

Supply Chain Management for Servitized Products: a multi-industry case study

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Abstract

Manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer more profitable business relationships. Organisations that pursue this route are following a strategy of servitization which requires the effective management of supply chains. A framework was developed from the extant literature that was used as a lens for the analysis of supply chains for servitized products. This research uses case studies to explore the challenges and opportunities that face the supply chain management function within organisations that are pursuing a strategy of servitization. The case studies indicate that servitized supply chains are different to their production counterparts and need to be responsive which is facilitated by real-time information.

Keywords: supply chain, products, services, servitization, case study.

1 Introduction

Levitt (1983) propounded that business transactions would move from discrete sales of products to relationships based on the provision and support of bundles of products and services. Vandermerwe and Rada (1988) used the term “servitization” to refer to this bundling of products and services; a strategy that according to Slack et al. (2004) is becoming increasingly relevant for manufacturers to improve competitive advantage. Several factors contribute to the increased competitiveness of a strategy of servitization:

- services tend to be more difficult to imitate and lock the user into a long-term relationship (Vandermerwe, 2000);
- services improve knowledge through an increased insight into how products are used (Alonso-Rasgado et al. 2004);
- services provide a differentiating factor from traditional manufacturing (Penttinen and Palmer, 2007);
- manufacturers that utilise servitization also increase revenues (Oliva and Kallenberg, 2003) as services tend to have higher margins and can provide a stable revenue stream throughout the life of the product (Cohen et al. 2006).

Users of servitized products experience enhanced value due to the comprehensive nature of the delivered proposition (Vandermerwe, 2000) and improvement in through-life support (Cohen and Whang, 1997). The nature of servitization dictates that it is mainly used by organisations that supply complex, long-life products that require through-life support such as aero engine manufacturers (Voss, 2005).

Effective servitization requires: “*the co-ordination of manufacturing systems, maintenance systems, spare parts supply systems, logistics systems, and so on*” (Slack et al. 2004). Whilst the product is nominally provided by one organisation, services and support may be provided by members of their supply network (Cohen et al. 2006). Furthermore Slack et al. (2004) propose that organisations need to be integrated with their supply chains in a similar fashion to the products and systems that they provide. Therefore, the effective deployment of a strategy of servitization encompasses and integrates many more organisational functions and actors and is an altogether more complicated proposition than developing an integrated supply chain strategy. This is due to the need to support the product over a period with the downstream supply chain delivering a range of products (e.g. spares, upgrades) and services (e.g. training, maintenance). Thus, the research questions were:

1. What are, from the extant literature, the key processes within supply chains for servitized products?
2. What are the current practices in the supply chains of organisations that provide and use servitized products?

The next section discusses the background to the research in terms of the differences between supply chains for production and those for support and details how the stages of product use influence the characteristics of the supply chain. The following sections discuss the methodology used and the case-studies and finishes with a discussion of the findings and implications for practice.

2 Literature review

Servitization involves a customer proposition that includes a product and a range of associated services. The delivery of such a proposition requires supply chains focused on the delivery of physical products and others that focus on the delivery of services. Within the physical product supply chain there are two types of demand. These demands are from the manufacture of the products and demand from the aftermarket support of the product, both of which need to be fulfilled from one supply chain. The demand between these two types of supply chain is different in nature. Production requirements are stable and known whilst those for the aftermarket are sporadic and unpredictable (Cohen et al. 2006). This is further compounded by variances in demand, dependent on the type of sub-system or component, between production and aftermarket. Further complicating the issue is that aftermarket support extends beyond the point at which the product is no longer available to purchase. Therefore demand for sub-systems and components will reduce significantly in volume when the product is no longer in production but can extend for many years after production has ceased.

A major challenge in researching servitized supply chains is the differences between product and service supply chains, which according to Ellram et al. (2004) make most supply chain frameworks inappropriate for services. Furthermore, a servitized supply chain requires the careful synchronization of product and service supply chains in order to deliver a complete product-service proposition to the customer. In this section the differences between product and service supply chains are analysed and different models used to study these two types of supply chains are compared. This leads to the development of a framework considered suitable for the analysis of supply chains for servitized products.

Products and services are different; as Shostack (1982) posited:

“Products are tangible objects that exist in both time and space; services consist solely of acts or process(es), and exist in time only... Services are rendered; products are possessed. Services cannot be possessed; they can only be experienced, created or participated in.”

Most definitions of supply chain management (SCM) focus on the flows of materials, information and funds involved in transforming raw materials into final products, overlooking the service aspects of the supply chain (Stevens, 1989; Simchi-Levi et al. 2002; Burt et al. 2003). An exception comes from Ellram et al. (2004) who defined SCM for services as: *“the management of information, processes, capacity, service performance and funds from the earliest supplier to the ultimate customer”*. For this research this definition was modified to encompass both products and services, leading to the following definition: *“supply chain management of servitized products is the management of information, processes, capacity (people, equipment and facilities), products, services and funds from the earliest supplier to the ultimate customer”*.

