RFID and Data Capture Technologies in Global Service Supply Chains: Meeting the Information Management Challenge

Martin R. Fellenz & Mairead Brady, School of Business, Trinity College Dublin, Dublin 2, Ireland
Martin.Fellenz@tcd.ie / Mairead.Brady@tcd.ie

Abstract

Data capture technologies such as RFID promise customer centric global service supply chains, but simultaneously threaten data overload. We argue that novel approaches to information management are required to successfully manage the data from sensor-based data capture technologies and to integrate them into successful inter-organizational service supply networks. We question the degree to which ICTs such as RFID as currently deployed support the customer orientation needed for successful service operations across supply chains, and identify difficulties inherent in current technology use along supply chains and in business systems. We argue for customer orientation at all stages of the supply chain, and identify the benefits of customer information that is available to all supply chain partners in real time, synchronized and updated in responsive and customer centric ways. We outline two general technical approaches, one that involves effective technical middleware along with intra- and inter-organizational coordination capabilities and another, considerably more revolutionary and ambitious in scope, that revolves around the idea of a centralized data clearinghouse.

Introduction

The provision of services typically involves immense uncertainty and complexity. These characteristics arise from service supply, service demand, and service provision issues. More specifically, they come from the broad variety of factors and inputs relevant for service creation, from the range and variability of customer preferences (and the resulting range of required service outputs), and the central role of the provider/consumer relationship as their interaction provides the setting for service value co-production. The complex and uncertain aspects of service creation, provision and consumption have given rise to complex, interlinked and increasingly global service supply chains (SSCs). In fact, even the simplest service offerings (e.g., a child's offer to wash and vacuum a neighbor's car) directly and indirectly involves numerous different products and services (e.g., detergent, water, buckets, brushes, vacuum cleaner, electricity, garbage bags, waste and waste water disposal, etc.) that are designed, manufactured, transformed, transported, regulated, marketed, offered, used, and disposed of by myriad different entities, and that often come from or end up in foreign countries.

In response to the complexity and uncertainty inherent in services, many service firms and other members of SSCs employ information and communication technology (ICT) to collect and manage information in attempts to successfully deal with the arising challenges. In theory, the collection of customer relevant data can provide the input needed to design and operate customer-centric services that are efficient, effective, and responsive. In practice, however, customer-centric data collection as well as information management and use are fraught with problems. The list of problems related to such data collection (e.g., data security, protection and privacy concerns; incompatible data formats; data quality and data corruption; etc.) and to information management (e.g., lack of interoperability of ICT systems; ubiquitous and real-time data access; selection of relevant information for specific tasks; managing linkages between datasets within and across specific systems; effective data mining and warehousing; etc.) appears endless.

In this paper we consider the role of modern data capture technologies, specifically Radio Frequency Identification Devices (RFID), that promise real interactivity and customer centric global service supply chains, as well as their implications for information management structures and processes. First, we contemplate SSC conceptions and models and then explore the role of ICT for the design and operation of such supply chains. We discuss the opportunities that RFID offers for SSCs, and the implications for SSCs and for service provision from its deployment. We then consider in more depth a central issue arising from our analysis, namely the challenges for information management in the data-saturated context created by modern data capture technologies such as RFID. A key implication in this context is the need for effective middleware solutions. Finally, we outline an ambitious approach to customer-centric information management in SSCs, namely a collaborative data warehouse as a centralized data management solution for global SSCs.

Conceptions of service supply chains

THE dominant models of supply chain management have a strong product orientation, with service supply chain models only starting to appear. The technologies used in existing supply chains generally

aim at improving production and logistical operations by increasing their efficiencies and by linking and integrating collaboration between individual supply chain partners – single loop narrow systems.
Supply chain management has four main orientations: The traditional logistics school, the modern logistics school, the integrated process redesign school, and the industrial organization school, with most research focused on the first two (Cogolini et al., 2004). All of these orientations adopt a product oriented logic in which operational effectiveness and efficiency within and across individual supply chain partners is the main objective. Thus, these schools reflect different developments of operations and supply chain management thinking dating back to origins in the Fordist era.

