Convergenomics
Strategic Innovation in the Convergence Era

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There has been a fundamental change in how business is done in the 21st century. The driving force for the change is convergence in a number of areas. Science continues its progress, although each advance seems to bring with it concerns about control. Information systems have converged allowing global exchange of data, information, and knowledge. Technology has advanced allowing greater compatibility between components produced across the globe. These convergences allow cooperative efforts for business and industry systems throughout the world. The data generated by compatible systems and organizations support a convergence in knowledge development and exchange. Finally, opportunities are being explored in the biological and computer science areas, leading to many complex developments that hold promise for a better quality of life.

**Evolution of Convergence**

Convergence is a result of human creativity, usually obtained by taking ideas from one area of experience and applying these ideas to other areas. Thus, convergence has been part of human history. In business innovations, convergence has also evolved through several major stages as shown in Figure 3.1.
Figure 3.1 Evolution of business environment, strategies and convergence

Organizations’ efforts for innovation through convergence were influenced by several layers of major factors:

1. megatrends;
2. change in industry mix;

3. change in economic structure;

4. change in the source of corporate competitive advantage; and

5. the primary innovation strategy.

Humans are creative when they make connections, absorbing diverse perspectives and ideas. The ability to connect ideas across areas has grown over cultures (globalization), knowledge (digitization, technology integration), industries, economic boundaries, strategic competitive advantage, and primary innovation strategy. The driving force of the economy in advanced countries has transitioned from agriculture to manufacturing and to knowledge-intensive service industries. The economic emphasis has also changed from national to regional and now to global economy. The source of competitive advantage has progressed from economies of scale, to economies of scale and scope, to economies of scale–scope–expertise to new economies of scale–scope–expertise–convergence. The primary innovative strategy has gradually gravitated from exploitation of current competencies to exploration of new competencies. The success of any organization is largely based on its ability to predict the future direction of convergence that can enrich the entire value chain—operational innovation, new products/services, new customer values, and new customer base. Evolution of convergence can be examined in six broad levels, from components/products, functions, organizations, technology, industry, and biological/artificial systems, that are relevant to organizational innovation. Figure 3.1 presents evolution of the business environment, corporate strategies,
and convergence. Table 3.1 summarizes the convergence levels and their basic purposes to create organizational innovation.

Table 3.1  **Evolution of convergence and organizational innovation**

<table>
<thead>
<tr>
<th>Convergence Level</th>
<th>Purpose</th>
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<tbody>
<tr>
<td><strong>Level 1</strong></td>
<td>Component/product convergence</td>
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<td><strong>Level 2</strong></td>
<td>Functional convergence</td>
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<td><strong>Level 3</strong></td>
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<td><strong>Level 4</strong></td>
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<td><strong>Level 5</strong></td>
<td>Industry convergence</td>
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<td><strong>Level 6</strong></td>
<td>Bio-artificial systems</td>
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**Convergence Level**

Convergence reflects human intelligence in putting things together in new ways. It has always been with us, and can be as simple as combining an eraser with a pencil, placing the eraser on one end of a lead pencil for obvious convenience. Things like adjustable wrenches represent a form of convergence, giving mechanics the ability to deal with any size of nut rather than having to have maybe 20 different sized wrenches. In more recent times, convergence appears in the form of an electronic toothbrush, converging the time-honored need to clean teeth, a brush with electronics to charge a battery that assures we brush our teeth the full two minutes our dentist requires, and a more thorough and consistent motion to the brush to
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assure it can get into those hard-to-reach places. For children, the electric toothbrush is combined with Disney characters to make fun to brush teeth more regularly. Component/product convergence can provide an organization with a new competitive advantage through product innovation.

