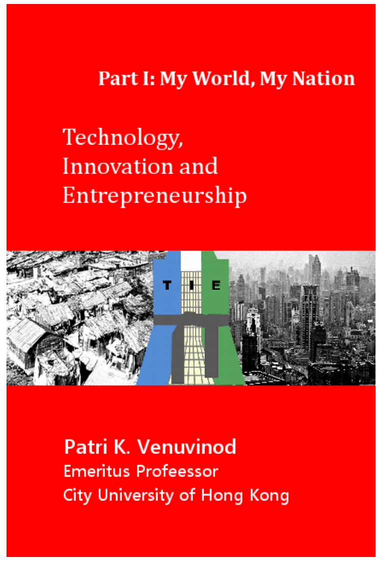

Technology, Innovation and Entrepreneurship
Part I: My World, My Nation

By Patri K. Venuvinod

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Dedication

To Mrudula, my wonderful wife.

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Contents
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About this Book

Back to top

Thomas Jefferson said "[E]very generation needs a new revolution." The revolution for the generations in the first half of the 20th century was socialism/communism. For the generations of the second half of the same century, it was the return to capitalism. For the current generation, it seems to be entrepreneurialism.

Three insights concerning economic growth have become clear in recent times. First, the key to economic growth is technology (T). Secondly, innovation (I) is the driver of technology growth. Finally, entrepreneurship (E) is a highly powerful but extremely underappreciated contributor to innovation. Yet, there continues a paucity of academic books covering the large variety of issues impinging on TIE-exploitation from a contemporary viewpoint. This book is the third and final part of a textbook-trilogy that seeks to fill this gap.

The first part (this book) is titled *My World, My Nation* as it examines TIE interactions from a world-perspective but stressing nation building. *Part II: My Firm* discusses how an established firm could prosper in the contemporary world of globalized competition and technology. *Part III: My Startup* discusses issues of particular interest to the growing number of youth pursuing an entrepreneurial career.

The origins of this trilogy lie in the class notes compiled by the author while teaching 'Management of Technological Innovation' to undergraduate and graduate students from science, engineering and business departments. The final contents have been influenced strongly by the insights derived by him while living and working in India, the UK, Hong Kong (including extensive travels to mainland China), and the USA. Thus, rather than focusing just on the lessons to be learnt from the experiences of a developed country such as the USA (as most books on the
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themes examined do), this trilogy empathizes with the biases and concerns of the developing parts of the world as well.

Among the topics examined in this book (Part I) are the techno-economic history of the world, the philosophies of science and technology, the industrial revolution, theories of economic growth, economic downturns, and the roles of technology and culture in national development.

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Preface

Back to top

My childhood was spent in a small Indian township housing the largest Asian sugar factory of the time. Yet the town didn't even have a primary school. Consequently, I couldn't receive formal education till I turned nine. Only then could I be trusted to lug my school bag across water-laden paddy fields to a small government school located in a larger neighboring town.

The difference between the two towns was palpable. In keeping with their rural setting, people in my school-town were mostly steeped in age-old traditions, and religious or caste rivalries. This was in sharp contrast with the people in the industrial township I lived who tended to temper blind belief with rationality, dogma with pluralism, and disorder with organization. This contrast provided me with my earliest practical lesson in the power of technology as a vehicle for bringing forth social transformation.

My technicism led to a dilemma, though, as I approached graduation from my high school and started thinking about what I could/should become. The choice was obvious for most of my classmates. A farmer's son would become a farmer, a grocer's a grocer, and a feudal landlord's a landlord. Being a technologist's son, none of these choices was immediately available to me. In any case, all were unexciting.

Meanwhile, independent India was struggling to find its road ahead. The "Father of the Nation", Mahatma Gandhi, passionately advocated a bottom-up, village-oriented approach underpinned by altruism. Technology was accorded only a peripheral role, if at all.

But, Gandhi's influence was already waning as that of Jawaharlal Nehru was rising. As India's prime Minister for seventeen years, Nehru pursued a national development strategy based on socialistic principles and central planning. (During his formative years, Marx's works were well-known while Schumpeter had not written his counter-thesis yet. Schumpeter gained some fame by the time Nehru became the prime minister. But, apparently, Nehru's mind had set by then.) Nehru also acknowledged the central role of technology in development and created a range of public sector industries which became vehicles for technology transfer mainly from the Soviet bloc. Taking cue from this trend, I joined an engineering college in the state capital in the hope of eventually becoming a public sector employee.

One of the few non-technical subjects we had to study was Economics. One would have thought that the syllabus of this subject reflected the prevailing Marxist bias. As it happened, the books
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prescribed dwelt essentially on classical capitalism. Further, my teacher was an eloquent laissez-faire enthusiast. All this exposed to me to the flipside of Nehru's strategy: it was ignoring the role of the individual through personal enterprise. In fact, individual entrepreneurship was being discouraged through elaborate licensing requirements. This didn't bother me since I, like most of my compatriots, believed that no public good can come out of greedy individuals.

Immediately upon obtaining my engineering degree, I proceeded to one of the premier institutes of technology in the country to specialize in design and production engineering. The particular institute I joined was set up with Soviet collaboration, so a good number of my professors were from the U.S.S.R. I learnt a lot about mechanical technologies from them but little about the new developments that were occurring in electronics and computers. There was also little curricular emphasis on the human and market sides of engineering.

My association with Russians and the like didn't end there as the UNESCO expert from the Soviet Union assessing my masters' thesis reacted favorably to it. He started persuading me to take up academic career at a newly established Regional Engineering College. The idea was that I would assist him on developing the curricula for eight post-graduate programs in technology across India. I agreed.

Over the next few years, I got associated with many more experts from the Soviet Union and Eastern Europe. From them I learnt more about technology and their countries where vertically integrated industries were producing the goods that the respective governments thought their citizens needed.

Next, I was selected to go to the U.K. as a UNESCO fellow to work on my Ph.D. The personal niche in technology (metal cutting) research I was to find there was to remain with me for the rest of my professional life. While in the U.K., I also spent some time at an ILO institute in Italy and secured a deeper appreciation of the role of technology in economic growth. These experiences helped me develop a more secular, and global outlook.

Upon receiving my research degree, I returned to my previous place of employment in India. The aura of my 'foreign' PhD helped intensify my research activity. It also made it easier for me to initiate several non-curricular learning activities amongst students. For instance, noting that the college's curricula had not included management science as a subject of formal study, I organized interested students into what we called the Management Studies Group. Not everyone was happy, though, with our enthusiasm for management science. For instance, during an address to the group, the main message of our Principal was that 'management' was no more than a euphemism for worker-exploitation. Many others were also offended as the campus was rapidly becoming a hotbed of communism. The resulting tensions made me think about finding a place more conducive to academic pursuits.

A few years later, I moved to Hong Kong—then still a British colony. I worked at two different polytechnic-universities. At the first, I obtained a broad understanding of how Hong Kong ticked. Hong Kong was very different from India or the U.K. While India was still struggling to find its path and the U.K. was past its prime at least in terms of world domination in technology, Hong Kong was fast becoming a prominent 'Asian Tiger' despite being just a city state without any natural resources and little industrial history. It had already acquired international reputation in finance and manufacturing. In terms of manufacturing, it had developed well past the era of Productivity (P) into the era of Quality (Q). It achieved all this by pursuing free market capitalism based on thousands of horizontally integrated small and medium-sized private enterprises. The government assiduously pursued a hands-off policy believing that other social problems would be mitigated automatically as economic prosperity is achieved. The reliance on personal enterprise (entrepreneurship) seemed to infuse many a young person with confidence in the future. These observations made me more sensitive to the power of individual entrepreneurship in economic growth. I also became convinced of the importance of creativity and broad-based education in the preparation of youth for entrepreneurial careers.

All this preparation proved to be particularly useful when I became the founding head of the Department of Manufacturing Engineering at a newly formed polytechnic-university in Hong Kong. I promptly set in motion several curricular and pedagogic experiments. The results only confirmed my convictions.

My 25-year stay in Hong Kong also provided me with ample opportunities not only to learn about but also to interact with mainland China. When I first arrived in Hong Kong, China had just embarked on a journey that was to lift some half a billion people out of poverty within the next 30 years. I had the good fortune of being chosen as a member of the first international delegation organized by some Hong Kong elders to visit China after Deng Xiaoping had declared China's "Open Doors Policy". This was only the first of many similar trips to come.

When I first went to South China, I found the place in a shambles following the self-inflicted injuries during the Cultural Revolution. Yet, today, the region is a thriving industrial complex actively contributing to China's well-earned reputation as the "factory of the world".

As I noticed during my subsequent trips to different parts of China, this was mainly the consequence of technological advancement resulting from technology transfer underpinned by unprecedented openness. Equally importantly, it was because the government managed to release the entrepreneurial energies of individuals without putting overall political stability in serious jeopardy. China was also wise in adopting the unprecedented "one country, two systems" policy with regard to post-1997 Hong Kong. The policy has already yielded rich dividends—Hong Kong's industrialists have been providing between 50 and 70% of FDI in China.

The above political developments suggested to us that our department's programs and curricula would have to recognize not only the local aspirations of Hong Kong but also how the territory could contribute to the rest of China. In particular, we had to take into account the fact that Hong Kong needed to move on to the era of Innovation (I). Keeping this in mind, we sought to broaden our program portfolio beyond manufacturing engineering in a manner that would enable students to equip themselves for the coming era of innovation and entrepreneurship. We also introduced, for the first time in Asia, a bachelor's program in Mechatronic Engineering and a master's program in Engineering Management. The former emphasized the design of products and processes involving the integration of mechanical, electronic and computer elements. The latter sought to convert engineers into managers capable of conceiving and operating technology-intensive firms and startups. For over ten years, I personally taught the subject of Management of Technological Innovation (MTI) to both engineering and non-engineering students drawn from sub-degree to doctoral levels.

A major problem I encountered while teaching MTI was that there was no suitable textbook to support my teaching. Whereas I was seeking to examine technology, innovation and entrepreneurship (TIE) in fair detail and in an integrated manner, the existing text books focused on the management of the first while treating the latter two only in a cursory manner. Clearly, there was a need for a new book. It was then that I set upon writing this trilogy.

It took me several years of personal research and learning to come to grips with the book's contents. I embarked upon such an exercise immediately upon retiring from active service in Hong Kong and setting up residence in the U.S. My work was significantly helped by the fact that my immediate circle in the U.S. included several young, budding entrepreneurs. I learnt a lot by keenly observing their entrepreneurial trials and tribulations.

Upon retirement from formal teaching, I tried to disseminate in India the TIE lessons I had learnt abroad. I managed to bring together over twenty engineering colleges in and around Hyderabad to collaborate under the umbrella of International Organization of Developing Universities (IODevUni). One of the projects initiated by the Chapter was the application of the emerging e-learning technologies to facilitate the teaching of subjects for which member-colleges did not have enough experts.

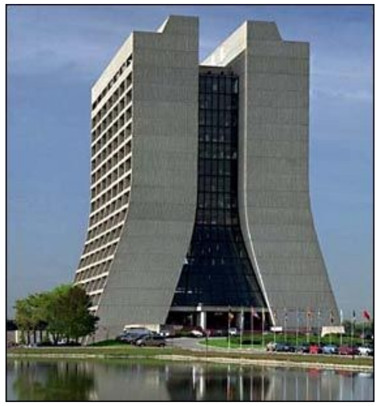
E-learning enables students to learn anywhere at the pace, time and location of their choosing. The contents of an e-book itself can be updated frequently. One can also use the power of the Internet to build and sustain a learning community around the particular professor/subject. The learning community itself can contribute material such as case studies, adaptation to local and current conditions, and so forth. This is why this trilogy is being offered first in the form of e-books and a website called tecinnovent.com has been set up in its support.

This trilogy is based on five premises that seem to hold in any economy irrespective of the 'ism' being followed:

~ *The key to economic growth is productivity improvement through improved technology.*
~ *Innovation drives technology growth.*
~ *Competition spurs innovation.*
~ *Entrepreneurship consummates innovation.*
~ *The above four premises are equally applicable at the levels of nation-building, managing an existing firm, as well as launching a new venture or a startup.*

The first four premises resonate with the recent arguments made by Edmund Phelps, 2006 winner of Nobel Prize for Economics, that general knowledge—encompassing business, technology, and the economic environment at large—is an important enabler of the virtuous circle of creativity, innovation, and growth.

Following the last premise, this work is organized into three parts, each devoted to one of these three levels. The picture on the cover page seeks to capture the way each part is addressed. The shape of the central structure in the picture is inspired by Wilson Hall of Fermilab situated close to the author's residence in the suburbs of Chicago (see picture below). Till very recently, Fermilab had been housing the largest particle accelerator in the world. Thus it captures the central role of systematic science. Systematic science of course is the springboard for a great deal of modern technology.



Adapted from Fermilab website.

The central structure is made up of three parts labeled Technology (T), Innovation (I), and Entrepreneurship (E). This, of course, is in agreement with this trilogy's title. However, the intention is not just to examine T, I and E as themes worth studying in their own right, but also to 'tie' them together in a purposeful manner. Nations, firms and professionals who understand how the three elements can be synergistically united will enjoy a clear competitive advantage in the modern, globalized world. This emphasis on pulling T, I, and E together so as to beat the competition is reflected by the black belt around the central structure's 'waist'.

