Managing Innovation

Lessons Learned Internationally

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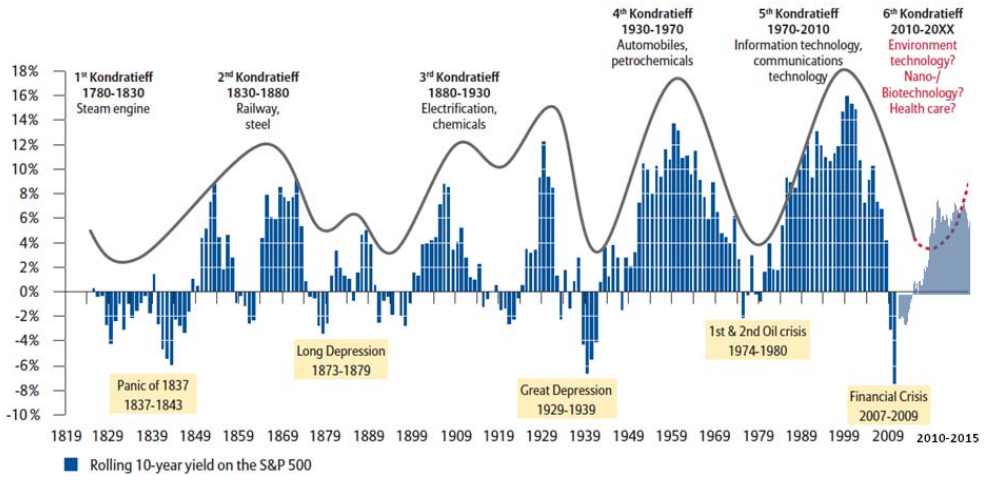
July 2017

Situational Context

- Wealth production and wealth consumption are interdependent.
- Sustaining an economy that produces sufficient wealth to meet public expectations and entitlements is a major challenge for developed economies, as is clearly evident from the fiscal pressures confronting the European Union and to some extent the United States. Most highly developed countries run fiscal deficits and many have balance of trade deficits.
- Dealing with levels of consumption that exceed national production has proven to be very difficult for democratic governments.
- In the medium and long term, such imbalances are not sustainable.
- Countries such as Canada and the United States with large natural resource bases may postpone the day of reckoning, but are unlikely to be able to do so in the long term.

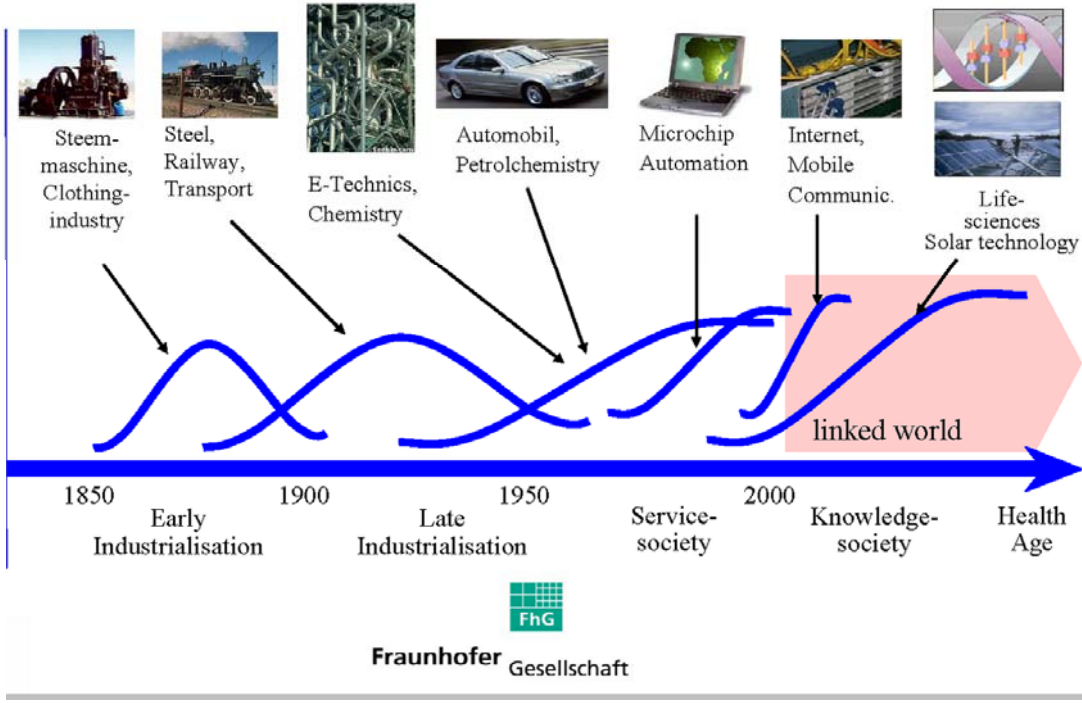
Is it the 6th Kondratieff Wave yet?



