Servitization of the manufacturing firm: Exploring the operations practices and technologies that deliver advanced services

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Introduction

Manufacturing and service industries are often assumed incommensurable. Whether discussing national economies, business classifications, education, training or employment, they tend to be thought of as separate. Yet manufacturers themselves can base their competitive strategies on services, and the process through which this is achieved is commonly known as servitization (though servitization and servicisation are often used interchangeably) (Wise and Baumgartner, 1999; Oliva and Kallenberg, 2003; Slack, 2005; Schmenner, 2009). This strategy can strengthen customer relationships, create new and resilient revenue streams, and set high barriers for competitors (Baines et al., 2009b; 2011a).

Interest in servitization continues to gain traction. Modern manufacturing is now seen to extend beyond production (The Financial Times, 2012), and product-service business models are accepted as essential to industrial success in the twenty-first century (Foresight Horizon Scanning Centre, 2010). As researchers we recognise that the commercial benefits of servitization are convincing (Rolls-Royce Plc earn around 50 per cent of their revenue from services); that the environmental arguments are compelling (significant reductions in materials and energy usage); and that the opportunities immense (three quarters of wealth world-wide is now created through services (Royal Society, 2009)).

This growing interest has induced a range of research challenges. These include opportunities to improve the terminology and models used to describe services (Spring and Araujo, 2009; Baines et al., 2007; Tukker, 2004; Mont, 2000; Goedkoop et al., 1999), improving our understanding of how integrated product-service business models impact economic success (Neely, 2009; Visnjic and Van Looy, 2009; Fang et al., 2008), how to innovate and design successful offerings (Gebauer and Friedli, 2005; De Joeng and Vanmeulen, 2003; Coyne, 1989), the relationships needed with partners (Edvardsson et al., 2008; Galbraith, 2002), and transformational issues facing manufacturers seeking to servitize (Davies et al., 2006; Windahl and Lakemond, 2006; Mathe and Stuadacher, 2004; Oliva and Kallenberg, 2003; Roscitt, 1990). Such challenges are especially acute for advanced services.

Advanced services are a special case in servitization. Sometimes known as capability, availability or performance contracts, here the manufacturer delivers services (coupled with incentivized contracting mechanism) that are critical to their customer's core business processes (i.e. power-by-the-hour). For many, such services are foundational and implicit to the debate about servitization (Spring and Araujo, 2009; Datta and Roy, 2011). Delivering these in practice demands that the operations of the manufacturer exhibit different capabilities to those of production (Oliva and Kallenberg, 2003; Gebauer and Friedli, 2005; Ceci and Masini, 2011; Datta and Roy, 2011; Biege et al., 2012). Indeed, a failure to put in place these capabilities begins to explain, in part, why some manufacturers fail to realise the anticipated benefits of their servitization strategies.

This study has therefore set out to question how manufacturers configure their operations to deliver advanced services. Our focus is on the practices and technologies that underpin the capability to successful deliver advanced services. Bridging from the exploratory work of Baines et al. (2009a), we have investigated four manufacturing organisations that are leaders in the delivery of advanced services. In each, data has been collected across the organisation, service-delivery partners, and key customers. Analyses has then convergence on distinct technologies and practices used within their operations, and then rationalised the logic that explains their adoption. These are then combined in an integrative framework that illustrates how operations are configured to successfully deliver advanced services.

This paper extends our knowledge of the operations management practices that support servitization. For manufacturers themselves, it explains that the successful delivery of advanced services is achieved by a tightly coupled delivery system that features; (1) facilities that are collocated and distributed throughout customers operations, (2) integrated both forwards and backwards in their supply chains, and (3) staffed by personnel who are flexible, relationship-builders, service-centric, authentic, technically adept, and resilient. These people work with, (4) business processes that are integrated into their customer's operations, (5) supported by information and communication technologies (ICTs) that enable remote product monitoring, with (6) the entire system being controlled by measures that reflect outcomes aligned to individual customers, and then cascaded down into various forms throughout the service delivery system.

Background and context

Concept of servitization and advanced services

Servitization is the term given to a transformation where manufacturers increasingly offer services that are tightly coupled to their products (Baines et al., 2007). Many models within the academic press build on a distinction between products and services, illustrating how a change in the balance between these, translates to differing levels of servitization. For example, Tukker (2004) puts forwards the concepts of product oriented services, use oriented services, and result oriented services. Whereas Mathieu (2001) uses a 3×3 matrix topology with an axis of service specificity (customer service, product service, service as a product) and an axis of organisational focus (tactical, strategic, cultural).

Leading adopters of servitization do not necessarily apply the product-service classification, and instead distinguish on the basis of the value proposition with their customers (RAE, 2010; Baines and Lightfoot, 2013). They recognise that different customers will seek different propositions, and three types of propositions are readily apparent. This is captured by the notion that manufacturers have:

1. customers who want to do it themselves;
2. customers who want us to do it with them; and
3. customers who want us to do it for them.

Those customers “who want to do it themselves” will own and repair products (or assets) themselves, only relying on the manufacturer to supply the product and spare parts. Those customers “who want us to do it with them” will carry out some maintenance themselves (i.e. periodic oil and filter changes), but engage the manufacturer for more significant repair and overhaul. Those customers “who want us to do it for them” will contract for the “capability” offered through their “use” of a product, and have the manufacturer take care of everything else. These differing forms of proposition are referred to as “base”, “intermediate” and “advanced” services (Table I).

Advanced services are of particular interest to the servitization agenda. These bundle together products and services in a sophisticated offering that is critical to the customer's core business process. Frequently, these features:

1. performance incentives (i.e. penalties if the product fails to perform in service);
2. revenue payments structured around product usage (e.g. power-by-the-hour); and
3. long-term contractual agreements (i.e. five, ten, and 15 year durations are common).

Examples of companies delivering advanced services include Alstom and ABB (Davies, 2004; Miller, 2002), Thales Training and Simulation (Davies, 2004; Mulholland, 2000), and Rolls-Royce Aerospace (Howells, 2000). In this study, we focus exclusively on advanced services.

Challenges in delivering advanced services

Understanding the financial risks and rewards of servitization is challenging as access to reliable and insightful data is difficult (Gebauer et al., 2005; Neely, 2009; Neely et al., 2011). Overall, revenue earned by the manufacturer appears to increase with greater servitization. This comes about if the manufacturer is successful in taking over, and selling

back to the customer, services that the customer has traditionally performed themselves. The relationship with profits is however more complex. Work by Brax (2005), Gebauer et al. (2005) and Neely (2009) all point towards a "service paradox" where revenues earned by the manufacturer may increase but profits actually decrease with greater servitization. Many factors impact this relationship, in particular the through-life management of costs and risks.

The manufacturer's operations potentially impact these costs and risks significantly. Alignment is needed between operations strategy and services offering (Datta and Roy, 2011; Biege et al., 2012). Chase and Garvin (1989), Voss (1992) and Oliva and Kallenberg (2003) all recognise that servitization requires guiding principles, structures, and processes that differ to those of production operations. The challenge is to define what form these should take to support the effective delivery of integrated product/service offerings (Datta and Roy, 2011).

Operations management research is growing around this challenge. For example, Schmenner (2009) explores the close association between servitization and forwards (vertical) integration to "reach" closer to customers. In this process buyer-supplier relationships change (Bastl et al., 2012), and "front-offices" expand with separate management and organisation structures being created (Roscitt, 1990; Oliva and Kallenberg, 2003; Mathe and Stuadacher, 2004; Windahl and Lakemond, 2006; Davies et al., 2006). Within such high contact front-offices utilisation may appear low (Chase and Garvin, 1989), while independence from in-house capabilities increases (Davies, 2004). People and their culture are also known to differ. Services frequently demand a 24-7 mind-set and people with good customer interface and communication capabilities (Brax, 2005; Gebauer et al., 2008). An ability to foster positive customer experience is a key feature (Verstrepen, 1999), and assessment often features intangible requirements which form part of the customer perception of an acceptable service (Morris and Johnson, 1987).

A complete picture of how operations should be configured to deliver advanced services is however still to emerge. Existing studies are largely conceptual and in general empirical evidence is sparse (Datta and Roy, 2011). For example, Spring and Araujo (2009) examine intra-firm capabilities in conceptual framework; Roy and Cheruvu (2009) provide an similar framework focusing on infrastructural factors; while most of the literature in industrial services has traditionally focuses on conceptual framework derivation (Boyt and Harvey, 1997; Johansson and Olhager, 2004). There is also a lack of focus on mainstream operations management. Datta and Roy (2011), for example, conduct two case to develop design principles for operations strategy, however their focus is on services design, costs, and contracting rather than the broader policies and processes of operations.

Of these studies Baines et al. (2009a) have synthesised production operations management and service operations management literature, along with evidence from an in-depth case study, to propose the principles, structures, and processes required to deliver product-centric servitization (or advanced services). Although pioneering, by their admission their work is limited by:

- a potential bias towards production operations;
- being based on a single case study; and
- a focuses on identifying "what" practices are deployed but not explaining "how" and "why".

Nevertheless, Baines et al. moved forwards our understanding of the operations required to successfully deliver advanced services, and offer a logical platform on which to conduct more intensive studies of practice.

Methodology

Overall approach to the research

This study set out to extend our knowledge on how operations should be configured to deliver advanced services successfully. The exploratory work of Baines et al. (2009a) offered a valuable starting point. Their propositions are a synthesis of production and services operations literature, and provide the basis for a comprehensive set of "guiding research questions" to orchestrate data collection. The proviso being that "data analysis and confirmation" should

be inductive and unconstrained to allow findings to emerge. Once underway, we would follow the most promising lines of enquiry, and reassemble the data as a framework that represents our findings.