Part I consisting of Chapters 1 to 8 is titled 'My World, My Nation' as it explores the theme of TIE from a world-perspective but stressing nation-building. As citizens of the world and of a specific nation we all engage in animated discussions about some aspect or other of current trends and events in the world. This part aims to make such discussions more informed and purposeful. The issues discussed should be of particular interest to public officials/workers and those at executive levels.

Part II (Chapters 9 to 17) is titled 'My Firm' as it discusses the TIE theme from the perspective of how an existing firm or organization could prosper in the contemporary world of globalized competition. The issues discussed should be of particular interest to professionals and managers at all levels.

Part III (Chapters 18 to 26), titled 'My Startup', focuses on issues of particular importance to the growing number of youth across the world seeking an entrepreneurial career. It should also be of interest to serial entrepreneurs and intrapreneurs (mentors of entrepreneurial employees).

Although much of the material covered in the present trilogy is available in other books, few have put all of them together. The trilogy also includes several segments drawing on the author's research.

An examination of literature on the subject of TIE reveals a variety of discursive approaches. Some rely on a selection of case studies to find commonalities to arrive at a list of do's and don'ts. Some choose a particular sociopolitical belief system, e.g., capitalism or socialism, and use it to theorize. The method adopted in this trilogy is neither. The term 'evidence-based reasoning' captures the preferred mode of discussion.

Although the trilogy adopts an academic writing style, it should be useful to working professionals as well as general readers in addition to university students and researchers. It is not necessary that all the chapters are covered in a single semester. Depending on the course objectives, one can pick and choose chapters. There is enough material in the trilogy to engage students for 2 to 3 semesters.

Patri, K. Venuvinod
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City University of Hong Kong

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Chapter 1
Introduction

"[P]eople use the word 'guru' only because 'charlatan' is too long."

—Peter F. Drucker, "the Father of Modern Management"

Back to top

Human Well-being

Back to top

Conscious pursuit of one's own survival and well-being is a hallmark of mankind. Almost all of us constantly strive to promote our own well-being or that of our near and dear ones. But it is not easy to pin down human well-being as it is made up many components, the most important being health, prosperity and that elusive entity called 'happiness'. According to the noted American psychologist, Abraham Maslow (1943), the degree of individual happiness at any given time critically depends on the subject's ability to satisfy his/her physiological, security, belonging, esteem, and self-actualization needs, *in that order*. Most people seem to work on the assumption that the process of meeting all the human needs is linked, either directly or indirectly, to human material prosperity. Obviously, one can find several psychological, ethical and philosophical arguments against adopting this assumption unconditionally. But it is undeniable that most people generally act as if the terms 'happiness' and 'material prosperity' are synonymous. A more tempered view is that, while happiness is not proportional to the wealth one possesses, one can't really be happy without a certain minimum of material support.

Economic Growth

Consider now how human material prosperity has changed over the millennia. A commonly used measure for the material prosperity of a nation is the gross domestic product (GDP) expressed in terms of a specified currency at a certain time divided by the population of the country at the time of the output. This measure, called GDP per capita, is in extensive use today.

Figures 1.1a and b show the historical trends of world population and world GDP in 1990 US$ as compiled by Bradford DeLong, Professor of Economics at U.C. Berkeley. Figure 1.1c shows the trend of GDP per capita as calculated from the data underlying Figures 1.1a and b. It is an easy step to calculate from these trends the annual rate of change in the average GDP per capita across the world (see Figure 1.1d).
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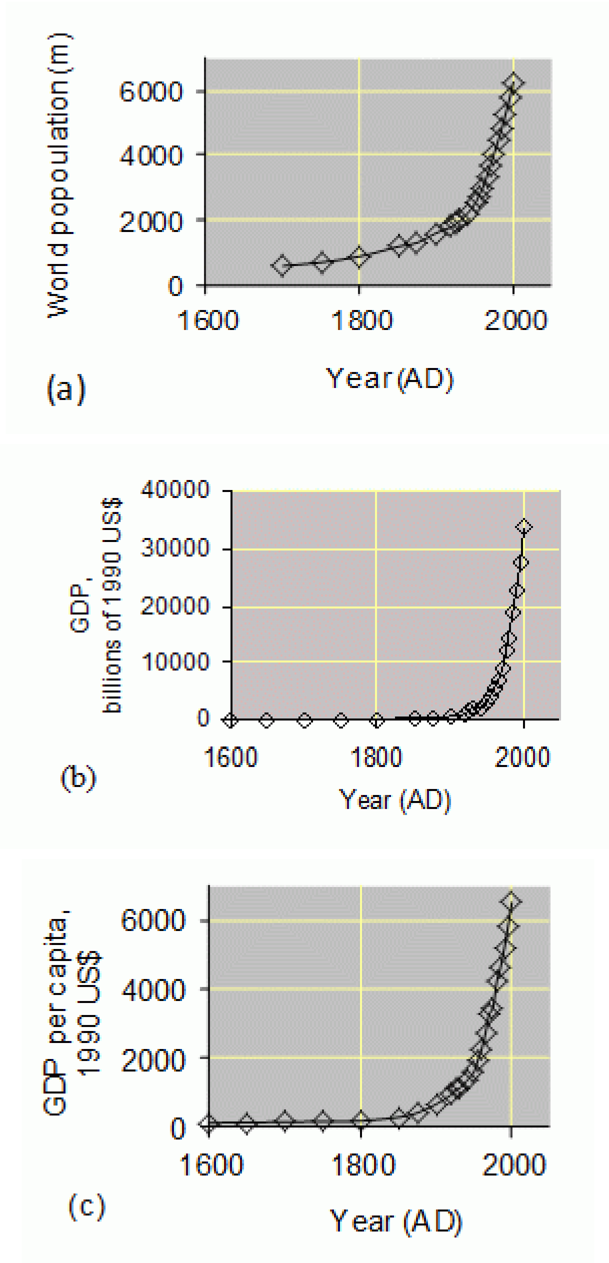

World popoulation (m)
6000
4000
2000
0
1600
1800
2000
Year (AD)
(a)
GDP, billions of 1990 US$
40000
30000
20000
10000
0
1600
1800
2000
Year (AD)
(b)
GDP per capita, 1990 US$
6000
4000
2000
0
1600
1800
2000
Year (AD)
(c)

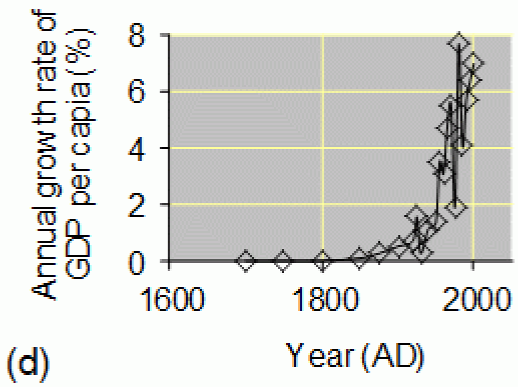


Figure 1.1 Historical trends in world economy, GDP figures in 1990 US $, data from DeLong (1998).

It can be seen from Figure 1.1c that humanity has progressed enormously in economic terms in recent times. The graph reveals a clear transition from slow growth to fast growth around the middle of the 18th century. For millennia before that time the average GDP per capita across the world had remained under US$0.70 per day, a figure well below the poverty line stipulated these days by the United Nations. This means that, except for a few feudal lords and their close associates, almost everyone around the world was wretchedly poor by today's standards. Further there was little hope as the annual economic growth rarely exceeded a fraction of one percent.

But, fortunately since the 18th century transition, many countries in the world started witnessing explosive growth—to the extent that, just a century later, the world as a whole was experiencing between 2 and 8% annual growth. As a result, the proportion of people living below the extreme poverty line decreased to 52% in 1981, to 42% in 1990, and to 26% in 2005. As a result, the middle class grew to the extent that many can now enjoy luxuries that once were available only to the ruling classes.

On the other hand, unfortunately, the story is not totally benign. We can see from Figure 1.1d that the dramatic growth rate since the transition has also been accompanied by more rapid economic fluctuations. A more detailed examination of the data for the period 1700 to 2010 reveals that some of the fluctuations have been very serious, e.g., the Great Depression of the 1930s and the 2008 global financial crisis. Both have had grave consequences in the form of high unemployment, stock market crashes, home foreclosures (mainly in the U.S.), and so forth. However, fortunately, after each economic crisis, the world quickly arrived at an economic position superior to that existing when the crisis had started. This means that the broad principles (whatever they are) underlying the long-term economic growth depicted in Figure 1.1c continue to be valid but with the caveat that societies should not let greed overcome prudence and one must always be prepared for a severe economic downturn.

The origins of the transition to fast economic growth have been debated widely. It is now commonly agreed that the transition was characterized by an unprecedented cluster of technological developments that took place in Western Europe, the most commonly cited one being the development of the steam engine in 1765 by a Scottish inventor by name James Watt. These and subsequent technological developments are now commonly referred to as the 'Industrial Revolution (IR)'.

The consequences of the IR have been profound. Before the revolution, agriculture was the main economic activity. The IR added *manufacturing* to it through the development of mechanically powered machinery located in factories away from workers' homes. A little later, machinery became electrically powered which further accelerated economic growth. In time, more and more countries joined the game. As the middle class grew, the *service sector* was added to the agricultural and manufacturing sectors. By the middle of the 20th century, developments in information and communication technologies (ICT)—mainframe computers, personal computers, the internet, and so forth—heralded the *information age*. A major outcome of the ICT revolution was business and cultural globalization (Venuvinod et al., 1998).

It is not that new technologies were not being developed prior to the IR. Indeed there were many technological developments even in ancient times, e.g., artificial fire, the wheel. But these were few and far between as the mechanisms for knowledge transmission from one tribe to another were missing. What is significant about the post-IR period is the high clustering of inventions followed by more rapid commercialization of selected inventions.

Technology is the Key to Economic Growth

Why does technology development improve the economy? Nobel Prize-winning economist, Robert Solow, was among the first to address this question quantitatively. A simplified version of his theory (Solow, 1956, 1957, 1970) assumes that the total production of material wealth in a given economy, Y, can be expressed as

$$Y=K^{a}(A_{T}L)^{1-a}\Big|_{0\leq a\leq 1}$$

where L is labor, K is capital (the money needed for acquiring the land, buildings, hardware, software etc. to sustain production), and A_T and a are empirically determined constants (see Figure 1.2).

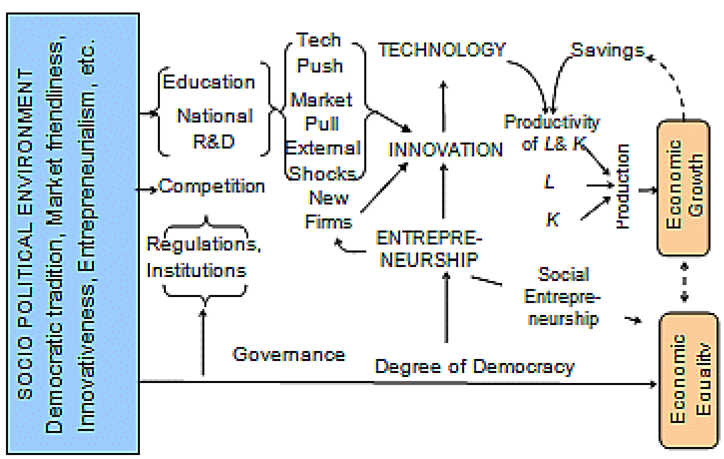


Figure 1.2 The roles of technology, innovation and entrepreneurship in achieving national economic growth.

The real role of technology however becomes apparent when we examine the empirically determined behavior of A_T. Solow found that a significant part of economic growth could not be accounted by known increases in K and L. This suggested that the unexplained part, the so-called Solow residual, could only be accounted for through an increase in A_T. Solow then went on to interpret A_T as being equivalent to total factor productivity, T_m, a parameter that accounts for all contributions to total production including and beyond those reflected in *K* and *L*.

Often, total factor productivity is interpreted as reflecting the way in which technological innovation allows capital and labor to be used in more effective and valuable ways. For example, the development of word-processing software has greatly increased efficiency compared to the use of typewriters. Typewriters themselves represented a huge productive advance over clerical work using pen and paper. This process of improved technological methods has resulted in an increase in labor productivity. More recently, other economists have suggested that further factors—good institutions that support markets, innovations in the organization of work, or access to global markets—should be thought of as equally important in promoting economic growth and, hence, should be folded into T_m.

Whatever be the interpretation of T_m, doubling the multifactor productivity doubles *Y* since its index is equal to 1. Conclusion: *Rapid economic progress is not possible without investing in new technology and establishing a cultural and institutional environment conducive to technology assimilation and development*.

Figure 1.3 illustrates some growth accounting results for the U.S. in the period 1929–1987. Note that the government was a negative factor actually reducing the output by some 9%. Imagine what would have happened in a totalitarian country!

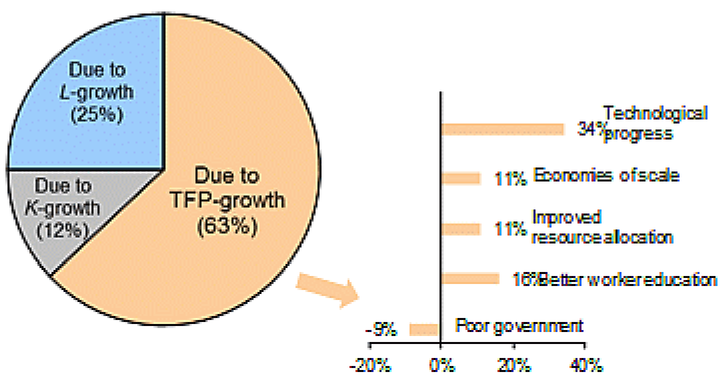


Figure 1.3 Growth accounting for the observed average annual growth rate of +3.1% in U.S. (1929-1987).

