INNOVATION - WINNING FORMULA OF THE NEW WORLD

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Abstract:

Innovation typically involves creativity, but is not identical to it. It involves acting on the creative ideas to make some specific and tangible difference in the domain in which the innovation occurs. The innovation happens only when conducive ground situation is created in a country as well as an organisation. It is possible only when intellectuals are nurtured as a formidable force and a resource.

"Innovation distinguishes between a leader and a follower." - Steve Jobs

The evolution of human being from a mere ape to a shepherd and then to a farmer has been marked with many innovative initiatives aimed at making his life easier and safe. As such one could deduce that the main drive behind innovation is nothing but a craving for a stable life style with no threats.

The word "innovate" is derived from Latin innovatus, past participle of innovare "to renew, restore; to change," from in- "into"+ novus "new" : Meaning "make changes in something established".

As the quote above implies, one who innovates desires to be the leader. So that, the human being also wanted to be a leader ahead of all other creatures, thanks to the wonderful creation of Mother Nature "the human brain".

"If you want something new, you have to stop doing something old" - Peter F. Drucker

Innovation is a new idea, more effective device or process. Innovation can be viewed as the application of better solutions that meet new requirements, inarticulate needs, or existing market needs. This is accomplished through more effective products, processes, services, technologies, or ideas that are readily available to markets, governments and society. The term innovation can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society.

While a novel device is often described as an innovation, in economics, management science, and other fields of practice and analysis innovation is generally considered to be a process that brings together various novel ideas in a way that they have an impact on society.

The Industrial Revolution, which took place from the 18th to 19th centuries, was a period during which predominantly agrarian, rural societies in Europe and America became industrial and urban. Prior to the Industrial Revolution, which began in Britain in the late 1700s, manufacturing was often done in people's homes, using hand tools or basic machines. Industrialisation marked a shift to powered, special-purpose machinery, factories and mass production. The iron and textile industries, along with the development of the steam engine, played central roles in the Industrial Revolution, which also saw improved systems of transportation, communication and banking.

While industrialisation brought about an increased volume and variety of manufactured goods and an improved standard of living for some, it also resulted in often grim employment and living conditions for the poor and working classes.

Innovation and industrialisation

The textile industry, in particular, was transformed by industrialisation. Before mechanisation and factories, textiles were made mainly in people's homes (giving rise to the term cottage industry), with merchants often providing the raw materials and basic equipment, and then picking up the finished product. Workers set their own schedules under this system, which proved difficult for merchants to regulate and resulted in numerous inefficiencies. In the 1700s, a series of innovations led to ever-increasing productivity, while requiring less human energy. For example, around 1764, Englishman James Hargreaves (1722-1778) invented the spinning jenny ("jenny" was an early abbreviation of the word "engine"), a machine that enabled an individual to produce multiple spools of threads simultaneously. By the time of Hargreaves' death, there were over 20,000 spinning jennys in use across Britain. The spinning jenny was improved upon by British inventor Samuel Compton's (1753-1827) spinning mule, as well as later machines. Another key innovation in textiles, the power loom, which mechanised the process of weaving cloth, was developed in the 1780s by English inventor Edmund Cartwright (1743-1823).

Developments in the iron industry also played a central role in the Industrial Revolution. In the early 18th century, Englishman Abraham Darby (1678-1717) discovered a cheaper, easier method to produce cast iron, using a coke-fuelled (as opposed to charcoal-fired) furnace. In the 1850s, British engineer Henry Bessemer (1813-1898) developed the first inexpensive process for mass-producing steel. Both iron and steel became essential materials, used to make everything from appliances, tools and machines, to ships, buildings and infrastructure.

The steam engine was also integral to industrialisation. In 1712, Englishman Thomas Newcomen (1664-1729) developed the first practical steam engine (which was used primarily to pump water out of mines). By the 1770s, Scottish inventor James Watt (1736-1819) had improved on Newcomen's work, and the steam engine went on to power machinery, locomotives and ships during the Industrial Revolution.

Transportation and Industrial Revolution

The transportation industry also underwent significant transformation during the Industrial Revolution. Before the advent of the steam engine, raw materials and finished goods were hauled and distributed via horse-drawn wagons, and by boats along canals and rivers. In the early 1800s, American Robert Fulton (1765-1815) built the first commercially successful steamboat, and by the mid-19th century, steamships were carrying freight across the Atlantic. As steam-powered ships were making their debut, the steam locomotive was also coming into use. In the early 1800s, British engineer Richard Trevithick (1771-1833) constructed the first railway steam locomotive. In 1830, England's Liverpool and Manchester Railway became the first to offer regular, timetabled passenger services. By 1850, Britain had more than 6,000 miles of railroad track. Additionally, around 1820, Scottish engineer John Macadam (1756-1836) developed a new process for road construction. His technique, which became known as macadam, resulted in roads that were smoother, more durable and less muddy.

Communication and banking in the industrial revolution

Communication became easier during the Industrial Revolution with such inventions as the telegraph. In 1837, two Brits, William Cooke (1806-1879) and Charles Wheatstone (1802-1875), patented the first commercial electrical telegraph. By 1840, railways were a Cooke-Wheatstone system, and in 1866, a telegraph cable was successfully laid across the Atlantic. The Industrial Revolution also saw the rise of banks and industrial financiers, as well as a factory system dependent on owners and managers. A stock exchange was established in London in the 1770s; the New York Stock Exchange was founded in the early 1790s. In 1776, Scottish social philosopher Adam Smith (1723-1790), who is regarded as the founder of modern economics, published "The Wealth of Nations." In it, Smith promoted an economic system based on free enterprise, the private ownership of means of production, and lack of government interference.