Also, Baines et al. found that a case study methodology was invaluable for exploring and gaining insight into the detailed workings of an organisation. A case study methodology was therefore favoured for our own study, but with a second proviso that a richer data set would be sought and so a broader selection of companies would be necessary.

Finally, we were keen to focus on the particular practices and technologies that underpin a capability to deliver advanced services. A reference frame was therefore needed that reflected a null hypothesis; the form operations take in manufacturers that are not servitized. Here, we considered including in our study a selection of organisations that had indeed failed with servitization, and sought to identify those aspects of their operations that have failed entirely because of the demands to deliver advanced services. Unfortunately this was too ambitious for the resources available to this programme, and so is set aside for future work. Instead, we followed the same approach as Baines et al. (2009a); we used those practices and technologies common for production operations as our reference frame. Our study would therefore examine how practices and technologies differed to those in production as a manufacturer delivered advanced services.

Four key stages of research subsequently emerged, and these are explained in the following subsections.

Guiding research questions

Detailed research questions were sought to guide the data collection protocol. The framework pioneered by Baines et al. (2009a) was taken and then extended to include questions around “why” and “how” practices and technologies support the delivery of advanced services. The subsequent research questions are captured in Table II.

Case selection and engagement

Critical to the success of this study was the identification and engagement of manufacturers that had a demonstrable record of successful delivery of advanced services. Yet identifying appropriate organisations was difficult.

A number of factors inhibit the identification of successful organisations. Common research practice is to base this selection on financial performance indicators, unfortunately publicly available reports fail to distinguish between revenue from products and different types of services (base, intermediate and advanced). Also, they are dependent on the accounting mechanisms that manufacturers use to apportion revenues within their organisations (i.e. revenue reported for services business can appear low, because internal charges for the re-manufacture of components are set high).

Financial success was therefore considered within a broad set of indicators. These included citations from other researchers (i.e. references made in publications), indicators of innovation (i.e. patents registered), and general reputation within the business community for delivering advanced services (i.e. conversations with practitioners). Searching for companies against these indicators led to the identification of a selection of potential cases (here we purposely excluded the organisation studied by Baines et al. (2009a)).

These potential cases were then scoped and filtered against a secondary set of factors. These were identified to ensure that the cases yielded a rich and diverse data set, and were:

- As servitization appears to significantly impact the operations of customers and partners, as well as the manufacturer (Wise and Baumgartner, 1999; Oliva and Kallenberg, 2003; Davies, 2004). Cases should allow data capture across this supply chain.
- As servitization impacts a wide range of functions within a manufacturer (Wise and Baumgartner, 1999; Oliva and Kallenberg, 2003; Davies, 2004). Cases should allow a broad interpretation of operations that constitute service delivery systems.

- As servitization appears to have a pronounced impact on organisational structure (i.e. creation of a front-office delivering services versus conventional OEM activities) (Davies, 2004; Davies et al., 2006). Cases should allow examination of differing structures.

Search, selection, and engagement processes reflected these factors. A short-list of companies was formed and prioritised, and then companies were approached in that order. This relied on informal networks for introductions to key personnel. During the process, care was taken to avoid approaching competing companies since this would inhibit willingness to participate. In all, four cases were identified and preliminarily engaged by mid-2009; they were visited, and negotiations concerning access and confidentiality were undertaken. A summary of the case organisations and the characteristics of their advanced services are shown in Table III.

Data collection protocol and execution

The cases were initiated sequentially but then largely executed in parallel, following guidelines in the literature (Voss et al., 2002; Yin, 2003).

A data collection protocol was developed around the research questions. Data was collected for:

- service offerings and the business context;
- service delivery system structures; and
- detailed characteristics of technologies and practices.

This data collection protocol is shown in the Appendix. This data protocol was executed in semi-structured interviews with the researchers asking the questions and recording the responses.

Care was taken to ensure questions were phrased so the process was applicable to a range of personnel, and most importantly guided to allow the conversation to flow. Two researchers were present at each interview, and answers were captured by both audio recording and note-taking. Triangulation (Jick, 1979; Yin, 2003) was performed to verify responses. This included using supplementary data such as organisational charts, process maps, operating protocols, and cross-checking responses from interviewees.

Participants were spread across organisations. These included vice presidents of service, operations directors, parts and services managers, frontline technical support personnel, technicians, and field maintenance staff. All cases were in progress by early 2010. On average, it took 18 months to complete each case study. Typically there were between 20 and 30 interviews conducted for each case and around 50 hours of conversation recorded.

Analysis and confirmation

Analyses sought to identify from the data those practice and technologies that are common to all the cases, to explain these, and to understand how they supported advanced services. Here, we were mindful that our data collection protocol had been informed by the work of Baines, and yet we sought to extend this work and avoid where possible a bias towards production operations.

A wealth of data had been collected in a variety of forms, and so our approach was to carry out a manual clustering of the data and capture the outcome using mind-mapping techniques. First, this was performed for each case individually. Systematically we examined the records of each interview, identified the practices and technologies being discussed, and captured these as branches of the mind-map. As each set of additional data was added, the mind-map was adjusted (e.g. branches were grouped together), and broad themes began to emerge.

The mind-maps for all four cases were then compared and combined. This was understandably complex; the companies, their offerings, and ways of expressing their operations all differed. The research team invariably had to apply judgement and synthesis to form a master mind-map. Care was taken to note the origin of data and highlight anomalies.

This initially clustering resulted in ten broad themes, namely:

1. capacity and stock-holding;
2. vertical integration and relationships;
3. organisational structure;
4. facilities;
5. predictive technologies;
6. financing and ownership;
7. design;
8. performance measurement;
9. information systems; and
10. human resources.

These themes were then refined and developed by critically examining the linkage between the prevailing practice (apparent for each theme) and successful delivery of an advanced service. This logic was rationalised using "influence diagrams". These helped to capture the cause and effect relationship. Figure 1 is given as an example of one such diagram developed during the project. This particular diagram indicates the rationale that relates "the retention of design and production" with key metrics for advanced services. The arrows represent the principal logical arguments that the case companies gave for their adoption of the practice.

Influence diagrams, such as the one in Figure 1, were constructed for each of the ten themes. This process caused the content of these themes to be refined, and subsequently reduced into six rich descriptions of the practices and technologies used to deliver advanced services.

These findings were confirmed and finalised in two stages. First, workshops were held at each company where the data, method, and findings were presented to senior staff and sponsors of the research. This verified our analysis and critical evidence, and familiarised personnel with the methods for representing the results.

Second, key staff members participated in a two-day cross-case validation workshop. Here, they debated each set of findings, refining and confirming them. The influence diagrams featured heavily in this process, helping to illustrate the logic we had taken to generate our findings. These discussions were recorded and refinements made where necessary to our logic and results. To illustrate, Table IV gives examples of verbatim comments given by the informants during this process, along with the finding they were taken to confirm.

Overall, the consistencies across the four companies were remarkable. Some refinements were made, inconsistencies identified, and additional anecdotal evidence offered. In some instances these subsumed the 12 sets of practices identified by Baines et al. (2009a), and in others they extended these (e.g. descriptions about skills-sets).

Finally, in reporting findings we must emphasise that our goal has been to gain a foundational understanding of operations rather than critique individual organisations. We therefore protect the anonymity of all personnel and respect the confidentiality of contributors by referring to organisations simply as Cases 1 through 4.

Key findings

Facilities and their location

Across the case companies, the delivery of advanced services is accompanied by the manufacturer having a presence within (or adjacent) to their customers' operations. This manifests as the manufacturer holding (either by adopting or creating) physical maintenance and overhaul facilities which are co-located and distributed throughout their customers own facilities.

Evidence of this was apparent in, for example, Case 3 where the company has established an extensive geographic network of autonomous dealers across the USA. Each of these has themselves placed maintenance depots

strategically close to customers of advanced services. Similarly, Case 2 has a policy of having servicing facilities within a ten-mile radius of the customer (the vehicle operator). Likewise, when Case 1 moved to offer advanced services for trains and rolling stock, they then adopted an existing network of rail-side maintenance and repair facilities for their customers.

This practice was given to exist for two principal reasons:

1. Localised facilities enable faster fault diagnostics and rectification. Largely because staff are physically closer and more likely to be available when a failure occurs, possibly witnessing an incident, and taking corrective actions more quickly and precisely.
2. Localised facilities sustain strong relationships between the manufacturer and customers at the level of day-to-day operations.

This ensures healthy communications and leads to an improved understanding of how products are used and perform. This knowledge then enables performance contingencies (e.g. knowing precisely where to locate spare parts for maintenance) and also modifications to product designs so that failure in service is less likely to occur.

The extent to which a physical presence is needed is relaxed by a number of factors. Case 4 has a policy of modular equipment design with built-in back-up systems. These modules are relatively small and portable, and ICTs are used to remotely diagnose problems and chose corrective actions. This built-in redundancy, portability and remote monitoring, means that a maintenance technician can cover several customer sites from a single maintenance hub.

Overall, we have summarised the relationship between the delivery of advanced services and facilities practices as follows:

- Finding 1. To deliver advanced services manufacturers deploy facilities that are co-located and distributed throughout their customer's operations. This enables responsive and reliable maintenance, along with on-going product design improvements. This practice is relaxed by product portability, built-in redundancy, and remote monitoring capabilities.

Micro-vertical integration and supplier relationships

The term vertical integration is usually taken as the extent to which a firm owns and takes responsibility for its upstream suppliers and its downstream customers. Vertical integration can be thought of at a macro-level (dealing with the combination of businesses) or at the micro-level (dealing with the combination of business activities or functions). This micro-level of vertical integration can also be referred to as the span-of-process or supply chain position (Baines et al., 2005). Here, our focus is on the micro-vertical integration associated with the delivery of advanced services.

