



Service Industrialization, Convergence, and Digital Transformation – II

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Digital technologies are changing the structure of information intensive services through a process of industrialization. The effects are specific to each service category including transactional, functional, content-based, and knowledge-based services.

Consumer consumption behavior and physical services are also affected. Uday Karmarkar argues that managers must analyze the changes to their particular industry and revamp their strategies, core processes, and supporting systems accordingly.

The US economy, already dominated by services, is becoming ever more information intensive in terms of GNP, job, and wage shares. The move toward services is visible in all the world's economies. Meanwhile, the shift to an information focus is driven by the information and communication technologies that have appeared since the beginning of the 20th century, a process which accelerated with the advent of digitization in the latter half of that century. This trend is most visible in highly developed economies. Less developed economies have not moved as far toward this "information economy," but they are heading in that direction, slowed only by the expense of personal digital devices. As those devices cost less and these economies do better, the same shift will occur everywhere. The largest telecom subscriber bases and the largest numbers of internet users¹ are already to be found in countries with large populations like China, India, Nigeria and Indonesia, despite their lower wealth levels. In fact, the information economy tends to scale with population, since it is driven in large part by consumer consumption patterns, as is exemplified by smartphones and apps.

The characteristics of each sector determine the specific changes that will occur in the sector.

Of course these trends affect the economy as a whole, and they are also transforming industries, sectors, and companies. Much of the change derives from the decisions made by local managers as they strive to improve performance and competitiveness. These deci-

sions and actions can be viewed as technology enabled service industrialization. Analogous to the 19th century industrialization of manufacturing yet combined with the economic and functional characteristics of modern information technologies, this process has created certain patterns of structural change in service systems. One important result is the convergence of different service verticals into a common form at many process stages. Another is that processes throughout the sector become modular due to simple standard interfaces, standard formats for inputs and outputs, and the disappearance of physical media. These changes in turn bring on structural consequences such as the de-integration of traditional industry verticals. While these effects generally apply to most information intensive services, each sector differs in terms of processes, services delivered, markets addressed, consumer behavior, and the preferred systems and channels. So the characteristics of each sector determine the specific changes that occur in that sector.

Initially, the consequences of service industrialization were felt most strongly by information intensive services. Even within those, there are different trends in the evolution of processes, competition, and the success of new entrants. Some sectors have already been severely disrupted, while others seem unaltered, even though they may be on the threshold of radical change. As we might expect, the effects on a content based sector, such as music distribution, look very different from those on a transaction intensive sector like retail banking or on a functional service like email or search. Some industries may appear to be shielded from industrialization to some extent or for some

time, but very few will be impervious in the long run.

It is important to understand the largest categories of information intensive services as well as the main approaches that comprise service industrialization. As I described in Part I of this paper, there are certain underlying causes of the digital convergence which is changing this sector.² The consequences include structural effects such as vertical de-integration, horizontal technology dominance, and modularization. Together, they inspire new and emergent strategies, including service platforms and bundling, that can apply to all categories of information intensive services. There are also factors and structural changes specific to each service category which may be traced through the evolution of some of the major information intensive services, including content delivery, transactional, knowledge based, and functional services.

Service Industrialization and Information Intensive Services

Service Industrialization³ refers to the application of technology accompanied by reengineered processes which managers and engineers implement in order to improve profitability, quality, customer retention, and market share. These actions and decisions include

- *Automation* of process steps and information logistics;
- *Outsourcing and offshoring* to geographically disperse processes outside the company;
- *New services creation* enabled by new technologies;
- *Redesign of services and processes*, both small and large;
- *New markets, exchanges, and networks* with many to one, one to many, or many to many interactions;

- *Online delivery* with global reach
- *Personal devices* for customer access, ordering, delivery, consumption, and data capture,
- *Self-service* and relocating operations within the service chain.