The service supply chain of today has developed through incremental changes to traditional, mostly product oriented practices and as such has remained inefficient, ineffective, and insufficient as a guiding model for service supply chains that can successfully address contemporary requirements while fully availing of current technological and other opportunities. For most services, elements of both product and service oriented operations need to be included. Advanced ICT must be designed and deployed to enable and support service supply and delivery in ways that the iterative adaptation of centralized legacy systems decades past their sell-by date cannot achieve. Efficiency-oriented contemporary service supply chains treat the customer as simply being the final receiver of a quasi-product. An alternative view that recognizes the central role of the customer in service design, provision and delivery would require that understanding and addressing customer requirements must be central to the design and operation of service supply chains.

The majority of global supply chain models are product-based models (e.g., the HP, SCOR and GSCF models). This focus belies the fact that services are fast overtaking products as the basis of the economic model for companies and countries. The service sector has outpaced product and manufacturing oriented sectors and replaced them as the motor of economic growth. Services account for 75% of the GDP in the United States and 70% of the aggregate production and employment in OECD nations (OECD, 2005). According to the WTO, the services sector accounts globally for $1.6 trillion of world trade.

Service science is seen as the next frontier discipline after computer and information science (Berry et al., 2006). Adopting a service perspective cannot be done by simply transferring product and manufacturing knowledge and models (Ellram, Tate, & Billington, 2004; Sengupta, Heiser, & Cook, 2006). Existing approaches to service provision need to be extended to more fully reflect service-driven global supply chain models. More research is needed on the actual transferability of our knowledge of the manufacturing supply chain to the service sector. While factors such as information sharing, distribution network systems and reliance on multiple suppliers support both types of supply chains, other factors have significantly different impacts in these different settings (Sengupta et al., 2006).

Some challenges to traditional supply chain conceptions have emerged. Initial formal conceptions of service supply chains have been offered (e.g., Baltacioglu, Ada, Kaplan, Yurt & Kaplan, 2007; Ellram et al., 2004). These model attempt to be sensitive to specific issues in service design and provision, and reflect attempts to move towards an understanding of supply chain models that goes beyond product oriented views. Similarly, Christopher (2004) argues that a more holistic view of supply chains that goes beyond an accumulation of dyadic interactions and linkages of individual supply chain partners would reflect a more useful conception of supply chains. Both approaches offer useful departures from the traditional views and inform our review of the use of ICT for service supply chains below.

ICT use in service supply chains

In tandem with the growth in services there has been a phenomenal rise in the adoption of ICT by a wide variety of companies within both product and service domains. By many ICT is viewed as the norm of business practice. Given that services by their nature process large amount of information, they can benefit from the appropriate deployment of a supporting ICT infrastructure. Many services beyond the spheres of traditional service activities such as banking, insurance and travel are also becoming heavily reliant on ICT. Overall, the dominant users of ICT can be found in the service sector (Meyronin, 2004). How can the ICT component of services be delivered? What are the challenges for this from a management perspective? If service organizations fully embrace this service logic, what are the implications for the ICT currently in use in their customer offerings, and how can ICT most usefully be deployed in ways that delivers efficient as well as customer centric operations?

In a recent study of IT along the supply chain Auramo and colleagues (2005) found that most of the ICT projects are individualistic, dyadic and that the ICT is mainly viewed from an operational perspective. Many of the systems installed are basic and proprietary and do not achieve higher level business impacts. These tailor made solutions are

difficult to copy. They found that to achieve real competitive advantage the focus must be on improving those processes that are most critical for customer services. Successful companies have been able to improve service levels and effectiveness simultaneously (Auramo et al., 2005: 96). Much ICT was designed for operational efficiencies aligned to supply chains and for the ability to track product and material orders and financial flows together with EDI as the traditional system in use. EDI, the most common form of electronic commerce, is the replacement of the paper documents, for financial transactions, by an electronic message, structured to an agreed standard and passed from one computer to another, without manual intervention. EDI is typically defined as a set of protocols used in electronic commerce that encompasses the exchange of business information in a standardized electronic form. It is a subset of electronic commerce that defines the structure for business data such as purchase orders, invoices and shipping notices. One visible form of IT-based interactions across organizational boundaries are EDI systems. Firm specific IT applications like EDI reflect the development of some level of a common electronic infrastructure between companies.
Naude and Holland's (1997) study focused on the potential of EDI to alter marketing practices through increased customer relations and economic value creation. They found that EDI was used mainly for purchasing, selling, and fund transfer, with a slow rate of maturity of systems. Reekers and Smithson (1996), using case-based research within the automotive industry that utilized transaction cost theory, resource theory, and the network perspective, found that the use of EDI enables both parties to rationalize their operations, but that manufactures optimize their production at the expense of their suppliers, which may have a long-term impact on the supplier/manufacture relationship. In research into the assimilation of EDI and the Internet for ecommerce within the supply chain, the Shell experience highlighted the use of IT to take the business into the *'realm of truly cooperative relationships between suppliers and customers'* (Chan and Swatman, 2000:81). They observed that EDI was the first stage of the implementation of ecommerce and confirmed that the driving forces for EDI and ecommerce developments changed significantly over time, from technical issues to management issues and business issues. Overall, however, the ICT use in supply chain management has been automational in nature.