Functional Convergence

A process is a logical set of related activities taking inputs, adding value through doing things, and creating an output. The traditional organizational structure is based on vertical semi-independent functional areas such as manufacturing, sales, finance, human resources, and so on. These silos had vertical walls and thus cross-functional processes were not very efficient. In business, there are many different ways to get work done. Information systems play a key role. They provide a means to collect data, store it efficiently, generate reports to let management know what the organization is doing, and archive data for future reference as needed. Operational processes have to do with accomplishing cross-functional value creation, including product development, order management, and customer support. Infrastructure processes are more administrative, such as establishing and implementing strategy, and managing many aspects of the organization to include human resources, physical assets, and information systems. Each of these generic processes, whether operational or relating to infrastructure, involves sets of tasks needed to accomplish work. For example, in the operational process of order management, it is necessary to forecast the volume of demand expected for the products produced by an organization. The function of forecasting can be accomplished in many ways:
• using last month’s demand as a prediction for this month;

• using the monthly demand from a year ago as the prediction for this month;

• applying a spreadsheet algorithm such as exponential smoothing over available monthly data;

• incorporating seasonality indices into such a spreadsheet algorithm;

• taking known orders and adjusting forecasts based on past demand records;

• relying upon managerial judgment;

• using Ouija boards (throwing darts; rolling dice; guessing).

Business process re-engineering (BPR) is an activity in which an organization accomplishes process innovation to make the value chain more efficient by destroying functional walls. BPR is closely tied to enterprise information systems (ERP, for enterprise resource planning), because in order for ERP to provide benefit to the organization, at least some of the ways in which that organization does business must change.

Hammer and Stanton noted that re-engineering has sometimes been a euphemism for mindless downsizing. They gave an example of how re-engineering should work. In the early 1990s, Texas Instruments faced long cycle times and declining sales. BPR was applied, with calculator development
accomplished by cross-disciplinary teams from engineering, marketing, and other departments. These teams were to be in control of every aspect of product development, from design through marketing. The first pilot teams failed, sabotaged by the existing functional departments, which felt threatened. Functional departments were unwilling to give up good people, space, or responsibility. Power continued to lie in the old functional departments. Texas Instruments responded by changing the way it was organized. Development teams became the primary organizational units. Functional departments focused on redefined missions supporting the product teams. Budget was accomplished by process instead of by department. Office space was re-allocated. After the new system became established, new product launch-time was cut by as much as one-half, and profitability was enhanced, with return on investment multiplied fourfold.

Organizational Convergence

Economist Ronald Coase theorized that firms will expand until the costs of organizing a marginal transaction internally equal the costs of conducting the same transaction in the open market.⁴ In terms of value chains, each organization will bring in its core competence to maximize value creation, shifting from vertical integration (internal operations) to horizontal integration (value networking).

New technological developments have changed the way organizations are structured. Communications technology has made it possible to combine the skills of people in different locations. When a firm had to physically send specialists to problem areas, this was a constraint on the physical structure of organizations. Either an organization had to be large enough to hire specialists in each location where they were needed,
or they had to rely upon transportation systems to send them to problem areas. Electronic communications release organizations from such constraints. Telephones helped, but were limited to voice mode. The internet enables richer communication in both reach and richness of information, with e-mail to provide written text, and file transfer to allow more complete document sharing. This break of the trade-off between reach and richness of information enables global networking. It is no longer necessary to move an Indian computer engineer from Hydrabad to New York City to gain their services. The engineer can stay in Hydrabad, remaining in his or her own traditional culture, paid much less for his or her time, than they would be in the US, but able to live as well or better. The same idea extended to subcontracting leads to outsourcing, and at an even higher level, the ability to create global supply chains. Service oriented architecture (SOA) and web services liberate businesses from their rigid legacy systems, enabling an on-demand business model.

Additional convergence is made possible across countries. The internet has been key in allowing the exchange of digital information globally. This has enabled real-time exchange of computer files, which quickly expanded into exchange of work. The latter half of the 20th century saw the development of more effective means of production, moving away from the old view of efficiency that stressed making more things cheaper to an approach that sought to minimize waste. Waste was minimized by only producing what was necessary, in addition to producing it well.

