Improving supply chain performance through improved visibility

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[Images and appendixes are available only in the published version in the journal]

Introduction

Today's supply chains are becoming more complex and the visibility of key information and collaboration across organisational boundaries is increasingly viewed as essential criteria to the long-term competitiveness of the supply network. This paper investigates the links between different types of visibility, joint initiatives and business performance using the concepts of transparency as a measure of visibility in supply chains. The research is case-based using a specific Rolls-Royce (RR) inbound supply stream to test the hypothesis that increased supply chain visibility will lead to improved business performance. The initiative was successful for the selected supply chain, improving both delivery performance and improved visibility of supply and demand.

Background

The industrial context

RR provides high-technology gas turbine power solutions to a worldwide market; they are a leading power-systems company in civil and defence aerospace, marine an energy markets. RR employs 50 nationalities in 50 countries, with 85 per cent of sales achieved outside of the company's home base of the United Kingdom (UK) and 40 per cent of RR employees based outside the UK. RR manufactures in 20 countries and serves customers in 150 countries. RR has experienced significant market growth over the last 20 years growing its market share at the expense of Pratt & Whitney and Snecma (Figure 1 [Figure omitted. See Article Image.]), resulting in record company order books and achievement of a better-balanced portfolio as protection from the cyclical pattern of its products.

A global, diverse and complex supply base supports the company and has been established over the last 100 years. This supply base evolution has created interdependencies and as such these supply chains cannot be considered commodities. Owing to the product life cycle of a gas turbine engine, RR is required to support many of the engines that were produced over 25 years ago. This has produced very complex networking scenarios where RR suppliers have numerous interfaces within the RR organisation. RR supply base measures can be broadly categorised under the headings of quality, cost, delivery and responsiveness.

During the past few years, incremental initiatives, focused on achieving price reductions during the term of the contract have been launched and year-on-year cost down performance is required of its suppliers. As a result global purchasing has established a credible, internal reputation for delivering piece price reductions and savings to the bottom line. While successful, this intense and often singular focus on piece price reduction has come at the expense of other performance priorities:

- supplier quality performance has plateaued;
- delivery performance from suppliers is low;
- supply base reduction targets have not been achieved; and
- relationships between RR and their suppliers have deteriorated.

The current supply base is under-performing on both delivery and the level of non-conforming parts delivered into RR. Only 20 per cent of the supply chain is achieving 95 per cent or greater against the on-time delivery measure. This level of underperformance drives inefficiencies in the internal manufacturing plants, with high-levels of overtime worked in most departments to address both late deliveries and non-conforming products.

The lack of clear visibility is considered by RR to be a key factor in these under-performing supply bases. RR believes that by having greater visibility of key information from suppliers, it would be able to manage the supply base more effectively, thus reducing the cost of internal inefficiencies.

Supply chain visibility

There are many different definitions of supply chains, [6] Christopher et al. (2002) describes a supply chain as:

The management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final market place at less cost to the supply chain as a whole.

The supply chain consists of different levels including supplier, manufacturer, distributor and consumer and is a network of companies that influence each other from raw materials to finished goods. ([6] Christopher et al. , 2002; [4] Chan, 2003). [19] Lamming et al. (2001) suggests that there are varying degrees of supply chain visibility or sharing of information between partners in a supply chain and refers to it as transparency. [19] Lamming's et al. (2001) categorisation of the varying degrees of transparency is shown in Table I [Figure omitted. See Article Image.].

An increase in available supply chain data gives the illusion of visibility, however, it can add to a firm's challenge of matching insights from the analyses to strategy. According to [4] Chan (2003) "visibility for a supply chain is important for accurate and fast delivery of information". [20] Lee et al. (1997) states, "The lack of accurate information can cause certain negative consequences such as the 'bullwhip-effect' in supply chains".