Much of the growth in services, particularly in those internationally traded, has been ICT induced. Given the increased coordination cost associated with the scale necessary for global service provision, it is not clear if purely transactional advantages arising from global service offerings provide enough value for such service firms. To fully exploit global service offerings, they need to maximize the value co-constructed with their customers as well as capture a sufficient part of this value. The more value the service encounter creates, the more value can be retained by the firm, which suggests that both transactional and relational opportunities inherent in service encounters need to be vigorously pursued.

As an example, the growth in self-service technologies and co-production of services heralds new and interesting developments at the customer interface (Howard & Worboys, 2003; Meuter et al., 1998, 2000). Academics have observed the growing popularity of self-service technologies and have commented on both the positive and negative consumer perception of same (Howard & Worboys, 2003). Meuter and her colleagues' (2000) empirical study confirm that self-service technology is accepted and growing in popularity particularly when handled as a customer support rather than a cost saving initiative. They did note that only 5% of customers wanted self-service through all the stages of the decision making process but that they would use self-service as long as a human element was available if needed. It appears that the scope for deploying ICTs that support such self-service based customer interfaces is tremendous. The obvious attraction for service providers is the potential for technology-based efficiency and resulting cost savings. An important challenge for service firms, however, is to not prioritize the technological or economical aspects to the detriment of the value ultimately delivered to their customers.

In this context, a range of challenges arise for global service providers. They need to develop and deploy technological enhanced self-service interfaces that are either universally deployable or easily customizable to specific local requirements to exploit the efficiencies inherent in such interface solutions. Initial capital investment into the development of such interfaces can be large, and specific technological, organizational or managerial knowledge is required for the successful use of such interfaces. None of the above are easy or cheap to develop.

The efficiency logic employed by many global service providers (Fellenz & Bray, 2008) makes it important to consider if the quest for economic and productivity gains through automated service interfaces is useful. Is there a loss of value with a rise in ICT, a loss of the interpersonal relationship with the customer? Within business–to-business relationships a recent study showed that the use of internet-based systems decreases the nature and quality of information shared by the participants and

reduces the frequency of their interactions (Schultz & Orlikowski, 2004). Meyronin (2004) suggest that automation contributes to the building of an informational wall. He asks whether the productivity gains from automation compensate for the losses in terms of value and differentiation so often inherent in the deployment of automating technologies. How can ICT based services be distinguished in the eyes of the customer? Does electronic anonymity (Meyronin, 2004) support the service environment?

Service innovation through ICT has often seen the service moved to a transactional rather than a relational focus. For example, a relational dominant marketing practice like book selling can be transformed by placing an ICT-based interface between the customer and the supplier. Now the relational aspects that previously may have been a central part of the customer experience have been incorporated in a transaction-oriented relationship that is IT mediated. Service provision becomes skewed towards what the ICT can deliver. In general, however, ICT does not deliver the relational as much as the transactional, and an often important part of the service value can be lost as a result. ICT's electronic mediation 'tends to impoverish service relations, insomuch as the technological interface can by no means replace the wealth of human interactions on which the creation of value and the differentiation of services are based' (Meyronin, 2004: 216).

The logic of how ICT is assimilated into organizations follows Nolan's (1973) Stage Theory through stages of data processing, personal computing and network, or in Zuboff's (1988) terms automation, information and transformation. Thus the fact that the first wave of ICT assimilations has produced efficiency gains rather than relational improvements is accepted but highlights our need to move towards what Nolan called the network era. Aligned to this is the continuing move to ubiquitous computing, Weiser's (1993) 3rd stage of computing. Much of IT along the supply chain is predominantly automational in focus, i.e., it is used to automate previously manual tasks and was only slowly resulting in more effectiveness with little evidence of ICT transforming practice (Auramo, 2005).

In summary, the use of ICT in service operations promises significant improvements in information availability that aids customer-oriented decision making and relevant operations. In practice, however, ICT deployment has only furthered the efficiency oriented automation in such supply chains. Examples of ICT deployment that directly improves customers' service experiences or that increases customer value are very rare.