Quality of life during industrialisation

The Industrial Revolution brought about a greater volume and variety of factory-produced goods and raised the standard of living for many people, particularly for the middle and upper classes. However, life for the poor and working classes continued to be filled with challenges. Wages for those who laboured in factories were low and working conditions dangerous and monotonous. Unskilled workers had little job security and were easily replaceable. Children were part of the labour force and often worked long hours and were used for such highly hazardous tasks as cleaning the machinery. In the early 1860s, an estimated one-fifth of the workers in Britain's textile industry were younger than 15. Industrialisation also meant that some craftspeople were replaced by machines. Additionally, urban, industrialised areas were unable to keep pace with the flow of workers arriving from the countryside, resulting in inadequate, overcrowded housing and polluted, unsanitary living conditions in which disease was rampant. Conditions of Britain's working-class began to gradually improve by the later part of the 19th century, as the government instituted various labour reforms and workers gained the right to form trade unions.

Industrialisation moves beyond Britain

The British enacted legislation to prohibit the export of their technology and skilled workers; however, they had little success in this regard. Industrialisation spread from Britain to other European countries, including Belgium, France and Germany, and to the United States. By the mid-19th century, industrialisation was well-established throughout the western part of Europe and America's north-eastern region. By the early 20th century, the U.S. had become the world's leading industrial nation.

The U.S. had been the centre of innovation since then and acquired many resources across the world including the best human resource. This has helped the U.S. to create a new breed of wealth creators or better known as entrepreneurs through the combination of new knowledge and resources. The result has been the creation of business empires that generate wealth whilst catering to the growing needs of goods and services from across the globe.

The most significant innovation and development under the dominance of U.S. has been the analogue and digital computer in the early part of the 20th century, a replication of some of the brain functions and more, where the speed of processing of information has been improved to unbelievable levels.

The next giant leap has been the popularising of computer as a unique and essential item for the human being thanks to the innovative and creative initiates taken by IBM and Microsoft Corporations in the U.S. and the mobile communication device as well as hand-held devices completely changed the behaviour and routines of the people of all walks of life, from average income earner to billionaire.

Industrialisation moves beyond Europe

In the early parts of 1980s Japan emerged as an industrialised nation with super performance with digital technology and robotics. The revolutionary manufacturing methods used by Japanese industrialists nearly made to close down the giant companies in the Europe or made their products economically non appealing. Along with Japan there have been four other countries which led to the miracle in South – East Asia, known as the dragons. Singapore, South Korea, Taiwan and Malaysia are the countries that had marvelled in economic performance to match the levels of developed countries like Germany, France and UK. The most significant part of the story is that those countries achieved such stature creating a totally new dimension in the theory of economic development.

Given the fact that the dragons had been the most visible example, it is noteworthy to examine each country's progress in order to find out the root causes of such a phenomenon.

There has been a power shift in research and innovation from the West to the East in the last two decades. This is attributed to the subdued economic growth in the West, along with the transformation in the economic and financial power of emerging economies. R&D spending in Asia has already exceeded that of Europe or the United States (US), and if spending in Asia persists at such an aggressive rate, the total expenditure on R&D by Asian countries could double that of both Europe and US by 2017.

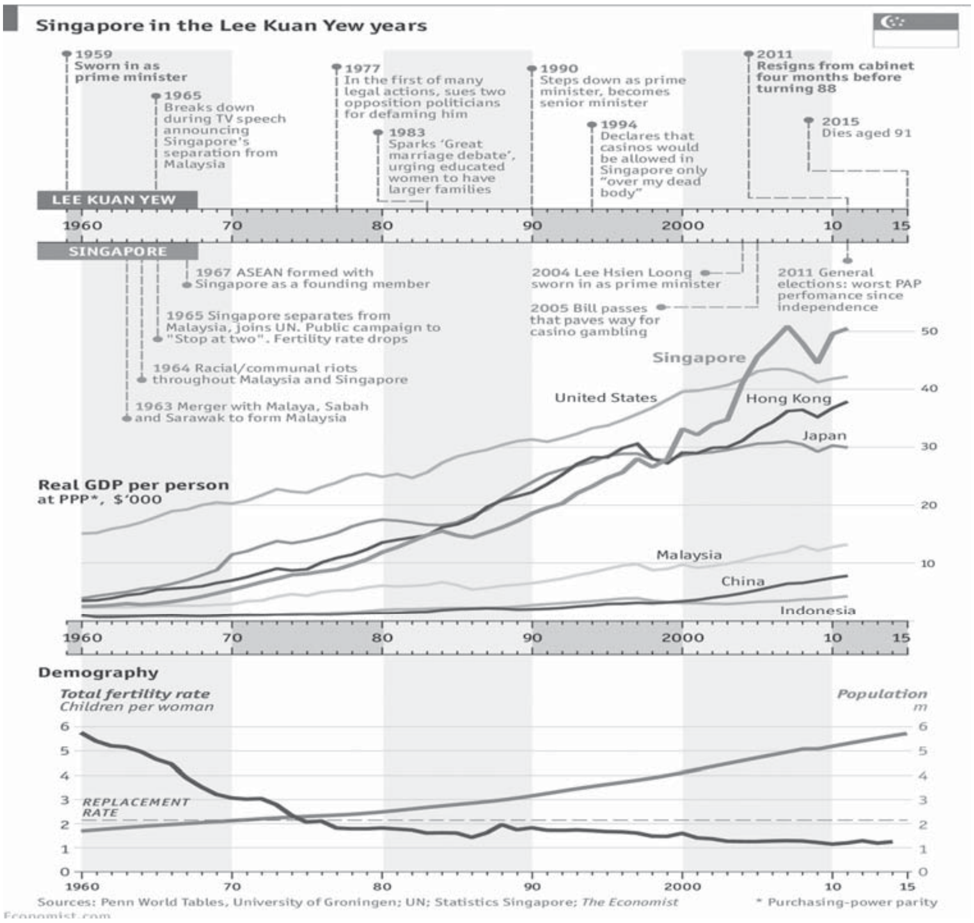
Singapore

Ranked 8th in the world on the Global Innovation Index, Singapore is an innovation powerhouse that aims to achieve its long-term vision of becoming a research-intensive, innovative and entrepreneurial economy. To take the island's innovation and value creation to the next level, the Singapore government has committed US$1.3 billion to developing the country's R&D capabilities, enterprise innovation and entrepreneurship through the Research, Innovation and Enterprise Plan (RIE 2015).