By sharp contrast, technological progress was the most important positive factor. Other estimates of the contribution of technical change to U.S. growth vary from 33% to 78% depending on the assumptions. Table 1.1 shows some results comparing the U.S. to a selection of other countries. Figure 1.4a illustrates the effect of technology on national prosperity for a selection of 102 countries. Note the strong exponential relationship—the exponential index is 1.11.

Table 1.1 Some growth accounting results, Data from Kim & Lau (1994).					
Region	Period	Rate of economic growth (%)	% contribution to economic growth		
			Capital	Labor	Tech. progress
S. Korea	1960–90	8.6	67	19	14
Taiwan	1953–90	8.7	72	13	15
Singapore	1964–90	8.9	55	23	23
Hong Kong	1966–90	7.8	48	17	35
Japan	1957–90	6.7	49	6	46
France	1957–90	3.7	33	–1	69
W. Germany	1960–90	3.2	36	–7	71
U.K.	1957–90	2.5	35	4	49
U.S.	1948–90	3.1	24	28	46

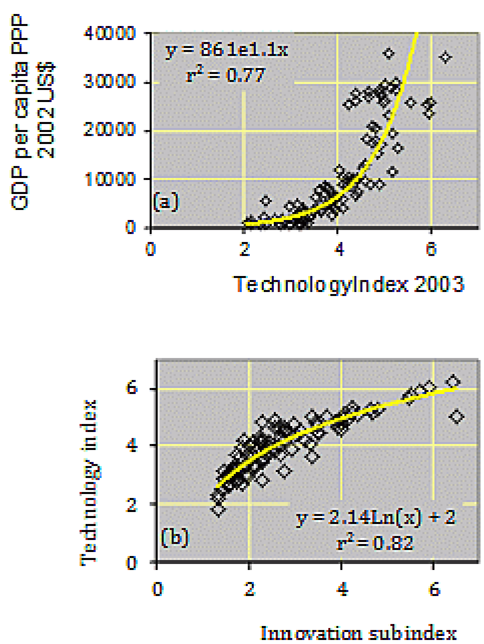


Figure 1.4 The impact of technology and innovation on national prosperity, GDP data from UNDP (2004), technology and innovation data from WEF(2005).

Innovation Drives Technology Growth

Whoever be the developer, all technology development starts with someone getting a new idea. More often than not, a group of people belonging to a profit-oriented firm collaborate to convert the idea into a commercially profitable reality. In recent times, it has become common to use the term 'innovation' while referring to the conception, invention and commercial exploitation of new ideas. Technology and innovation together constitute the primary key to economic growth. Box 1.1 shows some recent survey findings underscoring this point.

Clearly, the greater the innovative spirit of a region, the greater the scope and potential for technology development and utilization in the region. For Mokyr (1990), technological creativity is "the lever of riches" that forms "the very basis of the rise of the West". That this is indeed true is confirmed by Figure 1.4b which illustrates the correlation between the innovation sub-index and technology index data collected by the World Economic Forum (WEF) in 2005 for 99 countries presented in (WEF, 2005). Note that innovation has a greater effect on technology utilization when the country is less advanced technologically. One can't be sure however which is the cause and which the effect. It is perhaps safer to say that there is a mutually reinforcing relationship between the two. Consequently, as Alvin Toffler said "Technology feeds on itself. Technology makes more technology possible."

All the above implies that the study of the economic and commercial exploitation of technology and innovation should be of great benefit to any public leader, corporate professional, or entrepreneur. This is why the title of this book starts with the words *Technology* and *Innovation*.

However, notwithstanding the obvious importance of technology, the recognition of 'Technology and Innovation' as the primary key to economic growth is nowhere near being universal: "Technical change is like God. It is much discussed, worshipped by some, rejected by others, but little understood... At the individual level, we all love technology for the security, comfort, convenience, power and social-status it brings. At an abstract collective level, we hate it for our inability to understand and control it. We are deeply aware of the havoc wrought by technology through wars and environmental degradation. But, at a more concrete level, we hate technology for amplifying the economic disparities amongst groups of people, particularly if we are among the have-nots (Thomson, 1984, p. 243, as quoted in Mokyr, 1990)."

For instance, India's Mahatma Gandhi built an ethically-based anti-technology stance and movement which unwittingly had a confusing influence on many Indian students, teachers, engineers, bureaucrats and so forth of the time. To that extent the economic progress of India was delayed. (The present author was one of such youth and it took him decades to get over the confusion.)

Further, much of the rivalry between capitalism and socialism that dominated world politics during the 20th century seems to have downplayed the role of innovation in economic development. By the end of that century however, pure socialism gave way to democratic capitalism in much of the world. Pure socialism focused on the collective as opposed to the individual. But, as it turned out, it was not the so-called 'collective' that was ruling but a few elite who took over the reins claiming that they represent the collective. To sustain themselves in power, the 'few elite' *had* to suppress individual creativity.

But individual creativity sustained by an appropriate institutional framework is the fountainhead of innovation. Naturally, ideological believers in Marxist socialism (e.g., the former U.S.S.R. and China) could not compete in economic terms with market-oriented capitalist countries (e.g., the U.S.) until they managed to abandon undiluted socialism. This lesson from the protracted rivalry between autocratic socialism and democratic capitalism is yet to sink in fully across the world.

Competition Spurs Innovation

Let us now turn to the question “What drives innovation?” The resounding response must be competition. Innovation is about realizing something new. Newness implies that one doesn’t know in advance whether one would succeed. As a result of this uncertainty, innovation is always accompanied by risk.

So why do people engage in innovation? There are two reasons. The first is greed. If we do succeed, innovation can lead us to rich rewards. There is always a great deal of profit to be made by being the *first mover*. Most startups are motivated by this constructive type of greed.

The second reason is fear—in particular, the fear of competition. If you sit still by not innovating, sooner or later someone will come up with a better product or service and wipe you out of the market. Most well-established firms engage in innovation because of this negative reason. Simply speaking, they follow the adage “innovate or perish”. Boxes 1.2 and 1.3 recount the stories of two well-known companies (Wang Laboratories, and General Motors) that have perished or come to the brink because they had become lax at innovation.

Either way it is clear that innovation doesn’t flourish in the absence of competition. Hindsight shows that societies that stifled internal competition through nationalization of industries have not done as well as societies nurturing internal competition. As noted earlier, collectivization leads to restrictions on individual freedom thus stifling competition. As a result, more and more countries today (including many that had favored collectivization earlier) are taking active steps to make their societies ever more competitive. Meanwhile, owing to developments in technology (‘distance is dead’ now), the world is rapidly ‘globalizing’. As a result, competition has increased by an order of magnitude.

A review of the industrial history of nations reveals a recurring pattern (see Figure 1.5). Initially, countries focus on competing on the basis of reduced costs, i.e., increased productivity (P). For instance, Japan, Hong Kong, and China had all started off as countries producing cheap goods. However, very soon, countries shift their focus to the achievement of superior quality (Q) while still maintaining low costs. For instance, Hong Kong had progressed to the Q-era in the early 1980s although, as it appears, it is still stuck there.

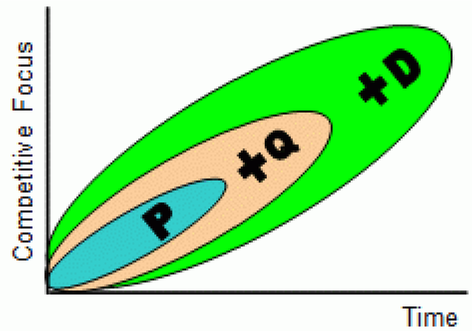


Figure 1.5 Competing through productivity, quality, and differentiation (Venuvinod & Sun, 2000).

Having successfully mastered P and Q, countries then start competing on the basis of superior differentiation (D), i.e., by offering products and services exhibiting new functionalities. A prerequisite to this phase is widespread and robust education and a well-developed R&D infrastructure, as in the case of the U.S. A similar PQD-sequence can be found in the case of China's recent domination of the world in manufacturing and India's IT journey.

Whatever be the stage of development, the need for innovation seems to be a constant factor in a nation's progress. During the P-era one innovates mainly to reduce costs, in the Q-era to improve P as well as Q, and in the D-era to improve P and Q as well as bestowing products, processes, institutions and so forth with new capabilities.

Entrepreneurship Accelerates Innovation

Finally, let us turn to the question "Who innovates?" Well-thought answers to this question have become available only in recent decades. Partly, this has been because the role of 'innovation' in 'economic growth' was not the focus of many early economic thinkers. Partly it has been because, as the world changed through socio-economic experimentation (e.g., recall the rivalry between autocratic socialism and free market capitalism), there arose new contributors to economic growth.

Broadly speaking, the parties contributing to innovation today are governmental institutions, private firms, individuals working as professionals, and entrepreneurs. Of these, the last class is attracting a great deal of attention in recent times. For instance, in 2000, the National Commission on Entrepreneurship found that some 67% of inventions and 95% of radical innovations made in the U.S. since 1945 came from small, entrepreneurial firms (NCOE, 2000). Further, venture-capital-backed entrepreneurial companies in the U.S. had output a whopping 17% of GDP in return for just 0.2% of VC-funding ($25 billion). It is therefore safe to say that technological innovation flourishes in societies possessing a sociopolitical environment conducive to the promotion of entrepreneurship. Likewise, firms encouraging internal entrepreneurship (entrepreneurship within an existing firm is called intrapreneurship) will be better able to sustain their competitive advantage. This is why the third and final component of the title of this book is 'entrepreneurship'.

The field of innovation-economics began with the work of Joseph Schumpeter (1934). He suggested that economic progress is triggered primarily by the market success of the creations of dynamic entrepreneurs. Box 1.4 outlines the early histories of eight globally-known companies. What do they have in common? A trivial response is that all the enterprises were founded after

1976. A more meaningful answer is that all the founders were novices exhibiting extra-ordinary flair for coming up with new ideas and commercializing them against great odds. Rather than compete within an existing market; they all chose to compete for a new market:

~ Apple introduced a radically new class of technological products that helped start a personal computer revolution.
~ Google and Yahoo totally transformed the internet scene by introducing radically new technologies that can be seen as products or services depending on the way we look at them.
~ FedEx, Dell and eBay found new ways of delivering products or services to customers.

In short, they all were inventors and entrepreneurs rolled into one, i.e., innovators.

There is another similarity worthy of note. All the innovations cited in Box 1.4 involve either the creation of totally new technologies (Apple, Google and Yahoo) or the use of existing technologies in novel ways (FedEx, Dell Computers and eBay). One may therefore say that all the six companies were formed by entrepreneurs engaging in technological innovation.

Does Box 1.4 necessarily imply that innovation is the only way to start a business? In fact, most successful companies we see around the world were not based on breakthrough innovations. Rather they represented simple opportunity seeking:

~ Sony's roots lie in an electrical repair shop established with an investment of GBP845 in 1946 in a bombed-out department store.
~ Nokia had started off in the town of Nokia in Finland as a wood-pulp mill to meet regional needs.

However, very soon many companies such as Sony and Nokia realized that they could not remain ahead without engaging in innovation.

What are the factors determining the kinds of innovations people engage in at any given time? In the beginning, it was believed that innovations were induced by the needs of the society. For instance, a change in the relative prices of the factors of production can be a spur to inventions directed towards economizing the use of factors which have become relatively expensive (Hicks, 1932). When labor is short there will be encouragement to labor-saving innovation. Likewise when energy costs increase there will be more rapid improvement in energy efficiency of goods than would normally occur. In short, shortages in supply can induce innovations aimed at increasing supply.

Subsequent analyses of time series and cross-sectional patent data and historical case studies demonstrated that demand-pull influences were also important. The more intense the demand, the greater were the number of patentable inventions generated. This observation suggested that more creative groups and individuals were being drawn to work on an unsolved problem related to what was being demanded (Schmookler, 1966).

However, as pointed out by Schumpeter, not all inventions need be induced by some external factor such as a short supply in or a manifest demand for something. Many innovations may be products of just the creative drive of certain individuals. Once a new product is created, demand will follow as long as there is some value in the creation. Such innovations are said to be Schumpeterian.

Schumpeterian models of innovation can be of two types: *entrepreneurial innovation* and *managed innovation* (Freeman et al., 1982). In the first case, risk-taking entrepreneurs grasp the techno-economic opportunities offered by new scientific developments to create radical innovations; thus fostering the emergence of new industries or new product groups. It is during this phase of the industrial cycle that dynamic, new, small but fast-growing firms play the key role as innovators. As the technology in question and the associated markets mature, the average firm size increases and inventive activity becomes progressively internalized in the form of large in-house R&D laboratories. However, after some time, the possibilities for major product innovations diminish. Market requirements become increasingly well-specified. Competing products are little differentiated technically. As a result, price becomes a more significant factor in competition, so development efforts become more and more directed towards cost reduction through process efficiency improvements. In other words, during the early stages of an industrial cycle, there is more product innovation conducted by entrepreneurial firms and, in the later stages, more process innovation conducted by established firms.