As I mentioned above, industrialization has its biggest impact on information intensive services. While there is a broad diversity to these services, we can categorize them into the following major types:

- *Transaction based services*, including banking, brokerage, reservations, and ticket sales;
- *Content based services*, such as music, news, data services, publishing, and education;
- *Functional services*, like telecommunications, search, email, web, and cloud services;
- *Knowledge based services*, which include financial planning, consulting, and medical diagnostics;
- *Networking, interaction, and exchange services*, such as social networks and content sharing;
- *Everything-as-a-service (XaaS)*, that transforms information and communications equipment and assets such as storage, transport, hardware, and software, into cloud and online services; and
- *Sharing services or micro-rental platforms* dealing in physical assets

Just fifteen years ago, these categories were relatively distinct and most firms tended to fall into just one of them. But those boundaries are blurring as the big players, like Amazon, Google, Apple and Microsoft, have begun to bundle together a vast range of services. Nevertheless, each category is still subject to its own distinct patterns of industrialization, competition, and process structure and therefore requires different operational and strategic approaches.

For each of these business to consumer (B2C) categories there are business to business (B2B) equivalents. For example, commercial banking and insurance are B2B transaction services, while web and cloud services (like Amazon Web Services) and enterprise software (like Salesforce.com), are B2B functional services. A firm's internal services are naturally even more specialized and firm-specific. They include management and decision making functions such as resource planning, financial management, human resource management, and sales management in addition to all internal transactional and functional services. Most organizations, including manufacturers, can be viewed as bundles of service processes, with embedded information and knowledge. These processes are equally vulnerable to industrialization and disruption to varying degrees.

The industrialization of internal services began many decades ago with mainframe computers, and before that with typewriters, telephones, calculators, tape recorders, and other electromechanical technologies. Much of this industrialization was not particularly visible to consumers except when it directly affected their own experiences. It hardly caused a ripple in the economic data, provoking Solow's famous 1987 quip: "You can see the computer age everywhere but in the productivity statistics."⁴ But the implications for jobs were very apparent even then. Consider how many accountants, payroll clerks, record keepers, filing clerks, and secretaries were employed in 1950, and how many were left by 1990. Nowadays, Solow's comment is no longer apt; the effect of information technology on aggregate productivity has been increasingly visible since the mid-1990's.⁵ Today we also see substantial effects on employment and wealth distribu-

tion, including a decline in the employment share and wage bill share of many basic white-collar jobs. This trend has been accompanied by an expansion in knowledge intensive professional jobs, which does not however compensate for the overall decline in employment share.⁶

Both B2B and internal service industrialization present a serious social issue in that they directly affect jobs and wages. When a sector is disrupted on a large scale, the effects on employment are sometimes quite visible. But all too often they happen piecemeal and seem to go unnoticed, except by the employees who are directly affected, and who can be disparaged as neo-Luddites. Secretarial and clerical jobs were mainstays of white collar employment fifty years ago, but their decline did not raise much public concern. Now that industrialization has reached the front office and begun to affect more visible white collar occupations like content management and financial services, people are becoming sharply aware of the problem. As the tide rises to affect knowledge-based professional jobs, public awareness will rise into crisis.

Convergence in Information Services

One important consequence of the digitization of information intensive sectors is convergence, which occurs across all information intensive sectors as:

- Convergence to digital form;
- Convergence of logistics, including transport and storage;
- Convergence of processing, from servers to personal devices;
- Convergence of processes, both large and small, within the organization and without;
- Convergence in use and consumption by both businesses and end users.

These types of convergence and their consequences for sectors are described at length in Part I of this article.⁷ Among the major effects on sector structure are

- Vertical de-integration and modularization of process stages;
- Lateral technology dominance across industries, caused by the convergence of sectors and processing tools;
- Ease of entry in many sectors, because of the declining costs of equipment and web services;
- Commoditization of functions and outputs leading to challenges for differentiation;
- Changes in competition patterns and competitive regimes;
- Novel designs for services and service processes;
- The emergence of platforms that can support multiple service categories;
- Bundling strategies, enabled by such platforms;
- The appearance and rapid growth of cloud and web services including infrastructure as a service (IaaS), platform as a service (PaaS), unified communications as a service (UCaaS), and software as a service (SaaS).

Beyond these general effects, each sector faces its own issues because each sector focuses on different services, different markets, and different customers and therefore uses different strategies.

