the adoption of the Theory of constraints (TOC) is presented.
Agility

The winning criterion of low cost that was epitomised in mass production and economies of scale is no longer the leading qualifier for order winning. Meredith and Francis (2000) found that price alone is not sufficient to sustain a competitive advantage, stating that order winning criteria include the rate of innovation, fitness for purpose, volume flexibility, variety, extreme customisation and above all rapid responsiveness. This view is shared by Soliman and Youssef (2001) who argued that low cost and high quality are merely qualifying criteria and not winning criteria in today’s markets. Within this dynamic environment Sharifi and Zhang (2001, p 773) state that, “Surviving and prospering in these turbulent situations will be possible if organisations have the essential capabilities to recognise and understand their changing environments and respond in a proper way to every unexpected change”. Thus, a shift in market preferences has caused a shift in manufacturing operations due to the new criteria for order winning.

The view that the era of mass production is coming to an end and is being replaced by a modern, agile manufacturer is held by a number of academic theorists. Lampel and Mintzberg (1996) described the environment that led to mass production and noted that management scholars have posited that we are now entering a new age that involves customisation, new technologies, increased competition and more assertive customers. Sharifi and Zhang (2001) supported the view that manufacturing is facing dramatic changes at an accelerated rate and noted that research has revealed the symptoms of a new era. The inappropriateness of mass production to deal with this changing environment has resulted in the emergence of a new manufacturing paradigm, consisting of lean and agile production and mass customisation (Lamming et al, 2000). The shift from mass production to a more agile/flexible system was noted by Duguay et al (1997, p 1187) as result of:

The globalization of markets has created entirely new dynamics of rapid environmental change. Faced with these changes, modern mass production today is helpless, notably because of the rigidity associated with several of its distinctive practices.

Sharifi and Zhang (2001) agree that a new paradigm known as agility is being promoted as the solution to achieving and sustaining a competitive advantage in today’s markets. The paradigm shift from mass production to agile manufacturing was noted by Burgess (1994) who also cited that the agile paradigm is still ill defined.

Agile manufacturing systems have arisen due to the short comings of mass production in dealing with a dynamic and global market. While agility is still an emerging field there is a strong body of research that has defined what agility means and its relative characteristics. McCullen and Towill (2001) trace the origins of agile manufacturing movement to U.S. defence manufacturing companies switching their no longer required capacity to commercial products but maintaining the ability to switch back to defence manufacturing in the event of an emergency. McCullen and Towill (2001) also attributed the emergence of agility to U.S. firms need to develop strategies to compete with far eastern firms that could not be easily copied. The operational origins of agility as a business concept lie in flexible manufacturing systems, as flexibility is the key characteristic of agility (Christopher and Towill, 2000). Power et al (2001) argued that the concept of agility is holistic rather than functional and of strategic rather than tactical importance. The view that agility is holistic was supported by Christopher and Towill (2001, 236) who stated that, “Agility is a business-wide capability that embraces organisational structures, information systems, logistics processes and in particular, mindsets”.

The key characteristic of agility is to have flexible operations to be able to respond rapidly to the changing environment. Crocitto and Youssef (2003) define agile manufacturing as a relatively newer form of
advanced manufacturing technology, with the attributes of flexibility and versatility, increased product development, process modelling capabilities, rapid parts acquisition and adaptation to continually changing customer specifications. This definition is similar to that offered by Mohamad et al (2001, p 707) in their definition of flexible manufacturing systems, “Flexible manufacturing systems are state-of-the-art production systems designed to emulate the flexibility of job shops while retaining the efficiency of dedicated production lines”. Having flexible manufacturing, while not fully encompassing the holistic nature of agility, is the cornerstone to an agile strategy.

With the call for firms to be more responsive to the changing environment, a strategy such as agility that is based on speed can provide a sustainable competitive advantage (Youssef, 1992). The view that through the process of rapid response, agility could achieve a competitive advantage was supported by McCullen and Towill (2001). Furthermore, Crocito and Youssef (2003) posited that this competitive advantage could be sustained through a reputation of innovation and quality, which comes from the implementation of an agile strategy. Furthermore, Meredith and Francis (2000) identified two independent aspects of agility, one being strategic, which is outward looking in approach. The second being operational that looks inwardly at processes of production, maintenance and process innovation.