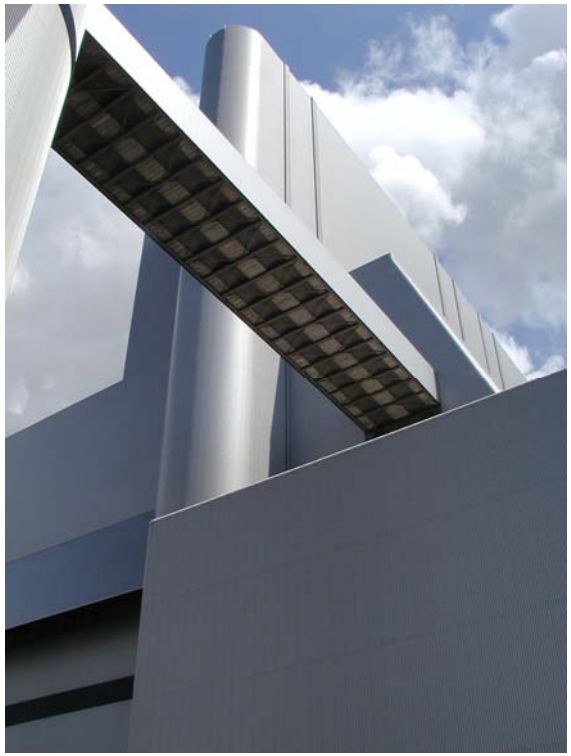
Source: Allianz Global Investors 2010 Report – "The Sixth Kondratieff , long waves of prosperity"
Updated to Q3 2015 by deconstructingrisk.com

Kondratieff-Cycles: Key Innovations….

… initiate new industrial and social stages of development



The world seems to be passing through a Kondratieff wave with political, social, economic and technological changes all at play. Managing innovation effectively in such an uncertain world is a significant challenge.



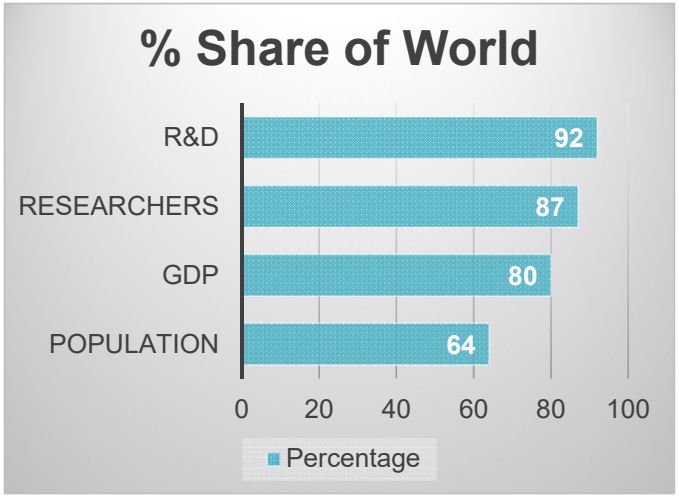
Economic Growth for Regions of the World

(f) Data in 2016 is a forecast in the January 2016 World Bank Global Economic Prospects

Country Groups	**2013**	**2014**	**2015**	**2016f**
BRICS	5.7	5.1	3.9	4.6
Developing economies	5.3	4.9	4.3	4.8
High-income economies	1.2	1.7	1.6	2.1
Low-income economies	6.4	6.1	5.1	6.2
World economy	**2.4**	**2.6**	**2.4**	**2.9**
Regions / Developing Countries				
Developing East Asia and Pacific	7.1	6.8	6.4	6.3
Developing Europe and Central Asia	3.9	2.3	2.1	3.0
Developing Latin America and the Caribbean	3.0	1.5	-0.7	0.1
Developing Middle East and N. Africa	0.6	2.5	2.5	5.1
Developing South Asia	6.2	6.8	7.0	7.3
Developing Sub-Saharan Africa	4.9	4.6	3.4	4.2