When it started life as an independent, separate country in 1965, Singapore's prospects did not look good. Tiny and underdeveloped, it had no natural resources and a population of relatively recent immigrants with little shared history. The country's first Prime Minister, the late Lee Kuan Yew is credited with transforming it. He called one volume of his memoirs, "From Third World to First".

Why did Singapore become an economic success?

First, its strategic location and natural harbour helped. It is at the mouth of the Malacca Strait, through which perhaps 40% of world maritime trade passes. It was an important trading post in the 14th century, and again from the 19th, when British diplomat Sir Stamford Raffles founded the modern city. Now it is at the heart of one of the world's most dynamic regions. Under Mr Lee, Singapore made the most of these advantages.



The above chart provides a sketch of the astonishing record of Lee Kuan Yew's Singapore.

Second, under Mr Lee, Singapore welcomed foreign trade and investment. Multinationals found Singapore a natural hub and were encouraged to expand and prosper.

Third, the government was kept small, efficient and honest—qualities absent in most of Singapore's neighbours. It regularly tops surveys for the ease of doing business.

Innovation track record in Singapore

When the development board was formed 50 years ago, it was mainly to create new jobs, attract multinational companies and stimulate the creation of export-oriented industries to help

Singapore — a tiny nation-state with limited natural resources — get off its feet after becoming an independent nation. Over time, as Singapore's prosperity has increased, the mission of the development board has evolved to include more of a focus on innovation. That has led to today's tripartite "Home" strategy for Singapore: "Home for Business. Home for Innovation. Home for Talent."

Singapore's "Home for Business" strategy expands to every industry, not just the ones you would expect from a modern innovation powerhouse. In other words, Singapore places as much emphasis on consumer goods, manufacturing, chemicals and energy as it does on IT, digital media or electronics. And to make it easy for multinationals to move operations to Singapore, the Singapore development board has become a "one-stop shop" that works to create the right conditions to attract talent and investment. When those conditions do not exist, Singapore has taken great pains to create them. Take IT and the Internet technology space, for example. Even five years ago, the entrepreneurial scene in Singapore was barren. A vast new entrepreneurial ecosystem is being created in Singapore, which aspires to be the Silicon Valley of Southeast Asia. Now it claims to be filled with over 42,000 start-ups, and according to estimates provided by the development board, nearly 1 in 10 working-age people in Singapore is trying to start a company or has already started one.

While Singapore does not yet have any breakout start-up tech companies, incubators such as Block 71 are intended to produce them. The only Singapore Company currently ranked in the Top 100 most innovative companies in the world by Forbes is ST Engineering.

In making Singapore a home for talent, one key has been adapting the nation's innovation strategy to respond to broad macro-trends happening in global markets. Singapore has benefited mightily from its geographic location close to the rising giant, China. With China now poised to be the world's No. 1 economy, Singapore has positioned itself as the place to go for Western companies who want exposure to China, but not necessarily the costs and complexity of setting up shop on the Chinese mainland.

A strong commitment to science and education within Singapore – typically cited by any innovation study on Singapore — means that there's a constant influx of new talent for any multinational looking to expand to China. Such is Singapore's allure for future knowledge workers that some top universities — including Yale University — are now developing separate overseas campuses in Singapore, in much the same way French business school INSEAD set up a Singapore campus back in 2000.

In many ways, the history of modern Singapore – which celebrates its 50th anniversary this year as an independent nation-state – can be seen as a constantly evolving innovation trajectory, as Singapore constantly finds new ways to insert itself into the world's economic growth cycles. In the mid-1960s and 1970s, it became a hub of low-cost manufacturing. Later, it moved up the value chain into electronics and semiconductors once other low-cost manufacturing centres in Asia began to emerge. And now, Singapore is moving into higher-margin, knowledge-intensive industries.

The showcase of this foreign know-how and expertise, of course, is the massive redevelopment of Jurong Island into an innovation showcase for the energy and chemicals industries. As part of a vast island reclamation project, Singapore has transformed Jurong Island into an integrated complex for 95 multinational companies – including Shell, ExxonMobil and DuPont. Singapore describes Jurong Island as a “plug-and-play” environment where downstream and upstream companies can be easily connected.

South Korea

After the Korean War, South Korea was one of the world’s poorest countries with only $64 per capita income. Economically, in the 1960s it lagged behind the Democratic Republic of the Congo (DRC) – currently holding elections marred by violence. Since then the country’s fortunes have diverged spectacularly. South Korea now belongs to the rich man’s club, the OECD development assistance committee (DAC). The DRC has gone backwards since independence and, out of 187 countries, ranked bottom in the 2011 Human Development Index.

South Korea, however, benefited from big injections of foreign aid, first from the US, then Japan. A briefing paper from KoFID, a South Korean network of civil society organisations, and ReDI, a South Korean thinktank, points out that the US offered about $60bn in grants and loans to South Korea between 1946 and 1978. In the same period, the total amount of aid provided by the US to the entire African continent was $68.9bn. Korea – considered by the US an important ally during the cold war – undisputedly used the aid well. Seoul was not afraid to stand up to the US when they differed on development strategy as well.

In a foretaste of the current debate on “ownership”, South Korea was not prepared to play second fiddle to the US and insisted on pursuing its own course. Aid was linked to South Korea’s planning and budget process, one of the principles set out in the Paris declaration on aid effectiveness in 2005 and expected to be reaffirmed in Busan.

South Korea, under strongman Park Chung-Hee, focused on building up large economic champions, or chaebols (business conglomerates), against American advice to focus on small- and medium-sized companies.

That policy laid the foundation for successful South Korean brands in the world market, such as Samsung and LG, although it came at a price in terms of political corruption in the close ties between business and political elites. KoFID and ReDI argue that the focus on conglomerates led to the chaebols exploiting their monopoly status, fostering increasing economic inequality.