According to [22] Svensson (2004) the two main influences on the perception of corporate vulnerability in supply chains are the degree of transparency and the degree of obscurity. He states that the more accurate the information, the higher the transparency, but the more the information deteriorates, the higher the obscurity. He believes that, together, these two influences create a conceptual framework and contribute to the dilemma of corporate vulnerability. The findings of [22] Svensson's (2004) research indicate that there is an obscurity in the access to information beyond 1st tier suppliers and 1st tier customers, which causes a lack of transparency in the supply chain and contributes to the supply chain's vulnerability.

Supply chain collaboration

Collaboration in the context of a supply chain is suppliers, partners and customers working jointly on an activity or project. [2] Anthony (2000) suggests that supply chain collaboration occurs when "two or more companies share the responsibility of exchanging common planning, management, execution, and performance measurement information" and that "collaborative relationships transform how information is shared between companies and drive change to the underlying business processes".

[3] Bowersox et al. (1999) state that firms collaborate in the sense of leveraging benefits to achieve common goals. According to [7] Cox et al. (2000):

The use of collaborative and co-ordinated supply relationships was a crucial means by which Japanese companies were able to enhance their operational efficiency and effectiveness and, thereby, maintain a competitive edge.

However, not all companies receive the expected benefits according to [16] Kapoor and Gupta (1997), who suggest there should be a return to "aggressive sourcing" based on free-market principles rather than collaboration.

[14] Johnsen and Ford (2001) state:

To most firms in a dyadic relationship there will be conflicting pressures in creating a balance in their relationships between self-serving motives and the advantages of close interaction and collaboration.

Changes and adaptations will have to be made throughout the relationship to keep it moving and for it to continue to work well. [13] Hakansson and Gadde (1992) suggest that the preparedness of a supplier to take part in various

types of adaptations, whether they be technical, knowledge-based, economic or legal means that he considers it beneficial for the relationship and is committed to its future.

[9] Ford (1980) stated "A supplier makes two types of adaptations, namely formal and informal" formal being a more structured form of collaboration such as partnerships, as suggested by [15] Kanter (1999), [18] Lamming (1993) and [21] Speckman (1988) and informal being a looser network approach to a relationship as suggested by [12] Hakansson (1987).

Supply chain collaboration does, however, require dedication to change and taking the time to create and manage the partnerships. According to [23] Willis (1998) a successful partnership will not only lead to improved customer service but also to better utilization of resources, a reduction in inventory investment, and a reduction in emergencies, better working relationships, and increased profit for all links in the supply chain.

Research design and methodology

The research presented in this paper is based on a single case study. The case study approach was selected due to this investigation seeking to explore a contemporary set of events unfolding over time ([24] Yin, 2003a). [24], [25] Yin (2003a, b) goes on to elaborate on the unique ability of case studies to deal with real life contexts where the researcher has little control over the events. This approach focuses on understanding the dynamics present within a single setting, helping to develop a very detailed understanding of the reality due to the extreme richness of the data collected ([1] Amaratunga and Baldry, 2001). [8] Eisenhardt (1989) lays out a roadmap for the use of case studies noting that the first key step is the definition of the research question. With that in mind the aim of the research carried on which this paper is based, was:

To test the prognosis that increased supply chain visibility can be achieved through suppliers and customers working on joint initiative(s), the deployment of which leads to collaborative successes.

The research was broken down into the following four stages:

Identify and select a case study supply chain where there is perceived to be a lack of visibility.

Verify the perceived lack of visibility in the selected supply chain by comparing it to required business performance measures.

Discuss with the supplier the visibility gap measures and agree a joint initiative.

The final stage was to evaluate the results and make recommendations at the conclusion of the joint initiative.

Selection of the case study supply chain

The criteria for selecting a supply chain were grouped in two categories: commercial and operational as illustrated in Table II [Figure omitted. See Article Image.].

Five suppliers were considered for the initiative, their scores were achieved through discussions with the individual supplier's buyer, RR's commodity buyer (responsible for commercial factors) and RR's operational buyer (responsible for the operational factors). These scores were then reviewed with the purchasing executive who is responsible for all the suppliers. Supplier C received the highest score, which identified it as the best candidate to work with to improve overall performance.