RFID and its implications for service supply chains

What do leading edge technologies like RFID offer for service supply chains and how can we manage the information flood expected? Pragmatic benefits include speedier product distribution, increased ability to locate specific items, theft and loss reduction, higher accuracy of available inventory data, and better real-time information on demand, among others (e.g., Thillairajah, Gosain, & Clarke, 2007; Imburgia, 2006). RFID has been heralded as the technology which will allow for transparency and speed along global supply chains. RFID provides the ability to management and monitor among various parties, data and inventory movement.

RFID is the generic name for a type of auto-identification technology that uses radio waves or wireless communication to identify objects. RFID tags have both a microchip and an antenna. The microchip is used to store object information such as a unique serial number. The antenna enables the microchip to transmit object information from the RFID tag, which transforms the information into a format understandable by computers (Angeles, 2005). Although RFID tags are not dramatically different from the existing capabilities of barcodes, RFID is considered a significant improvement as tags do not require line-of-sight to be read and can thus be read remotely, and the amount of information they can store and transmit is much higher. RFID tags are also be read in real-time, allowing the information gathered to be extremely accurate.

In theory, such automated data capture technology can provide the data input that makes possible the customer-centric integration of all service elements including suppliers, service providers, and customers. Current technology is focused at the inputs level of the supply chain with co-ordination between buyers and sellers of materials with some matched to order replenishment and overcoming the bullwhip effect. However, if the design of extant SSCs focused on the customer from the start the system would likely be different. The question is how SSCs can be redesigned to be customer centric, and what role ICTs such as RFID can contribute to such novel SSCs. At present RFID is typically deployed as the data capture element of operational data management architectures which capture data about events along that supply chain. There is little if any integration with events at the consumer-facing edge of the enterprise. Moreover, typical RFID deployments are focused on intra-organizational events (such as movement from one warehouse location to another). True integrative, cross-organizational deployments with effective cross-entity data sharing is almost unheard of.

In practice, however, RFID is a product focused technology (Brady & Fellenz, 2007) and as such is

focused primarily on solutions within the product domain. The standards for RFID are called Electronic Product Code (EPC) which developed from the MIT Auto-ID centre and now are based at EPC Global, a membership organization consisting mainly of early adopters of the technology. Predefined algorithms produce a unique Uniform Resource Locator (URL) which provides the 'map' to retrieve a host of product related data.

Given the predominance of product-oriented RFID usage, central questions are how service provision can effectively be supported by this technology, and what technological service roles and challenges RFID is not able to successfully address. RFID uses in the service arena are starting to develop, and some successful services make use of them at the customer interface. EZPASS is a good example of a service provision monitored and managed through RFID and acceptable to the customer. Smart shelves in retailing is another RFID-based innovation that has potentially positive implications for consumers. However, both of these examples are service propositions that have been mainly derived from service supply chain partners' drive towards efficiency rather than from their understanding of distinct, and novel, customer needs and demands. Their use could be integrated with the existing information processing capabilities in the service organizations. Ultimately, one can argue that they were deployed, at least in part, because the use of RFID could be matched with legacy systems within organizations.

There are problems with deploying RFID to holistically support service operations. Of critical importance is that unreflected use of technologies such as RFID can cement the efficiency-oriented product logic of traditional supply chain thinking. Imburgia (2006) for example suggests that linking EDI and RFID will provide a powerful suite of tools: pipeline management, synchronization of parties through RFID/EDI/XML; visibility of opportunities, accurate forecasting, bottom line reduction, and flexibility and responsiveness. There is, however, no mention of how such integration of RFID and ICT legacy systems will make operations more responsive to potentially changing customer needs and preferences. In fact, the efficiency motive typically driving ICT design and deployment in global service companies (Aharoni, 1996; Fellenz & Brady, 2008; Mathe & Dagi, 1996) bodes ill for the improvement for services unless fundamentally changed approaches are deployed to design, implement, integrate, and operate RFID based data collection systems in service contexts.