The call for more research on the affect agility has on the competitive position of a manufacturing firm was made in 1992 by Youssef and to date a complete framework that defines agility and develops models for its implementation has not been achieved. As Burgess (1994, p 23) states, “Despite academic involvement agile manufacturing has not yet entered the literature in any great depth and where it has done so the concept, reflecting its recent origins, remains ill-formed”. Lampel and Mintzberg (1996) acknowledged the shift from mass production to mass customisation and warned that we may be replacing one extreme for another and posited the need to set a strategy along this continuum, with a call for management writers to provide the conceptual tools to aid in this endeavour. With the dynamic, global environment requiring a rapid response for production, specifically for custom products to specific customer requirements, it would appear that manufacturing strategy, agility and mass customisation would be well documented in the literature. As Brown and Bessant (2003) found, to date the link between manufacturing strategy, agility and mass customisation has not been addressed. On this note Brown and Bessant (2003, p 726) put out a call for future research including the, “identification/ development/ elaboration of tools and techniques to help configure the organisation to deliver the requisite agility”. It is posited that by adopting the theory of constraints the operational side of agility can be met. Furthermore, by adopting a resource-based view of the business the strategic side of agility can be achieved.

The merging of lean production and agility was put forward as a solution to the problem of implementing an agile strategy. A brief review of the work on this merger is undertaken with the limitations examined. A working definition of lean production is provided by Mason-Jones et al (2000, p 54), “Leanness means developing a value stream to eliminate all waste, including time, and to enable a level schedule. Duguay et al (1997) argued that in a stable environment, lean production would out pace its flexible/agile competitor as there is no need to adapt. Once the environment shifts to unstable or dynamic the flexible/agile manufacturer would out pace its lean counterpart through the deployment of extra resources. Agility is focused on rapid responsiveness and mastering market turbulence and requires specific capabilities above and beyond those that can be achieved using lean production. Mason-Jones et al (2000) notes that the drive to reduce waste and to maintain level schedules, means that lean companies tend to operate with little spare capacity. And as such, surges in demand will be costly to meet since all resources along the lean manufacturing plant will need to be increased. It is argued that by replacing lean production with the theory of constraints a better system of production will ensue. The sprint capacity within the TOC and the identification of the constraint gives the business a greater capacity to meet fluctuations in the market.
Theory of Constraints

The Theory of Constraints is a theory developed by Goldratt and brought to public attention through the 1984 novel “The Goal”. The underlying process for implementing a TOC approach involves repeating applications of five key steps, ensuring on-going improvement. The five steps consist of: (1) identify the system’s bottlenecks, (2) decide how to exploit the bottlenecks, (3) subordinate everything else to the decision in step two, (4) elevate the system’s bottlenecks, and (5) if, in a previous step, a bottleneck has been broken go back to step one (Goldratt & Cox, 1993, 297). The benefits from adopting this approach are reported as being a reduction in lead-time, cycle time, lowering inventory and improving productivity and quality (Goldratt and Fox, 1987; Razae and Elmore, 1997). A production system based on the TOC is characterised by the implementation of Drum-Buffer-Rope (DBR).

Drum-Buffer-Rope is a production process that dictates what, when and how to schedule production in order increase sales and reduce inventory. The drum is the constraint that sets the pace of production, the buffer insulates the constraint from disruptions and the rope is a signalling mechanism that causes materials to be released into production (Blackstone, 2001). The rate at which a business can produce products is subject to the constraint. Assuming the constraint is a machine, any machine or process before the constraint that produces more parts than the constraint can process will result in a build up of work in process (WIP) inventory before the constraint (Coughlan & Darlington, 1993). Scheduling the pace of production to the drum and releasing materials by the rope ensures that production before the constraint is producing enough WIP to keep the constraint working to capacity (Goldratt & Fox, 1986). The buffers work as time buffers to protect the constraint by placing enough work in front of the constraint and after the constraint to allow constant production and a buffer of finished goods to ensure on-time delivery (Smith, 2000, 55). What sets this system at odds with other systems of production is that non-constrained resources are working below capacity causing local efficiency ratios to suffer. Yet it is the excess capacity in the non constrained resources that provide the sprint capacity to adequately respond to a rapidly changing environment.