Park took a pragmatic approach to corruption. Instead of cracking down on corrupt businessmen as urged by the US, he expropriated their bank shares and assigned them to invest in import-substitution industries, such as fertilisers, a point made in Catalysing Development, a book on aid edited by Homi Kharas, Koji Makino and Woojin Jung.
(The Korean innovation story)

The science and technology (S&T) situation was worse in 1960s in the country. There were only two public S&T institutions: the National Defence R&D Institute, created immediately after the end of the Korean War, and the Korea Atomic Energy Research Institute, founded in 1959. On such a base, Korea invested $5 million on R&D in 1964, which enabled the employment of fewer than 5,000 scientists and engineers. As far as S&T was concerned, S. Korea was no more than a barren land.

It was under such a setting that S. Korea started its drive for S&T development and transformed itself into one of the world's most dynamic economies. S.Korea has succeeded largely because it invested heavily in human resource development and because it forced companies to compete in global markets. In the process, however, scientific research capability played second fiddle to industrial development. Today, S. Korea recognises that it must bolster the basic system for innovation in order to sustain and build on its prosperity.

In 1962, S. Korea launched its first five-year economic development plan, aimed at developing an industrial base that could support both import substitution and export promotion. Lacking in technological capability, S. Korea had to rely almost completely on imported foreign technologies. Early on, S. Korea pursued two objectives: promoting the inward transfer of foreign technologies and developing the domestic absorptive capacity to digest, assimilate, and improve on the transferred technologies. Because of concerns about becoming dependent on multinational firms, S. Korea, unlike other developing countries, chose to largely forgo foreign direct investment (FDI) and instead focused on arm's-length methods such as reverse engineering, original equipment manufacturing (OEM), and foreign licensing. These methods had the benefit of providing a substantial amount of worker training.

S. Korea resorted to long-term foreign loans to finance industrial investments. The money was invested in selected industries, which led to massive imports of foreign capital goods and turnkey plants. In order to acquire necessary technologies, industry later reverse-engineered imported capital goods. S. Korean firms benefited most from OEM production arrangements because they offered opportunities to work with foreign buyers who provided everything from product designs and materials to quality control at the end of the production process. This was especially the case in the garment and electronic industries. Workers gained valuable experience.

During the 1970s, S. Korea made massive investments in machinery and chemicals. In chemicals, S. Korea relied largely on turnkey plants, which included technical training programs as part of the packages. In heavy machinery, foreign licensing was an important channel for technology acquisition. To help the two nascent industries further, the government created government R&D institutes, which worked with private industries to build the technological foundation for industrial development.

In short, S. Korean industries relied more on informal rather than formal channels for technology acquisition. The S. Korean approach resulted in both positive and negative effects. On the plus side, the policy enabled S. Korea to acquire technologies at lower costs and precluded the constraints often imposed by multinationals on local firms' efforts to develop their own capabilities. The downside is that S. Korea had to forgo access to technologies that might have been available through direct equity links with foreign firms. By restricting FDI, S. Korea failed to meet global standards in domestic business operations. Much worse, the reliance on large-scale foreign loans contributed to a major financial crisis in 1997. Yet in the end, S. Korea was able to succeed largely because the informal modes of technology transfer that it emphasized contributed in a major way to building a well-educated work force. The need for such a work force cannot be underestimated.

Building an indigenous R&D capacity

As industrial development continued into the 1980s, the technological requirements of S. Korean industries became more complex and sophisticated. At the same time, developed countries began to view S. Korea as a potential competitor in international markets, and foreign companies became increasingly reluctant to transfer new technologies to their S. Korean counterparts. The government responded by loosening its FDI regulations and liberalising foreign licensing, but the moves did not lead to significant increases in either area.

Consequently, the government concluded that to sustain development, it needed to build indigenous R&D capability. The National R&D Program was launched in 1982, and various actions were taken to promote and facilitate private R&D activities, including tax credits for R&D investments and worker development.

Some of the key steps taken were designed to implement the overall government strategy of exposing firms to international competition. The government provided companies with financial and other incentives based on export performance. Companies with better performance were given better business opportunities as well as better access to financial resources. S. Korean firms recognised that to keep pace with technological change and survive in this export-driven world, they would have to invest heavily in R&D. The government's export drive also favoured large firms, giving birth to a unique business organisation in Korea called the chaebol (similar to the zaibatsu in Japan before World War II). Chaebols enjoy greater financial affluence because of greater economies of scale and the greater scope of their business operations. Chaebol companies are thus able to engage in risky and expensive R&D projects that are unthinkable for small- and medium-sized firms. Today, the top 20 firms account for about 57% of the total industrial R&D investments in S. Korea.

The results of the government's actions were dramatic. The turn toward indigenous R&D for technology acquisition can be seen in the sharp decline in the ratio of technology imports to business R&D from about 40% in 1981, to 20% in the mid 1980s, and to 10% in the early 1990s. S. Korea's R&D investment, which stood at only $526 million or 0.81% of GDP in 1981, rose to $13.5 billion or 2.6% of GDP in 1996, and to $26.3 billion dollars or 2.9% of GDP in 2005. During a period of 24 years, R&D investment increased almost 50 times, with an average annual growth rate of almost 20%. S. Korea now is the sixth largest R&D spender among OECD countries.

As private-sector R&D spending rose, government spending declined. In 1981, the government accounted for 53.5% of total R&D investment, but that share declined to 19.4% in 1990 and 16% in 1994, before heading up again to 24.3% in 2005. Now the private sector accounts for 75.6% of the total. With industry leading the way, R&D activities in Korea are focused largely on applied research and technology development, reflecting shorter-term commercialisation concerns. In the 1980s, about 83% of R&D funds were used for applied research and technology development; in 2005, the share was 84.7%.

A key reason why S. Korea was able to increase R&D investment so rapidly was because it had an abundant pool of highly educated workers that could meet the increasing demand for R&D services in both private and public sectors. S. Korea recognised that R&D investment is more constrained by the lack of human resources than by financial limitations, and thus prepared itself well for development by investing heavily in education and human resource development.

R&D investment grew rapidly and continuously until S. Korea was hit by the 1997 financial crisis. R&D was one of the most damaged victims. In a survey undertaken in early 1998, many companies responded that they would cut R&D investments and personnel by almost 20% in response to the crisis. Actually, industrial R&D expenditures decreased by 10% in nominal terms from 884.4 billion Won in 1997 to 797.2 billion Won in 1998, but in dollar terms, the decline was even sharper (38.5%) because the value of the S. Korean currency relative to the dollar plummeted in 1998. R&D personnel also decreased by 15% from 102,000 in 1997 to 87,000 in 1998. This was a serious blow to the innovation system. If the crisis had continued for several more years, the system might have collapsed.

