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OM Forum

The Service and Information Economy: Research Opportunities

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The U.S. economy is already dominated by service and information-intensive industries in terms of both gross national product and jobs, and these trends are visible in all major world economies. These economic shifts are driven by productivity changes, which today often depend on new information and communication technologies. These changes can be thought of as service industrialization, which underlies productivity improvements. Industrialization is, in turn, closely related to the design and operation of service processes at the level of firms and sectors. Some of the implications for process economics, operations strategy, and process management are outlined, and the opportunities for research in operations and technology management related to these trends are discussed.

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Introduction

Service sectors taken together contribute the largest component of gross domestic product (GDP) in all major economies around the world. For most large economies, they are also the biggest source of jobs and wages. A second major trend visible in major economies is that toward information-intensive industries. In the United States, information-intensive sectors already contribute over 60% of GDP. At the intersection of these two trends are information-intensive services, which constitute over 50% of U.S. GDP (Porat and Rubin 1977; Apte et al. 2008, 2012; Wolff 2006). Other economies appear to be moving in the same direction, albeit at varying rates and with varying degrees of progress (Bidault et al. 2009, Choi et al. 2009, Cruz et al. 2009, Godoy et al. 2009).

The traditional explanation for the shift from products to services is that it is caused by the higher growth of productivity in manufacturing (products) relative to services (Baumol 1967). A more recent view (Iscan 2010, Karmarkar et al. 2015) is that higher productivity growth in a sector at first causes an increase in the GDP share of that sector followed eventually by a second phase of decline as markets mature and saturate. In developed economies like the United States and other Organisation for Economic Co-operation and Development countries, manufacturing is in the declining share phase. For the United States, it also appears that physical services such as freight and distribution might be at a plateau for GDP share, and perhaps approaching a declining phase as well. But information-intensive services appear to be in the former phase, with growing productivity accompanied by growing GDP, labor, and wage shares. The implications of these changes for industries, firms, jobs, and wages will be substantial well into the future.

The trends toward services and information intensity are linked, as their large and growing intersection suggests. Of course, information and communication technologies play a large role in that intersection. One way to look at this role is as a process of "industrialization" of services (Levitt 1976; Karmarkar 2004, 2008, 2010, 2014). The results of that process have finally shown up in the aggregate service productivity statistics for the United States (Jorgenson and Stiroh 2000, Stiroh 2002). The realities of industrialization have to do with firm-level implementation of automation; outsourcing; geographic dispersion, including off-shoring; operations shifting, including self-service; process engineering at both operational and sector levels; service redesign; and new service development. Except for self-service and operations shifting, these are not unlike what we have seen in manufacturing. These activities are supported by the information infrastructure that includes telecommunications, the Internet, and Web services. Here too, there

is a close analogy with the logistics infrastructure that supports manufacturing and supply chains.

The technology-driven industrialization of information-intensive activities has spanned centuries starting with the abacus, the printing press, the typewriter, and the mechanical calculator. Even the modern phase is already over a century old, starting with telecommunications and broadcasting, then accelerating with electronic processing tools including computers, calculators, and word processors, and culminating with data networks and the Internet. The most recent developments include mobile communications and the "Internet of things." The older technologies led to the industrialization of information-intensive services in terms of logistics, distribution, and the back room. The modern phase is taking the transformation further into the industrialization of the service front office, last mile delivery, market making, and core service processes.

Our research in operations management (OM) appears to lag the trends in the economy in certain respects. Service topics have been a fairly substantial part of OM research in the past. However, the major focus has been on physical and "systems-intensive" services like transportation, freight, and logistics. Human- or people-intensive services (e.g., leisure and hospitality) and information-intensive services (e.g., financial services) have received less attention. There are indeed successes in areas such as revenue management, call center operations, capacity management (queues), and healthcare operations. But even here, the tendency is to study resource management using traditional tools, rather than the core value producing processes related to people and or information.

In this paper I discuss some emerging areas for research in services and information-intensive sectors that I believe are interesting and useful, as well as being in high demand in teaching programs. Productivity and industrialization are at the core of current economic shifts. The strategic issues include service design, networks and chains, pricing, competition, and contracting. The operational issues include the management of processes for value, cost, time, and quality, subject to the special features of process behavior and process economics in these areas.