METHODOLOGY

The research methodology is action research that allows the construction of theoretical solutions and the testing of these solutions. Vinten (1994) described AR as a grounded method rooted in the realities of a situation and is best described as a concept, a philosophy, an emancipatory process and a methodology of learning. The essence of AR is to solve a practical problem and develop knowledge through a process of action. Coughlan and Coughlan (2002) argued that when action researchers are enrolled in an academic programme there are two AR projects co-existing in parallel. One project is the implementation of a solution to a practical problem and the other is the writing up of a thesis. The dual cycle presented by McKay and Marshall (2001) recognises these dual goals by providing two cycles that can be superimposed to satisfy the practical problem and the research output. The cycle involves the following iterative cycle. Problem identification, Reconnaissance / Fact Finding, Planning, Action Steps, Implementation, Monitor in terms of problem solving efficacy and evaluation. Following the evaluation step a decision is then made to exit the cycle if the outcomes are satisfactory or amend the plan and initiate the action steps. Action research is eclectic by nature as there is no one method to follow (Badger, 2000 and Mumford, 2001). The data collected for this research was a mixture of observation, interviews and cooperation as Kock (2003) argued, an organisation can be more deeply understood if the researcher is part of it.
CASE STUDY

AEM Australia Pty. Ltd. is a small manufacturer of custom built electrical components and is situated in the outer western suburbs of Sydney. It has successfully adopted optimised production technology (OPT) software and the theory of constraints (TOC) and has also managed to implement a cultural change to fully embed the TOC principles into the company culture. The initial adoption of the TOC and the implementation of OPT software occurred in November 1998. Since the instillation of OPT software AEM was able to iron out the teething problems that were experienced and has now moved to a sophisticated system of manufacturing, marketing and customer service that places it as a leader in its field. Whereas under traditional manufacturing planning AEM was battling to meet its orders for electrical equipment with TOC it was able to double its sales and have spare capacity to take on export markets. Inventory was slashed and cash flow dramatically improved. Although TOC had typically been used by large companies here was a small enterprise successfully implementing the methodology. The reduction in lead times together with the increased control were the two main benefits experienced. For example, products that used to take 20-24 weeks to manufacture are now produced in 6 weeks. Even though disconnectors and earthing switches (the main product lines) consist of approximately 300 parts and 5000 manufacturing operations it is possible to monitor the progress of these products, even with multiple products being produced at the same time. Towards the end of 2002 AEM had reached a point where it had outgrown existing markets and began implementing an agile strategy in order to increase sales. By 2005 AEM increased sales by 75% to $7.1 million with very little change to the 40 people workforce.

As mentioned in the literature (Stalk, 1998; Huang and Mak, 1999; and Brown and Bessant, 2003) rapid responsiveness was identified as a key factor for competing in a dynamic market place. Through the adoption of the TOC, AEM has created a flexible manufacturing system that is able to handle a product mix of dozens of custom made electrical switches at any one time, however the support services such as order processing was not at the same level. Managerial time was spent on reducing the amount of time taken to ready an order for production. It was found that an order spent a great deal of time waiting to be processed and this was overcome by implementing guidelines that dictated the flow of an order and highlighted the priority it should take. By taking a TOC perspective the bottleneck activity in the processing of an order was identified and acted upon. Each manufacturing operation is performed according to an engineering drawing that contains the relevant information on the process as well as containing the details necessary for control such as part, order and customer number. Previously each drawing had to be printed out and then individually marked with the necessary details in order to maintain control. This was a week long process (for a 6-8 week schedule) that hampered the speed at which orders could be sent to production. Printing technology together with internal IT development was implemented to reduce the time taken to produce drawings with the result that the operation is now being performed in one day. Using the TOC alone would not have resulted in the identification of this bottleneck due to scope similarly merely adopting an agile strategy does not provide the necessary steps to identify and solve bottleneck activities.

In the pursuit of growth AEM identified its strength via a resource-based view and highlighted product innovation as a source of competitive advantage. Through the culture of innovation AEM has been able to hold several patents, particularly dropout fuserlink technology that has been a source of sustained competitive advantage. Following on from innovation AEM developed and tested a new product for the distribution market while continuing to grow in the existing transmission market. The new product was a simpler design and required a T plant manufacturing system as opposed to the A plant system already in place. Furthermore, the new products required a lead time of ten day from order to receipt of goods and
with raw material suppliers offering fourteen day lead times a different system of handling the new products was needed.

AEM dedicated three machinists (the bottleneck resource) as well as factory space and a raw material bay for this new product line. Processing the orders in the existing way would take too long given the lead time of ten days from receipt of order to the delivery of the finished product. The new product line required the repetitive manufacture of similar products as opposed to the custom built made to order products. Therefore, it was possible to begin production of the product line up to final assembly that is based upon a forecast. The process involved a continuous flow of raw materials and the manufacture of the product up to a certain point, since all four variations shared identical base assemblies. At this point the products were completed according to real orders, thus being able to meet lead times that are shorter than the time taken to bring in raw materials.

