ADVANCED MANUFACTURING CAPABILITIES

Working Paper on how Japan, South Korea, China and Singapore manage R&D, Innovation and digitalization in industrial production

Teknikföretagen

KREATIVITETEN ÄR SVERIGES STYRKA

INTRODUCTION

This coverage report broadly describes how four countries in South East Asia, namely South Korea, Japan, Singapore and China use R&D, innovation and digitalization (RDID) in the advanced industrial manufacturing sector. The aim is to grasp how these countries deploy strategies to stay competitive in the local, regional and global settings and how RDID initiatives are promoted through local incentives and partnerships between governments, academia and the private sector.

Europe has in recent 20 years lost more than 10 percent in global market share in industry production. It has seen drastic job cuts in recent years: established markets such as the UK (-29 percent), France (-20 percent) and Germany (-8 percent) have been affected. During the same period, emerging markets have doubled their share in the global market to 40 percent.[1]

Sweden has historically had a strong legacy of industrial manufacturing with two dozen of global companies that supplying quality industrial products, services and system around the world but yet with a strong trade focus to EU and the United States. Similar to Europe however, Sweden needs to use the re-industrialization revolution with RDID to regain its clout. While some of the emerging economies in Asia are climbing the cost curve, knowledge and technology transfers to Asia as well as local curation of various RDID activities make Asia a strong region in which a competitive edge can be built for advanced manufacturing. South Korean and Japanese companies today lead the way in terms of overall influence in advanced manufacturing activities and include titans such as Samsung Electronics, Hyundai, Toyota, Hitachi and Sony.[2]

Fundamentally, what appears to drive advanced manufacturing efforts with various ingredients of RDID is cross-industry and cross-regional collaboration between companies, expert societies in various industry sectors as well as government agencies and academia. It is for instance predicted that as much as 30 percent of America's exports from China could be domestically produced by 2020. In 2013, President Obama proposed a USD 1bn additional budget to create a network of as many as 15 manufacturing-innovation institutes around the U.S. where one centre is already up and running in Youngstown, Ohio.[3]

Evidently, government incentives through leadership and funding represent one of the major catalysts to drive advanced manufacturing capabilities, i.e. to establish arenas where various groups across various layers of the economy can confluence, collaborate and communicate in order to create and coin meaningful and scalable commercial discoveries.

The forthcoming sections will, after a brief market update relevant to manufacturing, shed some light on examples of how South Korea, Japan, Singapore and China have put forth various collaboration initiatives to express visions that promote advanced manufacturing capabilities in each country. Additionally, each section will broadly describe a few examples for each country where frameworks for advanced manufacturing initiatives have been deployed and what results they have had or are achieving. The report concludes with examples on how to further investigate this topic and methods to better understand how multi-lateral RDID collaborations are formed.

The report was written for Teknikföretagen by Meysam Sadegh.

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[1] Industry 4.0: The digital world provides new opportunities for European industry to move into a new era, Roland Berger 3 Apr 2014

[2] Top 100 Most Influential Asian Companies 2014: Which Asian companies rule the roost? What are the limits of Asian economic transformation? Roland Berger, 11 Apr 2014

[3] A Revolution in the Making, Digital technology is transforming manufacturing, making it leaner and smarter and raising the prospect of an American industrial revival, WSJ.com, 10 Jun 2013

DEFINING THE MERITS OF ADVANCED MANUFACTURING

Let's first define the term "advanced manufacturing" which has for decades been employed in various industrial sectors. It has a wide range of meanings to different people and institutions. The OECD defines the term advanced manufacturing as a computer-controlled or micro-electronics-based equipment used in the design, manufacture or handling of products.4 The Boston Consulting Group, defines advanced-manufacturing as technologies that bring highly flexible, data-enabled, and cost-efficient manufacturing processes in making various products.[5]

The Engineer, one of the UK's oldest media groups for the engineering, technology and innovation sectors claims that manufacturing can be advanced in one area may not be advanced in another. As companies climb the experience curve, a higher level of technology, innovation, R&D or digitalization brings various benefits in terms of increasing manufacturing productivity, reducing costs and ultimately enhancing end user experience.[6]

The Boston Consulting Group summarizes advanced manufacturing by five different tools to have the greatest potential to influence the manufacturing landscape and improve productivity in the years ahead. These five tools have not been widely deployed as of yet but aim at replacing labor intensive and important steps in manufacturing in the next five to ten years. While predictions of a new technological leap in manufacturing have been circulating for quite some time, the move is now getting closer to reality for several reasons. While predictions of a new technological leap in manufacturing have been circulating for quite some time, the move is now getting closer to reality for several reasons.