Supplier C supplies highly engineered, high-strength forgings to RR. Their operation is the second largest forging facility in North America, employing circa 700 workers. The operations use advanced technologies in the forging process to achieve products with precise and sophisticated mechanical properties.

It is a strategic supplier, RR has few alternative suppliers and it would be very expensive to switch to another supplier. Although Supplier C was the smallest of the five companies, the level of business is significant and there is a

highly inter-dependent relationship. A further consideration was the timeframe in which this research was conducted, Supplier C, with the highest score in the relationship criteria was considered to be the easiest option for this research for ease of information sharing based on existing trust within the relationship. The next stage of the research was to establish the visibility gap for Supplier C.

Evaluation of visibility in the case study supply chain

Choice of evaluation criteria

This research seeks to justify the requirement for greater transparency by directly relating this to the need to improve a key area of supplier performance. RR's business performance indicators for quality, cost and delivery will be used as a way of highlighting the area(s) that require improvement. RR has operated a quality balance scorecard approach over the last two years. The quality balance scoring system is the means by which the performance exhibited across a range of five quality performance metrics can be expressed as a simple percentage (Figure 2 [Figure omitted. See Article Image.]).

A suppliers' overall performance is calculated and mapped onto the following four performance levels:

class leading - 100-95 per cent;

standard - 94-66 per cent;

sub-standard - 65-33 per cent; and

unsatisfactory - 0-32 per cent.

In this particular supply chain, cost is usually challenged during the period approaching the signing of a "long-term agreement" (LTA). In this process suppliers are asked to bid for various packages of work, which they will then supply to RR for an agreed price, over an agreed period of time if the bid is successful. Cost models are also constructed and used in this process, considering things like the amount of material used and the value added costs of a given supplier. Year on year cost reduction targets are normally built into the LTA where suppliers are challenged to reduce the cost of a part while in contract by working jointly with RR. The delivery measure is the percentage of orders fulfilled on time (to the day) and in full. The required quantity and date is communicated using RR's MRP (material requirement planning) system. If either the quantity is incorrect or the delivery is late the supplier will score zero for that particular order. In summary, Supplier C's performance when assessed against these KPI was as follows:

- Quality - currently achieving a quality score of 78 per cent - standard.
- Cost - considered acceptable from a business performance perspective with the achievement of the in contract cost reduction target of 5 per cent for the last two years.
- Delivery - performance measure is substantially below RR expectations with schedule adherence in some cases as low as 6 per cent.

Based on the current performance levels it was agreed that the area of greatest concern was the delivery adherence, with both quality and cost performances being considered acceptable at this time.

Establishing the visibility gap in Supplier C

The process used to establish the visibility gap was based on [19] Lamming's et al. (2001) work on defining the general aspects of a relationship using their opaque - transparent scale. Three separate tables (Appendix 1) for each of the key performance criteria have been developed which incorporate practical aspects of the day-to-day management of RR supply chains in order for the visibility gap to be pertinent to RR. Each of these tables reviewed visibility issues that could impact on the individual performance measures. Although in the preceding stage cost and

quality issues were not identified as the prime focus at this time the three tables were constructed for completeness.

This process indicated that the main visibility gaps were in the areas of capacity planning, material ordering and inventory management. As part of the process of launching a joint initiative Supplier C was expected to highlight issues/areas where RR's behaviours impact upon their ability to meet delivery targets (e.g. changing demand within lead-time).

Investigating the visibility gap

Identifying root causes

At the outset Supplier C suggested that a mill who supplies the material for the forgings should be involved in the joint initiative. The RR supplier approvals process restricted Supplier C in their choice of suppler to work with, to that particular mill, additionally the nine-month lead-time included the mill's lead-time. A process to deploy this initiative was agreed, stressing that all stakeholders should ratify this during a three-way dialog involving the mill.