Sector concentration, along with the size of the largest firms, presents an interesting conundrum. Low fixed costs, process modularization, widely available technological capability provided by third parties, and low operating costs would seem to favor low barriers to entry, as would the relative ease with which customers can switch firms. They would also then favor a plethora of firms in each sector, price competition, and the

fragmentation of sectors into niches. On the other hand, commoditization, design convergence, the lack of differentiation between companies, and sector specific barriers to entry, such as network externalities, scale economies in backroom server operations, large databases, the importance of branding in a commodity setting, platforms, and lateral bundling strategies can all combine to create a concentrated market dominated by a few large firms. It turns out that both can be true in different (vertical) sectors and across different stages of end-to-end information chains.

Transaction-based Services

Some of the first information intensive services to see industrialization, restructuring, and disruption were predictably those involving fairly simple transactions that were easily automated and required little bandwidth. Retailing and consumer product sales were clear candidates for the transition to online access, bringing unprecedented convenience to customers. E-commerce is growing rapidly worldwide, with Amazon the clear leader in the US and in the world too, though with Alibaba not far behind. No retailer can afford to ignore this trend. Walmart, for example, is expending substantial money and effort to avoid being sidelined and is now in second place in the US. Meanwhile, many new firms have entered monetary transaction sectors such as bill payment, payment processing, and cash transfer. They have succeeded in part because incumbents, like banks and credit card companies, were not fast enough to provide these services in a convenient digital form. Telecom companies that once had a distinct opportunity to provide such transaction services apparently did not see it even though they spent large sums on their own bill payment channels.

Financial services, meanwhile, have gone online rapidly. Table 1 shows the evolution of retail banking, which is in the middle of highly disruptive changes, caused in large part by automation. Most banks adopted automation in the back room some time ago; now they are bringing it to the front office, albeit somewhat late. Customer access is going online, while also shifting largely to mobile devices. Once banks were permitted to add investment services, they began to do so by outsourcing, with many building relationships with existing brokerage houses so they could rapidly expand into that service. Banks have also outsourced credit card services, acting for the most part only as sales channels.

As customers use mobile devices for more and more transactions, local accessibility becomes ever less important. Most customers already do not know where their banking transactions are actually processed, and probably do not care.

US banks (with the notable exception of Citibank) have not been quick to adopt offshoring or to globalize, perhaps because of security concerns. Now, most major banks are moving their call centers offshore and it seems likely that other processes will follow. Within the US, most back room banking resources have already been dispersed geographically. As customers use mobile devices for more and more transactions, local accessibility becomes ever less important. Most customers already do not know where their banking

transactions are actually processed, and probably do not care. Banks now face the danger of commoditization and intense competition over ever larger service areas.

Historically, customer service at branch banks was rarely outstanding. The service process designs for the branch offices of most banks had converged into a standard for-

to bundle services in innovative ways and combinations, while constantly managing and improving their customers' experience.

The biggest looming threat for banks, credit card issuers, and other payment intermediaries is the impending introduction of digital fiat currencies which several countries, most notably China, are now considering. The technology which underlies these currencies will probably be distributed duplicate ledgers rather than the full, complicated blockchain mechanism. Digital currencies could place transactions in the hands of government agencies, simplifying government activities such as taxation and funds distribution, and perhaps making them more secure. Tracing the movement of money should become easier, making illegal transactions more difficult, though cryptocurrencies could still confer anonymity. Governments may be able to more directly control the quantity of money, though it remains to be seen how exactly they will do so and whether banks will continue to play a role. In any event, the adoption of digital currencies will force banks to reconsider their service portfolios, perhaps shifting more towards loans and investments.

Functional Services

In recent years, a flood of new information intensive functional services have come into being. Email was an early example which was immediately valued and grew rapidly. Instant messaging followed close behind, offering a point of entry for some new companies. Now, there is a vast array of new services including search, navigation, location based services, ride sharing, and many others, all available through apps on personal mobile devices. At the core of this boom in service industrialization and innovation are technological advances in telecommunications

Table 1: Retail (consumer) banking industrialization and process changes

Service Stage	Traditional	Recent	Online Digital
Access	Branch	ATM	Online, phone
Diagnosis	Teller	ATM and self	AI, platform, self
Process Menu	Teller, script	Fixed menu	Flexible, adaptive
Process Selection	Teller and customer	Customer selected	Customer routed
Process Execution	Teller	ATM (local)	Multiple sites, remote
Exception Handling	Teller, supervisor	Branch based	Automated, hybrid, off-shore
Sales, Cross Selling	Minimal	Rigid, repetitive	Customized, learning, adaptive