Fig 1: Five Technological Tools for Advanced Manufacturing

Autonomous Robots	• A new generation of automation systems that links industrial robots with control systems using information technology • New robotic and automation systems equipped with sensors and standardized interfaces are gradually complementing (and, in some cases) eliminating human labor in many processes. • Can help enable manufacturers to cost-effectively produce items at smaller scale and to improve their ability to enhance quality
Integrated Computational Materials Engineering (ICME)	• Computer models of products and simulating their properties prior to fabrication • Avoids costly testing of physical prototypes • Allows engineers and designers to develop products better, faster, and cheaper
Digital Manufacturing	• Virtualization technology to generate complete digital factories that simulate the entire production process • Digital simulation can help engineers save time and money by optimizing the layout of a factory, identifying and automatically correcting flaws in each step of the production process, and modeling product quality and output • Complete assembly lines can be replicated in different locations at relatively low cost
The Industrial Internet and Flexible Automation	• Manufacturing hardware can be linked together so that machines communicate with one another and automatically adjust production based on data and metrics generated by sensors • Enables the system itself to see into the supply chain
Additive Manufacturing	• Conventionally denoted as 3-D printing where additive-manufacturing processes create threedimensional objects based on digital models by successively depositing thin layers of materials • Additive Manufacturing is gradually increasing in use for making prototypes in some industries, including aerospace, automotive parts, and basic consumer items • Supports product-customer interaction as well as the problem-solution validation process without heavy investments in large volume manufacturing of the product

Source: BCG (30 Jan 2015)

4 Glossary of Statistical Terms, OECD (accessed 20 Jul 2015)

5 Why Advanced Manufacturing Will Boost Productivity (Jan 30 2015)

6 Roundtable debate: What is Advanced Manufacturing? (18 Oct 2010)

A number of other trends are also having an impact. Rapid advances in information technology, sensors, and nano-materials as well as application of grapheme are dramatically lowering the costs of leading-edge manufacturing processes and improving their performance. Slowly but surely, digitization has begun to permeate every aspect of the production process, from engineering to organizational management of the supply chain to the assembly line—making production systems more intelligent and highly interconnected.

At the same time, companies are under mounting pressure to improve their productivity and become more responsive to shifting customer needs. Advanced-manufacturing technologies could potentially help address a number of these needs. New processes boost productivity and responsiveness to the market by making it possible for manufacturers to quickly and easily modify designs and reconfigure production lines according to customer demands.

Whereas there are numerously more definitions and descriptions to advanced manufacturing, the evolution of science and its communication to place applicable plans into existing manufacturing processes and systems can help improve a process in which a product or service is designed, produced and delivered. It is thus the science itself that can make a company, an industry and an entire economy more capable and thereby more competitive in the global marketplace especially where national borders no longer delimit buyers and sellers of products and services. In addition, advanced manufacturing technologies can boost productivity in a number of ways which by and large is a topic of its own.

Investments in advanced manufacturing capabilities are thus essential to boost productivity and to optimize resource use whilst increasing industry's innovation potential. Europe is a global heavy weight in advanced manufacturing technologies. In 2013, it generated 39 percent of the global machine tool output and out of total European exports (including intra-EU trade) 50 percent accounted for world export of machine tools. Europe's strength lies in the supply of advanced production technologies which have thus far underpinned the competitiveness of the entire European manufacturing base. These technologies give the industry significant efficiency and productivity gains and first-mover advantages.[7] The 2008 financial crisis reminded many countries of a fundamental reality: a strong manufacturing sector is required to maintain a healthy economy and to compete globally.[8]

Relatively low-cost countries, such as China, Vietnam or Bangladesh, are rapidly upgrading their technological base, albeit from a lower based compared to industrialized countries in the West, and improving productivity through investments in advanced automated production systems. At the same time, the US has dramatically reduced its manufacturing cost thanks to shale gas discoveries and its extraction and production.