The first step was for all the stakeholders to physically walk the process across all three sites. This provided an opportunity for all members of the supply chain to have a practical insight into the entire production process. The level of openness displayed in each of the facility tours was encouraging for all parties involved and gave good insights into not only the problems that can be inadvertently passed from one part of the supply chain to another but also the duplication of processes across the different organisations.

It was revealed that the current ordering process within the supply chain was primarily conducted through a commercial interface, and only when parts failed to be delivered on time did the production and planning people get together to expedite the late deliveries with little consideration of their actions on the rest of the planned production. This resulted in a never-ending spiral of expediting parts through the production process. This problem was further complicated because it was seen that RR constantly changed its requirements.

Inside RR the commercial department would create a plan that optimised their sales performance in a given time period. This plan would then be passed to the production planning department who would produce another plan to optimise equipment effectiveness. This would be entered into the MRP system and would drive the material ordering requirements to the buyers. The buyers would then create a plan and order material to optimise their sales figures. Individuals in a particular department only had visibility of their plans and the input information from the upstream department and not of all the different plans. This process was replicated across the entire supply chain resulting in a lack of visibility of RR's actual requirements internally and across the entire supply chain.

The actual lead-time for the whole supply chain is typically nine months, to lock demand for a period of this magnitude with no change was in direct opposition to the RR vision of the 40-day engine. In RR's ERP system the lead-time for these parts did not reflect the reality and was roughly one-third of the real lead-time. This would allow changes in the demand signal well within the lead-time required of the upstream supply chain which compounded the problems.

The RR thinking is that the supply chain would rather experience small incremental changes as opposed to large unmanageable changes that would occur outside a long planning window. The result for suppliers whose manufacturing lead-time is greater than 28 days, is constant changes within manufacturing lead-time that makes it difficult to plan and optimise effectively any associated manufacturing resources. There are typically three ways suppliers respond to these changes:

Spend time on link calls establishing the validity of the changes. This, although commendable, often leads to frustration when a week later things appear to have changed again.

Use end of line inventory as a buffer, however this can be very expensive due to the high-cost of material.

Ignore some of the changes by second guessing using past experience that some of the changes are errors, this approach often results in poor delivery performance.

The late supply of parts further compounds the situation leading to schedule nervousness and high inventory costs through the supply chain.

At the end of this step it was clear that the focus to optimise individual departmental effectiveness resulted in inefficiency of the overall supply chain. This caused a lack of clear visibility of the overall supply chain requirements, which was further exacerbated by changes of demand within real manufacturing lead-time.

A commitment acceptance process where the material requirement and planning controller agrees any changes with the supplier before making the changes executive in SAP are the underlining behaviours RR is seeking to establish.

Solution design

The concept design had to provide a solution to address both problems identified; changes within manufacturing lead-time and allow all supply chain stakeholders to see the holistic supply chain plan.

Schedule changes within manufacturing lead-time

RR agreed to work with this supply chain to develop a process that would be mutually beneficial to all parties. However, Supplier C was not the only RR supplier to express concerns regarding schedule instability, therefore if a solution could be found RR believed that the benefits could be wide reaching. After a number of reviews between RR, Supplier C and the mill an agreement was reached for the following proposals:

- A pilot would be run on a number of jointly agreed parts to test for solutions to the problem.
- The intent would be to fix the schedules for these parts for a rolling nine-month time frame.
- To hold a quarterly (three-monthly) review of RR demand for the parts within the pilot, at this review the whole supply chain would review any significant changes in demand and reflect these changes within the nine-month fixed period only if all parties agreed.
- To hold weekly reviews to confirm no changes had occurred within the nine-month fixed period, agree the demand/supply outside the nine months and to highlight any issues that could impact delivery within the nine months.

All parties would work together to reduce the current nine-month total manufacturing lead-time in support of the RR 40 day engine vision. It was decided to restrict the pilot to five part numbers, the reasons for selecting these part numbers were:

- Made from one material. The material was important in this particular supply chain as the selected material is difficult to manufacture, was unique to RR and took a lot of supply chain resources to manufacture.
- High volumes. Rotating discs, which are produced in this supply chain, are very expensive and last for some time.