Like other industrialized and commoditized services, the banking sector is experiencing consolidation through mergers and acquisitions which is likely to continue for some time. In banking, as in other commodity services, scale and brand are now vital for differentiation. Right now, there are simply too many banks in the US. Since 2002, the number of FDIC insured banks has already dropped from over 7800 to around 4700,⁸ a trend that is likely to continue for some time. Banks are now bundling some services like credit cards, brokerage (like Bank of America and Merrill Lynch), and mortgage banking by way of mergers and acquisitions (Norwest Mortgage and Wells Fargo). Some banks are trying to differentiate their branches by expanding them into stores, cafes, and lounges.⁹ At best, this is a transitional strategy that may boost market presence and new customer acquisition temporarily, but will not improve core services.

Perhaps the most important potential differentiator for banks in the short term is the provision of a superior mobile banking experience.

mat, driven more by history and efficiency than customer satisfaction. While banks had a strong hold on local service areas, this system was adequate. As branch locations become less important, consumers give more weight to their experience with mobile access. They will also find it easy to compare online services processes across providers and it seems that as yet, the process designs for those services have not converged to a dominant design.

Many of the issues facing retail banking also apply to other transaction-based consumer information services such as brokerage, mortgage origination, bill payment, reservations, and ticket sales. These sectors must also negotiate commoditization, mobile access, new entrants, and intense competition in which some firms consolidate while others succumb. The basic requirements for success are also changing. Internally, successful firms need automation, systems integration, data analytics, outsourcing, and cost reduction through outsourcing and off-shoring. In the front office, firms must be prepared

and the automation of many related process. Working through automated server-based platforms with an increasing reliance on data analytics, these services are available 24/7, are delivered fast, and have a growing range of advanced functionality.

Convergence of processing means that the equipment and tools used for processing information are essentially the same across service sectors, regardless of their nature or purpose. With the availability of near instantaneous low cost logistics, third parties can now provide many kinds of outsourced functional service to both B2C and B2B customers. Cloud and web services, including email, messaging, internet service, hosting, cloud storage, file transfer, and website development, have become a major market catering to both businesses and individuals. The B2B sector has recently seen explosive growth, including infrastructure as a service (IaaS), platforms as a service (PaaS), unified communications as a service (UCaaS), software as a service (SaaS) and functions as a service (FaaS), all of which permit companies to outsource a significant proportion of their IT function. Salesforce.com's customer relationship management (CRM) application was one of the earliest online services of this kind. It was quickly recognized as an effective way to centrally manage sales personnel who might be spread over a wide geographical area. Since then web service providers have proliferated rapidly. Among the many hundreds in the US, and thousands in the world, Amazon is both a pioneer and the largest player today.

Like telecom services, web services are highly standardized, largely quantifiable, remotely provided, and easy to compare by price. That makes competition intense and there have been significant price drops recently, which

will probably continue. It is likely that many providers will consolidate or exit, leaving only a few big players surviving. To withstand this intense competition, firms will be driven to bundle more and more specialized services, in addition to all their standard functions, in an effort to differentiate themselves. Of the major categories of web services, the SaaS category mentioned above currently shows the most potential for differentiation and specialization. So it can be expected that web services providers will start to provide functional capabilities in SaaS format, specialized to particular functions (such as finance, HR, resource planning) or to specific industries (such as financial services, health care, and retailing). This has already happened with ERP system providers, and one can expect a convergence between web services and enterprise systems. A fast way to achieve this will be through mergers and acquisitions, and we can expect a wave of those to appear.

Knowledge Based Services

The impact of technology and industrialization is now beginning to affect services that are either passively or actively knowledge intensive. Knowledge which can be expressed as static content in the form of books, research papers, databases, music scores, or blueprints, is already being widely converted into online forms which, unlike traditional media, remain open to continuous amendment, variation, and addition. Now, services that rely on more complex knowledge and expertise, and need to respond dynamically to specific situations, are increasingly available online. These systems were originally "rule-based" and usually addressed only a limited range of issues in a narrowly defined domain. In a sense they were analogous to an FAQ page. Now we see far more complex

systems using methods generally described as artificial intelligence (AI). Note that AI is not a cohesive methodology, but an umbrella term for a collection of many tools which range from variations on traditional statistics, logical processing, and mathematical modeling, to neural nets and deep learning. In this context, the relevant point is that this use of AI is effectively the automation of knowledge-based processes, which were historically performed by human experts and provided high wage jobs in many industries. This development begins to extend automation from routine tasks to those which once appeared to be protected from technology and industrialization.