In the above we introduced the notions of technology, innovation and entrepreneurship without having formally defined them and examined their natures in adequate detail. What do we mean by ‘technology’, ‘innovation’, and ‘entrepreneurship’? What is their importance? What drives them? We will address these and similar questions in the rest of this chapter. Since this is an introductory chapter, our discussion here will be broad-brush. We will return to these questions several times in subsequent chapters, each time advancing our understanding a little bit further. The overall intent is to provide a reasonably fine-grained understanding of how one can exploit the varied opportunities related to technology and innovation that will turn up, one way or another, in one’s life, irrespective of whether, professionally, one is a scientist, technician, engineer, information officer, manager, entrepreneur, and so forth.

Technology

Back to top

Man is a tool-using animal. Man’s domination of the earth owes much to his superior tool-making and tool-using skills. From the dawn of civilization, man has used technology. The plow, the wheel, and the chariot are just a few ancient examples. Technology refers to the ways in which people use discoveries to satisfy human needs and desires and to alter environment to improve lives. Man would not have become ‘Man the Thinker’ (*Homo sapiens*) had he not also been ‘Man the Maker’ (*Homo faber*). Man made tools, but tools also made man.

Nothing in the biological world matches man’s almost compulsive drive to invent. Man has been developing new tools and techniques so he can protect himself from the vagaries of nature (desire to control), to reduce the physical effort he had to exert in achieving his goals (desire to automate), and so on. In fact, technology accounts for much of human material progress. Without technological progress we would not have improved our clothing, housing, nutrition and health; reduced the need for human toil and drudgery; and avoided many diseases and famine. Technological progress has been such a potent force in history that it has provided society with what some economists have dubbed “a free lunch,” i.e., an “increase in output that is not commensurate with the increase in effort and cause necessary to bring it about (Mokyr, 1990).” Indeed the power of technology to transform virtually every aspect of our lives has never been more evident.

What is Technology?

Although ‘technology’ is a widely used term, there is no single universally accepted meaning attached to it. Different meanings emerge when it is examined from different perspectives or in different contexts. But one point is generally accepted. Technology is a 'bag of tools' available to us to improve our surroundings. Sometimes we focus on the 'bag', and sometimes on a specific tool in the bag. When the focus is on the 'bag', technology is seen as a single material thing with a homogenous, undifferentiated character. Such reification ("thingification") however misses the importance of detail. For instance, the term "mass communication" covers a multitude of very different techniques related to writing, printing, viewing a sequence of images on a slide projector, listening to music on radio, or enjoying a movie on television, and so forth. A closer examination reveals that each of these techniques, by itself, encompasses considerable diversity.

Quite often, though, the term 'technology' is used while referring to the vast collection of artifacts, i.e., objects produced by human effort that we can see, touch and feel. For instance, the 1941 report of the Temporary National Economic Committee of the U.S. defined technology as "the use of *physical things* to attain results which human hands and bodies unaided are incapable of achieving." At other times we use the term to refer to the unseen collection of methods by which the artifacts may be produced. For instance, Ellul (1964) defined technology as "the totality of methods rationally arrived at and having absolute efficiency...in every field of human activity."

Thus 'technology' can have at least two different meanings:

~ The individual technical means themselves, or
~ The generalized study of individual technical processes.

The French clearly distinguish between the two; they refer to the former as *technique* and the latter as *technologie*. The two notions are however intermixed in the English term 'technology'.

The English term 'technology' is derived from the Greek term *technologia* which, in turn, is a combination of *techn* meaning 'craft', and *logia*, literally meaning 'saying' but generally interpreted as the 'understanding of doing something'. Thus the term can be seen to combine the meanings of art and technique involving both knowledge of the relevant principles and an ability to achieve the appropriate results. In particular, the view of technology as knowledge has gained greater prominence in recent decades.

We may buy a technological artifact on a turnkey basis, or we can put it together ourselves and adapt it to our specific needs. In either case we will need some understanding of the parts and the interactions amongst them. The depth to which we need to understand will of course depend upon the complexity of the task at hand. For instance, many of us own a cell phone capable of functions well beyond just receiving and sending calls: saving messages, checking e-mail and using the phone as a still- or video-camera, and so on. Much of the knowledge needed to perform these diverse tasks is embedded in the cell phone itself. We may attend training sessions, consult outside experts, read the equipment manual and so forth but, mostly, we learn by experimenting with the cell phone.

Thus, as Aristotle had said long ago, technology is knowledge "whose origin is in the maker and not in the thing made." More recently, Mokyr (1990, p. 276) put the same idea as follows: "My basic premise is that technology is epistemological in nature. It is not something that somehow "exists" outside people's brains. Like science, culture, and art, technology is something we know, and technological change should be regarded properly as a set of changes in our knowledge."

A combination of all the above definitions of technology was captured by Burgleman et al. (2001) when they said "Technology is the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embedded in people, materials, cognitive and physical processes, plant, equipment, and tools. Key elements of technology may be implicit, existing only in an embedded form."

We have seen that it is not trivial to define technology precisely. However, we can get a fairly comprehensive idea of what technology is by noting the following generalized characteristics of technology (McGinn, 1978):

~ Technology is concerned with material, as opposed to ideational, outcomes.
~ Technologists make artifacts rather than just help something that is ordinarily done by nature.
~ Technology both expands human possibilities and enlarges the domain of human ends.
~ Technology is resource-based and resource-expending.
~ Technology is not exactly "applied science," but knowledge of resources and methods, how to do certain things.
~ The methods which technology uses range from trial and error to complex experimental techniques.
~ Economic, political, cultural, and ideological considerations enter into technological decisions; in turn they are conditioned by technological change, and technological activity both reflects and alters its context in any given stage of development.

A defining characteristic of technology is its relation to human needs. The purpose of technology is to serve human needs and human wants by providing the corresponding functionalities. The functionalities could concern the physical needs of humanity such as air, water, food, clothing, shelter, and safety. They may also be directed towards humanity's social needs, such as related to business, government, communication, justice, education, the military, and so forth. However, we usually would not call knowledge of the techniques used in arts such as painting, music, sculpting and acting as technology because the principal purpose of technology is utility rather than aesthetics. In other words, technology is essentially utilitarian. This doesn't mean that all technology is 'good' for man. Technology is essentially amoral, i.e., ethically neutral. In itself, it is neither good nor bad. For instance, a knife can be used to cook, cure, or kill. Likewise, computers can be used to liberate or oppress people.

Since technology aims to satisfy human needs and is created and utilized by humans, there is a close, codependent relationship between technology and society. Advances in technology influence and eventually change society. As the needs of society change, more new needs are created thus creating more technology (McGinn, 1991).

Technology as a System

As noted earlier, when we use the word 'technology', we often think of it as something physical which we can perceive through our senses as we interact with it. For instance when we look at a pickup truck we immediately recognize it as a technological artifact that can be used to transport stuff. To some extent this is also true of software, since we can 'feel' our way through it by interacting with it. But a large proportion of modern technology doesn't refer to physical entities at all. For instance when we talk about electrolytic plating technology we are referring to the process of creating a plated surface, not to the plated surface itself or, not necessarily, to the physical electroplating plant executing the process. But you may say that even the electrolytic plating process is a physical entity since we can see the process in action. Extending our argument a bit further, we can be excused for referring to an inventory control or financial control process as technology since we can physically perceive at least the effects of the processes.

All the above suggests that technology is better viewed as a system, i.e., as “a group of things or parts working together as a whole’ (Oxford Dictionary) towards achieving a practical human end. Some parts of the system can be hardware, some software, and some human intervention.

The interacting elements vary depending on the function and how closely we examine it. For instance, a gardening hose appears as a single piece of hardware consisting of a rubber tube. But look closer, it is more. It has end connectors that match the water supply and to the sprinkling head. Look even closer, the end connectors have threaded elements designed to prevent water leakage. Each of these elements has its own function. But all these are hardware elements. You can see, touch and feel them.

Now consider a desktop computer. It has many hardware elements: mouse, keyboard, monitor, hard drive, processing unit, and so forth. Each of these is an independent entity with its own function. As you open each of them, you will discover more and more subsystems. But the PC cannot function even if we have all the hardware elements in place. It needs software, the programs which instruct the computer what to do and when. We cannot see or touch the software. But it is vital. If the software crashes, the computer crashes. Thus software is a subsystem of the computer made up of its own subsystems such as the operating system, application program and so on. However, we would not be able to use the computer even if we have all the hardware and software elements are in place. We need to be aware of how to make them work. This is knowledge. Indeed to put together or use a computer, we need to have knowledge. Some of the knowledge is embedded in the hardware elements themselves. When we see the keyboard, its shape and structure immediately suggest some aspects of how it could be used. Likewise, the menus displayed during the computer’s operation provide us with some understanding of the way the software functions. But, as any computer user knows, this level of knowledge is often not sufficient to make efficient use of the computer. For instance, what do we do if there is a major crash? We first refer to the user manual that comes with the computer. The manual essentially codifies the knowledge required. So it is also a part of the technology system we call the computer. Finally, what do we do when we are unable to recover the computer even after reading the manual? We call the help desk of the computer company. In doing so, we use many other technologies, e.g., the telephone we use to contact the company. In fact, the simple act of consulting the company involves much more than the telephone. It draws upon several businesses, the computer company, the telephone company, the satellite business supporting the telephone system, and so on. Each of these businesses is a complex system in itself.

What can we surmise from all this? It is that technology as a system has no boundaries, it is an open system. Thus, viewed as system, any technology is “a functional totality, transforming inputs from its purposive environment into means-outputs of its purposive environment” (Betz, 1998).

It should be clear by now that managing technology is not a trivial task. Because the task is both of great importance and nontrivial, several university-based programs on Technology Management have been launched in recent decades. Management of technology has been defined as linking “engineering, science, and management disciplines to plan, develop, and implement technological capabilities to shape and accomplish the strategic and operational objectives of an organization (NRC, 1987).” While not addressing implementation issues, this book intends to be a resource book for students of technology management too.

Technology as Knowledge

A problem with Solow's model of economic growth is that it takes TFP growth as an exogenous factor. This means that the model doesn't attempt to clarify how technology itself grows. Subsequent economists tried to overcome this problem by developing endogenous models. An important variant of the endogenous group is evolutionary modeling which assumes that technology-economy-society is a co-evolving set following principles analogous to biological evolution.

But what exactly does evolve? Mokyr (1990) believes that it is "useful knowledge". Technology is nothing but knowledge that can be put to use in some fashion. But when some new knowledge is produced it impinges unintentionally on several existing pieces of knowledge thus enhancing or clarifying them. In the process the total human knowledge increases not additively but exponentially. This improved knowledge is at the core of modern economic growth. Further, knowledge is a nonrivalrous good, i.e., it doesn't diminish when shared. The same knowledge can be used repeatedly in new circumstances. No wonder that technology emerges as the most powerful factor affecting economic growth.

Thus all technology has some knowledge content. If all that is here is knowledge, the technology is said to be disembodied. *Disembodied technology* is mainly intangible; there are no specific products which give it its particular character. The scientific principles underlying disembodied technologies are social or management sciences rather than natural sciences. Industrial engineering and quality assurance are typical examples of disembodied technology. Their practitioners use generic (as opposed to physical) artifacts such as an operating manual or a computer software package. By contrast, *embodied technologies* are encapsulated in products and physical equipment, such as manufacturing plant. They have a technical root structure that determines its performance and application characteristics.

Kinds of Technology

Every industry uses a variety of technologies in their products, production, distribution services, and so forth. For instance, in the production of an assembled hard good, such as an automobile, different technologies (knowledge) are used in the design of the body, engine, gear box, fuel system, control system, and so on. Still different technologies are used in the production of the corresponding parts. For instance the production of the body panels alone involves press-forming, robotic welding, robotic spray painting, and so on. And different technologies are involved in the inspection, quality assurance, storage, transportation, delivery, maintenance, repair, and disposal of automobiles. Every one of these steps involves much information processing.

Consider now how technologies may be classified. We will start with Betz's classification (Betz, 1998):

~ Product/service technologies,
~ Manufacturing/service-delivery technologies, and
~ Information/operation technologies for management control.

It is usual to refer to these three categories simply as *product technologies*, *production technologies*, and *information technologies* respectively.

Each of these technology categories can be further subdivided into supporting and core technologies. Supporting technologies are not unique to the industry. They are usually used in many other industries. Being substitutable, they play only a secondary role in the firm's efforts to gain competitive advantage through innovation, although their proper selection and utilization is important for maintaining the competitive advantage of a firm in terms of productivity and quality. Therefore these technologies are usually acquired from the outside with minimal internal R&D directed towards their enhancement. Progress in an industry is mainly dictated by technologies that are unique to it, hence they are not substitutable. Since the industry is mainly defined by such technologies, these are called the core technologies of the industry. Companies strong in core technologies will be able to better defend their markets from encroachment by competitors and, even, grab market from others. Therefore identifying and watching developments in core technologies is important for the survival as well as growth of a firm. However, what are core technologies for one industry can be supporting technologies for another.

Some of the core technologies change faster than the rest, so they offer opportunities for improving competitiveness through product differentiation. A firm's lead in the industry depends mainly on the innovations it makes in core technologies. Hence such technologies are called strategic or pacing technologies (Betz, 1998). These are the technologies a firm usually needs to focus on while developing its R&D and innovation portfolio. Firms lagging in such technologies can expect to be at a serious competitive disadvantage while those leading will be able to ward off encroachments into their territory. Note that these observations underscore the importance of competition—technological innovation will be sedate whenever the sociopolitical environment is not supportive of competition. This is why technological progress is slow in industries dominated by a few players, irrespective of whether "the few" are certain large corporations or the government itself.