According to the Boston Consulting Group's Global Manufacturing Cost Competitiveness Index however, average manufacturing costs in Germany, France and Italy are around 25 percent higher than the US and 10 to 15 percent more expensive than South Korea and Japan. Such competitive disadvantage calls for higher attention to how Western economies, including Sweden, can better treasure its advanced installed manufacturing base and wealth of accumulated experiences to compete on advanced manufacturing and less on price.

Perhaps more than in any other discipline, manufacturing nowadays can no longer operate in a nutshell. As coined almost three decades ago by Goldhar and Lei (1991), two main factors characterize a manufacturing landscape: the intensifying global competition and the rapid advancement of manufacturing technologies.[9]

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[7] Advanced Manufacturing must be a top priority for the new European Commission, CECIMO (accessed 4 jul 2015)

[8] Competing with China: Lessons from South Korea's Manufacturers, BCG, 11 Oct 2012

[9] The Shape of Twenty-first Century Global Manufacturing, Journal of Business Strategy, Joel D. Goldhar et al (1991), Vol. 12 pp. 37–41

New technologies that advanced manufacturing ca dramatically increase the flexibility for manufacturers in some industries to offer customers the option to "have it their way." Manufacturers can make products in small bespoke series. They can equally adjust production lines in response to design changes, and even speed time to market by generating prototypes much quicker. Advanced manufacturing technologies can with the support of various RDID tools enable agile turn around shifts, put forth better products demanded by savvy customers. Manufacturers can thus become more competitive, profitable and stand out as leaders.

Advanced manufacturing technologies can boost innovation, too, by allowing manufacturers to create new kinds of products that can't be made cost effectively with conventional processes. They also permit manufacturers to produce high-quality goods made to buyers' exact specifications.

What's more, these processes are good for the environment because they often consume fewer raw materials and generate less scrap. They improve safety as well, by exposing workers to fewer hazardous materials. These tools offer a range of benefits that, taken together, could redefine the economics of global-manufacturing competitiveness in a number of industries. In fact, leading-edge manufacturers, such as Ford and General Electric, are already using some of the most advanced tools to make high-precision components. The following four chapters provide a higher level run through summary of the advanced manufacturing and digitalization of production in Japan, South Korea, Singapore and China.

SOUTH KOREA AND ADVANCED MANUFACTURING

Korea has been perceived as a model country, optimized for the era of the "fourth industrial revolution" or "industry 4.0," which is a convergence of the digital and manufacturing industries. The country is among the strongest in education, which is the basis for knowledge in which innovation rooted. The industry paradigm to lead economic development has gone through three stages of manpower in the first stage, infrastructure second, automation third, and now we are in the fourth stage digitalization . Digitalization means drawing accurate results by collecting and analyzing data, which gives a tremendous affect to the world.[10]

According to 2012 statistics from the International Federation of Robotics[11], South Korea had the highest robot density in the world by employing 396 robots for every 10,000 workers. South Korea was closely pursued by Japan and Germany, which recorded figures of 332 and 273 number of robots per 10,000 workers respectively.

On the consumer side, it's broadband Internet speed is at most seven times faster than those of other countries. South Koreans are so innovative, they don't even use credit or debit cards. Instead, residents use "T-money", which can be spent on trains, taxis, buses, bars, restaurants, or retail stores. The country also has one of the fastest broadband speeds among all. As most of the world continues to struggle with 4G connection, South Korea is investing in 5G, meaning its residents will be able to download HD movies without any problems by 2020.

South Korea has emerged as the world's largest shipbuilding nation and ranks first in terms of semiconductors and displays. It makes active infrastructure investments and adopting business friendly approach. The automobile manufacturers are now a significant force around the world as are its appliance makers.[12]

In recent decade however, South Korea's manufacturing sector has felt rising heat from China. Expert suggest that South Korea will fall behind China in all manufacturing sectors except for automobile, semiconductor and general machinery by 2018, a year where it is assumed that China will emerge as South Korea's biggest contestant in segments it currently leads. Worse, the Korea Economic Association, the Korea Institute for Industrial Economics and Trade (KIIET) and the Korea Economic Research Institute believe Samsung Electronics may even cede its global leadership in the smart phone market to a Chinese maker Xiaomi.[13]

Figure 2 shows a method to group a country's industry sectors are positioned and how competitive each sector in an economy is relative to a competing economy. In this case, the following analysis compares South Korea's manufacturing sector as a whole.