Finally, R&D efforts have contributed to the development of high-tech industries in S. Korea. Based on in-house R&D, S. Korean industries have recently emerged as world leaders in semiconductor memory chips, cellular phones, and liquid crystal displays. They have also established themselves in the world market in shipbuilding, home appliances, auto manufacturing, telecommunications, and other areas.

S. Korea, into the future

S. Korea has made enormous strides in S&T during the past four decades. By making continuous and massive investments in human resource development and R&D, S. Korea has succeeded in building a unique innovation system. Yet there are problems, too. First, even though S. Korea spends a larger share of GDP on R&D than most other countries, R&D activities are highly concentrated in a small number of large enterprises, causing a serious imbalance in the system. Indeed, industrial R&D is skewed in favour of industries such as electronics. If this high concentration persists for long, it will dichotomise S. Korean industries into technologically advanced and retarded firms and sectors. In addition, the high concentration means that the R&D system is vulnerable to changes in economic and business environments. For instance, large S. Korean enterprises responded to the financial crisis of 1997 by cutting their R&D spending by about 14%, hurting the entire system. Second, although S. Korea has reached nearly the level of advanced countries in terms of S&T inputs, it still has a long way to go in terms of R&D productivity. The most important source of inefficiency is the lack of interaction and exchanges among the major actors of innovation: universities, research institutes, and industry. Inter-sector mobility of scientists and engineers is extremely low. Third, a weakness in basic sciences poses a fundamental problem, because scientific capability determines a nation's technological potential. As S. Korea has emphasised industrial technology development, scientific research has been more or less neglected. Strengthening university research is a key to the future.

The S. Korean experience offers lessons for policymakers in developing countries. First, there is no doubt that education builds a nation's ability to absorb new knowledge and technology. Thus, government should assume full responsibility for taking the necessary measures to promote human resource development. Investing in education in advance, as S. Korea did in the 1960s and 1970s, is essential in laying a foundation for industrial development. To help workers cope with technological change, government should provide vocational and technical training or take measures to promote such training at work places. Later, as the economy becomes more advanced, technological competence becomes a critical factor, and the nurturing of high-calibre scientists and engineers capable of dealing with developments at the scientific and technological frontiers becomes necessary. In short, advanced education in S&T should come first in preparing for entrance into a developed world. In the case of S. Korea, education and industrialization helped each other in sustaining and accelerating development. Education made technological learning and therefore industrialisation possible, while industrialization enhanced the rate of return on investment in education, promoting further demand for education.

S. Korea's industrialisation evolved from imitation to innovation. In the initial stage, S. Korean industries attained technological capability through informal channels for technology transfer, such as OEM production arrangements, reverse engineering of imported machines, technical training as part of turnkey plant importation, and so on. To lay the initial technological foundation, many S. Korean industries resorted to nonmarket processes, relying on the absorptive capacity of their workers for technology acquisition. This approach enabled them to acquire technology at a lower cost and maintain independence in business operations. But this strategy came at great cost: S. Korea had to abandon many of the technological opportunities that foreign direct investors might have offered.

By adopting an outward-looking development strategy, the government drove S. Korean industries into the competitive international market, putting them under great pressure for technological learning and/or development. S. Korean industries responded by investing heavily in technology development. By developing technological competence, they have been able to survive internationally and establish prominence in key areas. Protectionist policy may be effective in creating initial market opportunities for domestic industries, but if such a policy is prolonged, industries will develop immunity against market pressure for innovation. It may be for this reason that export-oriented firms achieved technological learning more rapidly than import-substituting firms.

In sum, S. Korea owes its technological development and industrialisation to the development of a strong human resource base and an outward-looking development strategy. Two major lessons from the S. Korean experiences are that human resources are the key to S&T development and thus to economic growth, and that nothing can better motivate private businesses to invest in technology development than market competition. But for S. Korea to sustain past development into the future, it has to further strengthen basic scientific research capability and improve framework conditions for innovation.

Taiwan

Taiwan offers one of the great models of modern economic and political development. In 1960 Taiwan had GDP per capita and human development levels that placed it among the least developed countries in the world. Subsequent decades saw economic growth and industrialisation that not only transformed Taiwan into one of Asia's tiger economies, but also provided an economic model that has been successfully replicated by other regional economies. In parallel with this economic evolution, Taiwan began a process of political transformation that led to three decades of democracy.

Taiwan's success—from an underdeveloped and resource poor island, to a regional economic powerhouse with a multiparty democratic system—comes from its national commitment to investing in its people. While other factors certainly played a role in prompting Taiwan's transformation, including effective trade and financial policy, Taiwan has established itself as a dynamic and technology oriented economy by improving its base of human capital. Without mineral, carbon, or agricultural wealth, Taiwan recognised that its people were its most valuable national resource. Today, Taiwan has a human development index score that is comparable to France's and GDP per capita levels similar to Germany.

Historical research into the "Taiwanese miracle" has focused on government policy and its effects, but statistical data for the first few post-war decades is poor and the overall effect of the various government policies is unclear. During the 1960s and 1970s, real GDP grew about 10% (7% per capita) each year. Most of this growth can be explained by increases in factors of production. Savings rates began rising after the currency was stabilised and reached almost 30% by 1970. Meanwhile, primary education, in which 70% of Taiwanese children had participated under the Japanese, became universal, and students in higher education increased many-fold. Although recent research has emphasised the importance of factor growth in the Asian "miracle economies," studies show that productivity also grew substantially in Taiwan.

High-speed growth accompanied by quick industrialisation began in the late-1950s. Though it was slow at the outset it gradually picked up with maturity.

Taiwan became known for its cheap manufactured exports produced by small enterprises bound together by flexible sub-contracting networks. Taiwan's post-war industrialisation is usually attributed to:-

1) the decline in land per capita,
2) the change in export markets, and
3) Government policy.