Not only can organizations spread out throughout the globe, technology enables linkage of cooperative organizations into supply chains, which have enabled organizations such as Wal-Mart in retailing and Dell in personal computer
manufacturing to improve their performance. Value chains reflect a focus on contributions of each supply chain member toward delivering better products to consumers, thus accomplishing value chain innovation.

Technology Convergence

The 1990s saw a great deal of convergence in the technology area. Information technology boomed, with the power of computers growing by leaps and bounds (Moore’s Law). Communications technology also saw rapid development, and this led to a convergence of information and communications technology enabling devices such as personal digital assistants (PDAs), evolving into the ubiquitous Blackberry®, MP3 music technology, and a continuing growth of new and better ways to communicate and transfer information. The 1990s also saw the development of bio- and nano-technology, leading to biopills. Other developments in medicine saw the application of laser technology in medical treatments. Technology convergence creates new technologies and product innovation.

These advances are expected to bring better things, in food production, medical technology, and energy. However, the ramifications of these advances are expected to continue to be perplexing, bringing with them new dilemmas, just as coal power, nuclear energy, and petroleum have in the past. Convergences of technology lead to human creation of better ways of doing things, in the form of nanotechnology, better products and services, neuroscience, biotechnology, and other fields advancing progress.

Another example of technology convergence is digital convergence. Digital convergence is a consequence of ubiquitous computing, also referred to as invisible or ambient

We’ve already talked about the convergence of people linked by the web. There are two other major factors in digital convergence. Enterprise information systems (EIS, and ERP) have become very important in modern business operations.

Even as early as 1998, over 70 per cent of Fortune 1000 companies had either begun implementation of EIS, or were planning them. These systems have been credited with reducing inventories, shortening cycle times, lowering costs, and improving supply-chain management practices. Enterprise information systems are designed to integrate all of an organization’s information system computing. They have been credited with increasing the speed with which information flows through a company. Enterprise information systems have also been credited with:

- creating value through integrating networks across a firm or firms (Metcalfe’s Law);
- the implementation of best practices for each business process;
- the standardization of processes within organizations;
- one-source data resulting in less confusion and error; and
- on-line access to information.
All of these features facilitate better organizational planning, communication, and collaboration. Applied Robotics increased on-time deliveries 40 per cent after implementing their ERP, and Delta Electronics reduced production control labor requirements by 65 per cent. 

**Industry Convergence**

Convergence has occurred in many business and technological sectors, including the telecom and financial industries. The telecommunications and computer industries have seen powerful digital components brought to market at ever lower costs (Moore’s Law). The business applications of developing technology led to the replacement of analog telephone systems with fully digitized networks. This has evolved into a continuum of products that could be classified as either telecommunications or computer products, with the subsequent merging of industries. 

Duysters and Hagedoorn cite the convergence of the telecommunications and computer industries into a single information and entertainment industry. We can think of the *Star Wars* movies as a manifestation of this convergence. Chon *et al.* cited a similar convergence in the news media-telecommunications industry, which they attributed to the digitization cited earlier along with deregulation. 

There is also convergence within the financial services industry, with banks and insurance companies cross-selling products. Industry convergence can create new industries and customer value innovation.

Convergence can lead to gains in other areas as well. The convergence of technology with opportunities in the communications and music industries have led to the iPod®. Convergence of technological capability, educational opportunities, and the dispersed location of people has led to
the development of distance learning, utilizing media in the form of recording technology, communication technology for two-way (and multi-way) communication, file sharing technology for learning materials, and web-based education. Gains in healthcare were obtained by treating all processes as a series of ongoing experiments, which is accomplished by measuring and comparing results with standards. This step also requires that all processes be spelled out in detail to avoid ambiguity. Problems identified are immediately addressed. Rather than working around problems, their causes are identified, and countermeasures established. Successful methods are disseminated after assuring that it is appropriate for each process. Experimentation is encouraged at all levels of the organization.