One growing example of the automation of knowledge based services is medical diagnosis. Table 2, on diagnostic imaging, also illustrates other aspects of the industrialization of expertise. The first column shows the methods used for imaging in the recent past, when X-ray equipment, the diagnosing doctor, and the transcription clerk were generally all located in one hospital. Images were captured on film, which tied these stages together. Now imaging uses many different types of equipment, including MRI and ultrasound. The images are digital, and the diagnostic process has been de-integrated and modularized. Automation of diagnosis is already used for some categories of diagnostics like mammography¹⁰ and prostate screening. IBM's Watson system is being applied in oncology, though questions have been raised about its efficacy.¹¹ Nonetheless, it seems very likely that AI systems will be an increasingly common tool to provide support to human diagnosticians if not to replace them. Imaging is also increasingly outsourced to external providers since the equipment is highly automated and the output image

files are easily transported. Diagnosis can readily be outsourced, geographically dispersed, or even offshored, again due to the ease of transporting image data files. The work of medical clerks, such as transcribing diagnoses, is frequently outsourced and offshored already, and is gradually being au-

are already available for specific cases, and it is reasonable to expect SaaS versions to become widely available in future. We are already at the point where industrialization has negatively affected employment in transactional services (bank tellers), information services (help desks and travel

assembling articles on pages for a news website. Several logistical steps, such as storage, transport and final delivery, may be involved, and all of them employ industrialized information and communication technologies. These information products can be delivered to consumers through broadcasts, podcasts, streaming, or web page access. Most of the content will be consumed through devices with screens and speakers, which are increasingly personal and portable.

Though information chains might look superficially like supply chains, there are crucial differences when they are digital, with fundamentally different economics. The biggest difference is in the driving force behind the chain. In a supply chain, flow is driven by sales. Demand occurs at the end point where products are sold and inventories are depleted. The rest of the chain is set in motion by the need to replenish stock, partly as a “pull” due to demand and partly as a “push” from planned production, so that in the long term, net flow is roughly equal to sales. Digital information chains don’t work that way. Delivering digital content like music to satisfy demand does not cause any inventory depletion, so no replenishment is required. Instead, anything that goes into end inventory can in principle stay there forever. Inventories are depleted only by obsolescence and active purging. Obsolescence is due to a loss in the content’s value in the end market or to the appearance of new information that supersedes the old. So the end inventory store, whether it be a content library or a database, could just keep growing if it isn’t periodically purged of erroneous, obsolete, or low value information.

At the other end of the chain, content inflows only occur with the appearance of new material. And unlike cars or apparel, the influx of content does not necessarily match

Table 2: Diagnostic Imaging; resources and operations in past, current and future processes

Service Stage	Recent Past	Current	Future
Access	Patient to hospital	Patient to machine, machine to patient	Local sensors, remote consults, and diagnosis
Process (Imaging)	Co-located machine, and technician	Outsourced service, machine, technician	Outsourced, automated machine, attendant
Diagnosis	Co-located, doctor at hospital	Remote diagnosis, offshore, some AI aided	Remote diagnosis, AI supported
Transcription	Co-located clerk	Automated, offshore	Automated
Diagnosis Record	Text (paper), film	Audio, text, image files	AI output, image files

tomated. Over time, many types of patient visits and diagnostic procedures are likely to involve some degree of industrialization, whether by outsourcing, offshoring, or automation. Meanwhile self-service will work for some operations as sensors and imaging equipment become smaller, cheaper, safer, and easier to use.

The IBM Watson¹² system provides a good leading indicator of other areas in which automation of expertise is technically possible and economically feasible. So far, uses for Watson which have reached at least the trial stage include financial services, talent management, health care, regulatory compliance, systems diagnostics and maintenance, employee training, insurance claims assessment, and individualized customer service.¹³ IBM’s AI is a large-scale, multi-method enterprise system, which is not necessarily economically viable for all firms. However, many more modest applications

agents) and backroom tasks (filing clerks and accounting). Though jobs requiring more advanced expertise and knowledge have grown recently in both job share and wage share,¹⁴ that pattern may not continue for long.