This practice is difficult to observe should the servitized manufacturer exist within a wider corporation of more conventional manufacturing business units. For example, Rolls-Royce Plc can appear to have having extensive vertical integration supporting their service operations. Much of this integration is however exclusive to business units engaged with conventional product manufacture. Only by looking within the corporation does the micro-vertical integration become apparent for those business units supporting services.

Our cases revealed an intriguing picture of micro-vertical integration. As expected, all these servitized manufacturers have extended their operations forwards, to undertake a range of activities such as condition monitoring, maintenance, repair, overhaul and management of their own products on behalf of their customers. This action is implicit to the definition of servitization and is also clearly coupled with the co-location of facilities outlined in the previous section.

In all cases, however, there is also clear retention of design and production capabilities to support services deployment (rather than product manufacture). These activities are under the direct control of the business function that holds the responsibility for supporting services (sometimes referred to as the front-office).

This retention of design and production capabilities was illustrated clearly in Case 1 with their services contract for high-speed trains. On one contract in the UK they have over 50 trains, each having several air-conditioning units. When these trains were manufactured these units were sourced from suppliers in Germany, but now during the deployment of this contract the repair and overhaul of these large and complex units is carried out by the manufacturer within the maintenance facilities. A more conventional approach would be to rely on the original supplier for such services, but this in-sourcing reduces stockholding (external sourcing would require pipeline stock to increase by 120 units), and has led to design improvements that have made removal and servicing easier. Indeed, Case 1 now has a policy of wide-spread micro-vertical integration.

Such micro-vertical integration occurred across all the cases and was given to exist because it enables:

- reduced exposure to excessive stockholding delays and costs from acquiring components remanufactured in the supply chain;
- components can be more easily redesigned, removing design flaws, and so reducing chances of future failures and associated costs; and
- a route for transferring good practices developed in production into service operations (e.g. Case 1 exploits lean techniques through-out their service operations, and the route for this has been through their earlier adoption within the production operations of this organisation).

The extent of this micro-vertical integration is moderated by a range of factors. This “tail” of design and production activities appears shorter where strong links exist with a production facility and partners in the supply-base. Highly significant across all cases was the contractual relationship with these suppliers. Integration is relaxed where suppliers are willing and able to provide capabilities, that mirror the commitments given by the servitized manufacturer to their customers. Likewise, this integration is less for lower-value sub-systems where stock-holding is more affordable.

Overall, we have summarised the relationship between the delivery of advanced services and micro-vertical integration practices as follows:

- Finding 2. To deliver advanced services manufacturers integrate forwards to adopt a wide range of customer activities, and also backwards to retain design and production capabilities for complex and high-value subsystems. This enables responsiveness, continuous improvements to product designs, and offers a route to transfer best practices from production. This practice is relaxed where suppliers are willing and able to provide capabilities that reflect the manufacturers' contractual obligations to customers.

Information and communication technologies

ICTs are already widely used in production systems. For example, enterprise resource planning (ERP) is an integrated hardware and software application which links both customers and suppliers, and provides a raft of information for business management. In the automotive industry, for instance, such systems allow first tier suppliers to link directly with the procurement process of their customers to capture orders for vehicle sub-assemblies. They then enable these suppliers to place orders on their own supply chain for components and raw materials. ICTs used in the delivery of advanced services extend these capabilities.

Across our case companies there was a common architecture for such ICT systems (Figure 2). This architecture can be grouped into five functions. Monitor is concerned with capturing data from transducers located on critical components or subsystems of the product. Transmit deals with the process of communicating either basic data (e.g. temperature, pressure, run time) or fault codes (e.g. overheating, pump failure, scheduled maintenance required)

back to the manufacturer. Store is concerned with maintaining records of the transmitted data. Analyse deals with the translation of data into information. The respond function then establishes any necessary actions that are required (e.g. repair, inform customer, arrange maintenance).

Such ICT provide remote insight into the condition and use of a product, and advanced warning of impending failures. For example, all cases use ICT systems to register and diagnose faults on their products, and use the information to schedule preventive maintenance. Cases 1-3 incorporate in these systems a GPS capability which provides information on product location. These are mobile assets, and much time is saved by knowing where they are located when a fault occurs.

Cases 2 and 3 also gain significant value from knowing how their products are being used by customers. This information is used for:

- contract monitoring (e.g. monthly negotiations about equipment usage);
- to enhance productivity and reliability (e.g. incentivise and guide operator training so reducing consumables such as fuels and tyres); and
- ultimately feed through to the design process for future products.

The sophistication of ICT capabilities is relaxed by a number of factors that help to reduce risk exposure, in particular:

- assets are stationary and so do not require tracking;
- the proximity of the manufacturers facilities enable manual observation to be easily carried out;
- there are built-in back-up systems; and•there is easy access of conventional communication channels such as the internet.

Overall, we have summarised the relationship between the delivery of advanced services and ICTs as follows:

- Finding 3. To deliver advanced services manufacturers deploy ICTs that provide remote monitoring of product (asset) location, condition and use. This enables actions to manage maintenance, repair, field operation, and improvements to product design. The sophistication of ICTs is relaxed by asset location, proximity of facilities, built-in redundancy, and existing ICT systems.

Performance measurement and value demonstration

Production tends to focus on cost, quality and delivery. From one factory to the next these are prominent measures that feature strongly in conversations, performance charts, and overall reporting procedures. Such measures begin to explain the practices and technologies apparent within many production operations. Consequently, in our study of servitized manufacturers we set out to find an equivalent set of measures.

Initially Case 1 suggested that equivalent measures were product (or asset) performance, availability, and reliability. However, as the study progressed we came to appreciate that we had inadvertently sought product-centric measures, and also expected these to be similar from one organisation to the next. Subsequent cases illustrated how performance measurement differs; successful delivery of advanced services is enabled by measures focused on the outcomes aligned to individual customer processes, which are then cascaded in various forms throughout the service delivery system of the manufacturer, and complemented by indicators that broadly demonstrate value. Consequently, four categories were apparent:

1. customer facing measures;
2. internal macro-measures;
3. localised measures of contract fulfilment; and
4. value demonstrations.

The customer facing measures originate at the intersection of the customer and manufacturers operations. These measures are given by the customer to directly reflect the customers' business process. For instance, Case 1 use “lost customer (train passenger) hours” as the principal measure for their advanced services supporting tube-train contracts. Across the cases such measures are characterised by:

- a focus on the outcomes from product-use rather than delivery and sale;
- outcomes specific to individual customers; and
- on-going performance rather than a single transaction.

In all cases the “customer facing measures” are translated into macro-measures that relate directly to measurable performance of the products (assets) operation in the field (e.g. train availability, reliability, and performance). These are then cascaded into more localised performance measures and indicators (e.g. variance against standard times for product overhaul). These ensured effective alignment of activities with the customer facing measures, along with efficiency in contract fulfilment.

In addition, all case companies placed great emphasis on somewhat softer, more emotional measures, to reassure the customer of the manufacturers' efficiency in contract fulfilment. This motivation is captured succinctly by one senior manager who said: “that if the customer doesn't see what they are getting, they believe they are getting nothing”. To achieve this, all case companies expose customers to:

- operations, war, and training rooms that emphasise complexity of contract fulfilment;
- well-presented and organised maintenance facilities to demonstrate expertise and capability; and
- regular communication about actions and interventions.

Overall, we have summarised the relationship between the delivery of advanced services and performance measurement practices as follows:

- Finding 4. To deliver advanced services manufacturers adopt performance measures that reflect outcomes aligned to individual customers, and these are then cascaded into various forms throughout the service delivery system, and complemented by a set of more emotional measures that demonstrate value to the customer. These are necessitated to reflect the outcomes required by the customer, effective alignment of the manufacturers' activities to reflect these, and the on-going reassurance of efficient contract fulfilment.

People deployment and their skills

The evolution of manufacturing industry has seen significant changes in the organisation and skill-sets of workers. During the industrial revolution the introduction of the assembly line meant that relatively unskilled men and women (who were trained to carry out small repetitive tasks) could significantly increase their output over artisans in the conventional craft based systems. Today the process of servitization also demands innovations in the way people are organised and skilled.

We have partially examined this topic in our discussion of facilities practices; deployment of an advanced services contracts leads to the manufacturer developing or adopting facilities within their customers operations. As a consequence, staff who are in the front-line of services delivery are distributed through-out these facilities (rather than being a centrally organised as might be expected with production). With this in mind, we sought to understand more about these people in particular how they behave and their skill-sets.

Our investigation focused largely on skill-sets that underpin the “behaviour” of the people in the front-line of service delivery. Behaviour is known to be affected by an array of factors; physical condition (i.e. age, gender, strength, dexterity), psychological attributes (i.e. personality, attitudes, beliefs, emotions, skills), work environment (i.e. heat, light, noise, vibration), and the social environment (i.e. leadership, team working, communication, motivation and reward structures). Yet, in practice only a few of these factors can be modified by the manufacturer.

Skill-sets can be identified and developed. Some people have an aptitude for particular skills, and so are more easily nurtured, others have an aversion and so are limited in the role they can take in service delivery. Recruitment processes can test for important skills, worker selection can be carried out, and developmental training can be given.

Analysis and synthesis of our case data using mind-mapping techniques led us to identify six principal behaviours that collectively led to a positive customer experience and the skill-sets that underpinned these, namely:

1. flexibility;
2. relationship-building;
3. service-centricity;
4. authenticity;
5. technical adeptness; and
6. resilience (Table V).