Between 1940 and 1962, Taiwan's population increased at an annual rate of slightly over three percent. This cut the amount of land per capita in half. Taiwan's agricultural exports had been sold tariff-free at higher-than-world-market prices in pre-war Japan while Taiwan's only important pre-war manufactured export, imitation panama hats, faced a 25% tariff in the U.S., their primary market. After the war, agricultural products generally faced the greatest trade barriers. As for government policy, Taiwan went through a period of import substitution policy in the 1950s, followed by promotion of manufactured exports in the 1960s and 1970s. Subsidies were available for certain manufactures under both regimes. During the import substitution regime, domestic manufactures were protected both by tariffs and multiple overvalued exchange rates. Under the later export promotion regime, export processing zones were set up in which privileges were extended to businesses which produced products which would not be sold domestically.

According to the WEF Global Competitiveness Report 2013-2014, Taiwan is ranked 1st out of 148 economies around the world in terms of the "state of cluster development." There are three types of industrial parks in Taiwan:

1) Science-based industrial parks - under the jurisdiction of the National Science Council, Executive Yuan
2) Export processing zones - under the jurisdiction of the Export Processing Zone Administration Office, MOEA, and
3) Industrial parks - developed by the Industrial Development Board (IDB), local governments and private enterprises.

As of the end of August, 2013, 62 industrial parks were under the jurisdiction of the IDB (including 55 developed and 7 developing parks), and have provided 12,543 companies to set up factories and created 585,854 job opportunities.

Following the pace of industrial transformation, Taiwan's industrial parks have developed into specialised parks and corridors. For example, the Nankang Software Park in Taipei is a technology park for knowledge-intensive industries that focus on software development, digital content, IC design, and biotechnology. The parks in central Taiwan reflect the fact that the region, with its well-developed industrial supply chain, is an important manufacturing base for precision machinery. The Tainan Technology Industrial Park in southern Taiwan, with its Industrial Innovative R&D Zone, allows for research on core technologies, such as micro-nano systems, 3C integration, applications of communication software and the Internet, etc. The establishment of the Central Taiwan Science-based Industrial Park completes the linkage of the three science-based industrial parks in northern, central and southern Taiwan into a "technology corridor" along the western coast.

According to the WEF Global Competitiveness Report 2013-2014, Taiwan was ranked 33rd in Labour Market Efficiency out of 148 economies around the world. In order to improve the industrial structure and facilitate the cultivation of professionals, Government has endeavoured to strengthen industrial human resources.

The methods include talent training, industrial professional supply and demand surveying, as well as vocational standards and proficiency appraisal. Moreover, the IDB promotes the industrial talent root-taking program to guide students participating in practical training and increase the fundamental technical talent pool needed by industry. By the talent root-taking program and cooperation between industry and academia, the IDB cultivates professionals in four major areas, including precision machinery, moulds, surface treatment, and textiles.

In order to actively promote industrial development and upgrading, and to maintain continuous economic growth, the Development Fund of the Executive Yuan sets aside a special fund in cooperation with banks to provide various kinds of special low-interest loans. The loans include those for R&D; the purchase of automated, pollution-control and energy conservation machinery and equipment; small and medium enterprises; and traditional industries, etc. The government also provides mid- to long-term financing for major investment projects in amounts of NT$100 million or more upon application by private enterprises.

For small and medium-sized enterprises (SMEs) that were denied a loan due to a lack of sufficient collateral, the Small and Medium Business Credit Guarantee Fund, a non-profit organisation founded by the government and financial institutions, can provide credit guarantees to qualified firms.

To facilitate the development of high-tech industries, the IDB stipulated that, regardless of whether domestic or foreign, all approved companies with high-tech products or successfully developed technologies may apply for listing or OTC with simpler qualifications.

Each year, the IDB has a budget for upgrading technology in industries by providing R&D grants under the "New Leading Product Development Program" and the "Conventional Industry Technology Development Assistance Program." The MOEA's Department of Industrial Technology also provides grants for R&D projects conducted by industry and academia as well as planning and development activities of critical, forward-looking industrial technologies.

With regard to R&D activities, the participation of several important research institutes, including the Industrial Technology Research Institute (ITRI), Institute for Information Industry (III), Chung Shan Institute of Science and Technology (CSIST), Taiwan Textile Research Institute (TTRI), Metal Industry Research and Development Centre (MIRDC), and Food Industry Research and Development Institute (FIRDI), are instrumental in the development of new industrial technologies in private sectors.

To further promote the dissemination of technology, the IDB has established the Taiwan Technology Marketplace (TWTM, http://www.twtm.com.tw) as a worldwide technology/patent transaction platform for industries, academia, and research institutes. TWTM also provides a matching service for technology/patent transactions together with intellectual property consulting services.

Taiwan was ranked 5th globally in terms of the number of patents registered in the U.S. in 2012 (see Table A). Taiwan's R&D expenditures made up 3.02% of the GDP in 2011 and

2010 Ranking	**Country**	**No. of Patents**				**Share of All Patents Granted (%)**			
		2009	2010	2011	2012	2009	2010	2011	2012
1	America	95,038	121,179	121,261	134,187	49.52	49.59	48.95	48,48
2	Japan	38,066	46,978	48,256	52,773	19.83	19.23	19.48	19.07
3	Germany	10,352	13,633	12,986	15,041	5.39	5.58	5.24	5.43
4	South Korea	9,566	12,508	13,239	14,168	4.98	5.12	5.34	5.12
5	**Taiwan**	**7,781**	**9,635**	**9,907**	**11,624**	**4.05**	**3.94**	**4.00**	**4.20**
6	Canada	4,393	5,513	5,754	6,459	2.29	2.26	2.32	2.33
7	England	4,009	5,038	4,924	5,876	2.09	2.06	1.99	2.12
8	France	3,805	5,100	5,022	5,857	1.98	2.09	2.03	2.12
9	Israel	1,525	1,919	2,108	2,598	0.76	0.77	0.75	0.94
10	Italy	1,837	2,254	2,333	2,546	0.96	0.92	0.94	0.92
	Total	**191,933**	**244,358**	**247,728**	**276,788**	**100**	**100**	**100**	**100**