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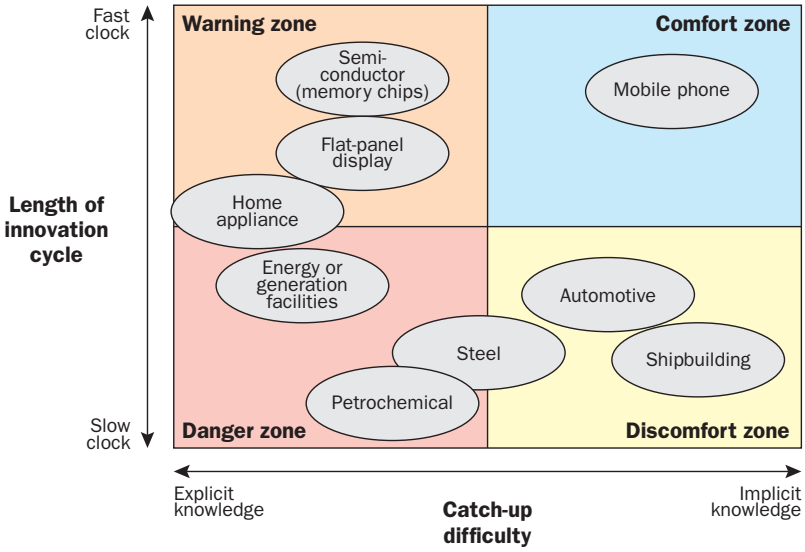
[10] Joe Kaeser, Chairman Siemens A.G., keynote speech at Smart Revolution Forum, Korea Oct 2014

[11] Advanced Manufacturing must be a top priority for the new European Commission, CECIMO (accessed 4 jul 2015)

[12] Department for Business, Innovation and Skills, Cluster Strategy (2010)

[13] Korea Inc. under pressure to retool amid China storm, KoreaTimes, 30 Oct 2014

Fig 2: Grouping South Korea's Industrial Sector



Source: BCG (11 Oct 2012)

The vertical axis measures the length of an innovation cycle that is required for an industry sector as a whole to push through new products and next generation of product funnels by employing various tools across the RDID space. The horizontal axis measures the time to catch-up of peers in that specific sector, i.e. what existing processes, incentives and institutionalized management drivers can keep an industry sector as a whole to stay ahead of peers. By staying ahead of sector peers, significant "implicit knowledge" obtained. This is the portfolio of knowledge a sector or a group of companies posses that is unbeknown to peers in a different country when developing next generation of soft- and hardware required in a product.

For South Korea, Samsung also world's largest smart phone vendor with its 24.6 percent global market share (followed by Apple with 18.3 percent)[14]. In 2013, Samsung's global revenues represented 17 percent of South Korea USD 1,082bn GDP.[15] Mobile itself represents 11 percent of the country's GDP, valued at USD 143bn.[16] As depicted in Figure 1, Samsung appears as a sector company well placed in the "comfort zone". This sector is incrementally innovative in the physical handset development, followed by agile software and applications which carry Samsung as a globally strong consumer brand.

Samsung Foundry the innovation arm of the group, is an example of a laterally advanced manufacturing initiative. It enables global clients to outsource parts or their entire design to Samsung. Samsung Foundry provides a full range of solutions including advanced process technology, design services, design intellectual property, and manufacturing facilities. Customer support is available at every step, from the initial engagement to volume manufacturing. And customer IP is stringently protected.[17] Samsung Foundry thus helps push new companies into the comfort zone. But in the end, significant work and tad amount of luck will be required to become a market dominion and in incumbent that can achieve this position in a marketplace.