The justification given for these skills is that they facilitate and sustain positive relationships with customers. However, the extent to which these skills are demanded of individual staff does vary according to role. For example, a condition monitoring technician will need stronger technical skills relative to an account sales manager, who will correspondingly need to be stronger at relationship building.

Overall, we have summarised the relationship between the delivery of advanced services and practices concerned with people organisation and skills as follows:

- Finding 5. To deliver advanced services manufacturers deploy people in their front-line (front-office) facilities that are skilled in flexible working, building relationships, service-centricity to empathise with customers, authentic and committed behaviour, technically adept and resilient to the stresses induced by this environment. These skills facilitate positive and sustained customer relationships. They are relaxed as staff move away from the front-line into more support activities (towards the back-office).

Business processes and customer relationships

Business processes are frequently overlooked during debates about advanced services. Rarely will academics or practitioners engage with this topic with the same enthusiasm as they show for new ICTs. Yet, across our cases these processes are clearly the threads that pull together the information, people, and facilities, that are essential to delivering services. Our cases revealed that processes are integrated into a wide range of customer “touch-points”, and set out to be proactive in the way they deal with issues.

Managers within Case 3 explained this situation in the following way. Conventionally, processes are arranged to respond to after-sale services (e.g. provision of spare parts and repairs). Should extensive repairs be required for equipment, there is likely to be an on-going negotiation between the customer and manufacturer. The manufacturer is paid on the basis of the time and materials invested, and may receive staged-payments. There is little incentive to progress the completion of a job. Here, the customer is often anxious about costs, seeing progress as slow, while its revenue generation from equipment utilisation ceases. Eventually the situation degenerates and senior executives become involved, and in response, the manufacturer expedites activities following a behaviour described best as “heroic recovery”.

With advanced services, however, processes are formed to deliver desired outcomes from products. At the outset of the contract, policies are established which agree the condition of the product and the actions necessary to maintain these. For example, Case 3 will typically agree an “availability” for a quarry truck of 20 hours each day, on the understanding that the remaining four hours the truck is given over for scheduled maintenance and minor repairs.

The interactions between the customer and manufacturer are then around communication rather that negotiating an action. For example, should the quarry truck become available earlier on an occasion, the manufacturer will be informed so that they can use any extra time to execute more lengthy repairs. Alternatively, the manufacturer might

on occasion struggle with a repair, meaning that the truck is unavailable. Here, the customer will be informed so that contingencies can be executed.

The outcome of the whole process is that the product is returned to be available for use rather than simply repaired. The manufacturer is incentivised to achieve this by penalties associated with the customer facing performance measures. In the example above, where the truck is not available for use, the manufacturer will be penalised.

The relationships that these processes engender between the manufacturer and the customer also differ. Yet these are easily misunderstood and inadvertently treated as a component of the service offering to the customer. In our cases a move away from a transactional approach to doing business, to one where there are strong relationships in place throughout the life-cycle of the service offering, was seen as a necessity for service delivery rather than a feature of the offering. Advanced services are enabled by such relationships, and these are fostered by people and the processes that guide their behaviour.

We have captured the relationship between the delivery of advanced services and practices with business processes and relationships as follows:

- Finding 6. To deliver advanced services manufacturers deploy business processes that are integrated into a wide range of customer "touch-points". These enable strong inter-organisational relationships, which are designed to proactively manage people, information and facilities to maintain the condition, use and location of products as they are used by customers. This practice is relaxed where incentives for contract fulfilment are less demanding.

Discussion

In this section we set out to assimilate our findings and consider the wider aspects of this study.

Developmental aspects of this study

The starting position for this programme was the work documented in Baines et al. (2009a), and so our first task is to review how this second study has extended our understand of how manufacturers manage their operations to deliver advanced services. The principal difference lies in the "characteristics of operations to support product-centric servitization" (Baines et al., 2009a). In particular, the "structural and infrastructural" categories in this earlier paper directly reflected those commonly used in the production operations management literature (Hill, 2000; Hayes and Wheelwright, 1984). Baines et al themselves were concerned that this was perhaps using an inappropriate "lens" to view the servitized organisation.

This second study shows operations to be impacted in six (rather than 12) main areas. This is not to suggest that the impact of servitization is any less pervasive than previously suggested by Baines et al., but rather that a tighter categorisation helps to highlight the "depth" of changes from production operations. Here, we have merely reconstructed the "lens" to improve the resolution for viewing servitized operations. The extent of our dataset (four cases, typically 20-30 interviews each) leaves us confident in this categorisation.

This focus on six areas has also enabled the practices and technologies to be more richly described. For example, Baines et al. said that people need to have "high levels of product knowledge and relationship development capability". Whereas, we are now able to define the skill-sets of the people involved with service delivery (e.g. flexible, building relationships, service-centricity, etc. as described in finding 5) and how/where these people are deployed in the organisation (Table V). Similarly, Baines et al. referred to a "range of technologies throughout operations", whereas we now know the form and extent of the ICT component (finding 3) along with the business processes that integrated these into the manufacturers organisation (finding 6). Indeed, this latter area was absent in the earlier framework.

This second study is also more precise in its definitions. Advanced services, in particular, are more tightly defined. Baines et al. say, for example, that value to customers is around "product availability, performance, along with risk

and reward sharing". Our definition of advanced services has now matured to be "a capability delivered through product performance and often featuring; relationship over extended life-cycle, extended responsibilities and regular revenue payments".

In addition to depth and definition, we are now also able to say more about the interactions within operations, and also between operations and the wider organisation. Internally, we have a better understanding of how the adoption of one set of practices can be offset by a second. For example, how the sophistication of ICT capabilities (finding 3) is interlinked with the facilities decision (finding 1). Cases 1 and 3 illustrate this relationship. Case 3 is sophisticated with its use of ICTs; in some instances having as many as 200 sensors on vehicles and significant investments in prognostics. By contrast, Case 1 has a lesser ICT capability to monitor high-speed trains, but here maintenance and repair facilities are more extensive.

There were also four prominent interactions between operations and the wider context of the service offering, namely:

1. the characteristics of advanced service offerings;
2. characteristics of customers;
3. the application; and
4. product design features.

For instance, Case 4 has relatively simple ICT capabilities and no repair facilities within its customers operations, but has invested in the design and development of modular and portable sub-systems. Case 4 also deals with contracts that are less complex and operating conditions that are less severe. Such interactions we not suggested in the model put forwards by Baines et al., but collectively help to convey how the "system" of technologies and practices within operations interact to deliver an advanced services contract.

An integrative framework for the delivery system for advanced services

Throughout this study our underlying ambition has been to improve understanding of the systems that successful manufacturers cultivate to deliver advanced services. We have been inspired by earlier operations management researchers, such has Schonberger (1982) and Womack et al. (1990) who tackled a similar challenge when studying systems such as just-in-time and lean. They rationalised these systems into discrete elements (e.g. Kanban, SMED, Kiezen) so they could describe and communicate their findings to a wider audience. Yet they always recognised that the organisations they studied exhibited tightly coupled systems, and that the practices they described could not be implemented in isolation with the same effect.

In much the same way, we have rationalised the systems we have observed into six components. All four cases exhibited all the practices and technologies as an integrated system. These interact with each other to collectively provide the manufacturers with the capabilities to successfully deliver the desired advanced service. This system is illustrated in Table VI.

Table VI has been developed around the findings from the previous section. Row 1 of this table specifies an advanced services offering; row 2 places operations in context of other key factors that impacting the successful delivery of the advanced service; while row 3 characterises the service delivery system. Here, each finding has been split into "what" (the practice/technology), "why" (popular evidence underpinning the practice/technology choice), and "mediation" (how the extent of adoption is impacted by other factors).

The framework in Table VI is limited to advanced services and only intended as valid in this context. Quite simply, companies can also servitize through offering a greater number of "base" and "intermediate" services (spare-parts, repair, maintenance, help-desk, etc.). Our focus on advanced services was maintained throughout this study. Universally, interviewees were reluctant to consider themselves as simply adding services to existing products, instead they described their business as "removing a customer's pain through a business model rather than product-based innovation". Seeing themselves as engaging their customers in business process outsourcing, and they then

exploit design and production-based competencies to offer wide-spread improvements in efficiency and effectiveness.

Conclusions and future work

Contribution

This paper is of a theory build nature. It sets out and rationalises the practices and technologies that are employed by a selection of successful servitized manufacturers. Bridging from the pioneering study of Baines et al. (2009a), it refines and extends the findings from this earlier work, and so provides a stronger platform for a more general theory explaining the operations management practice of servitized manufacturers. Moving forwards, we expect that the framework given in Table VI to provide the basis for generating hypotheses, which can then be developed through survey methods, and will eventually lead to the definition of a generic operations strategy for delivering advanced services.

In practice this study suggests significant implications for conventional manufacturers who seek to successfully servitize though advanced services. Table VI provides an integrative framework that illustrates how operations are commonly configured to deliver these. In particular, that they will need facilities that are co-located and distributed throughout customers operations, integrated both forwards and backwards in their supply chains, and staffed by personnel who are flexible, relationship-building, service-centric, authentic, technically adept, and resilient. These people work with business processes that are integrated into their customer's operations, and supported by ICT capabilities that enable remote product monitoring. The entire system is controlled by measures that reflect outcomes aligned to individual customers, and then cascaded down into various forms throughout the service delivery system. These are implemented by tactics that demonstrate value broadly across operations.

Limitations and confidence

As with all research, constraints were inevitable, and these place limits on our methods and findings. The most significant of these are as follows.

Our study is limited to four companies that operate in B2B environments. Although valuable as candidates for servitization, we are conscious that these are not necessarily archetypal manufacturers, and that our findings may be limited in their general applicability. This is reflects on the framework shown in Table VI, that its validity may be context specific, and further studies should test sensitivity the sensitivity of this.