Various models and frameworks have been developed to facilitate the analysis of product supply chains. These include the Supply Chain Operations Reference (SCOR) Model (Supply Chain Council, 2001; 2006), the Hewlett-Packard (H-P) model (Lee and Billington, 1995), the Global Supply Chain Forum (GSCF)

framework (Cooper et al. 1997), as well as other models presented by Srivastava et al. (1999) and Bowersox et al. (1999). Lambert et al. (2005) compared these models and concluded that only the SCOR and GSCF models include business processes that can be used for cross-functional integration and are described in sufficient detail for meaningful comparison.

Ellram et al. (2004) concluded that the H-P and SCOR models are difficult to apply to a service context although the GSCF model could be adapted to describe the key supply chain processes in a service context. Hence, it was decided to use the GSCF model as a foundation for the construction of a framework for the key processes in supply chains for servitized products. The GSCF model originally presented by Cooper et al. (1997) and later modified by Croxton et al. (2001) identifies eight key supply chain management processes which cut across the supply chain. These processes are depicted in Figure 1.

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Ellram et al. (2004) proposed that while the structure of the GSCF model appears to be appropriate for the provision of services, the processes are not. They go on to suggest an alternative set of processes which includes:

- Information Flow;
- Capacity and Skills Management;
- Demand Management;
- Customer Relationship Management;
- Supplier Relationship Management;
- Service Delivery Management, and
- Cash Flow Management.

As servitization involves both product and service supply chains the GSCF model (Croxton et al. 2001) and the service supply chain model proposed by Ellram et al. (2004) was combined. The resultant model deals with the entire range of supply chain processes that are required in a servitization context. Table 1 presents a comparison of the GSCF model (Croxton et al. 2001), Ellram et al.'s (2004) service supply chain model and proposes a set of processes for the model for the supply chain of servitized products. Each of the processes is discussed in more detail below the Table.

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1. **Information Flow Management** the GSCF and the service model do not describe Information Flow as a process but a flow that links the various participants in the chain (Ellram et al. 2004). For the servitization model it was decided to describe it as a management process. This was done as it involves a series of activities that enable data to be captured, transmitted and processed to generate information and knowledge that is useful for managing the other processes (Ackoff, 1989).
2. **Customer Relationship Management (CRM)** refers to the series of activities that provide the structure for maintaining and developing relationships with customers (Croxton et al. 2001). It includes activities such as understanding customer needs, tailoring product-service agreements (PSAs) to meet their needs,

segmenting customers, monitoring relationships and ensuring customer satisfaction (Croxtan et al. 2001; Ellram et al. 2004). Linking CRM to supply chain management and other key processes such as product/service development and supplier relationship management has been shown to improve firm performance and increase shareholder value (Srivastava et al. 1999; Wisner et al. 2003).

3. **Supplier Relationship Management (SRM)** refers to the creation of a structure for managing and developing relationships with suppliers (Croxtan et al. 2001; Lambert et al. 2004). As with CRM, it involves establishing PSAs (Croxtan et al. 2001) or Service Level Agreement [SLAs] (Ellram et al. 2004) with suppliers to support the relationships. Other activities include the identification and selection of suppliers as well as the negotiation and execution of contracts (Ellram et al. 2004).
4. **Demand Management.** In product supply chains, demand management refers to the balancing of customers requirements with supply chain capabilities to reduce variability and uncertainty and increase flexibility (Croxtan. et al. 2002). It includes activities such as demand creation, forecasting, planning and inventory management (Davis, 1993; Croxtan et al. 2002). Additional difficulties exist in managing demand for service supply chains. This is as demand uncertainty tends to be greater in this type of supply chain (Baltacioglu et al. 2007), and it is not possible to use inventory to buffer against demand uncertainty (Ellram et al. 2004).
5. **Production Management** is the result of combining two processes from the original models: Manufacturing Flow Management from the GSCF model (Croxtan et al. 2001) and Capacity Management from the service supply chain model (Ellram et al. 2004). Manufacturing Flow Management was defined by Goldsby and Garcia-Dastugue (2003) as *“the activities necessary to obtain, implement and manage manufacturing flexibility and move products through the plants in the supply chain”*. Ellram et al. (2004) argue that people are the key asset in service supply chains and hence the production of the service relies on managing the skills and capacity of people in the supply chain. However, services also require equipment and facilities which need to be managed in order to produce the service (Haynes and Thies, 1991). In merging these two concepts, it is assumed that both products and services have to be produced by managing, people, equipment, facilities and, in the case of products, inventory.
6. **Order Delivery Management** is the result of combining three processes: the Order Fulfilment process, the Customer Service Management process from the GSCF model (Croxtan et al. 2001) and the Service Delivery Management process from Ellram et al’s (2004) service supply chain model. The Order Fulfilment process has been defined by Croxtan (2003) as *“all the activities necessary to define customer requirements, design a network, and enable the firm to meet customer request while minimizing the total delivered cost”*. This process overlaps with the Customer Service Management process which has been defined as the process that *“provides the firm’s face to the customer, a single source of customer information, and the key point of contact for administering the product/service agreements”* (Bolumole et al. 2003). Ellram et al. (2004),

conversely, define Service Delivery Management as “*making promises to the customer, enabling service providers (internal or external) to meet those promises and meeting the promises*”. Although there are differences in the scope of these three definitions, all include activities to define a customer order, create a network to deliver the order and enable the network to deliver the order. For the servitization model, this set of activities has been termed the Order Delivery Process, which includes the delivery of both products and services.