Information management and systems integration

RFID presents the pragmatic difficulty of information management in an already data-saturated situation. The price of ubiquitous use of RFID is excess data. Bearing in mind that many companies struggle with the current level of data that they possess (Jones, Clarke-Hill, Shears, Comfort, & Hillier, 2004), it is likely that any additional information produced by advanced technologies will be met with considerable confusion and possibly trepidation. In the case of RFID, Levinson (2003) points out that *"RFID technology is going to generate mountains of data about the location of pallets, cases and cartons. It is going to produce oceans of information about when and where merchandise is manufactured, picked, packed and shipped. It is going to create rivers of numbers,…which will have to be stored, transmitted in real-time and shared with warehouse management and others"* (2003:1). In spite of the wealth of information available to them, retailers admit to using only a fraction of the data they already have stored in their data warehouses (Jones et al., 2004). RFID technology has the potential to become "*the mother lode of personally identifiable data collection for commercial enterprises"* (Kelly & Erickson, 2005: 707). Jones and colleagues (2004: 168) affirm that RFID systems will gather a "*massive and continuous stream of real time data*", but that "*the storage and transmission of these data will place severe strains on many retailers' current ICT infrastructure*". There are estimates for trillions of network requests as data about each item is available in real time. How can we manage the data from RFID when current information management systems and approaches are already overwhelmed?

Many of the benefits of increased data availability in production environments is the reduction of operational uncertainty. While the effective use of the massive amount of data captured by RFID systems throughout the supply chain is a real problem (Li et al., 2006), the added focus on making customer data available up the supply chain in accurate, timely, and usable manner is adding significantly to this challenge. This is not simply an issue of more effective data management. In many production environments, the information flowing to and beyond the de-coupling point, or "the point at which real demand penetrates upstream in a supply chain" (Christopher, 2000: 41), can be expressed satisfactorily in quantitative terms. In a service environment, however, where qualitative as well as quantitative changes in both output and process requirements can happen frequently, the challenge lies in finding ways to communicate rich, qualitative information along with relevant quantitative data effectively. Moreover, adaptive (i.e., flexible, responsive, and innovative) service provision requires that the ICT systems used to provide this

informational input within and across organizational boundaries perform this duty in ways that support complex, interactive, and often unprogrammed decision-making. All of this needs to function in settings where competitive pressures abound, where multiple supply-chain partners operate both independently and concertedly, and where the self-interests of the involved partners usually only partly aligns with each other. Thus, the potential for opportunism is significant, mistakes are likely, and commercial stakes are high. It is not clear if the availability of both operational and customer data from RFID and other sensor-based data capture technologies will result in support, or simply in additional difficulties, for the immense coordination challenge inherent in complex global SSCs.

A survey by O'Connor (2004) found that more than half of the respondents expressed concern with the quality and synchronization of the data generated by RFID devices. Jones and colleagues (2004) support this view, finding that a significant amount of noise and dirty data are generated from an RFID-based system. Successful information management will require significant increases in bandwidth, access opportunities and storage capacity (Jones et al., 2004), along with organizational arrangements that can support the intra- and inter-organizational coordination tasks, and relevant and comprehensive training for employees that use such ICT systems.

A central role for the success of such complex ICT systems will be the middleware that can help to link subsystems and transmit data across technological and organizational boundaries (Goyal & Krishna, 2007). Such middleware is central to the tasks of controlling the flow and providing filtering, classification and aggregation of relevant data. What is not clear is how these should be designed, and by whom. Coupled with the current lack of clear knowledge of SSCs, and exacerbated by the lack of the necessary information management skills within most business functions relevant for service design and provision, this design challenge is immense.

Beyond developing deeper skill sets in information management in many different functions, both technological and organizational arrangements need to be redesigned. It will take a fundamental effort to adapt current SSCs to make comprehensive use of the data available from fully rolled out and integrated RFID deployment for operational and customer data collection. Within organizations, members of different functions need to work together to challenge the collected data and their implications for service design and provision on an ongoing bases (Fellenz & Brady, 2008). The more market conditions and customer preferences change, the more different demands need to be identified and reflected in the information available for use. Moreover, the more the type of information that is relevant for decision-making changes, the more flexible and adaptable the ICT tools for investigating the data need to be. In short, what is needed is an adaptive and dynamic ICT infrastructure. Contemporary systems typically do not allow for this level of flexibility. Using current data and information management techniques will not deliver the full promise of advances in data capture technologies that provide bandwidth, storage capabilities, and data access far beyond traditional systems.