Not every country, though, has been able to keep pace with the technological progress achieved in the West since the Industrial Revolution. Although it is overly simplistic, the following classification of technology levels is useful in assessing how far up the technology ladder a country is at any point in time:

~ *Level 1*: simple artifacts and techniques, repetitive activities, mainly craft know-how, rudimentary use of scientific principles (e.g., as in far too many parts of Africa).
~ *Level 2*: technology mainly embodied in equipment, some technical know-how and application of scientific principles.
~ *Level 3*: considerable process and product know-how, some technology development, use of established techniques.
~ *Level 4*: extensive know-how, equipment with advanced technologies, substantial research and development (R&D) programs, use of advanced commercial practices, software.
~ *Level 5*: global technological leadership through a steady stream of breakthrough innovations, fusion of advanced technologies, and extension of science base, strategy and organization to extend competitive advantage.

Among the regions currently functioning at Level 5 are the U.S., Japan, and several West European nations. These are also the regions exhibiting the highest levels of per capita income. Common characteristics of these industrialized economies include capitalism (private ownership of the means of production and free markets), a democratic political system, well-developed mechanisms for corruption control, high commitment to education, substantial R&D, and an environment supportive of entrepreneurship.

By contrast, most nations that had adopted a totalitarian system prohibiting private ownership, e.g., nations of the former Soviet bloc and China until the 1970s, stagnated somewhere between levels 3 and 4. The spectacular economic progress that China is currently exhibiting started only after it had started adopting market-oriented policies. Similarly, India did not start showing signs of becoming an economic giant until it started opening up its markets in the 1990s. Another group of regions hovering between levels 3 and 4 consists of the four "Asian Tigers" (South Korea, Taiwan, Hong Kong Special Administrative Region, and Singapore), Israel, South Africa and a few other countries. At the other extreme are many African, South American and Central American countries which seem to be stuck around Level 1 or 2 because of lack of capital formation needed for supporting investment in new technologies (owing to extreme poverty), low levels of education, corruption, ethnic rivalry, and/or unstable political regimes. As for many oil-rich countries in the Middle East, it remains to be seen whether they would be able to convert the riches gained from their natural land-based endowments into long-term technological advantage.

Innovation

Back to top

What is Innovation?

The English word 'innovation' is rooted in the Latin *innovare*, meaning making something new (nova). But, what do we mean by "new" here? According to Webster's dictionary, it can be an "idea, method or device." It is sufficient if the "something" is perceived as new by some individual or other unit of adoption (Rogers, 1962/1995). "It matters very little, as far as human behavior is concerned, whether or not an idea is objectively new as measured by the lapse of time since its first use or discovery, The perceived newness of the idea for the individual determines his or her reaction to it. If the idea seems new to the individual, it is an innovation. The idea may be a recombination of old ideas, a scheme that challenges the present order, or a formula or unique approach that is perceived as new by the individuals involved. As long as the idea is perceived as being new by the people involved, it is an "innovative idea", even though it may appear to the others as "imitation" of something that exists elsewhere."

However, as the following more recent definitions suggest, the modern understanding of 'innovation' goes well beyond the simple view of invention or a new idea:

~ Innovation = Invention + Exploitation (Roberts, 1988).
~ $I = aF(C, Kn)^n$ where I = innovation, C = creativity, Kn= knowledge, *a* is made up of desire or need for innovation and resistance to the same, and *n* is the maturity level of the frameworks put in place to exploit innovation (Creative4Business Co., U.K.).

~ Innovation = Strengths development + Engagement (An IBM survey).
~ Innovation = Market insight + Technological Know-how (An IBM survey).
~ Innovation = Invention + Commercial Exploitation (An IBM survey).
~ Innovation = Creativity × Risk taking (Byrd & Brown, 2002).
~ Innovation is the point of first commercial application or production of a new process, product, or service.
~ Technological innovation is the transformation of an idea into a new or improved saleable product or operational process in industry or commerce.
~ Innovation is about new ways of delivering customer value (O'Hare, 1988).
~ Innovation is introducing a new or improved product, process, or service into the marketplace (Betz, 1998, p.4).
~ Innovation is the management of all the activities involved in the process of idea generation,

technology development, manufacturing and marketing of a new (or improved) product or manufacturing process or equipment (Trott, 1998).
~ Innovation is the embodiment, combination, or synthesis in original, relevant, valued new products, processes, or services (HBSP, 2003).

Let us pick for elaboration the definition by O'Hare (1988). There are four key terms in the definition: 'New', 'Delivery', 'Customer', and 'Value'. 'New' refers to new ways of solving existing problems and meeting market requirements, not optimizing the current setup. There will always be ways to fine tune the existing situation: careful attention to costs and operations can bring a product or service's price down over time; continuous attention to market research and customers' comments can ensure its continued relevance as customer needs evolve. These are necessary and must continue, but alone they are insufficient. Innovation calls for different ways of satisfying basic needs, not just doing existing tasks better. It requires lateral thinking. Existing molds and patterns of behavior have to be broken and cast aside.

'Delivery' suggests that the new thing doesn't become an innovation until it has been delivered to someone paying for it. It also suggests that an innovation need not relate only to the product or service itself—it can apply to any part of the business system or value chain associated with delivering the product or service to the customer. Toyota innovated in the manufacturing part of its value chain, with major beneficial effects for cost, product quality and model range. Federal Express innovated by competing on the basis of a completely new and different value chain; it replaced the point-to-point approach of its competitors with a hub-and-spoke system. Innovation, therefore, can consist of changes to a particular link in the value chain, or to the creation of a fundamentally new value chain, bypassing the traditional approach.

'Customer' refers to the principle that a truly successful innovation is always driven by a careful consideration of customers' needs rather than internal constraints. All too often the search for innovation is internally driven. How can we perform this function better? How can we optimize this process? However, unless it is related directly to customers' needs, such internal optimization is worth little. Truly successful innovation is always driven by a careful consideration of customers' needs rather than internal constraints. In many cases the innovation may even result in lower levels of efficiency, as measured by narrow internal measures. That need not matter, however, if the innovation meets customers' real needs in a better way than the previously available solution.

Finally, 'Value' suggests that achieving the highest possible performance of the product need not always be the goal of innovation. The search for innovation must be motivated by the will to offer the customer that which he/she values more than her/his current product or service. Sometimes this means a higher performance product. Sometimes it means lower performance—with greater simplicity, convenience, availability, affordability, etc. What it always means, however, is identifying unsatisfied needs—either among customers as a whole, or more frequently in some segment. There are often many different ways of creating new customer value within one industry.

A recurring message in the above definitions is that the introduction of a new idea or the invention of a new artifact is a necessary but not sufficient condition for being called an innovation. Invention is the creation of a new idea, but innovation is more encompassing and includes the process of developing and implementing the new idea. An invention becomes an innovation only when some customer finds value in and the value has been delivered to the customer. Thus innovation is not a single action but the total process of putting together, in an integrated fashion, several sub-processes such as the creation of the basic idea, invention, and market development (Myers & Marquis, 1969).

Who Needs to Innovate? Why?

According to a 2005 McKinsey survey of over 9000 global business executives, the majority (43%) selected the ability to innovate as the most important capability for growth of their business over the next 5 years while 71% said that a faster pace of technological innovation will have a positive impact on profits.

Owing to the accumulated developments in transportation, communication and information technologies, the world is rapidly becoming a global village, so competition is intensifying. At any time, a competitor from near or far can come up with a superior product or service and disrupt the businesses of established leaders. The notion that the world is predictable is a thing of the past. Change is the only thing constant in the modern world. Mere working hard is no more enough. One has to be smarter than one's competitors. One has to keep developing world class core competencies in selected areas and utilize them to continually launch new products or services:

~ In 1954, Sony obtained Japan's first license to make transistors. Sony's commitment to innovation is evident from the unrelenting series of product innovations: Japan's first transistor radio (1954), Trinitron color TV (1968), color video cassette (1971), Betamax VCR (1975), Walkman (1979), 3.5 inch micro-floppy disc (1989), electronic camera (1981), CD player (1982), consumer camcorder (1983), digital VTR (1985), digital 8mm video (1988), PlayStation (1995), ultrasonic pulses that induce sensory experiences such as smells, sounds and images (2005), Rolly digital robotic music player (2007), Green TV (2008). Today Sony employs over 100,000 people around the world.

~ In the period 1920 to late 1960's, Nokia diversified into rubber products including footwear, tires and cables. In the 1970s it moved into the telephone industry and developed the Nokia DX 200 digital switch equipped with high-level computer language. By 1988, Nokia became the largest IT Company in the Nordic countries. In 1992, it decided to shed its non-core operations by focusing on telecommunications. The result was spectacular. Today Nokia is a world leader in wireless data solutions, multimedia terminals, mobile phones and telecommunications networks.

~ See Box 1.5 for a narration of how Hewlett-Packard (HP) succeeded through an impressive series of product, managerial and strategy innovations.

Of course, industry is not simply made up of firms offering new products and services. In fact most people find new product/service development to be too risky and settle for borrowed ideas and technologies. They merely exploit business opportunities offered to them by meeting some locally unmet consumer demand. But innovation can be important for them too for a different reason. They may not compete for a new market. But they do compete within a market on the basis of low cost, better quality, shorter times to delivery, and so on. Unless they are enjoying a monopoly position owing to political clout or government protection, they are under constant threat of being overtaken by others. Their sustainability is assured only as long as their customers perceive them to be different (superior) in terms of something of value to them.

What a customer values depends on many factors including time and place. However it is possible to generalize to some extent. At the lowest level is price (recall Figure 1.5). As the customer segment becomes more affluent, customers will want (in addition) quality, choice, time of delivery, and uniqueness. In other words one has to keep finding new ways of conducting business— one can never get off the innovation-tiger.

Numerous recent surveys have confirmed the growing importance of innovation to firms irrespective of the industrial sector. Pakes (1985) noted that unexpected changes in patents and R&D performance of a firm are associated with quite large changes in its stock value. It has also been found that the announcement of a new product increases the company's stock pie approximately by 0.75% over a three-day period. Although the increase might not last, it helps establish consensus about the product's value to the company. In 1999, PricewaterhouseCoopers conducted a survey titled 'Global Growth and Innovation Study' and confirmed that innovation is a "lever of growth and value creation." They noted that a positive innovation image attracts shareholders and can add to the organization's stock price. They also observed that such an image attracts new employees while helping retain existing employees. Four years later the Boston Consulting Group also reasserted the importance of innovation—recall Box 1.1.

The conclusion from all this is that innovation is everyone's business. Unfortunately, this point is not well recognized in industry. For instance, there is the commonly perceived myth that "A company needs to be big to innovate." The fact is that the most innovative companies are small and, usually, their innovativeness diminishes as they grow and rest on their laurels:

~ Apple Computers began in Steve Jobs' garage.
~ PEOPLExpress started out in 1981 with three used Boeing 737s.
~ Tie Rack was founded with two shops in 1979 by entrepreneur Roy Bishko.
~ Sea Containers was a startup run by three partners when it entered the container leasing business.
~ Kwik-Fit started with one outlet in 1971.

Another commonly held myth is that innovation is the business of a high level committee charged with worrying about the future. The fact is the opposite. Each of us can contribute to innovation by playing one or more of the following roles (Betz, 1998):

~ Scientific gatekeeper
~ Inventor
~ Process, product, service champion
~ R&D strategist
~ R&D sponsor
~ Project manager
~ Problem solver
~ Business sponsor
~ Process user gatekeeper
~ Product user gatekeeper
~ Quality controller
~ Top management

Creativity

The sources of innovation can be classified into intrinsic and extrinsic (Drucker, 1993):

~ *Intrinsic*: the unexpected; the incongruity; process need; changes in industry or market structure.
~ *Extrinsic*: demographics, changes in perception, mood, and meaning; new knowledge.

Note the use of phrases as "the unexpected, "the incongruity" and "change in…" which suggests that the source of innovation is not just a rational extension of the past but a break of some order from the past. In other words it involves creation of something new, a spark or "Eureka!" moment. The ability to exploit such moments so as to yield practically useful results is called *creativity*.

Who gets the Eureka experience? It is now generally accepted that the experience almost always belongs to a certain individual, not a group. Groups are rarely in such emotional 'sync' as to experience such a moment. This means that the study of creativity belongs to the domain of psychology. Therefore it should not be a surprise that many a psychologist has investigated and conjectured upon the ability of humans to be creative.

Everyone can be creative to some extent. The problem is that most organizations are so status quo and procedure-oriented as to stifle creativity. This is particularly true with government-run bureaucratic organizations. No wonder few governments are known for innovation! Many well established firms also fall into this trap. All this suggests that organizational innovation doesn't come naturally and one needs to be conscious and deliberate in creating an organizational culture conducive to innovation. The most difficult part here is to develop an institutional ethos that actively embraces failure which is always associated with innovation.

There is much empirical evidence supporting the assertion that creativity doesn't flourish in environments contemptuous of individuality. The easiest way to kill individuality is to emphasize hierarchy and formality. The hallmarks of an innovative company are a flat organizational structure, a respect for individuality, putting a premium on talent rather than mere competence during recruitment, a system for mentoring employees with creative potential, assigning a part of the working time for creative endeavors, and the like. Creative organizations try to 'un-manage' the process of creation itself. All they do is manage knowledge that underpins innovation.