Source: US Patent and Trademark Office (USPTO)

Table B: Research and Development Expenditure Comparison

Category/Country	Total R&D Expenditure(US$ millions) (PPP)	Proportion of R&D Expenditure to GDP (%)	R&D Expenditure by Sector of Performance (2009)	
			Government (%)	Business Enterprises (%)
Taiwan, 2011	**26,318**	**3.02**	**27.5(2010)**	**71.5(2010)**
Japan, 2010	140,832	3.26	17.2	76.5
United States, 2009	401,576	2.77	32.1	70.3
Germany, 2010	86,299	2.84	29.7(2009)	67.2(2010)
France, 2010	49,990	2.25	39.7	61.2
United Kingdom, 2010	39,137	1.77	32.1	60.9
South Korea, 2010	53,184	3.74	26.7	74.8

Source: Indicators of Science and Technology 2012, National Science Council, Executive Yuan the proportion of R&D conducted by business enterprises accounted for 71.5% of the overall R&D expenditure in 2010 (see Table B).

Table A: Number of U.S. Patents Granted to the Citizens of Selected Countries

Malaysia

In the last 20 years, Malaysia's economy has been transformed from a protected low income supplier of raw materials to a middle income emerging multi-sector market economy driven by manufactured exports, particularly electronics and semiconductors, which constitute about 90% of exports. Since 1970, and the institution of the New Economic Policy (NEP) following deadly riots in 1969 against economically dominant ethnic Chinese, the government's commitment to the free market has been hedged by its Bumiputra (literally, "sons of the soil") policies aimed at providing "constructive protection" for Islamic Malays against economic competition from other ethnic groups and foreign investors, particularly in the domestic market.

In the Asian financial crisis of 1997, most of the major companies that the government had privatised and reserved for Bumiputra leadership, including Proton, the national car company, Malaysian Airlines, the Renong engineering group, the Malaysian Resources media group, had to be renationalised to prevent their collapse. A vigorous recovery program mounted by the government that was showing positive results in 1999 and 2000 ran abruptly into the wall of the 2001 global slowdown. Worldwide, foreign direct investment dropped almost 50%, and in Malaysia the decline was an even more precipitous 85%. Gross domestic product growth dropped to 0.7% for 2001, from its usual 7% to 9%. Business in Malaysia remains dominated by non-Malays. Annual growth rates, which had been running 7% to 9%, came abruptly up against a wall in 2001. The government remains generally committed to a policy of free enterprise, although it owns and operates the railway and the majority of the communications systems and has become increasingly involved in certain key industries.

In 1970, a government holding company, Perbadanan Nasional (PERNAS), was created to encourage Malay-controlled businesses; in 1975, the government attempted, through PERNAS, to strengthen Malaysian interests in the tin-mining sector. Also in 1974, the government established the National Oil Co. (PETRONAS), with the overall aim of acquiring majority control of the country's petroleum operations. The Industrial Coordination Act of 1975 attempted to accelerate indigenous Malay participation in the economy by setting limits on foreign participation in the processing, domestic distribution, and export of local raw materials. In 1971, the New Economic Policy (NEP) was adopted, with the aim of channeling a greater share of future economic growth into Malay hands. It specifically called for raising the level of corporate ownership by Malays to 30% by 1990, reducing corporate ownership by other Malaysians (i.e., Chinese and Indians) to 40%, and restricting foreigners to ownership of no more than 30%. Short-term investment strategies are set forth in a series of economic plans. The fourth Malaysia plan (1981–85) proposed a level of development spending of M $42.8 billion and called for acceleration of the NEP goals for Bumiputra economic participation. Major industrial and infrastructural development projects included a M $900-million bridge between Pulau Pinang and the mainland and a M $600-million automobile-manufacturing plant, both of which opened in 1985.

Recent economic planning has stressed a “look East” policy, with Malaysia attempting to emulate the economic successes of Japan and the Republic of Korea by importing technology from those countries. In response to deteriorating prices for oil and other exports, the fifth Malaysia plan (1986–90) has moved away from the goals of the NEP, aiming instead at promoting foreign investment, particularly in export industries.

The year 1990 marked the culmination of several economic development plans: the fifth Malaysia plan (FMP), 1986–90; the conclusion of the first outline perspective plan (OPP1) 1971– 1990; and the completion of the new economic policy (NEP) 1971–1990. The FMP emphasised industrialisation. Specific targets were formulated to ensure that the distribution of ownership and participation in the commercial and industrial sector would be characterised by ethnic group participation, 30% bumiputra—Malays and other indigenous peoples of Malaysia, 40% other Malaysians (Chinese and Indian descent), and 30% foreign. The government provided funds to purchase foreign-owned shareholding on behalf of the Bumiputra population, increasing their equity to 20% by 1990.

These policies are part of the new national development policy, although specific targets and time tables have been dropped. A post-1990 NEP defined Malaysian economic strategy for full development by 2020.

Three ten-year outline perspective plans, which included a new development plan and six five-year plans, made up the NEP. A second outline perspective plan (OPP2) 1991–2000 aimed to sustain growth momentum and to achieve a more balanced development of the economy. The sixth Malaysia plan called for an average annual growth rate of 7.5%, and expenditures on infrastructure were included to ensure prospects for further development. Development trends are toward privatisation, encouraging the spread of industry throughout the country, increasing manufacturing in the free trade zones, and providing financing for industry through the establishment of specialised financing institutions.

A five-year development plan announced by Dr Mahathir on 6 May 1996 fore-casted average growth of 8% per year from 1996 to 2000. But it also tackled issues that bothered skeptics of the Malaysian economy: low rises in productivity, a skills shortage, and a gaping current-account deficit. In 1997 and 1998, these issues, along with a global financial crisis based in Asia caused the downturn that skeptics expected. Prospects for continuation of the second industrial master plan for 1996 through 2005 seemed grim, although the economy began to rebound in 1999. Massive capital and infrastructure projects have attracted foreign investment and international respect.