Opposing views on Korea's success in terms of innovative manufacturing capabilities include the fact that Samsung did succeed overwhelmingly over its Japanese competitors but it no technologies or products of its own development that can be called the "first in the world."[18]

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[14] Smart phone Vendor Market Share, Q1 2015 (May 2015)

[15] Shell, Glencore, and Other Multinationals Dominate Their Home Economies, Bloomberg, 4 Apr 2013

[16] The Mobile Revolution: How Mobile Technologies Drive a Trillion-Dollar Impact, BCG Perspectives (Accessed 21 Jul 2015)

[17] Samsung Foundry (Accessed 21 Jul 2015)

[18] South Korea's export crisis, Japan Times, 27 May 2013

Although Korea seem to piggy-back on non-sovereign technology (as most is supplied by Japan), it has equally been able to build a significant installed based of advanced manufacturing that can emulate inflows of non-local technologies upon which it has build a giant global brand with the highest worldwide market share of consumer electronics. This is an achievement of its own, i.e. to enable a foundation to understand and assemble technologies that appealing to global consumer markets.

South Korea's Ministry of Education, Science and Technology (MEST) announced it is investing USD 1.5bn in this project alone. This can be compared to Obama's administrations USD 1.0bn budget for 15 manufacturing innovation institutes described earlier in this report. The South Korean government also promotes its startup economy by pouring some USD 2.7bn in funding startups and offering tax breaks for big companies that invest in startups.[19] As recently noted in Bloomberg's Global Innovation Index, South Korea is ranked first among all by examining factors such as research and development capability, productivity, tech density, and patent activity.

Ultimately, what has made South Korea's success? The country is a rich with comparable GDP per capita to Western peers. It is a technologically advanced hub, a mature democracy with an impressive record of industrial innovation, healthy and conforming attitude toward economic reforms, and sound leadership at the industrial and political outlets. South Korea's remarkable leap from poverty to riches come because of a unique set of historical circumstances. The initial rapid growth was characterized by both political authoritarianism as well as extensive state intervention in the economy.

Seoul channeled massive amounts of capital through subsidies and low-interest-rate loans into trusted family-led chaebol, or conglomerates, which today among others represent Hyundai and Samsung; two examples of massive mammoth business empires whose brands are recognized, envied and admired worldwide.

However, the historic preferential treatment to the chaebols also made their ongoing dominance so strong so that it is posing challenges to regulators seeking to make South Korea's markets more competitive. Such dominance can create significant structural barriers which may hamper South Korea's ability to adjust.

What South Korea needs it to squeeze the most productivity out of its labor and capital, especially given the competition it faces from its neighbor's low-wage China and the high-technology innovator Japan. Trade in manufacturing and the service sector in the country is largely open; only the agriculture sector is still protected. Another area that needs the most help is the heavily regulated service sector while automobile sector remains a source of contention. South Korea also needs more financial integration between its corporations and their foreign counterparts. South Korea still needs to fix a labor market in which some workers have extensive benefits and job protection and others do not. South Korea may also have to reconsider its immigration policies, which are currently among the most restrictive in the developed world.[20]

Conclusively, South Korea is intellectually, financially and culturally a capable innovation economy. Its industrial policy supports a broad base for manufacturing infrastructure development, including industrial parks, ports, and transportation systems. It works actively with using Japanese technology while exporting globally and procuring segments of China's manufacturing and in tandem, Koreas competes ever more fiercely with China.

The trending cross-country efforts; to partner with centers of excellence across the world, and in Korea's case, the United Kingdom and United States, are instances of how minds are gathered where common goals and vision are established where by new strategic agenda are drafted and executed. Such collaborations appear to predominantly to be initiated by government agencies to which corporate and academia and export societies joint forces. Yet South Korea has lots of work ahead as competition does not stand still.

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[19] 4 Countries That Are Leaving Silicon Valley In Their Tracks, fastcompany.com (Accessed 21 jul 2015)

[20] Six Markets to Watch: South Korea, Foreign Affairs (accessed 18 Jul 2015) https://www.foreignaffairs.com/articles/south-korea/2013-12-06/six-markets-watch-south-korea