7. **Financial Flow Management:** as a process comprises the activities required to facilitate the flow of funds across the supply chain, including invoicing customers, paying suppliers and any transfers between divisions of the firms involved. This process is termed Cash Flow Management in Ellram et al’s (2004) service model, however, it was decided to change the terminology to avoid confusion with the financial definition of cash flow management. This process does not have an equivalent in the GSCF model (Croxtan et al. 2001), however, it has been recognised by researchers (Burt et al, 2003; Farris and Hutchison, 2002) that financial flows are a central element of product supply chains.
8. **Returns Management and End-of-life.** The GSCF model (Croxtan et al. 2001) defines Returns Management as “*all activities related to returns, reverse logistics, gatekeeping and avoidance*” (Rogers et al. 2002). This process has no equivalent in Ellram et al’s (2004) service model, however, the management of returns and end-of-life is a service provided by the manufacturer or other firms in the network. For the servitized model it was decided to expand the concept to include the range of options at the end of the life of a product such as recycling, remanufacturing / refurbishing and decommissioning.
9. **Product Development Management** refers to the activities “*involved in providing a structure for developing and bringing to market products jointly with customers and suppliers*” (Rogers et al. 2004). Ellram et al’s (2004) service supply chain model does not consider a service development process, however, services also have to be designed and developed (Shostack, 1982). Hence, for the servitization model it was decided to adapt Roger’s et al. (2004) definition to include both products and services. Hence, the Product Development Management process has been defined as the series of activities involved in providing a structure for co-developing products and services with customers and suppliers, and bringing them to market.
10. **Risk Management** is the only process in the servitization model that has no equivalent in either the GSCF model or the service model. With the servitizing of product, much of the risk for non-performance transfers to the product provider as the product user is paying an ongoing fee for the availability or capability of a product or service. This means that the risks of not delivering the product/service promised, even if exogenous to the firm promising the result, need to be controlled and mitigated (Tukker and van den Berg, 2006). Thus: risks within the firm and supply chain need to be controlled and mitigated. This process has been recently recognised as a legitimate process of supply chain management (Christopher, 2003; Tang, 2006) and one that has particular relevance in a servitization context because servitized products are often complex and have long life-cycles, both factors contributing to a higher risk exposure. The Risk

Management process has been defined as: “*the collaborative activities which seek to ensure ‘profitability and continuity’ through supply chain wide risk reduction via identification and management*” (Christopher, 2003; Jüttner et al. 2003; Tang, 2006).

The model emerging from the synthesis of the GSCF model (Croxton et al. 2001) and Ellram et al’s (2004) service supply chain model comprises a range of processes that are capable of dealing with both the product and service aspects of the supply chain of a servitized product. Figure 2 presents a depiction of the servitized model, which will be used in Section 4 to frame the case studies.

INSERT FIGURE 2 ABOUT HERE

3 Methodology

Due to the exploratory nature of the project we used case study research to allow greater flexibility to adapt to the circumstances and terminology used in different industries (Yin, 2003). Five firms involved in servitization were selected for the study to allow the findings to be contrasted and replicated (Eisenhardt, 1989) and to improve external validity and observer bias (Voss et al. 2002). Table 2 shows the case summaries including company background, product management focus and stages of product use.

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The business units within the case companies studied all had customers, in some cases these were external customers and in other cases internal customers. For example, at NuCo the business unit studied provided and managed servitized products to internal customers, while at AerCo the business unit provided and managed servitized products to external customers. Five cases are within the accepted range of studies for the exploratory analysis of a new phenomenon (Eisenhardt, 1989; Meredith, 1998).

The framework developed was used as a lens for analysis by synthesising the framework into a semi-structured interview protocol. This ensured that all areas of enquiry were covered (Patten, 2002) and allowed clarification of questions that were uncertain to respondents (Schober and Conrad, 1997). The interviews were conducted over a period of two months. Additional methods of data collection were used to triangulate the data obtained from the interviews, including a review of company documentation, publicly available information and site visits. Case study reports were prepared and sent to the companies to validate the data and maintain participant engagement in the research process.