The Process of Innovation

All new ideas are built on old ideas. In the case of technological innovation, many new ideas come from science and existing technologies. Here 'science' refers to the discovery and understanding of nature (Betz 1998). Many modern technologies such as nuclear power and space flight depend upon science and the applications of scientific knowledge and principles. Each advance in pure science creates new opportunities for the development of new designs and ways of making things to be used in daily life. Technology provides science with new and more accurate instruments for investigations and research.

However, it was not until the 19th century that technology got to be truly based on science and inventors began to build on the works of scientists. For instance, Thomas Edison built on the early experiments of Henry Woodward (the original electric idea) and Michael Faraday (electric generator) in the invention of the first practical system of electric lighting. Edison carried on his invention until he found the carbon filament for the first ever electric light bulb in a research laboratory he had established in Menlo Park, New Jersey. This was the first truly modern technological research.

Much of the literature on innovation views innovation as a process made up of the simple linear sequence of the three stages shown in Figure 1.6. Other associated activities include R&D; other acquisition of knowledge (patents, licenses, and technical services); acquisition of machinery and equipment (both incorporating new technology and for standard use when producing a new product); various other preparations for production and delivery, including tooling up and staff training; and internal and external marketing aimed at the introduction of the innovation (OECD, 1992).

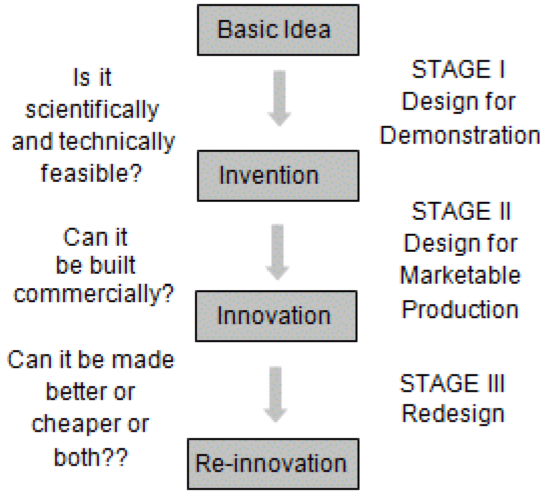


Figure 1.6 Stages in the innovation process.

Figure 1.7 shows another model popular in new product development (NPD) that is linear at the core but incorporates several feedback loops. The software development industry uses much less structured models with more frequent feedbacks.

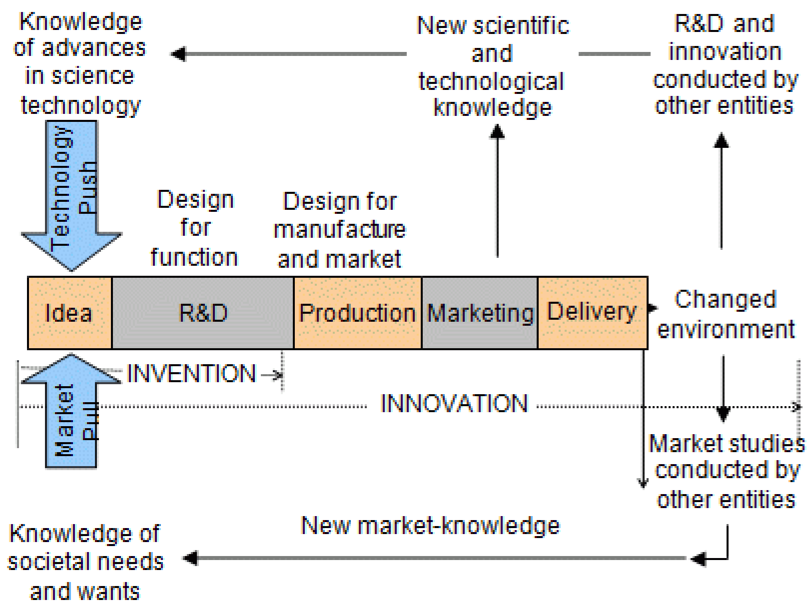


Figure 1.7 A model of new product development (NPD).

The best choice of the model for a given situation depends on the answers to a host of questions: Is one looking at an incremental or a radical innovation? How critical is it to be highly creative? Is the core development team located in one place or geographically distributed? How multidisciplinary does the development team need to be? Is the innovation happening in a startup or a well-established firm? And, so forth.

All innovation is governed by the simple principle that everything has a finite life cycle. Figure 1.8 illustrates this truism with respect to new product introduction and development. From the time of product concept to market introduction, the product is in the womb. The product is 'born' at the time of its introduction to the market. From the time of birth, just like humans, products go through four stages of life—see the curve labeled 'SALES VOLUME' in Figure 1.8.

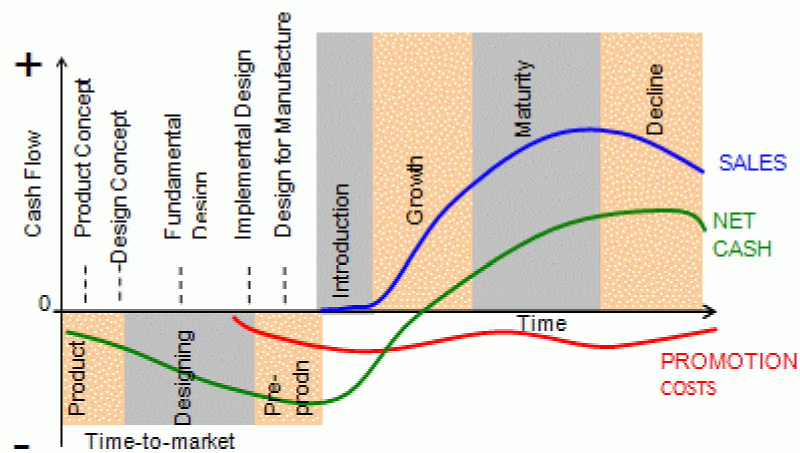


Figure 1.8 Product life cycle.

In *the introduction* (infant) stage, the product is introduced to the market through intense marketing effort so as to establish a clear identity and promote maximum awareness among potential customers. The product is still in its formative stages, so there is continued emphasis on R&D (Fox, 1973). Product prices tend to stay high. There are very few competitors because the market and industry are still relatively undefined. Customers mostly engage in trial or impulse purchases.

Next, as more consumers are attracted, the product enters the *growth* (youth) stage. Sales increase steadily as customers engage in repeat purchases. At the same time, spurred by the visibility of the product, new competitors emerge and try to share in the pie.

Next, the product moves to *maturity* (adult) stage when competitors begin to leave the market and sales volume reaches a steady state. The market reduces to loyal customers. In the early parts of this stage, the firm attempts to increase sales through activities such as market research, better plants, product design upgrades, and shifts towards mass distribution. As a result, product price starts declining while competition continues to increase. In the latter part of this stage, the firm tries to defend its market share through brand differentiation publicized through advertising. Competition gets fierce. After some time, previously loyal customers too start abandoning the product in favor of superior alternatives, signaling the onset of the decline (old age) stage. Several market shakeouts would already have taken place.

We have already noted that the process of innovation starts with the creation of a new idea. The new idea or invention may be inspired by certain latest developments in science and technology. This is called *technology push*. Scientists make unexpected discoveries and technologists apply them to create new products, processes, or services; and marketing people try to promote awareness of the creation amongst potential customers with a view to creating a market demand. The hope is that, once the new technologies have been developed, a search for market opportunities will yield commercially successful products.

The emphasis on market development suggests that the basic idea leading to innovation can also be derived from some perceived market need. This route to ideation is called market pull. Market-driven companies focus on developing deep awareness of their marketplace and then try to the technologies they already have in-house to develop products that meet the needs of that marketplace. Since existing technologies are used, the innovations that result from market-pull are mostly incremental rather than radical.

In 1983, researchers at the University of Minnesota launched a longitudinal research program called Minnesota Innovation Research Program (MIRP) with a view to developing a theory of the innovation process (Van de Ven et al., 2000). A conclusion from the program was that innovation is stimulated by "shocks" internal or external to the organization. When people have a reached a threshold of dissatisfaction with the existing state of affairs, they will initiate actions to resolve it. In the process, the initial idea proliferates into several ideas as the innovation process progresses. For instance, improved awareness of global warming coupled with the steep rise in oil price in 2008 forced many a government to consider introducing strong incentives for the rapid development of renewable energy sources such as solar, wind and geothermal along with devices such as the smart grid that help conserve energy. As a result, R&D work in renewable energy has picked up sharply in recent years. Firms succeeding first in this new 'gold rush' can expect to reap very rich dividends. Thus, entrepreneurship is likely to move sharply beyond the current 'Information Era' into the imminent 'Energy Era'. All this will happen faster in countries that have managed to create a dynamic and competitive sociopolitical ethos supported by a well-developed regulatory framework and institutional infrastructure. The resulting increased R&D and entrepreneurial activity will in turn require the support of highly educated people as well as a massive number of skilled persons.

Types of Innovation

Literature on innovation contains references to several alternative ways of classifying innovation. One way is to base on the notion of lifecycle which, on extension to the cumulative viewpoint, leads to an S-shaped curve. Innovations made within a given paradigm (a given S-curve) are said to be incremental as they usually aim at small performance improvements. These are the ones responsible for the movement up the curve. However, in a competitive society, several parties start scrambling to find a new paradigm well before the plateau of the current S-curve has been reached. Hopefully one of these is so profound that it initiates a new S-curve that is significantly above the previous one. Such an innovation is said to be *radical*. An example of a radical innovation is the digital camera which seriously undercut the market for the previous 'analog' cameras.

High competition across the industry in question is a prerequisite for the regular appearance of radical innovations. Societies unable to sustain high levels of competition are likely to suffer the continued persistence of obsolete technologies (those that have reached their respective plateaus).

A radical innovation need not be complex. It is just that it uses a totally new and substantially superior paradigm. Sometimes the radical innovation results in the development of a totally new industry. Sometimes it is so powerful as to completely displace (disrupt) the current market leaders. When the latter happens the innovation is said to be *disruptive*.

The periodic appearance of disruptive innovations is mainly responsible for the popularity of the term “creative destruction”—a term originally popularized by Joseph Schumpeter (1942). He used the term to describe the process of transformation that accompanies radical innovation. The implication was that if one were to ‘gain’ from the process of innovation, one also must be prepared to suffer from the ‘pain’ caused by the destruction (of existing industries) that inevitably follows the creation of something substantially superior.

But, fortunately, innovation is not a zero sum game since what gets ‘created’ is usually much more than what gets ‘destroyed’. Further, not all radical innovations are disruptive. Many radical innovations have created totally new industries rather than just displace existing ones, e.g., as in the case of personal computers.

Another way of classifying innovations is to distinguish between technological and non-technological innovations. “Technological innovation is the invention of new technology and the development and introduction into the marketplace of products, processes, or services based on the new technology (Betz, 1998, p.3).” It should be remembered here that innovation need not relate just to products, processes or services. It can apply to any part of the business system or value chain associated with delivering the product or service to the customer:

~ Toyota innovated in the manufacturing part of its value chain, with major beneficial effects for cost, product quality and model range.
~ Federal Express innovated by competing on the basis of a completely new and different value chain, it replaced the point-to-point approach of its competitors with a hub-and-spoke system.

Innovation, therefore, can consist of changes to a particular link in the value chain, or to the creation of a fundamentally new value chain, bypassing the traditional approach.

A classification proposed by the renowned management expert, Peter Drucker (1993), distinguishes between innovations directed at supply and demand:

~ Changing the yield of resources (supply): as in IT-based innovations such as software as service, virtualization, on-demand printing, e-commerce and participatory publishing.
~ Changing the value and satisfaction obtained from resources by the consumer (demand): as in internet-based innovations such as social/media networking, short term e-books, mobile content services, and ubiquitous internet access.
Trott (1998) has identified seven basic types of innovation:
~ *Product Innovation*: a new or improved product is introduced, e.g., a new design of car, a new insurance package, or a new home entertainment system.
~ *Process Innovation*: changes in manufacturing methods and equipment used to produce a car or the home entertainment system, or changes in the office procedures and sequencing in insurance business, etc.
~ *Production Innovation*: introduction of quality Circles, JIT, a new production planning software (e.g., MRPII), a new inspection system, etc.
~ *Organizational Innovation*: a new venture division, internal communication system, or accounting procedure.
~ *Management Innovation*: introduction of TQM, BPR, or SAP R3.
~ *Commercial/Marketing Innovation*: new financing arrangements, new sales approach such as direct marketing.
~ *Service Innovation*: new telephonic financial services.

The story of Hewlett-Packard presented in Box 1.5 illustrates several kinds of innovations described above.

Innovation Metrics

Innovation doesn't just happen in firms. It needs to be managed. But what can't be measured can't be managed. This is why consistent winners in the innovation arena like 3M, DuPont, Pfizer and HP extensively utilize metrics for their innovation efforts. For example, 3M has utilized for many years a high-level corporate metric, "% of total revenue from products introduced in the last 5 years." They had historically set a goal of 25% and were consistently hitting it. They then jacked the goal up to 30% and shortened the period of time to 4 years to accelerate their market growth. Likewise, Hewlett-Packard utilizes BET (break even time) for each new product development project.

Another excellent, overall measure of radical innovation is the Wealth Creation Index (WCI) proposed by Hamel (2002). "The WCI lets a company determine how it has performed against a relevant set of 'competitors' in creating new wealth. The process of determining your company's WCI involves two steps: defining the domain and calculating changes in the market value of your company versus the value of the entire domain."