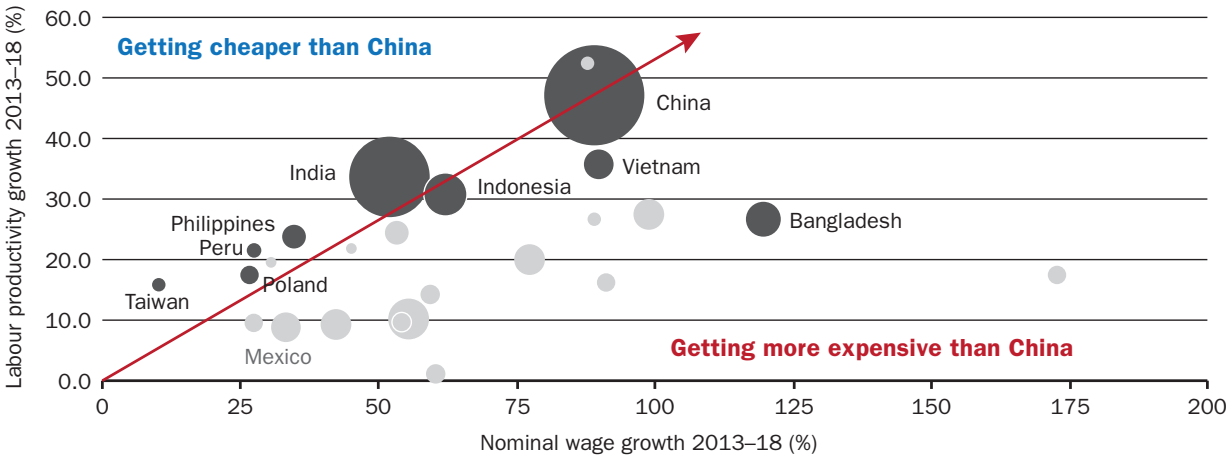
CHINA AND ADVANCED MANUFACTURING

In the years 2000s, China was paddling hard to become the "World factory" with its competitive advantage of labor costs lower than the rest of the world to support its economical growth and provide jobs to its billion inhabitants. But in the last five years, the situation has changed. Labor costs are increasing at a faster pace than other countries in Asia or Africa. This cost include employer taxes, including employer benefits pensions and union taxes, which at times can reach 44 percent of an employees salary.[21] The energy cost and environmental issues have brought in new challenges that Chinese Authorities had to address to maintain any economical growth on the next decade.

Reflecting the recent decade when Chinese wages were around one-twentieth of those in the U.S., labor costs would be considered a non-issue and relocation of production to China would rather be seen as a instrumental strategy to stay competitive, rather than investing and extending the installed base in the U.S.. After accounting for productivity, logistics, and other costs, the cost gap between China and the U.S. has nearly disappeared for many producers putting China's manufacturing sector in dire shape which thus is in need of a significant makeover.

In many emerging countries that are currently undergoing an industrialization where, many face significant room for increased productivity. China is a clear market leader in actively pursuing overall productivity gains in its manufacturing production. As reported by the Economist Intelligence Unit (EIU), China is also experiencing significant room to for more labor productivity. Clearly, China seem to stay ahead of many peers with highest growth in productivity as well as increasing salaries. Thus, China seem to charge well for its productivity whereby its productivity gains comes at a higher cost which could signal a weakening competitive position as a global manufacturer.

Figure 3: Productivity vs. Wages China and Selected Peers



Source: Economist (23 May 2014)

[21] Swedish Industrial Corporations in China - 2015 Situation Report, Association of Swedish Engineering Industries, Jul 2015 pp. 18

Above patterns can explain that if labor productivity grows proportionally to the cost of labor, an economy is not improving its competition position especially if the country, in this case China, is a "World Factory". Thus, China is equally in need of addressing its capabilities to drive an advanced manufacturing hub that better can convert R&D, innovation and digitalization efforts into commercial use.

In China, the robot density is only 21 per 10,000 workers which is less than half of the international average level of 55 robots per 10,000. This makes the industrial robot application in China to account for 6 percent.[22] As China's economy enters a phase of "new normal", the country has to revamps a gradually outdating production capacity and upgrade the installed based with more innovative and digital capabilities. In March 2015, Premier Li Keqiang disclosed China's intentions to implement the "Made in China 2025 Strategy". This strategy aims at a greener, more intelligent manufacturing, with a focus on quality and becoming increasingly more integrated with the Internet.