4 Case summaries

4.1 Information flow management

All of the case companies stressed the importance of information systems in facilitating their service delivery. In three of the five cases the assets were connected to the organisation (e.g. through telematics) which allows the provider to be both

reactive and proactive towards the upkeep of the asset. With servitized products AerCo use real-time data provided by telemetry fitted to the asset to monitor the system in-use. AerCo can predict with approximately 95% accuracy, to a 2 year time horizon, the point at which it will require repair or overhaul. This allows scheduling of a slot in its Maintenance, Repair and Overhaul (MR&O) facility in addition to generating an order within AerCo's ERP (Enterprise Resource Planning) system to deliver parts on a JIT basis using Supply Chain Event Management (SCEM) techniques. SCEM in this context is defined as "*systems that monitor events within the supply chain and react according to predefined rules*" (Bodendorf and Zimmerman, 2005). AerCo also use the information flows from the system to monitor usage patterns. This data informs the customer-facing business units of the organisation – to determine whether the charges levied on the contracts are correct – and the engineering unit – to improve future versions of the products. TransCo also use telematics to remotely monitor products and as with AerCo use this data to trigger orders within their ERP system. They also use Product Lifecycle Management software to manage the design, manufacture and support of their systems and products. At NuCo all critical processes are monitored in real-time allowing increased visibility of potential risks and facilitating the predictive maintenance of safety critical items. In NuCo's case as the asset base is fixed, telemetry is not used, NuCo also apply SCEM techniques for the ordering of inventory for maintenance operations.

The remaining two case companies also used IT to facilitate service delivery but this was not performed automatically. With FleetCo a proprietary IT system holds all vehicle-related data and is used to compare each vehicle to industry standards with exception reports generated, and customers contacted, if there is variation. Fleet managers that use FleetCo's services gain access to an online portal which allows them to obtain quotes for, and order, new vehicles and facilitates the analysis and optimisation of the usage of the vehicle fleet. Fleetco's portal also allows fleet vehicle drivers to determine whether the vehicle they are driving requires maintenance or taxing. CraneCo use a central IT system to schedule maintenance which is updated manually and used to schedule servicing and the ordering of parts for maintenance.

4.2 Customer relationship management

In two of the cases (AerCo, TransCo) relationships with customers were formalised and incentivised through contractual agreements that were related to the performance of the system supplied. For AerCo servitized systems provided through availability type contracts cover approximately 30% of the installed base. At the highest level of application the customer contracts for availability without buying a system: AerCo cover the costs of acquisition, maintenance and modification over a fixed period of time, typically 20 years. The customer pays a fee based on their usage of the system. Using this type of contract AerCo increase revenues over the course of the life of the product, stabilise cash flow (due to regular payments) allowing more regular investment in R&D. AerCo also gain a greater insight into the customer's practices and how their product performs in-use whilst maintaining customer lock-in-preventing the disintegration of lucrative profits in the aftermarket by third parties. A further service that is incorporated into availability contracts is access to AerCo's proprietary online portal that allows customers to access technical documents; view and manage asset repair and overhaul progress; and receive notice of technical

documents. TransCo also supplies a variety of solutions, from individual vehicles to complete transportation systems in conjunction with the provision of a range of system management services. Contracts with clients are based on specification or performance of the system or vehicle with contract type influencing the involvement of TransCo over the lifecycle. Involvement ranges from very basic responsibilities, to the servitization of the system. This option is selected by organisations that wish to focus on delivering the core service to customers with TransCo focussing upon the support of the network.

In a further case, relationships with customers were provided by a single point of contact for each customer. The decommissioning and waste storage parts of NuCo do not have customers in the traditional sense and instead have stakeholders that represent a wide range of interests. These range from members of the public to non-governmental agencies to international agencies. Each of the stakeholders is managed by a single point of contact within NuCo with regular internal communication between the contacts ensuring that there is a comprehensive overview of the requirements of the stakeholders.

4.3 Supplier relationship management

In two – AerCo and TransCo - of the cases there was evidence of long-term relationships with suppliers and a heavy reliance on their supply base for competences other than simple manufacture. AerCo have, in recent years, sought to consolidate their supply base and transition their suppliers away from the delivery of discrete parts to the delivery of systems, sub-systems and modules. This has meant that design responsibility has transferred from AerCo to the supplier, with these new suppliers being classed as “integrators”. AerCo have classed these organisations into a classification that ranks the integrators competence. This ranges from “systems integrators” that are capable of designing and delivering complex systems to “packaging integrators” that are able to integrate components into a complete kit that will be sold as a spares package. As integrators are responsible for more than the manufacture of a product they are rewarded appropriately. Systems integrators are contracted under a long-term risk/reward arrangement where the integrator will pay AerCo a sum to become a partner with this outlay being offset by ongoing fees paid through the life of the product and availability contracts. TransCo do not have the full suite of capabilities required to manufacture locomotives and as with AerCo use their suppliers as integrators, relying on their supply chain to provide systems such as diesel and electric motors and bogies with TransCo acting as a systems integrator. Suppliers of systems to TransCo do so under long-term collaborative contracts.

In a further case (CraneCo) we saw further evidence that organisations were building longer term relationships with suppliers although this was for slightly different reasons. Embedded knowledge and training of staff on equipment is leading CraneCo towards looking more favourably upon equipment from vendors with which they have experience. There was also supplier incentivisation with CraneCo although this was implicit rather than stated within a contract. For CraneCo the possibility of a supplier performing poorly and being the subject of bad press in a niche industry with are competitors for substantial contracts leads to vendors honouring the terms of the contract.