In addition to cutting waste and improving quality, the new industrial paradigm includes linkage in the form of supply chains, often global in scope. A variety of systems have evolved to coordinate the diverse players in global supply chains. Supply chains are networks of suppliers/vendors, manufacturers, distributors, and retailers that are connected by transportation, information, and financial infrastructure. The idea of a coordinated supply chain manifested itself in the form of vertical integration in the 19th century, leading to consolidation of ownership and interlocking centrally coordinated organizations. These mammoth business operations proved unwieldy, however, in the faster-paced business operations of the latter 20th century, where the ability to specialize and coordinate through e-business has led to complex supply chains that seem to develop from markets rather than the plans of specific people. Business brought many advances in the management of supply chains. Current supply chain technology includes potentially many suppliers/vendors linked to one or more manufacturers and/or
assemblers, who often distribute through multiple distributors to usually many retailers. Industry supply chain leaders such as i2 and Manugistics have developed tools to support sharing of sales and forecast data, and enterprise resource planning software often feature such support.\textsuperscript{12}

**Biological and Artificial System Convergence**

The march of technological progress continues, as it has for centuries. Norman Borlaug was recognized for developing wheat that was resistant to stem rust. This advance promised better yield of crops in areas of scarcity, which was labeled the “green revolution.” The expectation was that overpopulated and under-producing areas would be able to sustain themselves. In the 1990s, one of the most popular areas of technological growth was in genetic engineering of food. However, by 1998 the Japanese and Europeans had rejected what they referred to as “Frankenfood.”\textsuperscript{13} In the United States, genetic engineering has enabled much more cost-efficient food productivity. But the US also has a minority of consumers convinced of the value of natural, organic food. In Europe and Japan, this is a controlling majority. While further scientific progress is expected to continue in many fields, it is also expected that debates will follow each of them.

There is similar technological advance in the medical field. Fukuyama\textsuperscript{14} proposed three possible futuristic scenarios in this crucial branch of science:

1. Drugs such as Ritalin and Prozac aid self-esteem and concentration, but have side-effects for specific types of individuals. Functional foods combining focus on nutrition and health could change the entire life science sector, converging the food and pharmaceutical industry.\textsuperscript{15}
Genomics in the future may enable drugs to be tailored to genetic profiles (medical anthropology), minimizing side effects. This might provide a means for individuals (who can afford the drugs) to specifically attain psychological moods on demand without risk of addiction, hangover, or brain damage.

2. Stem-cell research can regenerate almost any body tissue, providing physicians with tools capable of extending life well beyond 100 years for those who can afford it. However, humans are complex systems, and other aspects of aging may make such gains moot. Further, extended life may clog social systems (minor ones being Social Security and Medicare in the US).

3. Human reproduction may be supported by technological advances allowing prospective parents to design their offspring in terms of intelligence and/or appearance, as some Chinese parents practice for their only child. This may sound attractive, but deeper reflection scares many people. Germans in the 1930s were pioneers in this area of biological study and the Chinese are making advances in this area today.

The idea that computers can evolve into life-forms is interesting to some. Ray Kurzweil discussed the potential of computers to gain intelligence in multiple books. Others have discussed the anticipated convergence of information technology, biology, and business. The former focus was on building organizations to predict and control, to sense change and to respond. Kurzweil has even predicted that by about 2040 we will reach a singularity, where computers attain the power to function as well and even better than humans. He finds that attractive. We aren’t so sure. Molecular technologies enable
bio- and nano-technology, with the potential for greater connectivity, utilizing autonomous software to converge information, biology, and business to achieve ubiquitous innovation.

The evolution proposed by Kurzweil, leading to ever-smarter computers capable of functioning at or beyond the human level, can lead to a greater understanding of molecular technology environments. This will lead to many new opportunities to develop radically new and better products as well as processes to get things done. Ubiquitous computer environments are emerging in our own time. This can, however, get out of hand. The danger is that we may reach the state of singularity where humans lose control to artificial systems. Kurzweil sees no danger in this, allowing computers to take care of mundane activities, freeing humans to presumably enjoy life in whatever manner they wish. We are not so sure that this would be a good thing. However, with the possibility of a singularity and the associated advance in computer potential, computers will be ever more ubiquitous, part of practically every aspect of human life. Some of this is already possible in monitoring the state of machinery and appliances, providing the potential for automatic fault detection and self-correction. The application of computers to aid in health care of individual humans offers another field of great potential benefit.