Service Economics

The usual product-centric paradigm for a market transaction consists of a simple boundary with production on one side and consumption on the other. But with services, the intangibility of outputs and the presence of the customer mean that the transaction is not as simple. This is familiar ground for operations, cast in terms of the degree of customer contact (Chase 1978). One aspect of customer presence is that the production function for services can include customer inputs of time, effort, material, equipment, and knowledge (Fuchs 1968, Karmarkar and Pitbladdo 1995, Chase and Apte 2007). In the extreme case of coproduction processes, outputs can depend conjunctively on both consumer and provider (Roels et al. 2010). This is a very fundamental issue for many services, affecting all aspects of economic and management analysis. For example, for a multiplicative production function, the productivity of each factor depends on the levels of other factor inputs. In terms of a familiar example, the output of education processes depends jointly on the effort of both the teacher and student. Lack of effort on the part of one collaborator renders the efforts of the other ineffective. Correspondingly, matching a superior and diligent instructor with a superior and diligent student leads to results that are more than the sum of the parts. Naturally, education service providers try to acquire customers who are likely to collaborate more effectively and vice versa. In some cases, like electronic banking, it appears that the service system itself may promote matching through self-selection (e.g., Xue and Harker 2002, Hitt and Frei 2002). Clearly, training and educating customers to be more efficient coproducers can be a worthwhile investment. That training process is still visibly underway at airline check-in kiosks and grocery checkout counters, and less visibly in the vast area of online consumer services.

Many questions arise regarding collaborative or joint production. A very basic one is about how markets function when both buyer and vendor coproduce. Roels et al. (2010) study the efficiency of contracts for collaborative production in contexts like business consulting and knowledge-intensive projects. Roels (2014) examines the implications of the form of the joint production function as it ranges from additive to multiplicative. Rahmani et al. (2013, 2014) study the effect of contracting on how collaborators choose to participate and exert effort in joint projects, and how the organization and leadership of collaborative teams affect the inherent free-riding problems that arise. The combination of collaboration and the lack of observability with respect to effort and output exacerbates the difficulties of controlling processes for efficiency and quality, determining responsibility, and sharing rewards. In many educational systems, when a student performs poorly, instructor-controlled tests and grades place the responsibility for outcomes largely with the student. If tests are standardized and administered by third parties, as with the Common Core initiative for schools, the onus can shift toward the educators. However, determining responsibility exactly will always be a problem. The same issues apply to other coproduction examples.

Pricing of and contracting for services are challenging topics even without the complexities of collaboration (Karmarkar and Pitbladdo 1995). Since there is often no tangible product, or even an observable output, the market agreement may be about inputs and processes rather than outputs and outcomes. For some consumer services, pricing is based on some measure of output or activity volume simply because it is observable, even when it does not reflect many important performance attributes. So restaurants usually price based on the dishes being ordered, even if other aspects of the experience are as important. The prices only include those indirectly and possibly imperfectly. With intangibility, there are also fundamental questions about how to establish nondelivery of a service and how to ensure some recourse. Intangibility and the lack of inventories typically mean that service production is "postcontractual," with obvious implications for opportunism. Repeat purchase markets and reputation effects can impose corrective incentives. An extreme solution in favor of customers is the unconditional service guarantee (Hart 1988), but few service providers appear to actually offer those.

Service Processes

Service processes have many special features not common to goods production (Apte et al. 2012). Joint production is just one such aspect. Other distinctive features include multiple decision makers, variable and flexible "route sheets," long-term outcomes that may not correlate well with short-term outputs, difficulty in measuring outputs and outcomes, uncertain outcomes, and unobservable efforts. These features are also present in the internal processes in organizations, which can be thought of as bundles of service processes. These characteristics have manifold consequences. Intangibility and the difficulty of measurement make management of productivity, efficiency, and quality difficult. Defining clear specifications and inspection against standards are often infeasible. These difficulties are further compounded by the presence and participation of customers who can also observe and experience process failures. The presence of multiple decision makers leads to game theoretic settings, where customers and multiple employees in the vendor's organization may make "routing" and effort allocation decisions. As yet we do not appear to have general tools or frameworks for such complex, stochastic, game theoretic, collaborative process models, though a few attempts have appeared; see Apte et al. (2012) for a brief review and Karmarkar and Roels (2014) for a decision framework.