Also, we have rationalised the delivery systems shared by these organisations into six practices and technologies. Although others may interpret these dimensions differently, the real limitation is that such distillation struggles to do justice to the tightly coupled and integrated systems of which these are components.

This study explored the cause/effect relationships between practices and advanced services. This was a motivation underpinning the selection of a case study methodology. The data from these studies enabled the construction of the “influence” diagrams (Figure 1). These figures illustrated the rationale. However, we recognise that this study we would need to extend considerably in order to claim strict “causality”.

More positively, we are confident in our findings. This is rooted in the extent of industrial engagement we have been fortunate in securing. Case engagement stretched three years, during which relationships strengthened and the reliability of our findings improved as a result. The culmination of this process was the validation workshop with senior executives from each of the cases, here there was extremely strong agreement across the companies with the findings presented in the paper. Finally, initial publication at conferences and as research notes as each set of findings emerged provided the means for rigorous examination of our work, allowing us to benefit from advice offered by a wide research community.

Future directions

In addition to responding to the limitations highlighted above there are two particular areas where future work would be immediately valued, namely:

1. building confidence and refinements through broader and more diverse studies; and
2. extending relevance by improving the resolution used to describe advanced services.

The findings captured in Table VI are sufficiently robust and relevant for these to be tested on a broad community of practitioners. We suggest these as propositions for further empirical studies which will help to refine and improve the validity of the results.

Selection of organisations for such a study will again be challenging. An alternative approach is to treat the unit of analysis as the entire supply chain, though this also invites complications. Either way, gathering a broad data set is the logical next step to understanding servitization and what it takes for an organisation to lead in the delivery of advanced services.

Key questions		Type of operations					
		Confirm differences against Product Focussed Operations	y/n ?	Confirm characteristics against product-centric servitized operations	y/n ?	Confirm differences against services focussed operations	y/n ?
Confirm scope of the study	1. What is the nature of the delivery system?	Tends toward physical transformation of materials into tangible goods		Tends towards physical transformation of materials into tangible assets, sold along with support services, to deliver functional capability to the customer		Tends toward creating experiential transformation through facilitation and mediation	
	2. What are the scope and capabilities of the delivery system?	Design, development, procurement, production, test, and distribution		Design, development, production, test, monitoring, maintenance, repair refurbishment, upgrading, and disposal		Design, co-development, delivery, facilitation,and evaluation.	
	3. What is the basis of the offering to the external customer?	Tends toward transactional based;focus on producing and selling material artefacts		Tends to be based on a blend of transactional and relationship;focus on providing an integrated product and service offering that delivers value in use		Tend toward relationship-based approach;focus on delivery of services	
Confirm characteristics of the service offering and associated customer value	4. What does the customer value?	Tends to focus on the ownership of an artefact		Tends to focus on product availability, performance, along with risk and reward sharing		Tends to focus on the delivery of functional result	
	5. What is the order of winning criteria for the customer?	Features of product; purchase cost of product specification and quality conformance; delivery of product		Features of product and service; total cost of ownership; availability of product and capacity to deliver services		Features of services; cost of services; quality conformance of services; delivery of services	
	6. What are the value metrics for the internal delivery systems?	Cost of production; product conformance; delivery performance		Product life-cycle costs; product conformance and service delivery; system responsiveness		Cost of service delivery; conformance to customer requirements; availability and service delivery performance	

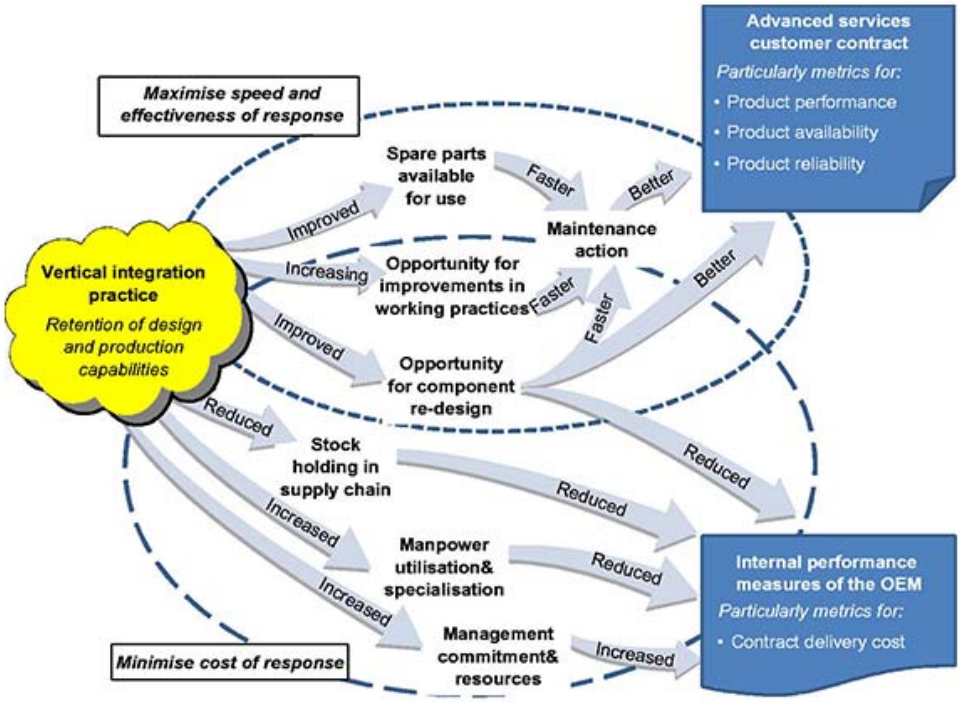
Key questions		Where possible, provide a concise answer to each question. Try to include company-specific terminology			
		Describe what they do now.	*What do they especially like about what they do now?*	*What do they dislike about what they do now; what concerns them?*	*What would they like to change in the future; what stops them?*
Confirm scope of the study	7. What is the nature of the delivery system?				
	8. What are the scope and capabilities of the delivery system?				
	9. What is the basis of the offering to the external customer?				
Confirm characteristics of the service offering and associated customer value	10. What does the customer value?				
	11. What is the order of winning criteria for the customer?				
	12. What are the value metrics for the internal delivery systems?				

Capture characteristics of the internal product and SDS	*13. What physical processes and technologies are used within the delivery system?*	Tend to exploit automation to deliver high levels of product conformance and volume with minimal worker intervention		Tend to exploit a range of technologies throughout operations to achieve efficiency in production and effectiveness in service delivery		Tend to exploit information technologies such as databases and integrated communications to enhance customer interaction	
	14. What capacities and capacity policies are in place within the delivery system?	Tend to match capacity to demand, controlling and balancing, to maximise utilisation of expensive resources		Tend to experience varying demand signals at multiple customer touch-points; need to operate with differing levels of capacity utilisation		Tend to accommodate fluctuations in demand by running at lower levels of capacity	
	15. What are the facilities within the delivery system; where are these located?	Tend to be large factories, arranged around similar products to exploit economies of scale; often located to exploit resource availability.		Tend to combine both centralised manufacturing, focusing on product final assembly and testing;multiple field facilities for maintenance and repairslocated close to market		Tend to be smaller, multiple facilities that are client friendly; located close to market; impress and reinforce relationships	
	16. What is the supply chain position of the delivery system?	Tend to be integrated vertically where such control maximises quality conformance and minimises cost.		Tend to retain vertical integration in product manufacturing,and a range of closely integrated partners to deliver services		Tend to focus only on brokerage of knowledge and capacity necessary to respond to customer requirements	
	17. How is planning and control achieved within the delivery system?	Tend to focus on replenishment systems, sometimes large and complex, that minimise stock holding costs		Tend to focus on the optimisation of product availability		Tend to rely on project management techniques and individuals to provide responsive service to customer	

	18. What people work within the delivery system; what are their skills, background; how are they managed?	Tend to use lower-skilled workers through minimisation of intervention and well-defined production routines		Tend to need workers with high levels of product knowledge and relationship-development capability		Tend to be highly skilled workers with particularly good communication skills to demonstrate value to customer	
	19. How is quality controlled within the delivery system?	Tend to have systems that measure and monitor quality conformance throughout production to minimise scrap materials and components		Tend to use product assurance methods combined with customer satisfaction assessments		Tend to rely on individuals developing acceptability criteria and judging performance against those criteria	
	20. How flexible and focused are activitieswithin the delivery system?	Tend to vary in size, though smaller product ranges are preferred to help maximise production efficiencies		Tend have limited range combined with bundles of supporting services		Tend to vary in size; smaller ranges of services are preferred to maximise delivery efficiencies	
	21. How are modifications to the delivery system designed and implemented?	Tend to use centralised capabilities to design and test new productsfullyprior to production to minimise in-market disturbances		Tend to used centralised capabilities for product design with particular consideration given tomaintenance and repair that complement services co-created with the customer		Tend to be co-created, tested, and refined with customers in the field	
	22. How is performance measurement carriedout within the delivery system;what are the metrics?	Tend to use parameters such as 'to specification,' 'to cost,' and 'on-time' delivery.		Tend to use product availability, response time, and customer satisfaction		Tend to use customer satisfaction metrics	
	23. How involved are supplies with the internal delivery system; what form does the relationship take?	Tend to apply direct; forcefully leverage to suppliers to minimise input costs		Tend to integrate internal and external supply chains into the delivery process to achieve cost effective flexibility in supply		Tend to expect same level of responsiveness and commitment from suppliers as they give to their own customers	
	24. How involved are customers with the internal delivery system; what form does the relationship take?	Tend to have limited interaction with customers, choosing instead to invest energies internally to improve efficiencies		Tend to have strong interaction with customers through relationships based on product availability and performance		Tend to invest heavily in developing and maintaining relationships with customers	

Capture characteristics of the internal product and SDS	Key questions (cont'd)	Describe what they do now.	What do they especially like about what they do now?	What do they dislike about what they do now; what concerns them?	What would they like to change in the future; what stops them?
	25. What physical processes and technologies are used within the delivery system?				
	26. What capacities and capacity policies are in place within the delivery system?				
	27. What are the facilities within the delivery system; where are they located?				
	28. What is the supply chain position of the delivery system?				
	29. How is planning and control achieved within the delivery system?				
	18. What people work within the delivery system; what are their skills and background; how are they managed?				
	30. How is quality controlled within the delivery system?				
	31. How flexible or focused are activities within the delivery system?				
	32. How are modifications to the delivery system designed and implemented?				
	33. How is performance measurement carried out within the delivery system; what are the metrics?				
	34. How involved are supplies with the internal delivery system; what form does the relationship take?				
	35. How involved are customers with the internal delivery system; what form does the relationship take?				