**Convergence of Economies**

The highest structural convergence would be convergence of economies, such as the EU. There are also other types of cooperative or collaborative convergence, such as OPEC, ASEAN, NAFTA, WTO, the G5, the G7, OECD, Free Trade Agreements, and so on. We have seen an evolution in political
structure. Fukuyama traced progress from tribal-based organizations depending upon agricultural subsistence and slavery, replaced by better systems with theocracies, monarchies, and feudal aristocracies.\(^1\) The United States is based upon a reaction to these centralized forms of political structure. Communism was another reaction. We now see modern liberal democracy dominating in the political domain, and technologically driven capitalism in the economic domain.

Many economic agreements have formed over the past four decades. Practically every area of the world has a trade association such as ASEAN in south-east Asia. Some have disappeared, such as the Comintern (replaced by similar organizations crossing former ideological lines). More recent organizations of this type include NAFTA and the EU. The overall trend is to a more open, free trade environment worldwide, although protectionism still appears on occasion.

**Conclusion**

We have seen developments that led to a revolution in how the world of business is organized and conducted. Technologically, great challenges exist in food, medicine and energy. We have developed the ability to produce ample food, but have two problems. First is the problem of distribution. Some areas of the world have surplus, others starve. Getting food from one to the other is an age-old problem. The physical problems are easily solved. The economic and political transfer problems are not. Great strides are being made in the medical field, but the system for payment is a complex problem. Energy is an even greater challenge. Fossil fuel energy has served the world quite well for almost two centuries. However, it has created
many difficulties in the form of pollution, and there are real concerns about the sustainability of petroleum. A great deal of energy is being devoted to developing alternative forms of energy, but the problem is not at all easy, and the impact on the world is very threatening.

A second area of convergence offers mitigation of problems if not solution. We have made tremendous gains in digital technology, leading to extensive global communication on an individual basis. People can talk, which should help solve easy problems. They also can reach markets, which gives them greater reasons for hope. Organizations have more powerful, integrated tools to aid them in coping with the masses of data they now face. Organizations can also reach broader markets to obtain the digital services they need. They also have more powerful tools to manipulate and interpret the data generated. However, there still remain problems with controlling the internet, dealing with the complexity of massive organizational systems, assuring quality in an open web services environment, and ethical issues in the use of data.

Another area of convergence is the organization of production. Digital technology provides the opportunity to link businesses. Supply chains have emerged linking raw materials to customers through ever-more efficient groupings of organizations. By accessing broader markets of suppliers and vendors world-wide, production organizations have shifted manufacturing work around the globe, impacting every social system. China faces problems in dealing with exploding opportunities in the manufacturing sector versus declining interest in agricultural production. Mexico faces transitional problems in trying to respond to a once-growing maquiladora system which is being outsourced to China. The US faces complex problems
in dealing with a shifting work-force structure with rust belt employment disappearing, heavy influx of Mexican workers causing concerns about immigration, and the need to develop new skills of value to the world from a growing workforce. Similar problems occur in Europe.

Some of the most exciting opportunities involve convergence in biotechnology. This is a sensitive area, as consumers are easily scared away from products if there is the slightest hint of possible problems. However, any technology involves complex relationships that could be potential problems. We have evolved over millennia, with natural selection discarding characteristics with the worst problems, and will continue to do so. New ways of doing things are needed to make life better. Convergence of scientific thinking and needs for improvement will lead to further progress in biotechnology, as it has in other areas.

Overall, we appear to be making quite a bit of progress. We have made impressive gains in food, medical, and energy technology, in digital technology, in supply chain organization, and in knowledge management. However, as has been true throughout history, every gain in human understanding is like opening a door to many more mysteries. The need for greater understanding grows exponentially as we learn more.

References