In one of the cases (NuCo) where the company studied used, as opposed to provided, servitized assets multiple contract types were used to deal with suppliers. This is similar to the findings in sub-section 4.2 of this analysis. NuCo use multiple modes of contracting when acquiring products, ranging from simple acquisition to using servitized products. Products that are servitized tend to be of a more standardised nature where the risk to safety of failure is minimal. The reasons given for the use of servitized assets was to “improve cash flow” due to the lack of a large payment to acquire the asset.

4.4 Demand management

In two of the cases (AerCo, NuCo) the demand was managed centrally using information gathered from decentralised units and remotely from the assets in the field. Demand management at AerCo is performed by a quarterly review of the orders for new assets and the forecast of demand for aftermarket parts. This review is performed centrally to the business although information is gathered from around the business, including overseas bases and real-time data that has been analysed for issues that will have an impact upon the demand placed upon the supply chain. This is due to AerCo operating in a make-to-order (MTO) environment for production parts – with a 3-5 year lead-time for customers - and a make-to-stock (MTS) environment for aftermarket – where the requirement for a replacement part or system may be instantaneous if the aircraft has suffered unexpected damage. This quarterly review of demand is then placed upon the supply chain through an explicit process that ensures that orders can be met fully within lead-time. NuCo have a central department managing the support of the site which is updated regularly depending on the condition of assets within the facility. This department has a strategy spanning to the expected end-of-life of the facilities (70+ years). Long-term goals, including all planned work and the forecasts for related material requirements, are captured and held centrally with the plans further stratified to shorter-term objectives and plans.

4.5 Production management

Internal process management varied between each of the five case companies. We suggest that this is to be expected given the differing industrial contexts.

At NuCo safety-critical systems are triplicated and all critical processes monitored in real-time to allow increased visibility of process performance. This facilitates predictive maintenance of safety critical items where possible with non-critical systems maintained using preventive and failure-driven maintenance philosophies. The extreme specialisation of the industry has also led NuCo to forecast demand and purchase and manage their own spare parts using SCQM techniques. This has allowed the company to centralise the maintenance inventory to be more responsive to maintenance requirements.

Internal process flow within AerCo is facilitated by an ERP system that, despite the real-time information flow available from the telemetry on the assets, is run on a weekly basis due to the volume of data within the system. AerCo has very few dedicated manufacturing flowlines, with the majority of manufacturing processes being arranged into jobshops capable of multiple process routes. When the product is

no longer in serial production, and parts are supplied to aftermarket demands only, AerCo transitions the supply chain to a stand-alone business unit that is better equipped to deal with the supply and demand volatilities that occur.

With FleetCo the vehicles are acquired based on a customer specification, the vehicles are then handed over to the customer who will be responsible for planning the maintenance of the vehicle – using the online portal - and making sure it is “fit for purpose”. Maintenance, both routine (services) and reactive (breakdowns or accidents), is outsourced to a network of garages available in every country where they operate. Whenever a customer takes a vehicle for service, the garage collects and sends relevant data to FleetCo to check the status of the vehicle against industry standards.

At CraneCo maintenance for both types of product is outsourced with the lease agreement for the forklift trucks also incorporating a small level of maintenance work. When CraneCo acquire equipment they acquire not only the hardware but training, spares packages and technical documentation. Spare parts for major products are managed on CraneCo’s site by a 3rd party maintenance provider. They are property of the vendor until three years after the acquisition of the equipment, after which CraneCo can decide whether they wish to purchase the spares which are typically the full parts package required. This may be advantageous as the spares package provided by the vendor may not be suitable for CraneCo - it may be too large, tying up cash; or too small; giving sub-optimal levels of spares. If spares are used within the initial three year agreement CraneCo pays the vendor the cost of the part with no mark-up.

4.6 Order fulfilment

AerCo and TransCo used a number of techniques to decentralise their order fulfilment. At AerCo the order fulfilment – for physical items and services – for servitized assets is provided through a number of mechanisms. This includes the use of inventory pooled between airlines and held at major airports to provide rapid response to unexpected failures, an approach also used by another case company. TransCo undertake Maintenance, Repair and Overhaul to the standards agreed in the contract and whilst that asset is overhauled a further asset from a pool replaces that being serviced. A further mechanism used for order fulfilment by AerCo is the establishment of overseas MR&O facilities under joint (JV) agreements. The establishment of the JV’s was performed with organisations that contracted for availability and allows AerCo to reduce the capital invested in service facilities through the partnering arrangement. The arrangement also increases access to further markets as the asset users need not return the assets to AerCo’s European headquarters and has benefits for the asset user as it allows the partner – an asset user itself – to have full visibility of service costs.

4.7 Financial flow management

All five of the case companies studied provided or used systems or assets under lease agreements where an ongoing fee was paid, and in some instances the companies provided an ‘extended offering’ that included a range of services. In most cases this

was dependent upon usage with only CraneCo paying a flat lease rate. AerCo provided systems and assets under availability contracts where the users pay an ongoing lease fee. They are contractually bound to meet performance measures for service responsiveness or they pay a financial penalty. TransCo also provide systems and products under performance-based capability contracts where penalties are levied by the asset user for poor performance. FleetCo provide vehicles under lease agreements with the vehicle lease being augmented by a range of services such as fuels cards and insurance; NuCo lease standardised assets which include some support; and CraneCo lease forklifts with the lease agreement incorporating maintenance.