G20 Countries & Fortune 500 Companies

G20 COUNTRIES



FORTUNE 500 COMPANIES

Revenue	$ 27.6 T
Profit	$ 1.5 T
Employment	67 M
Countries	33

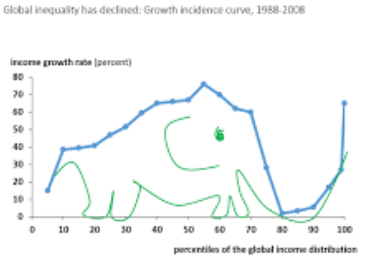
“The Innovation Illusion:
How so Little is Created by so Many Working so Hard”
Fredrik Erixon and Bjorn Weigel, Yale University Press, 2016

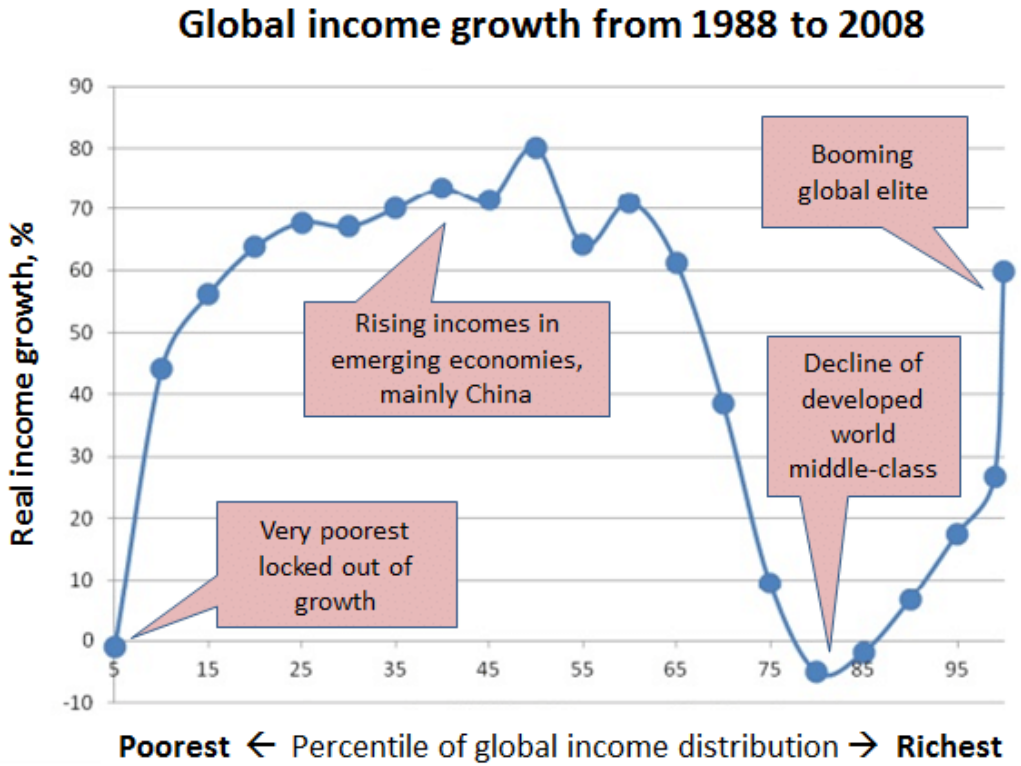
“It has become common to hear warnings that in the near future, automation will destroy jobs and technological advances will accelerate economic and social turbulence. The authors of this sobering book argue the contrary: innovation – by which they mean the commercialization of new discoveries – is slowing down, mainly because Western societies have become sclerotic.

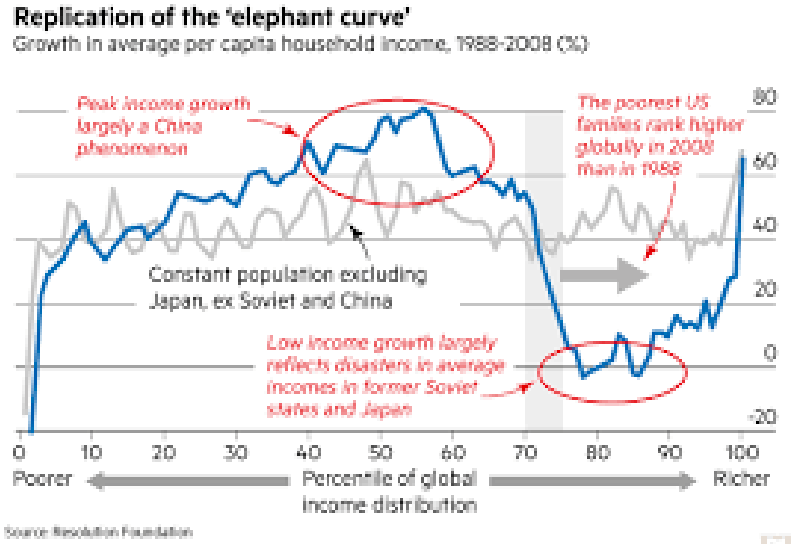
Corporations have grown more risk averse, owing to three factors: their increased reliance on financial markets (as opposed to internal funding), a shift in the corporate world from entrepreneurship to rent seeking, and the growth in complex and continually changing regulations.