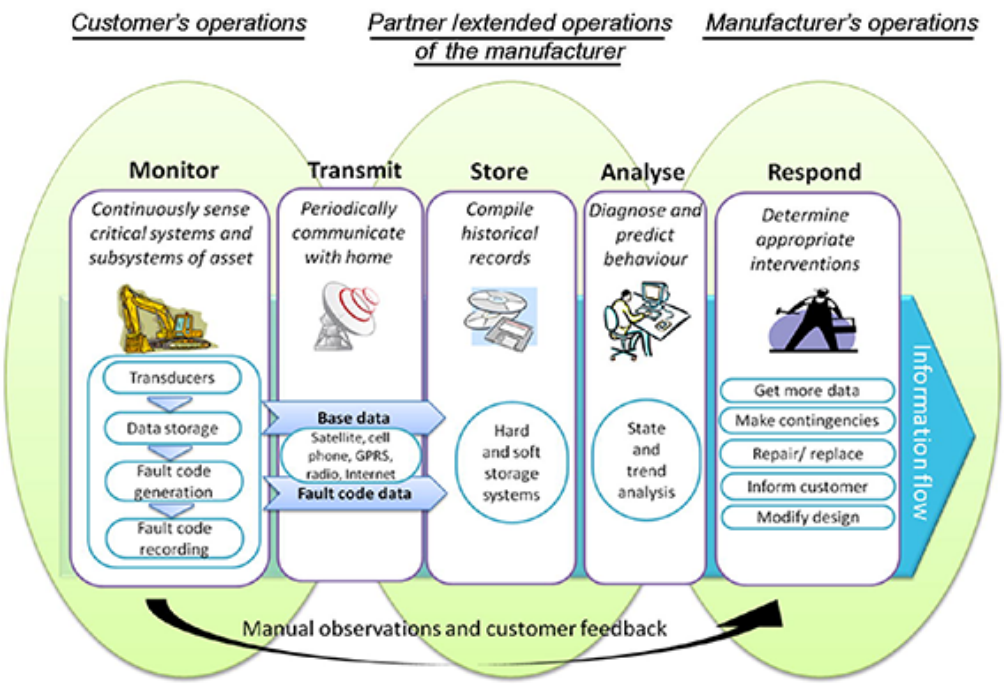
Figure 1 Example of an influence diagram generated during data analysis



Notes: This is a "work-in-progress" example that is shown here to explain the method of analysis; the findings section of this paper described the relationships that diagrams such as this helped to identify

Source: Baines *et al*. (2011b)

Figure 2 Common architecture for ICTs



Source: Baines and Lightfoot (2013)

Figure A1

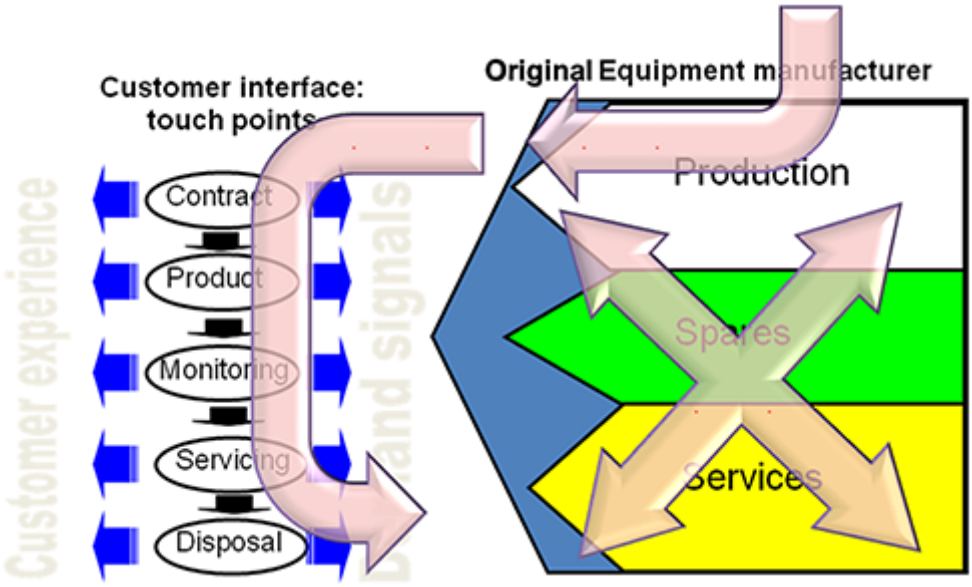


Table I Categorisation of product-services offered by a manufacturer

Type	Defined by	Organisational stretch	Examples of services offered
Base services	An outcome focused on product provision	Based on an execution of production competence (i.e. we know how to build it)	Product/equipment provision, spare part provision, warranty
Intermediate services	An outcome focused on maintenance of product condition	Based on exploitation of production competences to also maintain the condition of products (i.e. because we know how to build it we know how to repair it)	Scheduled maintenance, technical help-desk, repair, overhaul, delivery to site, operator training, condition monitoring, in-field service
Advanced services	An outcome focused on capability delivered through performance of the product	Based on translation of production competences to also manage the products performance (i.e. because we know how to build it we know how to keep it operational)	Customer support agreement, risk and reward sharing contract, revenue-through-use contact

Source: Baines and Lightfoot (2013)

Table II Preliminary propositions given by Baines et al. (2009a) and resultant research questions chosen for this study

Characteristics of operations		
Preliminary categorisation and propositions of Baines *et al.* (2009a)		Research questions for study
Structural		
Process and technology	Tend to exploit a range of technologies, throughout operations, to achieve efficiency in production and effectiveness in service delivery	What technologies are applied the delivery of advanced services? Why are these needed? How are these deployed?
Capacity	Tend to experience varying demand signals at multiple customer "touch points" and so need to operate with differing levels of capacity utilisation	What capacity policies are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Facilities	Tend to combine both centralised manufacture, but mainly focusing on product final assembly and test, along with multiple field facilities for maintenance and repair located close to market	What facilities are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Supply chain positioning	Tend to retain vertical integration in product manufacture and a range of closely integrated partners to deliver services	What is the extent of vertical integration that is applied in the delivery of advanced services? Why is this needed? How is this deployed?
Planning and control	Tend to focus on the optimisation of product availability	What planning and control systems are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Infrastructural		
Human resources	Tend to need workers with high levels of product knowledge and relationship development capability	What are the worker characteristics that are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Quality control	Tend to use product assurance methods combined with customer satisfaction assessments	What quality control systems are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Product/ service range	Tend to have limited range combined with "bundles" of supporting services	What is the extent of the product range that is applied in the delivery of advanced services? Why are these needed? How are these deployed?
New product/ service introduction	Tend to used centralised capabilities for product design, taking particular account of maintenance and repair, and that complement services co-created with the customer	What are the service introduction processes that are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Performance measurement	Tend to use product availability, response time and customer satisfaction	What performance measures are applied in the delivery of advanced services? Why are these needed? How are these deployed?
Supplier relations	Tend to integrate internal and external supply chains into the delivery process to achieve cost effective flexibility in supply	What supply chain relationships? Why are these needed? How are these deployed?
Customer relations	Tend to have strong interaction with customers through relationships based on product availability and performance	What customer relationships are applied in the delivery of advanced services? Why are these needed? How are these deployed?