Content Based Services and Information Chains

Content based services include music distribution, magazines, news, images, video, weather, books, financial information, and education. Most of these sectors involve information chains, a sequence of activities which delivers content in much the way that supply chains deliver products. These chains begin with acquiring content, whether through purchase, recording, transactions and data capture by sensors (including cameras), or through creation, as with writing, art, music composition, or speech. The production process which follows can be as complex as making a movie or as simple as

either recent sales or current purge removals. Content production is not intended to replenish depleted inventory levels, so inflows look more like random arrivals of content, sometimes from unexpected sources. New content must then be processed and stored in the end database, ready for delivery. The key to new “inventory” therefore is not that the incoming content fills a specific void, but rather that it must be new, different, and of some incremental value to consumers to be worth accepting, processing, and adding to storage. The closest supply chain analogies to such information chains might be those for fashion goods or craft objects, products whose value is driven by their own novelty and their predecessor’s obsolescence. Even there, depletion and replenishment still drive production. Conversely, the information chains most analogous to supply chains are those with fixed delivery schedules like news, in which a certain amount of air time or column inches must be filled and old news cannot be reused. The content production schedule in these markets is also regular, though again firms prefer new content that their competitors don’t have. If new content is not available, as on the proverbial slow news day, older stock content or low

quality items may have to be used as filler. As news moves increasingly to online distribution and mobile access, consumption patterns move closer to news arrival and fixed schedules begin to fade away, though some information categories, such as weather, stock prices, and flight tracking, will continue to require regular update schedules to match demand patterns and changing conditions.

Consider the effects of digitization and industrialization on the distribution of recorded music. The information chain (Table 3) for this sector has evolved in ways similar to that of diagnostic medicine (Table 2).

Physical media once played a major role in music distribution, from capture to consumption. A few big companies dominated almost 90 percent of the market until 2012. But digitization and industrialization have caused massive changes in a very short time. Competition is now fierce, because the relative ease of content creation and capture make it an easy sector to enter while the diversity of content allows for differentiation between firms. In addition, obsolescence rates are high for many kinds of music, and new performers and performances appear constantly even for long-lived examples like the classical

relationships with artistes, and content acquisition. Today, power is rapidly shifting towards large players at the distribution and database end which is digitized and commoditized. As a result, total industry revenues have dropped substantially from 2000 till today.

For music distribution, large new firms have appeared at the on-demand service (content) delivery stage, including Spotify, Pandora, Apple Music, Amazon Music and Google Play. So far their pricing is quite similar; but with many entrants and similar services offerings, price competition is becoming more intense, and could soon lead to a shakeout. These new distributors still acquire older content from existing publishing firms, but with new artists constantly producing new music, distributors will increasingly be able to bypass publishers and deal directly with performers and independent studios.

This trend is already present with video content. Amazon and Netflix are producing and funding new content. Symmetrically, Disney is acquiring (Hulu, ESPN) and creating distribution channels for their own content (Disney Plus). These channels are also available as a bundle. As on-demand channels proliferate online, broadcast TV is seeing the first signs of decline. Film viewing in theaters is also decreasing, with ticket sales having peaked around 2002. Apple’s bundling of video streaming with other content and Disney’s entry into streaming video have increased the threat to other firms and the competitive intensity in video distribution. Furthermore, a considerable proportion of video viewing has shifted to advertising supported exchange, with YouTube the dominant leader.

The decline in book publishing has recently slowed, despite Amazon’s relatively early start with

music of various world regions. The rest of the chain, apart from the performance itself, has been industrialized and digitized. Until recently, the music industry operated as a clear vertical, dominated by three companies that controlled rela-

Table 3: Evolution of the Information Chain for Recorded Music Distribution

Stage of Chain	Music (2000)	Music (2020)
Creation	Composers, performers	Composers, performers
Capture	Large studios, tape	Small studios, digital
Processing	Audio tape engineering	Digital processing
Master Copy	Master CD	Digital file
Transport	CD, DVD copies	File, internet
Storage	Physical inventory	Data center
Delivery	Retail, CD, DVD	Streaming, downloads
Consumption	CD player	Digital devices

e-books and online distribution. Printed books may now be holding their own due to physical experiential value and familiarity. However, this could simply be a generational issue, since children and young adults (CYA) are moving towards online channels faster than older generations. Books may also soon need to compete against video and other online activities as delivery and consumption converge on mobile devices. On the supply side, as entry into the market becomes easier, there are a growing number of independent publishers and vanity presses for self-publishing which occupy a certain share of the total market.