4.8 Returns and end-of-life

All of the case companies dealt with the end of an assets life in similar ways with only one organisation having formal methods for dealing with an asset at the end-of-life. AerCo do not have an explicit process for dealing with assets at the end of their working life. At the end of the lease agreement the assets are returned to AerCo where, due to the long working life of the systems, very few are disposed of in the traditional sense. There is an active market for used systems which will typically go into use on freight aircraft or shorter airline routes with regional airlines. Further options include the cannibalisation of the system by AerCo or other organisations to provide further spares for the installed base or the remanufacture of the system for use by further users. Whilst TransCo do not have an explicit policy for the end of a system or vehicles life, they have a policy of upgrading all vehicles at the mid-point (typically 15 years). CraneCo do have a strategy for the disposal of products from their business; this is either by scrapping the equipment or selling “as seen” to another party.

FleetCo collect and inspect vehicles at the end of the lease period. Digital pictures of the vehicles are taken and posted on a website so that customers can access and verify all the information. In some cases the customer decides to buy the vehicle at the end of the lease period. If this is not the case, the vehicle is disposed of through a variety of channels including auctions (both traditional and online), retailers and traders. With NuCo there are no defined end-of-life options and NuCo are in the process of defining the end-of-life of the assets through the decommissioning work that they are performing.

4.9 Product development

At AerCo and TransCo a whole-life view was taken during product development with systems integrators also contributing to the development of the systems and assets. AerCo use a suite of tools during the design stage which forces them to focus on the lifecycle of the product, they also involve organisations in the design of the product with systems integrators taking responsibility for some design activities. At TransCo support issues that occur through life are covered through the involvement of a maintenance team and members of the supply chain in the product design process from conception with maintenance targets included as part of the system specification. Vehicles are designed using a modular architecture for ease of manufacture and assembly. This design also has benefits for the maintenance and support of the

system, facilitating the removal of components and the installation of updates and upgrades.

4.10 Risk management

When an organisation contracts for availability – by leasing servitized assets – they reduce operational risk caused by delays in service. In two of the cases (AerCo, TransCo) we witnessed explicit strategies for mitigating the risk on the focal firm. AerCo reduce their exposure to risk by transferring some of the disincentives for non-conformance to the supply chain and by partnering with other organisations at overseas MR&O facilities. Moreover, through the use of a servitized system the user focuses on the delivery of its core offering, in this case flights, and transfers risk to AerCo as support of the system is now in the realm of the system provider not user. CraneCo's use of a third party for maintenance was a business decision taken to mitigate the possible impacts upon CraneCo by industrial action by unions.

5 Summary and Conclusions

A servitization strategy requires the coordination of complex networks of product and service providers. To understand the challenges involved in using this strategy it is important to have a framework that identifies the key processes involved. The literature review revealed the absence of supply chain frameworks for managing a combination of both products and services. This gap was addressed by combining two frameworks, one aimed at product supply chains and one at service supply chains. The result of this synthesis was a new model for supply chains for servitized products. The model was then used for analysing the cases studies, testing its applicability and helping to identify patterns across the cases. Its application revealed that all ten processes were applicable to all the cases to a greater or lesser degree.

In the analysis of the cases it became evident that some of the processes were particularly important in the use of a servitization strategy. Information Flow Management stood out as a key process, by linking other processes using real-time data from the product, collected through condition monitoring and telemetry equipment. This data can be used to remotely place orders in the supply chain, both for spares and other maintenance services and is a key input for processes such as Demand Management, Production Management and Order Delivery Management, allowing greater responsiveness in all these processes. Additionally, information flow will also affect Customer Relationship Management and Supplier Relationship Management, by allowing the most efficient and effective flow of information between supply chain partners. Hence, an important challenge for managers in this type of supply chain is the establishment of supply systems that can respond to real-time information by effectively deploying resources, including people, equipment and spares.

Another process that appeared particularly important in a servitization context was Risk Management. It was found that supply chains for servitized products make the network the bearer of risks. This is due to capability contracts containing penalties for non-conformance with the risk often mitigated by the product supplier to the providers of sub-systems and components within the network. This implies that when organisations are establishing a strategy of servitization, long-term agreements should

also be established with strategic suppliers. This has a direct impact on both Customer Relationship Management and Supplier Relationship Management processes.

A further finding of this research is that the characteristics of supply chains for servitized products is different to that of 'traditional' supply chains for physical products, whether the demand is from production or from the aftermarket. The strategy of production supply chains is typically to deliver products efficiently while that of aftermarket supply chains is to be responsive as products can only fulfil operational goals when functioning. Thus: spares need to be available for maintenance or repair. The research indicates that supply chains for servitized products needs to focus on the delivery of 'value'¹ to the user of the product. This indicates that servitized supply chains deliver a range of options, from products such as spare parts and modules to services such as maintenance. This is an evolution of the supply chain away from the delivery of the physical towards the co-ordination and delivery of the physical (e.g. spare) and the non-physical (maintenance fitter). Table 3 summarises the difference between production, aftermarket and servitized supply chains.