One of the intangible but vital aspects of consumer services is the experience delivered to the customer (Chase and Dasu 2008). This is clearly central to services like entertainment or hospitality, but is also a significant factor in services like education or healthcare, even when it is not necessarily the core value of the service. Here, recent research in psychology and marketing is beginning to provide an understanding of how experiences are perceived and how these results can inform service design (Karmarkar and Karmarkar 2014). Some of the experimental results can at first seem rather counterintuitive. A well-known example is the study by Kahneman et al. (1993), where patients asked to evaluate a diagnostic procedure (colonoscopy) retrospectively appeared to prefer experiences in which the total pain was greater when there was a less painful ending. The explanation given by the investigators was that the remembered experience depended mainly on the peak(s) and the end of the experience, and not on the total pain. Dixon and Verma (2013) used the peak-end model to evaluate and design service offers to maximize positive remembered experience. A different approach was taken by Das Gupta et al. (2015), who developed a utility-based model for remembered experience that incorporates memory decay and acclimation, both of which have been extensively studied in the psychological literature. Either of these phenomena is sufficient to explain the colonoscopy study results even though they act quite differently. They applied this model to the design of service encounters in terms of the sequencing and duration of service stages, and demonstrated that a U-shaped sequence for service intensity is optimal. Other recent research incorporating experiential mechanisms includes the work by Baucells and Sarin (2010) on satiation and acclimation in the prospective evaluation of consumption streams, by Caro and Martınez-de-Albeniz (2012) on satiation and variety in retailing, and by Nasiry and Popescu (2011) on pricing with peak-end anchoring and loss aversion.

Information Technology and Services

The effect of information technologies is not just a matter of the changes at the level of the economy through productivity. For information-intensive services, many of the standard assumptions about services do not hold. Information-intensive services are easily delivered remotely, whether they are banking transactions, responses to a search query, or an online lecture. The outputs can be tangible in some intermediate form if not always in the way they are consumed—for example, an image, audio, or video file. Customers need not be physically present. Even when they are, service processes may be industrialized and standardized. Cinema theaters and broadcast TV are older examples; computer games are newer ones. Mass customization can be achieved with a combination of

self-service, modular processes and content variety. Online delivery and e-commerce are making the old retail mantra of "location, location, location" irrelevant for many services.

Some large differences in industrialization between physical and information sectors arise from the very different economics of production, creation, and delivery processes (Karmarkar 2014) across different types of services. Early discussions of information economics were presented by Whinston et al. (1997), Shapiro and Varian (1998), and Varian et al. (2004). More recent technology developments continue to force structural change in information sectors. For manufacturing, the application of power, increases in processing volume, and centralized scale were correlated. Scale also means efficiency for many physical services. For information processing, although processing power is increasing exponentially, the trend for resources is instead toward low power, mobility, and distributed processing. Basic processing, storage, and distribution costs are already low and still dropping inexorably along the path of Moore's Law. Even where there is centralized capacity in server farms, data centers, and super computers, their location is of little importance to businesses or consumers, except in a few cases like stock trading. A huge amount of processing and storage capacity is now distributed in PCs, mobile devices, and, increasingly, objects. There are perhaps a billion computers in use today, of which most are desktops and laptops, and growth of this base is slowing. Mobile devices are already estimated to have passed the 7 billion mark, with a billion sold every year. Since the rate of penetration of these devices is still low for many large countries, their proliferation will continue. For much of the world, mobile devices will be the primary last mile delivery and collection channel, and phones will play the role that desktops had in developed economies. The size of the population of connected objects will be orders of magnitudes larger, and the next generation of addressing protocols (IPv6: Internet Protocol version 6) will accommodate 3.4×10^{38} (340 trillion trillion trillion) unique addresses. Big data is about to become a lot bigger, and so are the needs and opportunities for rapid analytics and decision making.

With low cost capacity and infrastructure available to all firms, and low operating costs, competing on costs is difficult. And differentiation becomes important. But there is a tendency toward commoditization due to the ease of copying functionality and the wide availability of technologies. Even for centralized resources like servers, the availability of Web services means that capacity can be acquired and used on an as-needed, pay-as-you-go basis. The irrelevance of scale means that entry is easier, and competition can both emerge and grow rapidly. But although traditional scale economies based on large fixed costs do not apply, there can be other factors that favor size and scale, including branding, positive network externalities, standards, and the installed bases of users, where there is often little incentive to switch even when switching costs are not very high.