The general patterns visible in content based services and information chains are modularization, de-integration of verticals, bundling strategies across various types of content and beyond, and the emergence and growing dominance of distribution platforms. Those platforms are converging to similar designs and, with new large companies entering the sector, competition is becoming intense. This pressure is leading to price wars, extensive bundling of channels and services, and backward integration as the biggest players move into creating content, especially for films and multi-episode programming. At the same time, some content is also evolving towards more finely granular formats, especially when consumed on mobile devices, as exemplified by YouTube, Twitter, and Snapchat.

Consumption Devices, Delivery Channels, and Hardware

Sony is still a presence in consumer electronics, but it has lost its leading position to Apple and Samsung. Ironically, given its early success with transistor radios, it failed to recognize the huge consumer shift to mobile devices. Pre-

vious leaders in mobile devices like Palm, Nokia, and Blackberry have also declined or disappeared. Samsung and Apple, the current leaders in smartphone sales, have a host of competitors like Huawei, Oppo, Xiaomi, Vivo, OnePlus, Lenovo, and HTC close behind them. These and several other Chinese and Taiwanese firms, are already leading in the fastest growing markets in Asia (except for Japan and Korea, where Samsung still dominates). Although for the moment they are largely unknown elsewhere, Transsion's Itel, Infinix, and Tecno brands are now leaders in Africa.¹⁵ Africa and Asia are cost-sensitive markets and the Chinese companies have distinct cost advantages. None of the Chinese firms are very active in the US yet, perhaps out of concern over the legal challenges that Samsung's designs have already faced. Design patents issued before 2015 remain in force for 14 years, so it is interesting to consider that the first iPhone was released in 2007 with patents granted in 2010. Of course, the company has continued to file new patents for subsequent designs, so it remains to be seen when the legal issues around design will be fully resolved.

For CPU chips, Intel is still the revenue leader, but it has lost ground to ARM in terms of unit sales and design wins. ARM (now owned by SoftBank Group) supplies designs for low cost, low power chips which are especially well suited to mobile applications and personal devices, but are also now used in server farms where sheer numbers and parallel processing can deliver performance, and where heat removal is a big issue. The growth of parallel processing is also driving an increased use of graphical processors.¹⁷ In telecommunications, companies have been subject to commoditization and in danger of relegation to bit-pipe status

as mere transporters of data. It remains to be seen whether bundling content and other services will create enough differentiation to slow exits and consolidation.

Physical Services

Because they rely upon physical operations and transformations, physical services have, until recently, been somewhat removed from information intensive services and less subject to industrialization. These operations can be anything from metal machining to bagging groceries, to chemical reactions, cooking, or even simply moving things from place to place. It appeared in the past that jobs like truck driving, janitorial work, food services, policing and security, fire fighting, machine maintenance, and home delivery could not be offshored, or viably automated. They could certainly be outsourced, and often were, but they still provided an economic foothold for domestic firms, along with substantial employment, without requiring expensive and extensive educational preparation for workers. For example, by 1996, truck driving had replaced secretarial work as the leading source of jobs in twenty-nine US states.¹⁸ But now it appears that even this bastion of employment is likely to see disruptive changes with the appearance of autonomous vehicles. In work categories that require rapid responses to unpredictable conditions, like policing and fire-fighting, industrialization may take the form of enhancing capabilities rather than replacing the person.