The middleware currently can take the data from EPC readers, store the data in an operational database, check for errors and operational anomalies and apply business intelligence to identify critical business-level events than propagates the data via the enterprises' middleware to another database or user or both. There are multiple layers currently and multiple systems along the supply chain and adding more is not the solution. We suggest a new perspective which centralizes the data and which is independent of any member of the supply chain but which can be accessed by all. How to cope with all the feeds of data will be an issue. From on distributor reader for example at a distribution center with 10 dock doors you need to integrate the readers and also have data feeds to local inventory databases, one to regional databases, one to financial database and where is the customer. What information is needed by all and what is the customer centric information that can really challenge the data to support innovation in service delivery. The need to build a RFID architecture which is scalable is going to become crucial. What we suggest is that we rethink how we have designed the current global supply chain and we rethink the actual business needs and build an innovative platform or data centre for this data. As we are challenged to envisage the amount of data from RFID and other data capture technologies as the technology advances the data will increase and data management in a novel transformation rather than automational view will be critical. If we continue to add new technologies to old process we continue to underuse and underexploited what could be really important chances for real change within organizations. In its current deployment RFID is an automation tool. It is instructive to ask if by viewing it differently it could move away from process automation and towards real innovation in services. Currently, most RFID applications are within narrow closed loop systems rather than an open networked system. Thus, beyond the technical challenges of interoperability, security, ubiquitous access and so forth, the difficulties of creating functional integration among many different, often bespoke and proprietary systems along SSCs needs considerable and immediate attention.

Christopher (2004) suggests that all supply chains should be operated in such a way that customer are serviced at higher levels yet at lower costs. Yet the reality is different: Service issues abound and many individual systems are, and much of the integration between and among individual systems is, inefficient and ineffectual at judging and managing demand and supply. Both manufacturing and service sectors need to equip themselves with tools to detect changes in their supply chains and be prepared to counteract any undesirable consequences. While in theory RFID gives such real time ability, the pragmatic technical solutions and the overarching conception of how RFIDs capabilities can beneficially be used for service operations remain open.

Any successful solution to this service quagmire, we argue, will be build around real customer orientation at all stages of the SSC. This necessarily includes customer-relevant information to be available to all relevant parties in usable, updated, and suitably processes formats. Effective middleware solutions that help create successful data flows across organizational boundaries up the SSC, and that assist in the functional integration of both customer-oriented and operational information originating and held in distributed systems, may only be able to provide some of the necessary functionality. A more ambitious approach to these integration, coordination, and information management challenges is discussed in the next section.

Data clearinghouse approach

Another approach to address the many coordination, information management, and customer orientation challenges that contemporary SSCs face is based on a centralized solution to data sharing and access. A data clearinghouse that combines operational data from all relevant SSC partners with customer relevant data collected by downstream SSC partners that have direct customer interaction promises, in theory, the opportunity to integrate and distribute relevant data efficiently and effectively. In short, such a data clearinghouse would likely be either a shared effort of many SSC partners (with possibly a separate legal standing, e.g., a membership organization), or a service provided by a third party to the members of a SSC. Such a data clearinghouse would need to address a set of core requirements to fulfil its integration and collaboration functions. These requirements include ubiquitous and reliable data access for authorized SSC members, adequate data security; access management protocols that protect commercially or otherwise sensitive data from unauthorized access even from within the SSC; the provision of an audit trail of data submission, access and use; compatible and mutually agreed upon data formats/standards; agreements on cost sharing; and protocols on data collection, maintenance, and future data format development. Partners would require IT systems that are fully compatible with clearinghouse systems. This includes both data capture systems as well as operational control and Management Information Systems used for service relevant decision making.

The concept of a central data clearinghouse for SSCs promises a range of benefits that current, largely dyadic linkages among members of SSCs simply cannot offer, provided that the relevant problems and issues that arise can be solved. Benefits that could accrue to SSC members include efficiency gains through integration of operational and customer-centric data (including information on consumer preferences and shopping behavior that may help predict trends and improves production planning); opportunities to push the penetration point further up the SSC because data is available to upstream players in unprocessed form, avoiding cumulative errors and information distortion as information travels through dyadic interfaces up the SSC; more timely information distribution up the SSC which can help avoiding the dreaded bull-whip effect; and the reduction of interface management and data and systems compatibility issues. More importantly, from a service perspective it would enable fundamentally improved opportunities for collaboration among SSC members in response to specific consumer requests and changing consumer needs.