Erixon and Weigel take aim in particular at the so-called precautionary principle, which holds that companies must prove their products are not harmful before they can bring them to the market. This approach is common in Europe, where the authors contend, it severely penalizes risk taking and flies in the face of the EU’s official goal of encouraging innovation.”

Branko Milanovic
Global Inequality Elephant Curve







Comparative Indicators for Selected Countries

(2015 or latest available economic data)

Country	Competitiveness 2016 Rank	Innovation 2016 Rank	R&D Expenditure % GDP	Net Exports $US Billions	GDP $US Billions	GDP per capita $US	GDP per capita $US PPP
Switzerland	1	1	2.967	38.8	664	80,675	61.086
USA	3	4	2.742	-803.0	17,947	55,805	56,116
Germany	5	10	2.897	274.9	3,358	40,996	47,377
Sweden	6	2	3.161	2.1	493	49,865	46,704
United Kingdom	7	3	1.700	-163.07	2,849	43,771	41,459
Japan	8	16	3.588	-1.1	4,123	32,486	37,322
Finland	10	5	3.172	-0.5	230	41,972	40,979
Norway	11	22	1.708	29.3	389	74,828	61,197
New Zealand	13	17	1.155	-2.2	172	37,043	36,982
Taiwan	14	NA	3.004		524	22,288	47,500
Canada	15	15	1.613	-11.7	1.552	43,333	44,310
France	21	18	2.256	-78.4	2,421	37,675	39,631
Australia	22	19	2.112	-12.3	1,224	50,961	45,501
Israel	24	21	4.109	2.0	296	35,344	35,831
South Korea	26	11	4.292	47.5	1,377	27,195	34,549
China	28	25	2.047	600.2	10,983	7,900	14,450
TOTAL				-77.5	48,602		

Innovation is the Basis for Economic Success

Countries strive to expand **wealth and prosperity** for their citizens. That requires research and innovation that provides technologies and processes appropriate to their economies. The system needs to be both sustainable and adaptable – evolving in response to external changes rather than subsidizing obsolescence and maintaining the status quo.

Innovation requires **technological competence** – obtained by accumulating knowledge through learning, interaction and experience. Globally, ST&I organizations are important sources of knowledge and advice for decision-makers and for business.

Emerging and developing economies access and apply technology from others to create jobs and economic growth. Such economies typically provide citizens with basic education and establish public scientific and industrial research organizations to assist in the transfer and effective use of technology to local industry.

Developed economies are globally integrated and seek to be globally competitive. They need an innovation system that provides a sustained flow of innovative technologies and processes that move successfully into domestic application and use. Their citizens are highly educated and they support research and development in order to stimulate innovation.

A model for Envisaging Economic Development

Hierarchy of Economies

Stage of Development	Competitive Position	Global Role	Strategy	Outcome
Highly Developed	Innovation High Tech Industry	Leadership	Research and Development	Quality of Life
Developed	Medium High Tech Industry	High end value chains	Quality	Sustainable development
Developing	Heavy Industry	Medium end manufacturing	Efficiency	Wealth
Lesser Developed	Low Tech Industry	Low end manufacturing	Copy, Cheap	Employment
Undeveloped	Manual labour	Any Job	Cheap, Unregulated	Survival

Knowledge Economy requires a substantial domestic capability in education, technology and product development and innovation.

RTOs History Role and Mandate

In the early 20th century, governments in many countries and regions created research entities such as the UK Dept. of Scientific and Industrial Research, Canada's National Research Council, and NIST in the US to provide:

- advisory and technological support to government departments and agencies;

- an enabling role to industry to stimulate economic development, access technology and assist in technology transfer; and

- to work as collaborative system integrators in broad partnerships incorporating academia, industry and government.

The RTO mandate is typically economic development, "improving and discovering processes and methods that may promote the expansion of existing or the development of new industries" .

What We Know and Generally Accept

Innovation is generally accepted as the foundation for economic advancement.

Historically, academics and the independently wealthy pursued knowledge – primarily through the arts, astronomy, religion and medicine. Industry was the focal point for application and outcome-based research and innovation.