Malaysia is embarking upon a new phase of development towards realising its aspiration of becoming a developed nation by 2020. Given the changing domestic and global economic landscape, initiatives to enhance national competitiveness and resilience will be given priority.

One major thrust of the country's Development Plan is to move the economy up the value chain, and inherent to this is the need to develop more innovation driven enterprises.

For innovation to occur, something more than the generation of a creative idea or insight is required. The insight must be put into action to make a genuine difference, resulting for example, in new or altered business processes within the organisation, or changes in the products and services provided.

MATRADE's (Malaysia's External Trade Development Corporation) one of the initiatives is to promote Malaysia's innovations globally. This web page provides viewers with a list of inventions that are already commercialised, information on Ministries and Government Agencies that are involved in R&D and commercialisation of Malaysian inventions besides information on related programmes and activities.

Support for promoting innovation and R&D activities from the Government is through a number of plans and incentives. For example, the National Action Plan for Industrial Technology Development in 1990, the National Multimedia Plan in 1995, the Second National Science and Technology Policy in 2003, the National Biotechnology Policy in 2005, the National Innovation Model in 2007, the Green Technology Policy in 2009, the Digital Transformation Program in 2011, and the National Transformation Policy (NTP) in 2012.

Where does Sri Lanka stand?

Given the above facts it is quite clear that as a nation, Sri Lanka need to invest heavily on R&D in the medium to long term under a comprehensive policy frame work under the patronage of the government.

In order to understand where Sri Lanka stands in the R&D sector, it is more apt to quote from key note address delivered by A S. A. Kulasooriya, Emeritus Professor of Botany, University of Peradeniya and Visiting Research Professor, Institute of Fundamental Studies on "The Status of Research and Development in Sri Lanka" at the annual review meeting of the Institute of Fundamental Studies, in Kandy in 2011. The extracts given here were published in the Sunday Times of 13 February 2011.

According to him:-

Sixty three years since gaining independence it is time to look where Sri Lanka is, in comparison to other neighbouring countries which were also colonies of the British Empire. Unfortunately, it has to be admitted that we are far behind most of them so much so that we are sending Sri Lankans to work as unskilled labourers and house maids in some of these countries. It is therefore necessary to take stock of what happened, to find out where we went wrong and explore remedial measures that can be taken to reverse this situation.

Although significant socio-political changes took place in Sri Lanka during this period to move away from the post-colonial mentality, our scientific research and industries perhaps did not keep pace with such changes to strengthen local capacity and concentrate on the utilisation of indigenous resources. Even today most of our industrialists prefer to depend upon either imported technology and/or export raw material rather than add value to local resources. There is a misconception that a small developing country like Sri Lanka which has numerous socio-political responsibilities should give less priority to scientific research. It is high time that we change these attitudes and develop a positive mentality; "Yes we can, Sri Lankans can be innovative and productive".

The professor next dwells upon the local manpower capacity for scientific research. It is reported (Sri Lanka Science, Technology & Innovation Statistical Handbook, NSF 2008) that the total number of scientists recorded under Human Resources for Science & Technology was 4,037 in 2008 and this is a decline from the 4,520 the country had in 2006.

In terms of their qualifications this includes approximately 23% PhDs, 28% M.Phil/M. Scs, 9% MD/MSs, 5% B.Sc + PG Diplomas, 16% B.Sc. Special, 15% B.Sc. General and 4% others. It should be noted that only about 60% with PhDs, MPhil/MSc and MD/MS are really competent to conduct independent research since those with bachelor's degrees need guidance and supervision. Even most of the M.Sc. graduates are limited in their research capabilities. This means that strengthening the scientific manpower capacity is also necessary to establish a research oriented knowledge based society that will bring about rapid economic development. Therefore institutes devoted for research such as the IFS, ITI, NERD, Universities and Postgraduate Institutes have an additional responsibility of training graduate students and orienting them for research work.

At the same time contributions by the private sector have been dismal with 0% in 2004, through 0.03% in 2006 to 0.02% in 2008. Even foreign funding has declined from 0.05% to 0.01% to 0.005% during these three years. Research output of Sri Lanka in terms of publications included in the Scientific Citation Index (SCI) is nothing to be proud of.

In comparison to other countries in our region we occupy the last position. The interesting fact is the position of India being a country that recorded significant achievements in relation to industrialisation, as against China.

Table 1: Gross Expenditure on R&D as a % of GDP in Selected Countries

India	**0.76**
Singapore	2.43
China	1.7
Japan	3.36
Sri Lanka	0.16

Source: Sri Lanka Science, Technology and Innovation Handbook: 2010, National Science Foundation

The scientific community has a critical role to play to bring about such attitudinal changes. In this respect professional associations such as the National Academy of Sciences, the Sri Lanka Association for the Advancement of Science, Institute of Engineers Sri Lanka, Institute of Chemistry, Institute of Physics, Institute of Biology etc. have a responsibility to interact closely with policy makers and administrators and convince them of the importance of Research, Innovation and Technology for National Development. Sri Lanka possesses resources that can be better utilised for its economic development. We also have well qualified, capable and competent scientists and technologists who can provide leadership and training to strengthen the scientific manpower requirements of this country. All that is necessary is a National Policy on Science and Research which is directed towards strengthening local industries and other economic sectors while minimising the negative impacts on our environment.

Such a policy should be supported with adequate funding and incentives to scientists who contribute to economic development and improvement of the quality of life of this nation.

Conclusion

The reading on the wall is very clear; which is that without R&D, no innovation and with no innovation, the march towards prosperity would be a mere day dream.

Even though many would argue otherwise the writer believes that the key to innovation is already with us as a nation but it is the attitude that needs to be changed across the country. In this regard the work done by "The Inventors Commission of Sri Lanka" through the formation of Inventors Clubs in the schools and giving enough media exposure to students with a knack for invention is commendable. The most notably, a simple solution to a persisting problem in a society could be an invention if it can be commercially exploited,

My recommendation is to form such Inventions Clubs not only in schools but also in the corporates and to combine with the academia to explore the possibility of ideas generated through the Clubs under a workable structure to make them realisable.

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