TAKE IN TABLE 3 HERE

It is recognized that the research has its limitations. Firstly, the case method has limitations in terms of generalisability; hence, future research using alternative approaches that allow a larger and more diverse population, such as survey research, would improve reliability. A further limitation is that the research focused on the practices within the supply chain of servitized products, not on the rationale behind its use or the conditions for its effectiveness. Future research focusing into these aspects of servitization would allow the identification of critical success factors and the development of guidelines for the effective deployment of this strategy. These further investigations could also examine the impacts of different organisational cultures, information protocols and further barriers to the flow of information across the network.

Further empirical testing of the model is recommended through alternative methods to strengthen its generalisability. Future research into supply chains for servitized products could also consider the changes in supply chain configuration over the lifecycle of the product. This is due to the value required by the customer, and hence the proposition delivered by the supply chain whether product or service, being in flux over the lifecycle of the product.

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6 References

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¹ Value in this context is analogous to 'use value' as defined by Bowman and Ambrosini (2000) which is: "defined by customers, based on their perceptions of the usefulness of the product on offer."

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FIGURES

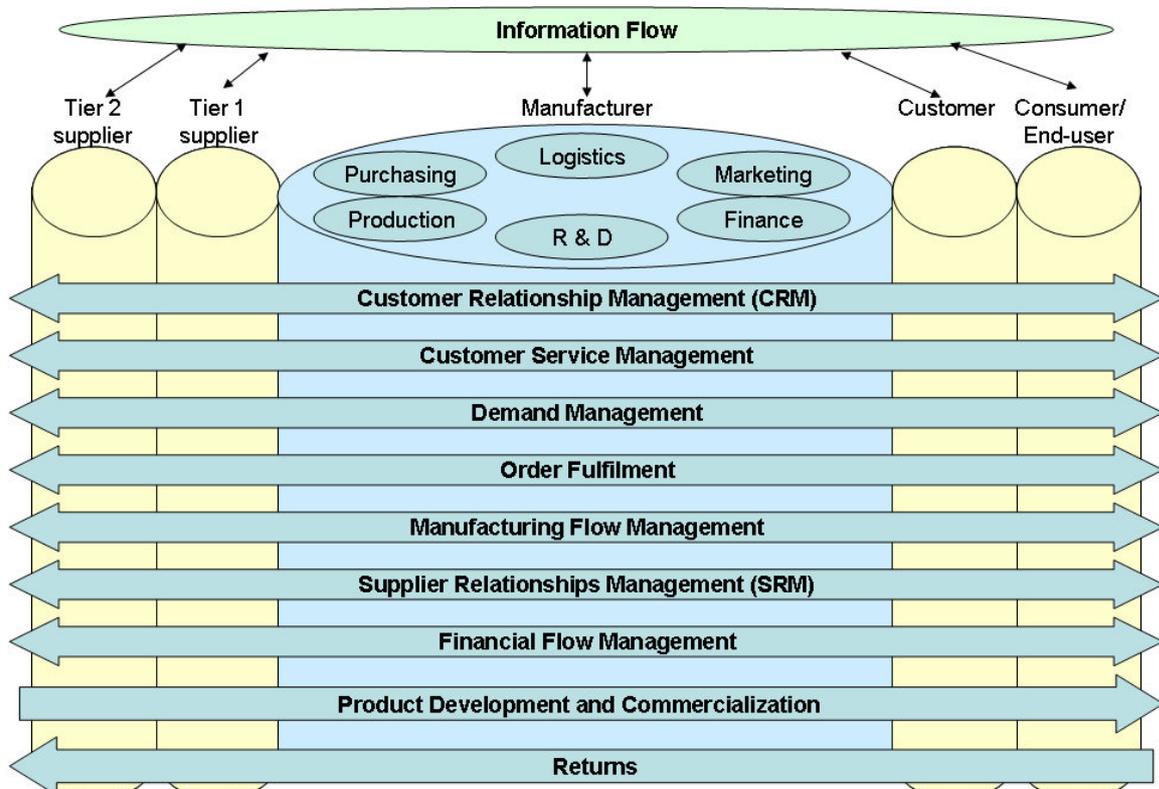


FIGURE 1: Global Supply Chain Forum (GSCF) model of Supply Chain Management for products. Adapted from: Croxton et al. (2001).