Based on US experience with research to support the military and space, research and especially basic research, moved from industry to academia where it was funded by public sector grants adjudicated through peer review. Innovation became confused with invention and the pursuit of new knowledge.

Although discovery is clearly the exception not the norm for innovation, most developed nations rely more on education and discovery research to underpin economic development.

In recent decades, the visibility and pervasiveness of high technology and its disruptive effects on everyday life through computers, smart phones and social media, also created a perception that disruptive, hockey-stick style technology and related product development is the most pervasive form of innovation.

Forms of innovation

Outcome	Disruptive (Create New Opportunities)	Evolutionary (Build the Future)	Incremental (Exploit what we know)
Time Horizon	**5 - 50 years**	**2-10 years**	**0-3 years**
Driving Force	Curiosity, Serendipity - push	Mission – pull and push	Customer – market pull
Business Focus	**Blue sky Research Discovery - Ideas**	**Product & Technology development**	**Production & Sales**
Activities	Basic Research, Applied Research, proof of concept	Applied research, demonstrations, prototypes, standards development	Problem solving, adaptation, testing, manufacturing, consulting
Key Knowledge	Foresight, research processes	Competitive intelligence, science & engineering methods	Markets, production processes, standards, management
Success Factors	**Expertise, reputation**	**Experts, IP, management**	**Efficiency, quality, cost**
Level of Risk	High	Medium	Low
Share of Innovation	5-10%	20-30%	60-70%
Research Funders	**Grants (Public)**	**Contracts + Equity + Grants (Industry + Public)**	**Contracts - Customers (Industry and Government)**
Business Return	Knowledge, HQP	Social and Economic ROI	Gross margin
Impact	**New line of business, wealth, jobs, quality of life**	**Wealth, jobs, quality of life**	**Wealth, employment**

TECHNOLOGY TRANSFER

Questions and Findings – Research & Innovation

There is a widespread desire to enhance innovation. Globally, almost everyone is asking themselves the same public policy questions with respect to research and innovation:

1. What overall level of national R&D funding is appropriate?
2. Is an industrial strategy required to guide and focus the policy agenda?
3. How should public funding be allocated between basic and applied research?
4. Should public funding support needs driven R&D and industrial research?
5. What is the appropriate balance between top down and bottom up ST&I?
6. Is excellence the best basis for funding?
7. Should collaboration be mandatory?
8. What elements and capabilities are key to developing sustainable clusters?

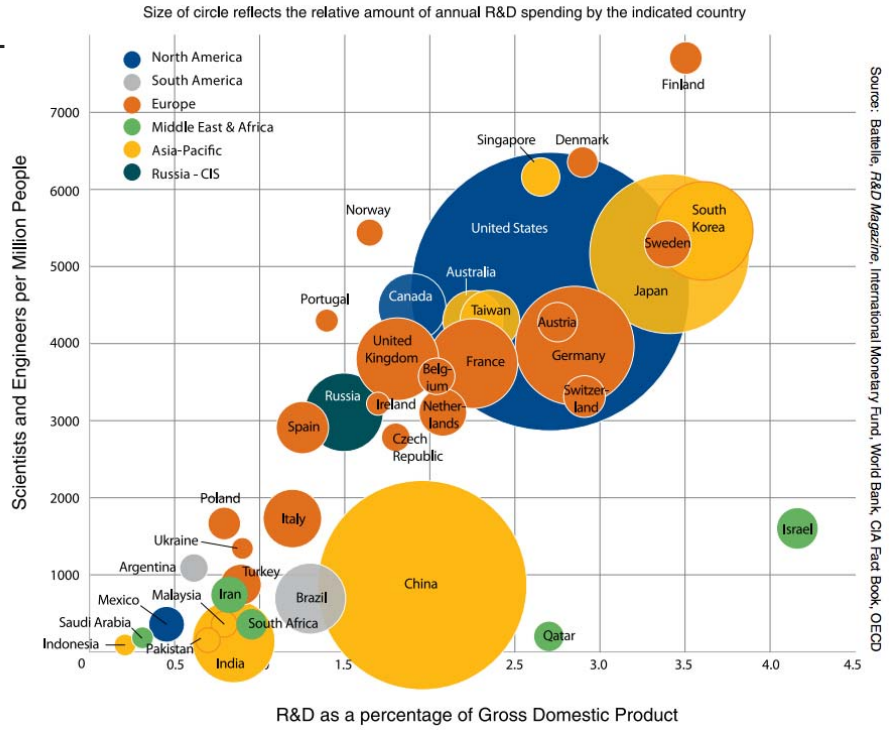
1. Level of ST&I Funding

About 1% of GDP is typical for academic research expenditures in developed countries. The portion of R&D undertaken by academic institutions is steadily increasing – now typically 25 – 30 % of overall R&D but 90% or more of basic research.