To add to the complexity of the manufacturing floor AEM also manufactures off the schedule items. These are products that are not part of the existing schedule due to the late placement of the order, but are nevertheless manufactured simultaneously. At any given time AEM is in the process of manufacturing a 6-8 week schedule of Transmission switches (70% of production), Distribution Switch gear (20% of production), drop out fuselinks (That requires 1-2 people with resources separate from the above two), as well as off the schedule transmission products, which are manufactured using the sprint capacity identified in the schedule. The manufacture of all these products would not be possible given a lean production system as there would be no spare capacity to handle new orders once production is scheduled to capacity. Furthermore, with the exception of the distribution products, there does not exist any trends or forecasts to predict the infinite number of product mixes that can arise as a result of a make-to-order business. In order to manage such an elaborate system AEM adopted agile principles through a TOC perspective. Using ST-Point (OPT software) a synchronised, static schedule is produced that takes into account raw material lead times, resource utilisation and delivery dates. AEM’s input is in manipulating the schedule to get the best results. For example, the schedule might report that a raw material component has a 25-day delivery time that is holding up production and as such preventing on-time-delivery. AEM would then get in contact with the supplier and try to negotiate a better delivery time from 25 days to 15 or 10 days. This information is then input back into the system and another constraint might arise and the process repeated to ensure the best possible outcome. A similar process is followed for internal production with bottleneck operations outsourced if they can not meet the required delivery dates. Having a number of suppliers for each component and being able to identify in advance what constraints will hamper production provide the necessary information on how to make production flow quicker. Adopting agile principles such as a outsourcing policy contingent on fluctuations in demand further strengthens the production system.

In a lean manufacturing plant surges in demand are difficult and costly to meet due to the elimination of sprint capacity, which is erroneously identified as waste. The elimination of all waste to support a level schedule means that in order to increase capacity all resources need to be increased across the board. In the case of a TOC production system such as the one at AEM, the bottleneck activity is identified and as such buying in extra capacity or outsourcing production solely for the bottleneck activity increases total capacity and as such makes it a more agile system that can handle surges in demand.
A great deal of the push towards agility has come from the managing director, however recent developments and calls for a more proactive approach to problem solving has seen AEM adopt more agile principles throughout the organisation. Production is managed through a daily meeting of middle managers with the main focus on buffer management. The buffers represent WIP before the constraint and act as safety nets to any disruptions to production by providing time in which to rectify the problem and keep the constraint working to capacity. Scrap, re-work, supplier reliability, breakdowns, absenteeism and other unforeseen circumstances disrupt the flow of production. As long as the constraint continues to work to capacity the total output remains unchanged. The sprint capacity of the supporting resources is used to replenish the buffers and overcome any disruptions to the constraint. The daily production meetings are focused on maintaining the buffers and at times requires proactive decision making to keep production flowing.

For example, a good proportion of parts need to be sent outside for surface finishing before final assembly. Three months prior to the Christmas shutdown, the manager responsible for outsourcing surface finishing began sending work to other suppliers that were not as competitive as the existing one on issues such as cost, quality and reliability, even though the existing supplier had available capacity. The purpose of this action was due to the main supplier’s plan to shut down for a period greater than AEM’s break. Without an alternative surface finish supplier production would stop. Through the incorporation of an additional supplier in the supply chain that was more expensive and less reliable than the existing supplier, production was able to continue. Similar actions such as targeted overtime, the exchange of machinists between transmission, distribution and off the schedule items, and the monitoring of supplier performance are examples of an agile strategy to respond to the rapidly changing environment.

CONCLUSION

The dynamic forces that characterise today’s environment calls for a new type of manufacturing process that of agility. The literature recognises that responsiveness, mass customisation, adaptability, speed and innovation are characteristics that a business must posses in order to be classified as agile and more importantly characteristics needed to effectively compete in the market place. The gap in the literature revolves around providing the necessary steps and processes for achieving agility. The theoretical solution provided here is that the TOC perspective can provide the necessary heuristics to lead a business towards becoming an agile manufacturer. The case study provides good evidence to suggest that this process is not only feasible but has been successfully implemented in a SME. The agile characteristics of responsiveness, mass customisation, adaptability, speed and innovation are present within AEM’s processes through a history of continuous improvement. This improvement was driven by the adoption of the TOC perspective for the purpose of becoming an agile manufacturer.
Reference List