The challenges of a data clearinghouse approach to information management in SSCs include organizational, managerial, technical, and legal issues. More pragmatically, it requires a comprehensive and well supported business case that shows how sufficient additional value over and above what current SSC arrangements offer to the collective of SSC partners can be created. This additional value can then be distributed across all relevant players to induce them to participate in such an approach. This may be easier said than done. Concerns about data security by SSC members and about data protection by consumers may stymie such approaches. Moreover, fears of SSC partners of opportunistic behaviors by other SSC members may be induced or enabled by such a data clearinghouse need to be considered. As an example, upstream players may use data collected and made available by downstream players to provide alternative or competing service offerings directly to consumers, or may supply service inputs to competitors of the downstream players. In effect, all factors that contribute to any SSC member's unwillingness to share data with others for commercial and competitive reasons would need to be successfully dealt with.

At present, a data clearinghouse approach appears futuristic. Nevertheless, the required technology for data capture and information management and sharing already exists, although substantial adaptation would be required. What is missing is an understanding of how SSC partners can better collaborate, and how such collaboration and information integration of operational and customer-oriented data couls successfully be achieved. From a pragmatic perspective, it is not clear where the impetus for change toward such a collectivist approach could come from. Powerful downstream players in service industries such as retail (e..g., Walmart and Metro) or financial services show little interest in deploying RFID and other technologies for anything but efficiency oriented objectives. Similarly, given that the data clearinghouse approach is not based on a technological innovation per se, there is little self-interest of technology providers to drive towards such a solution. The large systems integrators may lack the credibility to sell this concept as it may appear to be a market creation exercise on their part. It is more likely that local integration efforts, assisted by technology and systems integration providers, may prove to be successful for parts of SSCs (particularly downstream parts). Such local solutions may create a critical mass of SSC partners to provide working models approximating data clearinghouses as described above. This may provide the test cases that can generate the attention and the proof of cocnept needed to drive conceptual and practical developments that can aid the development of this idea.

Conclusion

Along global SSCs that already struggle to provide flexible, responsive, and innovative services, the deployment of modern data capture technologies threatens to overwhelm existing information systems with a flood of data. What is needed is the provision of systems that help to cope with the available mountains of real-time data in ways that effectively and efficiently help to improve service provision and innovation. Only a part of this challenge is technical – much needs to be done in terms of appropriate organizational arrangements, available skill sets among relevant personnel, and the appropriate inter-organizational arrangements and SSC-wide business models.

Considering the challenge of information management in this context affords the opportunity to rethink current IT and management systems and their role in supporting service innovation and provision. Focusing on technical aspects of new technologies along global SSCs and ignoring opportunities to study and develop novel approaches to deploy available technologies in service of more customer-centric SSCs would be extremely shortsighted. The chance to enable a fundamental transformation of global SSCs through novel ICT deployment and use is an opportunity too valuable to ignore.

References

Aharoni, Y. (1996). "The organization of global service MNEs". *International Studies of Management & Organization,* 26(2): 6-24.

Angeles, R. (2005). "RFID technologies: Supply-chain applications and implementation issues". *Information Systems Management,*.22(1): 51-61.

Auramo, J., Kauremaa, J., & Tanskanen, K. (2005). "Benefits of IT in supply chain management: An explorative study of progressive companies". *International Journal of Physical Distribution & Logistic Management,* 35(2): 82-100.

Baltacioglu, T., Ada, E., Kaplan, M., Yurt, O., & Kaplan, Y. (2007). "A new framework for service supply chains". *The Service Industries Journal,* 27(2): 105 – 124.

Berry, L., Venkatesh, S., Parish, J., Cadwallader, S., & Dotzel, T. (2006). "Creating new markets through service innovation". *MIT Sloan Management Review,* 47(2): 56-63.

Brady, M., & Fellenz, M.R. (2007). "The service paradox: Supporting service supply chains with product-oriented ICT". *IEEE/INFORMS International Conference on Service Operations and Logistics, and Informatics (SOLI)*, Philadelphia, USA, August 27-29, 2007.

Brady, M., Saren, M., & Tzokas, N. (2002). "Integrating Information Technology into Marketing Practice – The IT Reality of Contemporary Marketing Practice", *Journal of Marketing Management,* 18(5-6): 555 – 578.

Chan, C., & Swatman, P. (2000). "From EDI to internet commerce: The BHP Shell experience". *Internet Research, Electronic Networking Applications and Policy*, 10(1): 72-82.

Christopher, M. (2004). *Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service*, 2nd Edition. London, Pearson.

Cogolini, M., Cozzi, M., & Perona, M. (2004). "A new framework for supply chain management: Conceptual model and empirical test". *International Journal of Operations & Production Management*, 24(1): 7 -41.