Industrial research ranges from 1 to 4 % of GDP, and generally represents around 70% of total national ST&I expenditure.

The national economic structure, position and support of industrial R&D, priorities chosen, linkages between firms, and the manner in which technology and products are taken to market have significantly more influence on innovation than the absolute amount of R&D being done.

It is unclear whether a high GERD is the "cause of" or the "natural outcome of" a strong economy.



2. Is an Industrial Strategy required?

Most of countries reviewed have a strategic industrial agenda with broadly based agendas and targeted areas to steer STI activities and generate impact.

Policy interventions must be taken with a rich understanding and careful design in order to:

1. Take into account the structure and characteristics of the national economy.
2. Define important broad-based missions which may both curiosity and applied such as “the Cloud” or more specific such as “marine litter”.
3. Pick “races” in the form of sectors and ubiquitous platform technologies – but avoid trying to pick “winners” (by supporting individual business enterprises).

Achieving global competitiveness and sustained economic success appear to require public policy intervention. Left to its own devices, the market rarely addresses longer term strategic national interests.

3. Funding Basic and Applied Research

Basic and applied research are not competitive agendas. In practice, R&D priorities associated with innovation projects oscillate between basic and applied whether in academia, RTOs or industry. The overall balance shifts based on the level of economic development and fiscal capacity of a nation and its ability to accept risk relative to the need for near-term positive economic impacts.

Government typically funds 90% of basic research.

A vocal group of scientists in the United States is concerned there is not enough federal funding for research and development (R&D) in pure and applied sciences, which is leading to a decline in technological discoveries, advancements, and commercialization by U.S. companies.

The real question is the appropriate balance between mission-oriented and curiosity-driven research. In essence, how much should a national research effort focus on targeted economic, social and environmental challenges and how much should be done purely for the sake of expanding knowledge?

(Knowledge and) The possession of patents does not guarantee subsequent competitive commercial application sales or exports. - Francois Chesnay, The French National System of Innovation

4. Public funding for needs driven R&D

Most countries fund applied research and development with industry in high risk areas as they believe it is reasonable for the public to carry more of the burden for higher risk and longer-term innovation efforts.

RTOs in many countries undertake R&D in the public interest focused in areas of strategic importance, with a market-based perspective. Core public funding is typically 30 to 70% of their total budget.

Public funding programs also provide direct support to business as grants or loans, and indirect support through tax credits. Grants and loans, increasingly repayable, are the most common forms of support.

Defence investments can stimulate civilian innovation and many defence firms have significant civilian business. However, major spending on defence R&D, especially in economies that are not large and diversified, may actually harm commercial performance because it draws the best technological resources away from industry, draws industry away from the civil sector, and in the absence of specific policies or encouragement may not generate spin-offs to the civilian sector. (The UK has faced this problem).

In practice, government positions around the world with respect to public funding for industrial R&D vary widely and range from "necessity" to "hands off".

5. "Top Down" or "Bottom up"

Innovation is "the *conversion of ideas and knowledge into commercially successful products and services"* to support national economic, social and environmental agendas.

Many researchers desire to work independently without much, if any, consideration of external factors.

Consensus has grown around the need to balance challenge-based research agendas with those based solely on scholarly relevance and excellence to increase the probability economic impacts will be achieved.

RTOs are crucial determinants of innovation success in most nations as they address targeted agendas, integrate and facilitate the work of industry and universities, and stimulate alignment of funding between collaborators.

Science systems have been traditionally very bottom up and bottom up systems remain critical to career development and discovery (basic) science. But this feed-forward system creates growing mismatches in science systems and especially R&D capacities. Gradually countries are starting to use more extensive metrics to explore performance and capacities and are taking a more utilitarian view of R&D investment. This inevitably means a more ***impact driven*** *approach and a more* ***mission-led/strategic*** *approach. But, this can create tensions with the academic community. Sir Peter Glucksman, Chief Scientist New Zealand*

Conclusion – Both top down and bottom up approaches are needed.

6. Is excellence the best basis for funding?

Success in research is different than success in innovation.

- Research success is discovering new knowledge and understanding and developing new talent.
- Innovation success occurs when a problem or issue is addressed in a manner that leads to its successful application in the marketplace.

Excellence is an appropriate basis for research based on curiosity and scholarly output.

There is growing consensus that research focused on relevant problems and search for solutions to challenge-based agendas is most appropriate for "innovation".