Table III Summary of case study organisations and the advanced services studied

	Case 1	Case 2	Case 3	Case 4
Host organisation	European manufacturer of trains and rolling stock	European manufacturer of trucks and buses	North American manufacturer of excavation equipment	European manufacturer of office equipment
Typical characteristics of offering				
Typical advanced service	Train-life services	Fleet management of trucks	Customer support agreement	Managed print services
Customers include	Train operating companies such as Virgin Trains	Distribution companies such as Wincanton	Mine operators such as Rio Tinto, AngloGold Ashanti	Small, medium (e.g. local authorities) and large corporations (e.g. Fiat Group)
Service activities include	Maintenance, renovation, spare parts management and technical support	Inspection, maintenance and worthiness, along with visibility of driver and vehicle performance	Monitoring condition, use and location, preventive maintenance, unscheduled repair	Multi-brand print fleet management, document management, print infrastructure optimisation
Structured/ delivered by	OEM	OEM/independent distributors	OEM and closely dealerships	OEM and partner re-sellers/ distributors
Duration	Ten to 20 years	Five years	Two to ten years	One to five years
Basis of revenue received/ penalised	Reliability, availability, "hotel standards"	Miles travelled/time out of service	Fixed dollar per operating hour/ hours out of service	Pay per copy, reduced "total cost of ownership"

Table IV Examples of feedback given during the cross-case validation workshops

Theme	Examples of verbatim extracts/informant	Resulting proposition
Facilities and their location	"It's about taking over existing facilities and navigating your way through that."[b] "Facilities are about people as well as premises."[j] "We have to deliver service at the point the customer uses it."[a] "Facilities enhance the visibility of the brand."[c] "We get the business because we're there, and once we are it increases the customer's costs to switch."[g]	Facilities are co-located and distributed throughout customers operations
Micro-vertical integration and supplier relationships	"We move forwards into the customers operations,"[j] "We have to keep control if we are to respond, but it's not just about responding, our capabilities help us get the cost down."[b] "Our operations, and our customers operations, we meld at the interface."[c]	Integrated to ensure control over responsiveness and continuous improvement
ICTs	"Condition monitoring has to link with our business processes. It has to link with budgeting and financial systems."[e] "The technology system isn't the issue, knowing how to use the information is."[h] "We think of it as the sentiment asset."[k]	Remote asset monitoring to inform and advancing actions on maintenance, repair and use
Performance measures and the demonstration of value	"The principal measures have to be those that help our customers succeed in their business [...]"[a] "My performance measures are given to me by my customer [...]"[j] "Key measures are contract specific [...]"[c] "We scale our KPIs to what's important to the customer [...]"[i] "We have budget templates for the time/cost of activities in the delivery of contracts, and we measure ourselves against these [...]"[d]	Measures focused on the outcomes aligned to individual customers, and complemented by broad demonstration of value
People deployment and skills	"You've missed out resilience, people need to be resilient."[d] "Front office people have to be the advocate for the customer."[f] "Technician is the highest trusted person on the job."[c] "You must have courage; tell the customer the truth."[g]	Staff, co-located in a front-office, and flexible, relationship builders, service-centric, authentic, technically adept and resilient
Organisational processes	"It's all about pre-agreement."[e] "Frequent communication and reporting keeps the process smooth and give the customer peace of mind."[j] "It devolves decision making authority"[k]	Proactive and customer integrated to manage the condition, use and location of assets in the field

Notes: [a]MD UK operations, Case 1; [b]director of strategy, Case 1; [c]vice president services, Case 2; [d]services manager, Case 2; [e]world-wide technical support, Case 2; [f]marketing director, Case 2; [g]MD UK sales, Case 3; [h]UK technical support, Case 3; [i]European services director, Case 4; [j]director of services, Case 4; [k]service engineering manager, Case 4

Table V Desired behaviours and supportive skill-set

Desired behaviour	Supportive skill-set	Description of skill-set
Prepared to vary working hours or task to match customer demand	Flexibility	Ability to modify working routine in order to comply with customer requirements
Readily have meaningful conversations with customers. Forging strong people/ team relationships with other staff within the front-office	Relationship building	Ability to develop and sustain close customer trust, and similar relationships with other staff internal to the manufacturer
Appreciating the consequences of an equipment failure on the customers of our customer. Talking to people, engaging people, and understand where they are coming from	Service-centricity	An empathy with customer's problems and delivering against these; capable of putting themselves in the customer's shoes
Demonstrating belief in the manufacturer, its products and services. Only making commitments that can be fully delivered	Authenticity	Genuinely committed to delivering a successful outcome for the customer; prepared to tell the customer the truth
Being able to understand the consequences of an electrical sub-system failure on a machine	Technically adept	Understanding of the principal operation and sub-systems of products and equipment
Appreciating when the customer's anxiety is with the situation although it may come across as more personal: being able to sleep at night!	Resilience	Capable of dealing with the personal stress incurred by working at the frontline with the customer

Source: Baines and Lightfoot (2013)

Table VI Integrative framework of the delivery system for advanced services

Factor	*Characteristic*		
1. Delivery of an advanced services offering	Advanced service: capability delivered through product performance and featuring: relationship over extended life-cycle; extended responsibilities, risks; regular revenue payments		
2. Within the context of the manufacturers operations	Factors beyond the scope of operations that impact the organisation's success in the delivery of advanced services include: product design features; characteristics of customer; characteristics of application; characteristics of offering		
3. Is enabled by the following			
Practice/ technology	*What*	*Why*	*Mediation*
	Characteristics of the service delivery system		
Performance measures and value demonstration	Performance measures aligned to individual customers, and then cascaded into various forms throughout the service delivery system. Complemented by emotional indicators that demonstrate customer value	Reflects the outcomes required by the customer; effective alignment of the manufacturers' activities to reflect these; and the on-going reassurance of efficient contract fulfillment	Determined by the specification of the advanced services offering
Facilities and their location	Co-located and distributed throughout their customer's operations	Enables responsive and reliable maintenance, along with on-going product design improvements	Relaxed by product portability, built-in redundancy, and remote monitoring capabilities
Micro-vertical integration and supplier relationships	Integrated forwards to adopt a wide range of customer activities, and also backwards to retain design and production capabilities for complex and high-value subsystems	Enables responsiveness, continuous improvements to product designs, and offers a route to transfer best practices from production to service operations	Relaxed where suppliers are willing and able to provide capabilities that reflect the manufacturers' contractual obligations to their customers
ICTs	Remote monitoring of product (asset) location, condition and use	Enables responsiveness by advancing and informing actions to manage maintenance, repair, field operation, and improvements to product design	Relaxed by asset location, proximity of facilities, built-in redundancy, and existing ICT systems
People deployment and their skills	People in front-line (front-office) facilities are skilled in flexible working, building relationships, service-centricity to empathise with customers, authentic and committed behaviour, technically adept and resilient to the stress	Enables responsiveness by sustaining positive and sustained customer relationships	Relaxed as staff move away from the front-line into more support activities (towards the back-office)
Business processes and customer relationships	Integrated into a wide range of customer "touch-points". Proactively manage people, information and facilities to maintain the condition, use and location of products	Enable responsiveness as conditions leading to actions are predetermined rather than negotiated	Relaxed where incentives for contract fulfilment are less demanding

Table AI

Task	Event title	Description	Who	Duration	Outputs
1	Scope study	Identify the service offering that is the focus of the study	Senior management team of OEM	Half day	1. Service business focus 2. Overview of service offering and ideally three example applications 3. Overview of how service offerings emerged 4. Overview of the service delivery system 5. Identify key customer interfaces 6. Identify key players (internal and external), and arrange introduction
2	Explore and confirm service offering with front-office	Interview customer facing personnel internal to the OEM, and understand their view of the services offering and service delivery system	Typically sales, service centres, possibly dealers	Initially 1-2 hours each	1. Refined understanding of service offering and delivery system 2. Confirm key customer interfaces 3. Ideally gain introduction to customer 4. Set-up follow-up meeting mechanisms NB: be prepared to repeat this step for more complex OEM/customer/end-user structures
3	Explore and confirm service offering with end-users	Interview customer/end-users (and other possible intermediary) external to the OEM, and understand their view of the service offering and delivery system	Typically operators, service centres, possibly dealers	Initially 1-2 hours with each	1. Refined understanding of service offering and delivery system 2. Confirm key end-user interfaces NB: be prepared to repeat this step for more complex OEM/end-user structures

Table AII

Task	Event title	Description	Who	Duration	Outputs
1	Understand end-user/customer experience of service delivery system	Interview key end-user personnel to understand/experience the service offering and delivery system. Ideally, gain understanding of how it fits into the business	Key end-user personnel	Initially 1-2 hours with each	1. Refined understanding of service offering and delivery system 2. Confirm key end-user touch-points 3. Set up follow-up meeting mechanisms
2	Follow SDS through OEM	Work back through OEM to capture key activities involved in the SDS	OEM personnel	Typically 1-2 hours with each	Refined understanding of service delivery system
3	Follow-up customer/OEM interactions	Periodically/when useful visit customers to witness interactions	End-user/customer/OEM personnel	Typically 1-2 hours with each	Complete understanding of service offering and delivery system
4	Confirm consistency of the model	Ensure internal/external views of the model coincide	End-user/customer/OEM personnel	As required	Validated process model

References

Baines, T.S., Lightfoot, H. (2013), Made to Serve: Understanding What It Takes for a Manufacturer to Compete Through Servitization and Product-Service Systems, Wiley, Hoboken, NJ.

Baines, T.S., Lightfoot, H., Smart, P. (2011a), "An exploration of vertical integrations and facilities practices within servitized operations", Proceedings of the European Operations Management Association Conference, Cambridge, UK.

Baines, T.S., Lightfoot, H., Smart, P. (2011b), "Servitization within manufacturing: exploring the provision of advanced services and their impact on vertical integration", Journal of Manufacturing Technology Management, Vol. 22 No.7, pp.947-954.

Baines, T.S., Kay, G., Adesola, S., Higson, M. (2005), "Strategic positioning – an integrated decision process for manufacturers", International Journal of Operations & Production Management, Vol. 25 No.2, pp.180-201.

Baines, T.S., Lightfoot, H., Benedettini, O., Whitney, D., Kay, J.M. (2009a), "The adoption of servitization strategies by UK based manufacturers", IJMechE Part B, Vol. 223 No.1-9, pp.1207-1215.

Baines, T.S., Lightfoot, H., Peppard, J., Johnson, M., Tiwari, A., Shehab, E., Swink, M. (2009b), "Towards an operations strategy for product-centric servitization", International Journal of Operations & Production Management, Vol. 29 No.5, pp.494-519.

Baines, T.S., Lightfoot, H., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J., Angus, J., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Micheli, P., Tranfield, D., Walton, I., Wilson, H. (2007), "State-of-the-art in product service-systems", Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, Vol. 221 pp.1543-1553.

Bastl, M., Johnson, M., Lightfoot, H., Evans, S. (2012), "Buyer-supplier relationships in a servitized environment: an examination with Cannon and Perreault's framework", International Journal of Operations & Production Management, Vol. 32 No.6.