Many jobs in transactional or information intensive physical services have already been industrialized or some substitution has arisen, often including a combination of simple mechanization, automation, and self-service. Filling service at gas stations is long gone. Grocery checkout and bagging are

in the midst of exploratory changes. Self-service at the front end of restaurants was first introduced in Berlin in 1895 by Quisisana in the form of the automat. Automats allowed diners to select their own food out of coin operated compartments which were restocked by an unseen kitchen staff. The process was licensed to Horn and Hardart in the US. The first American automat opened in Philadelphia in 1902, followed by the first New York branch in 1912.¹⁹ While that automat company disappeared (though the brand still exists as a coffee shop), a new incarnation called Eatsa opened in San Francisco in 2015, with iPad ordering replacing counter workers. Recently, Eatsa too has been forced to retrench and reappear as a restaurant technology company (Brightloom) but the automat model is likely to surface again for economic reasons. In a similar trend, an expansion of machine vending to retailing has already appeared in airports. We are likely to see more automated retailing and food service in coming years, which is bad news for one of the biggest and still growing areas of employment in the US today.²⁰

The disruption brought on by the combination of IoT systems with AI software is likely to affect all economies around the globe, starting with the more developed ones.

The collection of hardware and software technologies called the Internet of Things (IoT) is enabling a major leap in automation. IoT is an umbrella term for a diverse collection of devices that combine sensors, radios, actuators, Inter-

net connections, and increasingly complex control and decision making software. Its applications range from the simple identification of tagged objects and data collection by sensors, to sense and respond systems and autonomous devices. Some of these technologies, like self driving vehicles, will be extremely disruptive for multiple industries. While the information chains of the Internet and web reach from screen to screen, IoT tools and technologies are able to connect sensors, machines, objects, computers, and people into complex networked systems that include all of these. Some early examples include smart transportation, smart energy grids, security, health monitoring, and home service systems. The disruption brought on by the combination of IoT systems with AI software is likely to affect all economies around the globe, starting with the more developed ones. The automotive sector will see disruptions at many stages, from manufacturing, sales, and ownership to rentals, ride sharing, insurance, and repair. The automation of physical consumer services, meanwhile, may have a devastating impact on employment.

Bundling is not like the financial portfolio conglomeration of the 60's. Rather, it is a way of taking advantage of the commonality of underlying technologies and processes to bring together services which were historically quite distinct.

We are in the midst of a new wave of industrialization of physical services, going far beyond just their

information components. In all likelihood, the magnitude of the impact will be immense; a McKinsey study estimated that the value of IoT products and services will reach between four and eleven trillion dollars by 2025.²¹ We are now at the very start of that change, which is why those estimates are so uncertain.

Summary

The development of information and communication technologies over the past century has driven information intensive services to become the largest part of the US economy. This growth has brought about significant changes in many industries, underpinned by digital convergence and the special characteristics of information process economics. These common factors provide a top-down perspective from which to analyze and understand how information services are changing. Scrutinizing the impact of service industrialization, which is applied at the process level and moves upwards into service designs and industry-wide information and service chains, yields a more detailed, bottom-up perspective. The eventual consequences vary by type of service. Large and disruptive effects have come early to transaction based services, while functional services have been strongly influenced by new service designs. Web and cloud services have made it far easier to outsource back room functions and information processing to the point that they have begun to resemble utilities. Meanwhile, the same factors have allowed many back room processes to be offshored and dispersed regionally and globally. Incumbents in content based services have declined as large new players have established themselves, first in distribution and delivery, and now integrating backwards to content production in response to competition. Knowledge

based services, on the other hand, are just beginning to feel the onset of industrialization, although the potential there is extensive. Physical services are also in the early stages of a wave of IoT based automation, which will likely bring radical change to industries such as the automotive sector.

The biggest danger for companies is hesitation in understanding and addressing the approaching threats. New companies may enter any sector from unexpected quarters and seemingly unrelated industries. Convergence and industrialization are driving the largest players to use lateral service bundling as a basic growth and expansion strategy. Bundling is not like the financial portfolio conglomeration of the 60's. Rather, it is a way of

taking advantage of the commonality of underlying technologies and processes to bring together services which were historically quite distinct. The tight integration of information processes means that changes in a distant part of a service delivery chain can ripple across many stages. Firms would be wise to take an end-to-end view of their industry to avoid being caught unprepared. In these dynamic times, even large and technologically able companies have fallen from industry leading positions.

Digital technologies and service industrialization have transformed the US and other developed economies on every level. We are still in the midst of this vast change, with much more to come. ■



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