It was also important to monitor the number of changes to either quantity or delivery date within the nine-month fixed period, as it was considered by RR that the inventory cost associated with allowing no changes was too high especially if the supply chain could accommodate them. Therefore, changes were divided into two types:

Unapproved changes. Changes that the supply chain experiences within the nine-month period that had not formally been accepted.

Commitment accepted changes. Changes within the nine-month period that had been formally accepted due to business needs.

Schedules are fixed for a nine-month period with an agreed process for change, originally the design suggested that RR could make changes within a 10 per cent tolerance band, this however became very difficult to both understand and implement in reality. Therefore, if a change was required within the nine-month planning window then this had to be fully bought off by all members of the supply chain.

Holistic supply chain plan

The scope of the initiative was not to change the way individual departments evaluate their performance, however it was thought that providing visibility of a single plan would help the various departments operate more effectively. The rationale behind this thinking was that improved decision making would happen if each party had more information, and could understand the impact of their decisions on the rest of the supply chain.

Each member of the supply chain had different MRP systems, and to hardwire these systems together was deemed unpractical, after reviewing a number of IT platforms one was selected that would provide visibility of the selected parts through a secure web-based portal. The information required could be easily extracted from each MRP system and sent to a central hub, where the data could be constructed to provide visibility of one plan that all members of the supply chain could then view, as shown in Figure 3 [Figure omitted. See Article Image.].

Data was extracted from the various MRP systems and information was reviewed on a weekly basis using link calls and e-space (where each party can view the same data at the same time through the internet). Initial attempts to analyse the data in great detail was a problem but as the initiative progressed key information such as inventory levels and supply and demand graphs were produced.

It was important to ensure that the critical success factors reflected the overall initiative purpose, which was to improve the schedule adherence score for the five part numbers. The target was to move Supplier C's delivery performance from 27 to 100 per cent, and the mill's to Supplier C from 25 to 100 per cent. The visibility measures highlighted earlier for improvement between Supplier C and RR were all ranked as opaque at the outset, and were given the targets of:

- capacity planning, i.e. from opaque to translucent;
- material ordering, i.e. from opaque to transparent; and
- inventory management, i.e. from opaque to transparent.

Analysis of results

The following section evaluates the initiative's results against the critical success criteria, where the study set out to demonstrate that supply chain visibility would be improved as a result of joint supply chain initiatives.

Capacity planning

This aspect of the supply chain was originally considered to be opaque. The primary reason for lack of information sharing with regard to this aspect was that RR competitors also use this supply chain to varying degrees and it was considered that to share commercially sensitive information was risky. Therefore, to consider changing this from opaque to transparent was considered overly optimistic, and translucent was a more realistic target.

As demands from all their customers fluctuate throughout the year, it proved difficult to build a model reflecting the percentage capacity across key equipment available for all RR products. To use this approach in this supply chain across all RR parts could be considered achievable however the cost versus the benefits would have to be evaluated and it is considered unlikely that the benefits would justify the costs.

A key enabler was the IT solution that provided visibility of both demand and supply. This acted as an integrated MRP system as a criteria to support transparent capacity planning. It was considered therefore that transparency rather than translucency was achieved for these five part numbers as information was shared across selected key bottleneck resources and it was possible for the first time to set up and monitor regular monthly output across these key resources without compromising commercially sensitive data.

Material ordering

This aspect was considered opaque with a target of achieving transparent. Dialogue with the supply chain prior to launching the initiative considered transparency to be an achievable target and vital to improving confidence of supply. A key limitation was the sharing of information that could undermine a company's ability to maintain a competitive commercial position.

This particular aspect of the initiative succeeded beyond all expectations. The complexity of the ordering process only became obvious during the early stages of the initiative when the number of plans and conflicting emphasis on each plan became apparent.