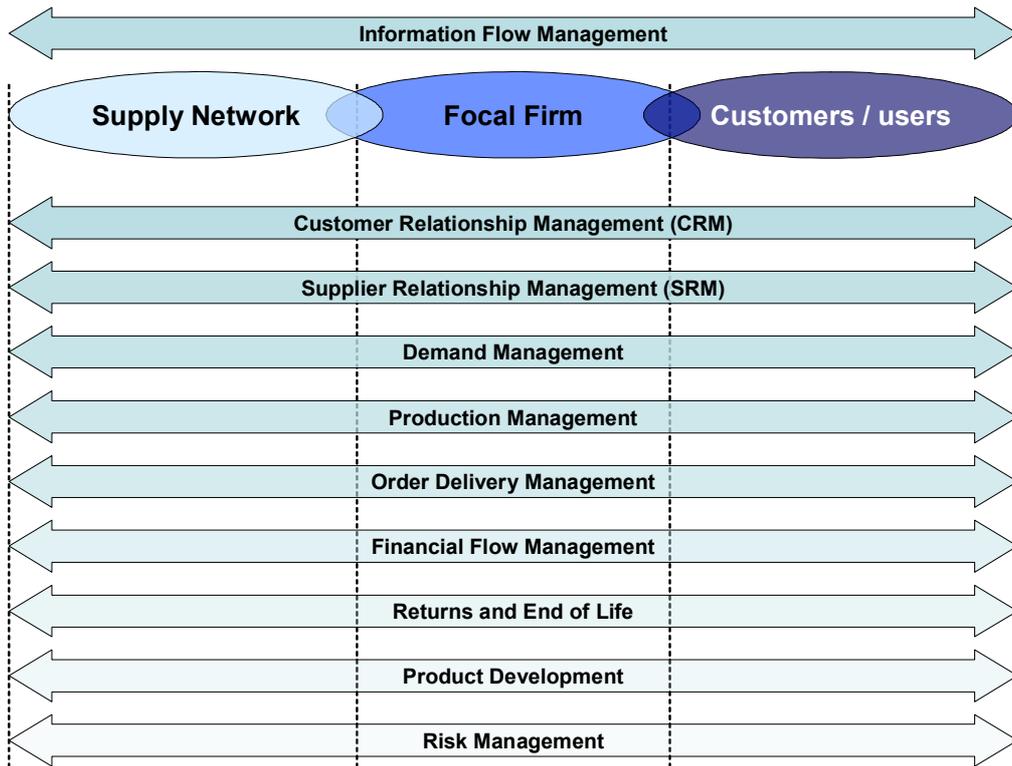


FIGURE 2: Servitization Supply Chain Model

TABLE 1: Servitization Supply Chain Management Processes

Servitization Model	Definition for Servitization Model	GSCF Model	Service Model
1. Information Flow Management	The process of linking the participants in the chain through information. It involves collecting and transmitting and processing data to create information to support all the other management processes.	Information Flow	Information Flow
2. Customer Relationship Management (CRM)	Provides a structure for how relationships with customers are developed and maintained, including the establishment of product/service agreements (PSAs) to meet the needs customers.	Customer Relationship Management	Customer Relationship Management
3. Supplier Relationship Management (SRM)	Provides the structure for how relationships between customers and suppliers are developed and maintained, including the establishment of PSAs between a customer and its suppliers.	Supplier Relationship Management	Supplier Relationship Management
4. Demand Management	The balancing of demand for products and services with internal capabilities.	Demand Management	Demand Management
5. Production Management	The activities required to produce the products and services. For products, it refers to managing manufacturing operations and for services to managing capacity of people equipment and facilities.	Manufacturing Flow Management	Capacity and Skills Management
6. Order Delivery Management	The activities involved in the defining customer requirements, making a promise to the customer, enabling a network to deliver the order and ensuring the delivery of the product and/or service at the minimum cost.	Order Fulfilment	Service Delivery Management
		Customer Service Management	
7. Financial Flow Management	The activities required to facilitate the flow of funds across the supply chain, including invoicing customers, paying suppliers and internal transfers.		Cash Flow Management
8. Returns and End-of-life Management	The activities related to the return and disposal of products, which includes options such as recycling, remanufacturing and decommissioning.	Returns Management	
9. Product Development Management	The activities involved in providing a structure for developing and bringing to market products and services jointly with customers and suppliers.	Product Development and Commercialization	
10. Risk Management	The activities which seek to ensure 'profitability and continuity' through supply chain wide risk reduction via identification and management.		

TABLE 2: Case company summary including the product stages in which the company is engaged.

Company	NuCo	AerCo	TransCo	FleetCo	CraneCo
Sector	Nuclear	Aerospace	Transport equipment	Vehicle leasing	Materials handling
No. of employees	Many 1000s	Many 1000s	Many 1000s	100+	1000+
Turnover	£1000m+	£1000m+	£1000m+	£100m+	£100m+
Role in dyad	User	Manufacturer & provider	Manufacturer & provider	Lessor	User
Estimated Product Life	70+ years	20+ years	30 years	2-5 years	30+ years

TABLE 3: Case company summary including the product stages in which the company is engaged.

Characteristic	Production	Aftermarket	Servitized
Strategy	Cost	Responsiveness	Value
Offering	Part / module	Part / module	Part / module / info / resource
Demand and supply uncertainty	Low	Tends to high	Low (facilitated through info)
Ordering	Centralised	Decentralised (firm)	Dispersed (product)
Control	JIT	Forecast/MRP	Real-time
Bearer of risk	Producer	User	Network

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