Many verticals in information-intensive service sectors are being radically restructured with vertical deintegration, disruption, and disintermediation on a large scale (Karmarkar 2004, Jacobides 2005, Karmarkar and Apte 2007). We have already mentioned the impact of industrialization and the wave of front office automation that is in progress. Back-room industrialization also continues into a new phase with cloud infrastructure and software "as a service" (IaaS, SaaS). Content-based services like music and publishing are already hard hit. So are transaction-based services like financial services and retailing, which will continue to see further disruption. Education is ready to follow very soon.

Among the many kinds of new services that have appeared recently are social networks, online consumer services like search, and markets and exchanges for both business-to-business (B2B) and business-to-consumer (B2C) transactions. Resource sharing services are a new wave that also affects physical services. The underlying enabler is reduced transaction and monitoring costs for renting and leasing, with two-way evaluation and reviews and real-time spot markets, which permit more flexible and reliable time sharing of resources and ease of entry for the owners of those resources.

Information production and delivery chains are in many ways like supply chains for physical objects. However, information chains function quite differently from supply chains (Choi and Karmarkar 2014a, b). First of all, flows in information chains for information products are not driven by demand, since sales do not deplete inventory. Rather, information inventories lose value due to aging and obsolescence and then are depleted by active purging by the vendor. Correspondingly, production is not triggered by a need to replenish inventories. Instead, processing is often driven by the arrival of new content, which may be regular (as with weather data), but is often random (as with financial transactions or news events). So processing becomes more like a service, with uncertain arrivals and processing time. Operational capacity, time, and quality management require a decision to accept or decline new content. The rate of increase or decrease of inventory depends on arrival, acceptance, and purging rates, with the latter driven by obsolescence rates. The latter rate rises with the size of the data base, and the balance between net input and output rates determines the size of the inventory,

data base, or library of content. There are some situations where fixed production volumes are needed to fill delivery schedules, as with a daily news broadcast. Arrival shortfalls are filled from inventory or by relaxing acceptance standards. A slow news day may mean accepting marginal stories about cats in trees or the use of stock video footage to fill time. The operating aspects of batching and buffering of flows in this environment have been studied by Papadimitriou (2004). Content data base size and delivery channels for business data are studied by Bashyam and Karmarkar (2004). Capacity decisions in stationary stochastic and deterministic dynamic models are analyzed by Choi and Karmarkar (2014a, b).

Summary

The opportunities for research in service and informa-tion-intensive sectors are substantial. The research literature in these areas is already quite large, growing, and distributed across many functional areas including management information systems (MIS), marketing, strategy, economics, technology management, and OM. Journals directed toward services and the digital economy are proliferating. An extensive review is wanting. Many research topics cut across traditional functional areas. For example, the presence of customers in the service process means that customer behavior is both an operations and a marketing subject. When customers participate in value production, thinking of them only as purchasers and consumers is inadequate. Similar issues hold with information-intensive production. With technology-based industrialization of all kinds of services including management processes, it is not feasible to separate technology from operations, or MIS from OM, as many leading schools have already decided.

The opportunities for new work remain very substantial. A fundamental topic for OM research is the study of service process models that incorporate features such as customer involvement, joint production, multiple decision makers, stochastic outcomes, lack of observability (of outputs and effort), and value derived through experience. The engineering issues related to storage, transport, and processing capacity are well understood, and these resources are efficiently priced. But many aspects of content creation, value, and consumption are less studied.

Process models support the operational management of processes including quality, cost, time, and value. For experiential services, process design includes the sequencing, duration, and intensity of service stages, modularization and flexibility, the assignment of routing decisions, effort, and responsibility. With changing economics, there are significant changes in sector structure in many industries, and these require revisiting legacy business relationships and practices. There are new approaches to pricing and contracting, and structural alternatives such as open sourcing, dynamic sourcing, and new markets and exchanges. At the strategic level, research could address positioning in evolving service and information networks, platform models, industrialization, and globalization. All of these represent substantial research opportunities. These topics relate to management practice as well, and are also in demand in educational programs.

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