Here are some further measures of innovation that are worthy of note:

~ *Return on innovation* = cumulative 3-year net profits from commercialized new products + cumulative 3-year new product total expenditures for commercialized, failed or killed products (Do not confuse this measure with the more common return on investment, generally referred to as ROI).
~ *Survival rate* = the number of commercialized new products still in the market + the total number of new products commercialized.
~ Success rate = the number of new products exceeding their original 3-year revenue forecast + the total number of new products commercialized.
~ *R&D innovation effectiveness ratio* = cumulative 3-year gross profits from commercialized new products + cumulative 3-year R&D expenditure solely for new products.
~ *Innovation sales ratio* = total 3rd year revenues from commercialized new products + total annual revenues.
~ *Innovation portfolio mix* = percentage of new products (number and revenue) commercialized by type, where type includes incremental product improvements, product line extensions, new-to-the-world products, new business concepts, etc.
~ *Innovation revenues per employee* = total cumulative 3-year annual revenues from commercialized new products + total equivalent full-time employees devoted to innovation initiatives.
~*The percentage of sales from proprietary product.*

Entrepreneurship

Back to top

J.B. Say, a French economist, is generally credited for having coined the term "entrepreneur" around 1800. According to him the term means someone who shifts economic resources out of an area of lower productivity into one of higher productivity and yield.

The English word 'Entrepreneur' is rooted in the French verb *enterprendre* which literally means 'between-taker', i.e., to undertake or to assume a responsibility or task. Because of the literal meaning, many people outside the U.S. have traditionally used the word to refer to a "get-rich-quick fast-buck artist."

In the U.S., the entrepreneur is usually understood as one who starts his/her own, new, and small business. But not every new small business represents entrepreneurship. According to Drucker (1993), to be recognized as entrepreneurial, the new business must create a new satisfaction or new consumer demand. By this definition, you are not necessarily being entrepreneurial when you open a small fast food shop in your neighborhood. You may have taken financial risk and yours may be the only fast food shop in the neighborhood, but you are doing what has been done many times before. On the other hand one can say that the first ever McDonald's in the world was entrepreneurial since it created a new market and new customer by drastically increasing the yield from resources—by asking what is "value" to the customer, standardizing the product, standardizing training of workers, franchising, and so forth.

Secondly, small organizations are better at creativity and entrepreneurship than large ones. Hence, many large organizations such as Marks & Spencer and GE and several universities have followed the policy of sponsoring and launching autonomous, small entrepreneurial ventures.

Entrepreneurship is usually understood as the process of starting a new business. The founders of a new business are called e*ntrepreneurs*. However, the scope of the term has been expanded in recent years to include the process of revitalizing existing businesses through the creation of new business opportunities (Onuoha, 2007). These two viewpoints are apparent in the following two alternative definitions provided recently by Professor Tom Bryers of Stanford Technology Ventures Program (stvp.stanford.edu):

~ "Entrepreneurship is a management style that involves pursuing opportunity without regard to the resources currently controlled. Entrepreneurs identify opportunity, assemble required resources, implement a practical action plan, and harvest the rewards in a timely, flexible way."
~ "Any attempt at new venture creation, such as self-employment, a new business organization, or the expansion of an existing business, by an individual, a team, or an established business."

Just as in the case of 'innovation', the credit for bringing the significance of entrepreneurship to public attention goes to Schumpeter (1942). He was particularly enchanted by capitalism's intrinsic ability to promote economic growth by encouraging entrepreneurs to undertake the risks involved in starting up new ventures.

But why do entrepreneurs stick their necks out and take up the risks involved in creating a new venture with an uncertain future? At one time, before people had started recognizing the importance of entrepreneurship to economic growth in general, the answer was greed—the compelling desire to make money by whatever means. Indeed there are many so called entrepreneurs of this type. But such entrepreneurs rarely create something of long term value. They merely engage in rent-seeking or function on the fringes of law and ethically acceptable behavior. Schumpeter was however referring not to such evasive entrepreneurs but to productive ones who are primarily motivated by an overwhelming need for achievement (n-ach) and strong urge to build (McClelland, 1961)—recall GM's story (Box 1.3). In short they make money by being legitimately productive and, in the process, create something of value to the society.

Unfortunately there still exist many societies which under-appreciate the value of the entrepreneur. For instance, under Nehru, India had embraced the public sector to the extent that it started stifling the private entrepreneurship through its "License Raj". The Raj however started being dismantled slowly since the mid-1990s and, by the turn of the century, India shot forward in IT and certain other industries. A similar story is behind the recent success of China on the manufacturing scene. Thus, in the last two decades, country after country has started recognizing and acting upon the numerous benefits derivable from entrepreneurial activities.

Here are some benefits accruable to countries encouraging entrepreneurship:

~ Incomes increase owing to economic growth.
~ Healthy competition encourages higher quality products.
~ More goods and services become available.
~ New markets get developed.
~ Productivity is enhanced in the small-scale sector owing to the increased use of modern technology.
~ More R&D is encouraged into the development of modern machines and equipment particularly suited to the domestic market.
~ Rural areas get rejuvenated through imaginative activities undertaken by locals.
~ The informal ('black') economy becomes weaker.
~ There is reduced emigration of talent owing to improved domestic industrial and entrepreneurship climate.

Entrepreneurship can also be a good career choice for people with a suitable disposition. Here are some benefits derivable by the individuals engaging in entrepreneurship:

~ You can obtain enormous personal financial gain although the risks can also be high.
~ You will have self-employment, own bossing, greater job satisfaction, greater decision-making, freedom from dependency on job provided by others, and so forth.
~ You have the satisfaction of providing employment for others, often in better jobs.
~ You can develop the ability to have great accomplishments.
~ You may enjoy significant tax advantages.

Inclusive Economic Growth

Back to top

Almost all nations today are striving to achieve economic growth as quickly as possible. We have noted already that technological innovation is the primary key to economic progress and that innovation can be stimulated strongly through the promotion of entrepreneurship. This is why the title of this book reads 'Technology, Innovation and Entrepreneurship' (TIE). But our discussion so far has just dwelt on the natures of T, I and E while leaving unaddressed issues concerning how these themselves might be developed. This section seeks to examine a few of such issues.

What kind of sociopolitical environment should one aim for? Adam Smith (1723–1790), a Scottish moral philosopher, advocated a free market approach and said that markets provide 'the invisible hand' that sustains economic development in a bottom-up manner, i.e., without the need for central planning. Naturally, free markets flourished better in societies that were organized in a bottom-up manner, i.e., in societies with a strong democratic tradition. Smith also highlighted the importance of the role of capitalists (the owners of K) in sustaining industrial expansion. He and many subsequent economic philosophers said that the capitalist owners of productive enterprises will find the most rational ways of organizing industry since they will seek to maximize their own profits.

Unfortunately, all this led not just to economic growth but some social problems too. Karl Marx (1818–1883), a German political economist, identified the main problem as the exploitation of workers by capitalists and urged the former to revolt. As it turned out, Marxism triumphed politically during the 20th century in several countries including the Soviet Union and China which banned private property. Marxism also had a profound influence on countries such as India which developed a burgeoning democracy and retained private property rights but initially discouraged private participation in nation-building.

Thus, during much of the 20th century the world was divided into the so-called capitalistic and socialistic (Marxist) camps. The ‘Cold War’ between them consumed much of the century with serious consequences to many a developing country. Initially there was some euphoria in the Marxist camp as it produced fairly impressive economic growth and some spectacular technological achievements. Yuri Gagarin of the Soviet Union became the first man in outer space in 1961. A good part of the world celebrated the event believing that they had found a recipe for economic growth consistent with economic equality, i.e., a recipe for inclusive growth (growth accompanied by an equitable allocation of resources with benefits accruing to every section of society).

However, within a few decades, the utopian dream of inclusive growth through the denial of market forces turned out to be mirage. In the absence of market guidance, governments in the Marxist camp turned more and more towards central planning. As a result, the power of the government bureaucrat increased vis-à-vis that of the so-called common man. Political dissent was denied. The countries became progressively more totalitarian. All this was a death knell to competition. As competition withered, so did innovation. Consequently, technological progress did not keep up with what was being achieved in the western world (the U.K., the U.S., Western Europe, etc.). For instance, the Soviet Union missed out on the information and communication technologies (ICT) revolution witnessed in the West (Ostafiev & Venuvinod, 1994; Venuvinod & Ostafiev, 1997). So, economic progress stalled in the Marxist camp. The resulting internal political tensions eventually resulted in the total political collapse of the Soviet Union and the reintroduction of market economics in China (1980s) and India (1990s).

Meanwhile, in the capitalistic camp, there was a gradual move towards promoting innovation through the development of entrepreneurialism. Slowly but steadily Schumpeterian views gained ground. Countries like China followed quickly by establishing ‘Special Economic Zones (SEZ)’ where entrepreneurialism could go on unfettered. By the early 21st century, China emerged as the “workshop of the world” while India emerged as a major hub in the Information Technology (IT) sector. As a result, there emerged a significant body of opinion reasserting the virtues of democracy organized on the principles of market and, by implication, less government.

On the other hand, the worldwide recession of 2008 took place arguably because of the excessive greed indulged in by a fair share of market participants. Bank after bank was in distress quickly. Western governments tried to respond through massive government intervention. For instance, the U.S. government bought over 60% of General Motors at extremely depressed stock prices and sharply increased government regulation of industry. Whether this so-called “correction” to the Western ideal of democratic capitalism will last continues to be debated.

So far we have focused on aggregate economic growth without paying attention to how it is distributed. Ideally, one would like it to be uniformly distributed over the entire humanity. That it should be so is self-evident on moral or ethical grounds. There may also be other reasons why economic equality is a desirable goal. Empirical evidence shows that, in more equal societies, there is more social cohesion; people trust each other more. There is also better health across the nation.

But the reality about economic equality across the world leaves much to be desired. For instance, in 2005, the wealthiest 20% of the world accounted for 76.6% of total private consumption; the poorest fifth just 1.5%. There is also tremendous variation in the income levels across nations; the average income in the richest nation is over 100 times that in the poorest nation.

But are we being too fussy? However desirable as an ideal, is total income equality practically desirable? Is there no room for, for instance, meritocracy? Wouldn't economies be better off by encouraging more rewarding more capable people through economic incentives? After all, as we have already seen, technological innovation is the key to economic growth. So, would it not be better if those who have the passion, opportunity and ability to innovate get on with whatever they are seeking? If we stop them in the name of equality, wouldn't technological innovation stall (as it happened in some ultra-socialistic societies)? No universally acceptable answers to these questions have emerged so far. Opinions about redistribution of wealth vary considerably. For instance, richer people are less keen on redistribution as they have much to lose from it while poorer people support it as they are the sole gainers of redistribution. There is also variation between countries. "[T]he average American is far less favorably disposed… than the typical European…There is tremendous variation within Europe, too. People in former communist countries tend to favor more redistribution (*The Economist*, 06/06/2009)…"

Whatever be the arguments for or against setting economic equality as a non-negotiable goal, one thing is clear; we cannot tolerate undue poverty in the world while, at the same time, we find filthily rich people around. The World Bank defines extreme poverty as living on less than US$1.25 (purchasing power parity) per day, and moderate poverty as less than $2 a day. Now, as recently as in 2001, there were 1.1 billion people earning below $1 a day and 2.7 billion on less than $2 a day. But, fortunately, things are improving as the overall economy improves through technological progress. For instance, looking at the period 1981–2001, the percentage of the world's population living on less than $1 per day has halved. But this is only true in countries where there has been peace, better governance, and government accountability (owing to strong democratic traditions). For instance, between 1990 and 2004, the percentage of people living below the poverty line decreased only by 5 percentage points from 46%.

It appears that the only recourse we have in the short term is to keep remembering that (technology + innovation) is the primary key not only for aggregate economic growth but also for progress towards the goal of poverty alleviation and economic equality. It is heartening to note that this message is gaining ground in many parts of the world. For instance, many entrepreneurial persons are now diverting their attention to empowering and assisting the poor through the application modern technology and management principles. A good example of this is the work being done in the form of micro-credit by the winner of 2006 Nobel Peace Prize, Muhammad Yunus of Bangladesh. Fortunately, the number of such social entrepreneurs is growing.

Box 1.1 The importance of innovation to firms: BCG survey.

In 2003, Boston Consulting Group conducted a survey titled 'Raising the Return on Innovation (BCG, 2003). The goal was to assess senior managers' views and experiences concerning the innovation-to-cash process (ITC). In all 236 top executives from 30 countries and all major industries including consumer products, financial services, industrial goods, and technology (computing, IT, telecommunication, and related fields), and financial services. The following were among the observations contained in the survey report:

~ 20% ranked innovation as their company's top priority while 69% ranked it as one of the top three priorities.

~ 64% said that they would be increasing investment in innovation in 2004 while only 5% said they would be lowering it; North America had the highest percentage increasing investments in innovation.

However, 57% were dissatisfied with the returns on investments in innovation. The rates of dissatisfaction were higher for Asia-Pacific and North America than for Europe.

The following ten companies were mentioned most frequently when asked which companies were the "most innovative": 3M, Microsoft, Sony, Nokia, Apple Computer, Dell, General Electric, BMW, Intel, and HP (in that order).

Box 1.2 The demise of Wang Laboratories.