Biege, S., Lay, G., Buschak, D. (2012), "Mapping service processes in manufacturing companies: industrial service blueprinting", International Journal of Operations & Production Management, Vol. 32 No.8.

Boyt, T., Harvey, M. (1997), "Classification of industrial services: a model with strategic implications", Industrial Marketing Management, Vol. 26 No.4, pp.291-300.

Brax, S. (2005), "A manufacturer becoming service provider – challenges and a paradox", Manufacturing Service Quality, Vol. 15 No.2, pp.142-156.

Ceci, F., Masini, A. (2011), "Balancing specialized and generic capabilities in the provision of integrated solutions: empirical evidence from the IT sector", Industrial and Corporate Change, Vol. 20 pp.91-132.

Chase, R.B., Garvin, D.A. (1989), "The service factory", Harvard Business Review, Vol. 67 No.4, pp.61-69.

Coyne, K. (1989), "Beyond service fads meaningful strategies for the real world", Sloan Management Review, Vol. 30 No.4, pp.69-76.

Datta, P., Roy, R. (2011), "Operations strategy for the effective delivery of integrated industrial product-service offerings: two exploratory defence industry case studies", International Journal of Operations & Production Management, Vol. 31 No.5, pp.579-603.

Davies, A. (2004), "Moving base into high-value integrated solutions: a value stream approach", Industrial and Corporate Change, Vol. 13 No.5, pp.727-756.

Davies, A., Brady, T., Hobday, M. (2006), "Charting a path towards integrated solutions", MIT Sloan Management Review, Vol. 43 No.7.

De Joeng, J., Vermeulen, P. (2003), "Organising new successful service development", Management Decision, Vol. 41 No.9, pp.844-856.

Edvardsson, B., Holmlund, M., Strandvik, T. (2008), "Initiation of business relationships in service-dominant settings", Industrial Marketing Management, Vol. 37 pp.339-350.

Fang, E., Palmatier, R., Steenkamp, J. (2008), "Effect of service transition strategies on firm value", Journal of Marketing, Vol. 72 pp.1-14.

(The) Financial Times (2012), "UK groups lag behind in adding services", available at: www.ft.com/intl/cms/s/0/890ae896-a1bd-11e1-ae4c-00144feabdc0.html#axzz1wKrwCKVX (accessed 30 May 2012).

Foresight Horizon Scanning Centre (2010), Government Office for Science, London.

Galbraith, J. (2002), "Organising to deliver solutions", Organizational Dynamics, Vol. 13 No.2, pp.194-207.

Gebauer, H., Friedli, T. (2005), "Behavioural implications of the transition process from products to services", Journal of Business & Industrial Marketing, Vol. 20 No.2, pp.70-80.

Gebauer, H., Fleisch, E., Friedli, T. (2005), "Overcoming the service paradox in manufacturing companies", European Management Journal, Vol. 23 No.1, pp.14-26.

Gebauer, H., Kremple, R., Fleisch, E., Friedli, T. (2008), "Innovation of product-related services", Managing Service Quality, Vol. 18 No.4, pp.387-404.

Goedkoop, M., van Halen, C., te Riele, H., Rommens, P. (1999), "Product service-systems, ecological and economic basics", Report for Dutch Ministries of Environment (VROM) and Economic Affairs (EZ).

Hayes, R., Wheelwright, S. (1984), Restoring Our Competitive Advantage Through Manufacturing, Wiley, New York, NY.

Hill, T. (2000), Manufacturing Strategy, Palgrave, London.

Howells, J. (2000), Innovation and Services, UMIST Internal Publication, Manchester.

Jick, T. (1979), "Mixing qualitative and quantitative methods: triangulation in action", Administrative Science Quarterly, Vol. 24 No.4, pp.602-611.

Johansson, P., Olhager, J. (2004), "Industrial service profiling: matching service offerings and processes", International Journal of Production Economics, Vol. 89.

Mathe, H., Stuadacher, R. (2004), "Innovative services that reinvent manufacturing", paper presented at IMS Intl. Forum, Italy.

Mathieu, V. (2001), "Product services: from a service supporting the product to service supporting the client", Journal of Business & Industrial Marketing, Vol. 16 No.1, pp.39-58.

Miller, D. (2002), "The problem of solutions: balancing clients and capabilities", Business Horizons, No.March/April, pp.3-12.

Mont, O. (2000), "Product service-systems", Lund University, Lund, Final Report for IIIEE.

Morris, B., Johnson, R. (1987), "Dealing with inherent variability: the difference between manufacturing and service", International Journal of Operations & Production Management, Vol. 7 No.4, pp.13-22.

Mulholland, D. (2000), "Technology threatens sector's profits, companies need to shift business to service, upgrade sales", Defence News, No.7 February.

Neely, A. (2009), "Exploring the financial consequences of the servitization of manufacturing", Operations Management Research, Vol. 1 No.2.

Neely, A., Benedettini, O., Visnjic, I. (2011), "The servitization of manufacturing: further evidence", Proceedings of the European Operations Management Association Conference, Cambridge, UK.

Oliva, R., Kallenberg, R. (2003), "Managing the transition from products to services", International Journal of service Industry Management, Vol. 14 No.2, pp.1-10.

RAE (2010), "Organising for services growth and productivity within manufacturing", Report to the Royal Academy of Engineering on Caterpillar, USA.

Roscitt, R. (1990), "Strategic service management", Journal of Business & Industrial Marketing, Vol. 5 No.1, pp.27-40.

Roy, R., Cheruvu, K. (2009), "A competitive framework for industrial product-service systems", International Journal of Internet Manufacturing and Services, Vol. 2 pp.4-29.

Royal Society (2009), "Hidden wealth: the contribution of science to service sector innovation", The Royal Society Report.

Schmenner, R. (2009), "Manufacturing, service, and their integration: some history and theory", International Journal of Operations & Production Management, Vol. 29 No.5.

Schonberger, R. (1982), Japanese Manufacturing Techniques, Nine Hidden Lessons in Simplicity, Collier/Mcmillan, London.

Slack, N. (2005), Patterns of "Servitization": Beyond Products and Services, Institute for Manufacturing, Cambridge.

Spring, M., Araujo, L. (2009), "Service and products: rethinking operations strategy", Journal of Operations & Production Management, Vol. 29 No.5, pp.444-467.

Tukker, A. (2004), "Eight types of product service system: eight ways to sustainability? Experiences from SUSPRONET", Business Strategy & The Environment, Vol. 14 No.4, pp.246-260.

Verstrepen, S. (1999), Servitization in the Automotive Sector: Creating Value and Competitive Advantage Through Service After Sales, Kluwer Publishers, Dordrecht, Global Production Management, pp.538-545.

Visnjic, I., Van Looy, B. (2009), "Manufacturing firms diversifying into services: a conceptual and empirical assessment", Proceedings of the 20th POMS Conference, Orlando, FL.

Voss, C. (1992), "Applying service concepts in manufacturing", International Journal of Operations & Production Management, Vol. 12 No.4, pp.93-99.

Voss, C., Tsikriktsis, N., Frohlich, M. (2002), "Case research in operations management", International Journal of Operations & Production Management, Vol. 22 No.2, pp.195-219.

Windahl, C., Lakemond, N. (2006), "Developing integrated solutions: the importance of relationships within the network", Industrial Marketing Management, Vol. 35 No.7, pp.806-818.

Wise, R., Baumgartner, P. (1999), "Go downstream: the new profit imperative in manufacturing", Harvard Business Review, No.September/October, pp.133-141.

Womack, J., Jones, D., Roos, D. (1990), The Machine That Changed the World, Maxwell Macmillan International, New York, NY.

Yin, R.K. (2003), Case Study Research: Design and Methods, 3rd ed., Sage, London.

Appendix. Data collection protocol: the overall approach to data collection during the case studies

Summary

This appendix details the approach to data collection taken during the case studies that are core to the service delivery system (SDS) project. It is structured to first give an overview of the data collection protocol within the case study programme. The basic approach to data collection is introduced as three steps, and data sought during each of these steps is described. By applying this protocol at the case study companies, we gain thorough insight into the workings of each, and generate valuable knowledge on leading practices in this area.

Overall approach to data collection

The purpose of the data collection protocol is to capture the structure and characteristics of the SDS of the original equipment manufacturer (OEM).The purpose is to explore services offered to customers (especially offerings that are the focus of the study) and then set out to understand how the OEM is organised internally to deliver these services. The internal structure of the delivery system is captured using a process modelling technique called IDEF0.

Additional information about the characteristics of the SDS are captured using data collection sheets. This data collection protocol is represented as three steps, illustrated and described in Figure A1 for further detail.

Step 1: contextualise service offering and SDS

The purpose is to focus the study and gain a broad understanding of the service offering and associated delivery systems. This is achieved through a series of interviews with key personnel at the company, each moving the investigation forward through the organisation until the service offering is understood broadly. Much of the data collected here is captured in a process model. Table AI illustrates how we navigate through the OEM to collect the data.

Step 2: expand and confirm SDS structure

The purpose of this step is to develop a thorough understanding of the SDS and capture it as a detailed IDEF0 process model (or similar). We use the customer interface as key routes into the OEM (Table AII).

Step 3: capture characteristics of the SDS

The purpose of this step is to capture the characteristics of the SDS fully. The following questions are asked of each principal activity within the SDS. Not all data are answered for each activity; taken collectively, a complete picture of the characteristics of the whole system should be apparent. In some instances, activities are associated with both product and service delivery. Here, data should be captured for both. When an activity is associated only with product delivery, the characteristics should be captured at a general level, but then no further information is sought for that activity.