Changes have been made as a direct consequence of this initiative. RR now has a single point of contact for managing the schedules within this supply chain. This contact interfaces with one planning person within Supplier C who manages all RR parts resulting in better ownership and more effective communication with regard to any problems.

The process used in the initiative has subsequently evolved into monthly reviews with Supplier C to evaluate their material coverage profile. Reviews are held using a part-by-part profile of orders placed, work in progress and any issues. This process has significantly improved Supplier C's overall delivery performance into RR and has subsequently been rolled out to a number of key forging suppliers.

Another aspect of this initiative, which directly relates to the ordering process, was to alter the lead-times in RR's MRP system to reflect real lead-times of the manufacturing process. This was successfully achieved and helped to improve the stability of the demand signal.

Inventory management

The target for inventory management was to progress from opaque to transparent, however due to the timescales to conduct both the research and implement the initiative this target proved to be unrealistic. Significant progress was made however in that inventory were both visible and effectively managed using the web portal and the weekly link-calls. The drumbeat for the five parts although not pulled through the supply chain via kanban were directly managed inline with the customer needs.

The current process being operated provides visibility of the amount of inventory in the first tier supply chain, work in progress and raw material on order. However, it does not provide visibility of where the inventory is in that process. Joint consignment stocking programmes were not in place, however to suggest that no progress has been made would be wrong and further work is ongoing to move to some form of lean/pull system. It could be challenged that the definitions described in Appendix 1 are too simplistic and therefore could be improved.

Overall business performance

The business performance objective for the initiative was to improve schedule adherence score from 27 to 100 per cent for the five parts. The business performance measure steadily improved during the first six weeks of the joint initiative and maintained 100 per cent throughout the remainder of the initiative as shown in Figure 4 [Figure omitted. See Article Image.], the dotted line represents the individual deliveries whilst the solid line is an average.

Although the initiative was focussed on five-part numbers Supplier C's overall schedule adherence performance for all parts improved (Figure 5 [Figure omitted. See Article Image.]). This could have been a direct result of the collaborative working and learning that was transferred to the other parts. Although not graphically illustrated the delivery performance from the mill to Supplier C followed a similar profile, achieving 100 per cent and maintaining this throughout the period of this initiative.

The number of schedule changes in the early part of the initiative was higher than planned as a result of learning how to re-configure SAP and late deliveries. However, this was soon brought under control resulting in the only schedule changes being those that were agreed through a commitment acceptance process on a quarterly basis. The

number of changes associated with this was lower than the target as shown in Figure 6 [Figure omitted. See Article Image.]. This could be contributed to the high-focus on these five-part numbers and the improved long-term planning throughout the supply chain. Another contributing factor could be the improved delivery performance for these five-part numbers requiring no changes to be made due to late delivery.

Discussion and key learnings

This supply chain had experienced what they described as "initiative overload" from RR and reservations regarding RR's sincerity to follow through with this initiative were evident. The fact that this initiative had a defined timescale, identified stakeholders and agreed measurable deliverables helped to allay initial concerns. Additionally there was some nervousness regarding sharing of information which was overcome by agreeing that each party had the right to withhold information either due to commercial sensitivity or competitive advantage.

Although the companies had been in business together for 30 years, this is the first time that the whole chain was being considered as one manufacturing process instead of trying to optimise individual processes within each plant. This resulted in a better understanding of where processes were being duplicated and improved appreciation of the difficulties faced by each member of the supply chain in producing their components.

The deployment of this initiative was quite difficult at the beginning due to two traditional simplistic opposing viewpoints. RR believed that if the supplier delivered on-time RR would not need to reschedule as much, while the supplier's belief was that if RR did not reschedule as much then they could deliver on-time. In order to resolve these opposing viewpoints data was collected by the RR logistic team and the supply chain to highlight some of the reasons for schedule instability (Appendix 2).