7. Collaboration

Forced collaboration tends to result in superficial approaches in which “collaboration” ends after funding is awarded and shared among the parties who then proceed largely independently.

Successful collaboration is based on win/win approaches, and requires mutual respect between collaborating partners.

Meaningful collaboration is valuable, and becomes more necessary as the need for teamwork grows for work that is closer to marketable application.

8. Cluster Elements and Capabilities

Innovation is higher in cities and other agglomerations due to more efficient use of infrastructure; efficient matching between skills, research institutions, products, entrepreneurs, and financiers; and greater spill-overs and knowledge sharing.

Policy makers have pursued Porter's cluster concept with mixed success, especially as a regional development tool. In the absence of attributes such as proximity to a strong market, the ability to scale, a supportive regulatory and tax environment, an entrepreneurial mindset, and an attractive climate, culture and lifestyle; efforts have generally been unsuccessful.

The SME-technology-oriented business sector requires qualified workers, applied research and development, and access to value chains.

Successful clusters contain a leading research-oriented university, one or more multinationals, an interconnected talent pool and access to financial resources. An RTO is also a key player in many clusters around the world.

A rational basis (existing natural advantages and/or an established industry base) is needed to develop clusters. Government and public agencies should fund gaps, not push on a rope.

Findings

Growth and Development

Globalization and trade expansion enabled the world to grow economic benefits and lift massive numbers of people from poverty. Procurement is also used by governments as a technological development tool.

China, the United States, Germany and Japan are the four top merchandize traders in terms of both imports and exports. The United States, United Kingdom, China and Germany are the top four services traders.

The largest economies (US, China, Japan and Germany) followed similar paths to industrialization – drawing upon and improving technology from others – but each ultimately confronted a different challenge that influenced their performance and led to the positions they now currently occupy.

Industrialization has resulted in significant differentiation as states fail, catch-up, develop resources and pursue knowledge driven economic agendas.

There is emerging pushback, especially in developed economies like the US who shouldered much of the employment dislocation and financial burden of the world for six decades.

Science Technology & Innovation

Countries emulate each other in their policy approaches to research and innovation but there are also differences:

- the roles of universities vary from country to country

- reliance on industry funding for research varies from about 50% to 80%.

- some countries are more top down (typically those catching up) and others rely more heavily on bottom up (typically the wealthier).

- countries with large resource endowments aspire to become disruptive discoverers, those without resources adopt more targeted agendas.

The five largest global R&D spenders are dominated by MNEs (US, Germany), conglomerate (JAPAN, Korea) or state-owned (China) firms which are all large R&D investors and performers.

The UK, US and Switzerland have a gap in their innovation system – a lack of RTOs whose context, focus and mode of operation are directed explicitly to economic development.

Culture plays a significant role in technological advance and innovation. Cultural effects present more than a century ago remain significant in France, the UK, Germany, Japan, Israel and even Canada to some degree. Culture is significantly influenced by a nation's schooling, training and retraining systems, industrial relations practices, the commitment of management and labour to the firm and to one another, and relationships between businesses. Social policies, political alignment, national security issues, the stage of economic development and the mix of industries are also factors.

Research and Technology Institutions

Governments support four types of research agency:

1. **Intramural laboratories** providing scientific support to government departments.

2. **Research councils** primarily funding "curiosity-driven" research in academia that does not directly address specific demands from industry or society.

3. Sector oriented **collaborative research initiatives** involving academia and industry.

4. Mission and market oriented agencies described as **Research and Technology Organizations (RTOs)** whose fundamental objective is economic development through technology and innovation typically tied to public sector missions such as competitiveness, health, energy, manufacturing and environment. RTOs generally perform R&D and provide testing and scale-up, commercialization, advice to government, networking and international cooperation.

RTOs are an important element in the most successful and rapidly growing economies.

Development Trajectories

There is a degree of cross-fertilization of systems – countries emulate, adopt and adapt elements they see working elsewhere.

Catching up is easier than staying in front because a follower can adopt new technology from others without much concern for the organizational and institutional inertia. But catch-up economies still need discipline to follow trajectories demonstrated successfully by others.

Size seems to matter – both in terms of land area and population. Land area increases the availability of significant natural resources that in turn provide a strategic framework for development. Population provides a domestic pool of mobile talent and ideas.

Resource based economies can do very well economically, but that does not necessarily translate into sustainable leadership or balanced economic positions as commodity price cycles often distort costs and prices creating volatility in other sectors. R&D spending dropped since 2013 in economies such as Australia and the Russian Federation which had previously enjoyed rapid economic gains from their exports of fossil fuels and minerals.