Only a few remember today that Wang was a big name in the 1980s. The company was one of the first to sense the potential in office automation and more particularly in word processing. In the late 1970s, Wang's computers and software were widely accepted as a standard for word processing in the industrialized nations. Wang made its success by designing a family of special purpose computers, specifically optimized for the tasks of word processing. These machines treated text much faster and more efficiently than the general purpose mainframe computers then available. At that time, personal computers (PC) were not yet popular and flexible as they became by the end of 1980s. The technology offered by Wang was by far the best answer to the need for computer assisted word processing. This brought Wang in a very few years to the position of a world leader in word processing.

Unfortunately for Wang, the advances made in microprocessors and in compact memory devices soon allowed the building and marketing of a new generation of general purpose personal computers known as PC. One of the first application software packages offered to PC customers was for word processing. The possibility of replacing the typewriter with a much more flexible and powerful machine was one of the driving factors that made PCs so popular in a very short time.

Box 1.3 General Motors files for Chapter 11 bankruptcy on June 1, 2009.

GM was the global sales leader for 77 consecutive calendar years from 1931 to 2007. It manufactured cars and trucks in 34 countries. In 2008, it employed nearly 250,000 people around the world, and sold vehicles in some 140 countries. All this was partly because it had developed a divisional structure around the needs of its customers. "A car for every purpose" was its motto. Yet it filed for Chapter 11 bankruptcy on June 1, 2009? What went wrong? According to *The Economist (*06/06/2009), the problem "was not really the arrival of better, smaller, lighter Japanese cars (in the 1970s); it was GM's failure to respond in kind. Rather than hitting back with superior products, the company (GM) hid behind politicians who helped it in the short term. Rules on fuel economy distorted the market because they had a loophole for pickups and other light trucks—a sop to farmers and tool-toting artisans. The American carmakers exploited that by producing squadrons of SUVS (Sport Utility Vehicles), while the government restricted the import of small, efficient Japanese cars." If only Detroit had spent less time lobbying for government protection and more on improving its products (innovating)!

Box 1.4 Early histories of eight major U.S. enterprises.

FedEx: In 1965, Yale University economics major Fred Smith wrote a term paper on airline freight shipping. The paper received an unflattering grade although, as time would prove, it had contained some revolutionary ideas including the "hub-and-spoke system" for realizing the dream of worldwide overnight delivery of parcels. Undeterred, Fred went on to launch FedEx in 1973. Despite initial difficulties, he hung on. Today FedEx commands about 45% of the air express market. More importantly, the airline industry has been completely transformed through diffusion of the hub-and-spoke model. Some estimates indicate that the model has yielded about 40% savings on airline passenger fares.

Apple Computers: In 1977, the world's first readymade personal computer, Apple I, was introduced into the U.S. market. The inventors were Steve Jobs and Steve Wozniak. At that time Jobs was just 27 years old and Wozniak 25. Engineering talent was the forte of Jobs and ingenuity and marketing those of Wozniak. The pair had decided to combine their talents with the dream of developing unusual products when they met some 12 years earlier. A few years later they came up with a crude model of PC using a microprocessor they had bought for $25. In view of its simplicity they gave it the name "Apple". The duo raised $1,300 to finance the venture. Jobs sold his van and Wozniak his programmable calculator. Within a few weeks they secured an order for 50 units of Apple I at $666 each. By the early 1980's Apple made it to Fortune 500 list.

Dell Computers: In 1984, 19 years old Michael Dell founded Dell Computers Corporation. He had gone to college intending to become a doctor, but soon his passion for computers won out and he started selling computers from his dorm room. His philosophy was simple. Through direct selling to customers, one can understand the customers' needs better and, therefore, provide the most effective solutions for them. Dell then enhanced this model by increasingly applying the efficiencies of the internet to its entire business. In 2005, Fortune 500 judged Dell Computers as America's "most admired company".

Yahoo: In 1994, David Filo and Jerry Yang, both Ph.D. students at Stanford University and avid internet users, had started maintaining lists of their favorite links. Before long, the lists became too long and unwieldy. Soon, they were spending more time on this work than on their doctoral research. To solve the problem, they broke down the lists into categories, subcategories, and so on. Thus was born the core concept of Yahoo. Next they put their lists on their own website which they called "Yet Another Hierarchical Officious Oracle (YAHOO)". The site became so popular that by the fall of the same year they were having one million hits a day. Recognizing the business potential of their approach, they started looking for investors. In April 1995, they received $2 million funding from Sequoia Capital, firm which had already invested wisely in Apple, Atari, Oracle and Cisco systems. By 2009, Yahoo became a global internet company serving over 350 million individuals a month.

Amazon: In 1995, at the age of 31, Jeff Bezos left a cushy job in finance to pursue his crazy dream of establishing an online bookstore. An attractive feature of his software was that it suggested books for further reading. In 1998, Amazon branched out into CDs and DVDs; in 2001, into e-commerce infrastructure for use by third party vendors; in 2006, into music and video down loading service (with mixed results) to challenge Apple's iTunes, and in 2007, into the e-books industry with the first handheld reading device (Kindle) with an online e-book store going with it. Amazon also started a print-on-demand service (BookSurge) and a self-publishing service (CreateSpace).

eBay: In 1998, Pierre Omidya, sitting in the living room of his San Jose home, conceived a new way of person-to-person trading. The idea consisted of using the WWW as a platform for bringing together buyers and sellers. Sellers are permitted to list items for sale, buyers to bid on items of interest and all eBay users to browse through listed items in a fully automated way. The aim was to create a garage sale, collectible show, or flea market in the cyberspace. Initially, eBay's 'market' attracted consumers looking to swap relatively simple collectibles. However, soon, it grew to become a powerhouse selling everything from phones to automobiles. For instance, more than 300,000 cars were sold on the site in 2003. Thus, within seven years the company reached a market capitalization of around $50 billion. Today, hundreds of thousands of users make enough money buying and selling goods on eBay that they consider it to be their primary profession.

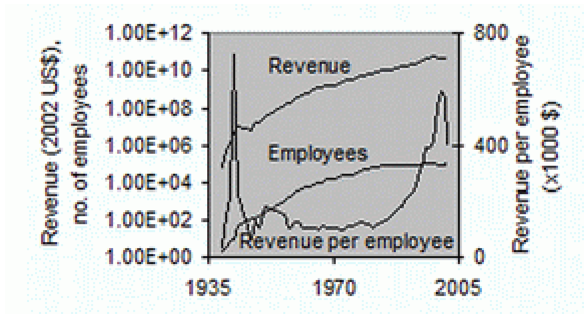
Google: In 1998, Larry Page and Sergey Brin were graduate students at Stanford University. The two were working privately on a unique approach to retrieving information from massive data, a major challenge in computing at that time. In the process, they arrived at a solution they called "Backrub" because of its ability to analyze the back-links pointing to a given website. Within one year the engine caused a buzz around computer enthusiasts on the campus. Elated, they went looking for an angel investor to back them so they could put their Ph.D. plans on hold and start a search engine business. After several frustrating experiences, they managed to give a brief demonstration of their search engine to one of the founders of Sun Microsystems, Andy Bechtolsheim, who recognized the long-term potential of the new technology and instantly wrote a check for $100,000. Within weeks, Google, Inc. started functioning with a staff of three in a garage sublet by a friend. By the end of 2000, Google was handling over 100 million queries a day.

BYD: In 1980, Deng Xiaoping invited capitalism to take root in China by designating a village just across prosperous Hong Kong, Shenzhen, as the country's first Special Economic Zone (SEZ). Today, Shenzhen is one of the fastest growing cities in the world with a population of about 13 million.

One of the people participating in the Shenzhen miracle was Wang Chaun-Fu. Wang started off as a chemist and government researcher, but managed to raise US$300,000 from relatives and rented about 2,000 square meters of space in Shenzhen in 1995 to manufacture rechargeable batteries to compete with imported batteries from Sony and Sanyo. He named his company BYD which were the initials of its Chinese name. By 2000, the company moved on to design and manufacture mobile-phone handsets and parts to compete with the likes of Ericsson, Motorola, Nokia, and Samsung. The company's expertise in rechargeable batteries became particularly useful when, in response to initiatives directed at fighting global warming, the world started looking for battery-operated electric cars. So, in 2003, Wang entered the automobile business by buying a Chinese state-owned car company that was on the verge of bankruptcy. Soon, BYD's F3 became the best-selling plug-in electric sedan in China. The car has a range of 62 miles with an MPG of 88 miles while costing just around US$22,000. Today, BYD employs some 130,000 people in 11 factories spread across the world. Around the end of 2008, Warren Buffet's Berkshire Hathaway bought 10% of BYD for $230 million, ostensibly, with the hope of giving a jolt to the sagging electric car industry in the U.S.

Box 1.5 Innovations at Hewlett-Packard (HP).

In 1939, two former Stanford University classmates and close friends, Bill Hewlett and Dave Packard, founded HP following encouragement from Stanford professor and mentor Fred Terman. They decided the name of the company following a coin toss. Their first product was an audio oscillator built in their garage. In that year they generated revenue of $5,369 from just two employees. However, with the onset of World War II, orders picked up rapidly. The figure below shows the growth in revenue (equivalent 2002 US$) and number of employees over the following 63 years.



Growth of HP

The spectacular growth was obviously the result of HP's extraordinary commitment to innovation. The following are some major innovations undertaken by the company.

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Contents of Parts II and III

Back to top

Part II My Firm

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About the Author

Back to top
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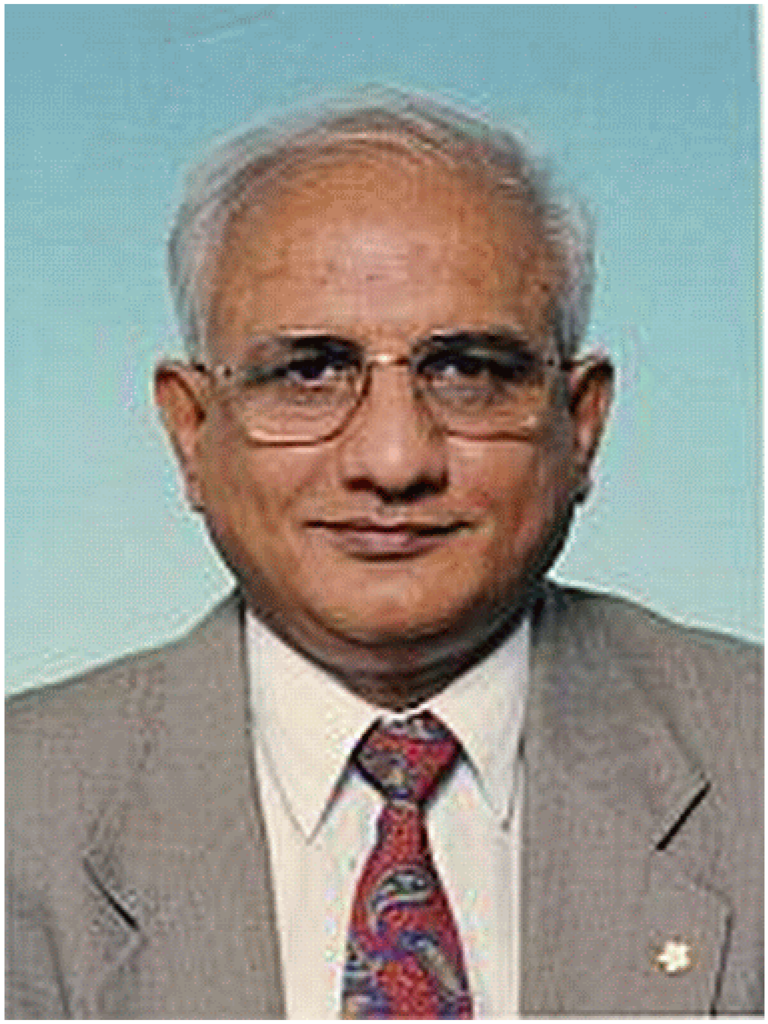
Patri, K. Venuvinod is a technology-academic with extensive international experience. Educated at College of Engineering, Osmania University, Hyderabad, and Indian Institute of Technology, Bombay, Venuvinod has a PhD from University of Manchester Institute and Science and Technology (UMIST), U.K. Subsequently, he was elected as a Fellow of CIRP, Institution of Electrical Engineers (UK), and Hong Kong Institution of Engineers; and Senior Member of Institute of Industrial Engineers.

Venuvinod's 37-year teaching career included long stints at Regional Engineering College, Warangal, India; Hong Kong Polytechnic; and City University of Hong Kong. At the last institute, he was the founding Head of the Department of Manufacturing Engineering and Engineering Management. He also became the university's Chair Professor of Manufacturing Engineering. During his 25-year stay in Hong Kong, he frequently visited mainland China to collaborate on several projects.

Venuvinod retired from active service in 2002. However, he continues to be associated with City University of Hong Kong as an Emeritus Professor. In 2004, he co-authored a book on rapid prototyping (published by Kluwer Academic Publishers). In 2001, he started the International Organization for Developing Universities (IODevUni) which engaged over 22 engineering colleges in Hyderabad, India, in a range of activities promoting the growth of technology, innovation and entrepreneurship (TIE).

In 2010, Venuvinod set up tecinnovent.com to act as an international forum for discussing TIE-related issues. There are many ways you can participate. You may comment on TIE-related books including the present trilogy or offer teaching support material (e.g., local case studies). You may recount your entrepreneurial experiences. Or, you can initiate discussions concerning the promotion of TIE in your region and workplace. It is all up to you.



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Back to top

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