A consensus was reached that it would not be practical to resolve all these issues within one initiative. However, RR began to understand that they contribute to the problem of late delivery in that they change their requirements inside the manufacturing lead-time of the supply chain and that this makes it difficult for suppliers to plan effectively. However, the supplier also understood that they contribute to this problem, as RR re-schedules due to late deliveries.

A major difficulty was to obtain agreement from senior management within RR to fix all schedules for this supply chain for nine months without allowing any changes. This was achieved by agreeing on the part numbers for the pilot and also a process to change the schedules but only in exceptional circumstances. In addition, the implementation of this initiative involved a significant role change for the plan-makers, as a key element of this initiative was to have only one plan which was clearly visible to the whole supply chain.

The impact of this on the plan-makers was overlooked during the solution design process and the resistance to change from key members had to be managed. It was never the intention to remove this level of expertise, as production planning and control play a vital role in any supply chain. The intent was to have greater visibility of their part within the process and their impact upon the whole supply chain and to allow them to create better plans by having improved visibility of other activities within the supply chain.

By the end of the initiative the RR planners realised that their fears were unfounded and when the initiative drew to an end they realised that it had had a positive impact on their role. Supplier C also appreciated the benefits of improved schedule adherence without the emotion associated with late deliveries. The mill also improved their delivery performance to Supplier C and felt a more involved and valued member of the supply chain.

The whole supply chain was initially focused around a short-term planning horizon as that was the traditional mindset. It took perseverance and a number of weeks to start using this process for long-term planning and ensuring that the whole supply chain was acting in unison. Weekly reviews with Supplier C to manage the delivery issues inside 12 weeks continued outside of this process but it was interesting that the five parts involved in the pilot began to figure less and less as the long-term planning and visibility of the whole supply chain improved.

It soon became apparent that the expediting of these five-part numbers was non-existent as better long-term planning was taking place and visibility of issues was improved. Business performance for all parties was improved as a direct result of the joint initiative. RR had improved delivery adherence and both the forger and the mill had improved clarity and stability of RR requirements. Operational efficiency was improved due to better planning and monitoring, reducing the non-value added activity associated with expediting late deliveries. The mill improved their operational efficiency even further by working to a monthly flat-lined schedule demand that facilitated better use of key plant equipment.

Conclusion

Results from the [17] Kim et al. (2006) study indicate that the exchange of high-quality information between partners improves the channel coordination and improves the overall responsiveness of the partnership and ultimately market performance. Furthermore, the sharing of information across the chain will also lead to closer integration, which has been linked to improvements in productivity, customer service and overall marketplace performance ([11] Frohlich and Westbrook, 2002).

Agility, transparency and information integration have all been described as competitive weapons in increasingly volatile markets ([5] Christopher, 2000; [19] Lamming et al. , 2001; [11], [10] Frohlich and Westbrook, 2002, 2001). Certainly the results from this case study demonstrate tangibly that the exchange of high-quality information as part of an improvement initiative does lead to significant improvements in the overall performance of the supply chain. The approach presented appears deceptively simple however, the development of a robust set of templates to assist in the identification of the gaps in current practice to act as the focus for the project team are key to the effective use of resources. Also the leveraging of an internet-based platform to facilitate the exchange of information between supply chain partners has shown itself to be a powerful approach to avoid the complexities of trying to integrate IT systems across the partner organisations.

In terms of future research, there are many different types of supply chains within RR and this particular approach is not suitable for all supply chains, as it requires collaborative investment from all parties and some supply chains, for example, commodities, have an adversarial relationship and parts are sourced primarily on a cost basis. It is recommended that a selection criteria table is used to determine which supply chains would be suitable for this approach. In addition, the criterion used may need to be adapted to suit the specific supply chain context, as the ones developed as part of this research are specific to RR supply chains and even more specific to the forging supply chains. Future work could be to provide a more generic set of criterion thus expanding the supply chains where this approach could be used.

Finally, the approach employed in this study and the templates developed could be easily adapted to the needs of other types of organisations in other manufacturing sectors.

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