High knowledge economies high-grade activities by offshoring or automating labour-intensive activities, and growing business services. However, in countries with large populations which cannot rely solely on services, fragmented value chains and loss of system knowledge may make it difficult to retain a leading-edge position in non-service sectors.

Nations address economic growth best when they do so based on the specific nature of their own resource endowments, geography, culture and market position.

Productivity

Competitiveness means different things to different countries and regions.

- In high wage economies, it means unique, attractive products with better production processes than low wage competitors.
- In low wage economies it means the ability to learn, diffuse and if necessary adapt foreign technology in a timely manner.

Europe has an overall 15% gap in productivity relative to the US, although countries vary widely with some ahead and some behind. Canada has a productivity gap of about 25%, although again it varies regionally with weakness especially evident in Quebec and the Atlantic region.

Germany innovates to empower workers and improve their productivity while the U.S. focuses on technologies that reduce or eliminate human beings.

Productivity is heavily influenced by economic structure.

Strong economies have strong firms but not necessarily the largest firms, and their firms do not necessarily spend large amounts on R&D, but they do have strong direction and interactive linkages, including technology, with key upstream suppliers and inputs and downstream users.

Business Innovation

In 2010, countries with the highest proportions of R&D performed by business were Japan (76%), Korea (75%), China (73%), the United States (70%) and Germany (67%). Chinese companies now represent one fifth of total global R&D spending by business.

Generally, MNEs invest the largest amounts on their home country, but also make important investments globally. In 2014, the Top 50 Firms performed over $250 B USD on R&D or about 25% of the world's total of $1,105 B USD. Forty-four of the top 50 Business R&D performers are based in the US (18), Europe (17) and Japan (9).

EU businesses tend to concentrate on R&D of medium-to-low and low intensity, the USA and Japan on medium to high. The automotive sector represents one-quarter of R&D spending by EU companies.

Eleven of the 15 largest public internet companies are US-based and the remaining four are Chinese. The EU is largely absent from the internet arena in new and emerging forms of innovation. SAP is the only European IT company among the global top 50 R&D performers.

Three sectors dominate R&D spending by the Top 50 firms – automotive and parts (25%), pharmaceuticals (30%) and electronics, communications and IT (43%).

Business currently tends to focus on short-term profits at the expense of long-term objectives, and is increasingly unwilling to invest in the longer term future.

Complicated processes, small deals and extensive arguments over IP consume critical time and resources, and increase the probability of innovation failure, especially in start-ups and small firms.

Challenges for the Developed World

It is fairly evident that technological change had a significant influence in developed economies, leading to increased levels of automation, reduced employment in traditional industries and social disruption.

Reduced trade barriers and increased global competition assisted companies in North America and Europe to outsource significant amounts of labour intensive manufacturing to low cost regions, resulting in a major loss of employment for many blue collar employees.

Over time, resultant incomplete domestic supply chains have trouble competing globally. Tacit knowledge makes co-location synergies critical (Tassey 2010).

Social Considerations

The innovation system is threatened by growing public distrust of technological progress and the economic, political, and social institutions that help create it.

One group insists the government should not partner with private industries, another decries the “one-percent” who benefit from innovation and industry success.

Both viewpoints reflect a growing and widespread fear of innovation and technological progress - whether genetically modified organisms (GMOs), big data, or automation.

Concerns, proliferated by vested interest groups and the social media, about how technology will impact privacy, labor markets, health outcomes, and personal freedoms are damaging the ability of the most-advanced industries and nations to compete.

General Conclusions

1. Nations are in a race to design and build the most effective National Innovation Systems. But **no one has discovered a "magic model of innovation".**
2. The strongest size-adjusted economic performer globally is Germany which has a strategy that values workers and focuses on continuous improvement rather than breakthrough disruptive innovation. Switzerland is number 2.
3. Other than Switzerland, the US, the UK and Canada, most economies employ some form of strategic agenda to guide their ST&I efforts.
4. Switzerland relies predominantly on the private sector but is heavily influenced by proximity to Germany and France.
5. Public ST&I expenditures in the US, UK and Canada rely predominantly on bottom up peer-reviewed science. All three punch above their weight in scientific knowledge generation but struggle to capture an equivalent share of economic benefit. Even the US, where industry may be sufficiently broadly-based to integrate advances from any field, is struggling in that regard.
6. Europe (excluding the UK and Switzerland) and Asia rely heavily on RTO laboratories connected to academia and on not-for-profit research institutions. The US has a small but important set of RTOs. In Canada, RTOs remain a fragile and unique component, mostly maintaining, but not growing their core funding.