Ellram, L., Tate, W., & Billington, C. (2004). "Understanding and managing the services supply chain". *Journal of Supply Chain Management,* 40: 17-32.

Fellenz, M.R., & Brady, M. (2008). "Managing the innovative deployment of Information and Communication Technology (ICT) for global

service organizations". *International Journal of Technology Marketing,* 3(1):39-55.

Goyal, K. & Krishna, D. (2007). "RFID Middleware: Integration to the Entire Supply Chain". In S. Rane (Ed.), *RFID: Changing the Face of Supply Chain Mana*gement, pp. 112 - 129. Colcutta: ICFAI Books.

Howard, M., & Worboys, C. (2003). "Self-service – A Contradiction in Terms or Customer-Led Choice". *Journal of Consumer Behavior,* 2(4): 382-393.

Imburgia, P. (2006). "The Role of RFID within EDI: Building a Competitive Advantage in the Supply Chain". *IEEE International Conference on Service Operations and Logistics and Informatics,* Pg. 1047-1052.

Jones, P., Clarke-Hill, C., Shears, P., Comfort, D., & Hillier, D., (2004). 'Radio frequency identification in the UK: Opportunities and challenges. *International Journal of Retail & Distribution Management*, 32(3): 164-174.

Levinson, M. (2003). "The RFID Imperative". CIO Magazine, 1st December 2003: 2-11.

Li, S., Visich, J., Khumawala, B., & Zhang, C. (2006). "Radio frequency identification technology: applications: Technical challenges and strategies". *Sensor Review*, 26(3): 193-202.

Kelly, E., & Erickson, S. (2005). "RFID tags: Commercial applications v. privacy rights. Industrial Management and Data Systems". 105(5/6): 703-713.

Mathe, H., & Dagi, T.F. (1996). "Harnessing technology in global service businesses". *Long Range Planning*, 29(4): 449 – 461.

Meyronin, B. (2004). "ICT: The creation of value and differentiation in services". *Managing Service Quality,* 14(2/3): 216-225.

Meuter, M., Ostrom, A., Roundtree, R., & Bitner, M. (2000). "Self-service technologies: Understanding customer satisfaction with technology-based service encounters". *Journal of Marketing*, 64(3): 35-46.

Naude, P., & Holland, C. (1997). "What are the benefits of IT-based supply chain relationships?" In *Conference proceeding of the 5th International Colloquium on Relationship Marketing,* Cranfield University, November, pp 1-24.

Neu, W., & Brown, S. (2000). "Manufacturers marketing services: Factors underlying the changing business domain". *American Marketing Association Conference Proceedings,* Chicago, 11: 189- 191.

Nolan, R. (1973). "Computer data bases: The future is now". *Harvard Business Review*, September-October: 98-112.

OECD (2005). *Annual Report*. OECD Publications, Paris, Pg. 1-47.

Prahalad, C., & Ramaswamy, V. (2004). "Co-creation experiences: The next practice in value creation". *Journal of Interactive Marketing,* 18(3): 5-14.

Reekers, N., & Smithson, S. (1996). "The Role of EDI in inter-organisational co-ordination in the European automotive industry". *European Journal of Information Systems*, 2: 120-130.

Schultz, U., & Orlikowski, W. (2004). "A practice perspective on technology-mediated network relations: The use of internet-based self-serve technologies". *Information Systems Research,* 15(1): 87-106.

Sengupta, K., Heiser, O., & Cook, L. (2006). "Manufacturing and service supply chain performance: A comparative analysis". *Journal of Supply Chain Management,* 42: 4-15.

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2003). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies.* McGraw Hill, New York, NY

Vargo, S., & Lusch, R. (2004). "The four service marketing myths: Remnants of a goods-based, manufacturing model". *Journal of Service Research*, 6(4): 324-335.

Thillairajah, V., Gosain, S., & Clarke, D. (2007). "Realizing the promise of RFID: Insights from early adopters and the future potential". In W. Lam & V. Shankararaman (Eds.): *Enterprise architecture and integration: Methods, implementation, and technologies*, pp 306 – 318. IGI Global.

Weiser, M. (1993). "Some computer science issues in ubiquitous computing". *Association for Computing Machinery. Communications of the AC*M, New York: 36(7): 74-85.

Zuboff, S. (1988). *In the Age of the Smart Machine.* Heinemann Professional Publishing, Oxford.