Initially, this strategy was formulated by China Engineering Academy (CEA) in 2013 and evolved to nine major tasks, ten high technology industrial sectors (including robotics, aerospace, new-energy vehicles and advanced transport) [23] and five project categories that will be given development priority, setting the tone for the first step of China's manufacturing industrial transformation. With fiscal and financial support, the government Beijing wants to increase research spending to 1.68 percent of manufacturing revenues by 2025 from 0.88 percent in 2013.[24] China's Ministry of Industry and Information Technology (MIIT) announced earlier in April 2015 that more than 30 intelligent manufacturing pilot demonstration projects will be launched this year and the scope of pilot will be further expanded in 2017.[25]

In some sense, the Made in China 2025 strategy has something in common with the Industry 4.0 strategy that was put forth in 2013 by the German Government. Both strategies advocate the deep integration of information and manufacturing technologies, i.e. to encourage cross fertilization between the internet industry and traditional sectors of the economy.[26] Furthermore and according to the Ministry of Industry and Information Technology, the objective is to push forward the digitalization, networking and "intelligentization" of the manufacturing industry by using mobile Internet, the Internet of Things (IoT), big data, cloud computing and robots. E-commerce in China is today among the best established infrastructures.

On the e-commerce front, China has already moved ahead of the pack. The e-ecommerce sales accounts for nearly 10 per cent of total retail sales in the country. Its total value is now larger than the American e-commerce sector, according to McKinsey. If you for example live in a big city like Beijing or Shanghai and you order goods via one of the many e-commerce websites, you can expect same-day delivery. Beijing aspires the country's booming internet sector, today accounting for 4.4 percent of GDP and is larger than similar sectors in both the US and Germany, to play a leading role in the planned transformation of the Chinese economy. The next step is to transform the consumer internetification into the industry.

Made in China 2025 is a strategy that can support to upgrade China's manufacturing industry by conforming to the development trend of the "Internet+", i.e. taking a deep combination of informatization and industrialization as the main direction in this strategy. The key to the next steps is to add the "Internet +" into the field of industry to build industrial Internet and transform the installed manufacturing based in a more intelligent infrastructure. There is still very big space in integration of Internet and manufacturing industry.[27]

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[22] China Industrial Robot Market Research & Development Prospects 2015-2020, Business Wire, 25 May 2015

[23] China Unveils Blueprint to Upgrade Manufacturing Sector, WSJ.com 19 May 2015

[24] Leaping into the First Echelon, Beijing Review, 23 Apr 2015

[25] Made in China' brands eyeing medium- and high-end market

[26] Interview: Pony Ma, chairman and founder of mobile gamingand social media giant Tencent, Accessed 1 Aug 2015

[27] Made in China' brands eyeing medium- and high-end market China Economic Net, 22 Apr 2015

The major drivers from this structural shift in China result from that the manufacturing sector is facing new challenges: bigger constraints from the environment and resources, rising labor costs and a notable slowdown in investment and exports. About 33 percept of FDIs to China from international companies went in 2013 into manufacturing.

This number is declining while average factory worker salaries of 2,832 RMB (USD 457) per month in 2014 is climbing at an average of 11.6 percent per annum[28] – a salary inflation that can be assumed to be rapidly exponential. Comparing that to the an average of 40-50 percent increased labor productivity per year, China is, at a very fast pace, rescheduling its manufacturing base to build competitiveness in its production.

Furthermore and to enhance productivity, the premise should be that a work flow or an entire system required to produce a product or a service is currently inefficient. Finding pockets of improvements via traditional means or by employing various RDID models can simply save cost and time for producers and thereby enhance the overall experience and total cost of ownership for the customer.

A fresh report from the Association of Swedish Engineering Industries on China[29] also shows that rising labor costs (ranging from wages to employer contributions) are pushing local as well as international industrial manufacturers to invest more in advanced manufacturing or consider relocation from China.

The report also discovered that some studied companies maintain steady investments in advanced machinery in China while others deliberately choose not to "over-automate". Instead the latter group of companies choose to facilitate more of the still relatively inexpensive manpower in production while achieving the very same quality of production as they would do in their Western manufacturing plants.[30]

One explanation for this strategy could be that some companies still choose not to automate as much since lucrative profit margins can be captured in China. While, labor costs are only one factor in relocation decisions, production is affected by the cost and availability of capital expenditure, infrastructure, inputs and the risks of operating in the market.

It can therefore be deemed that delaying investments in automation or relocation partly depend on management expectation on profits in going concerns provided cost of labor and rivalry. In addition, automation by advanced manufacturing depends on company's state of affairs, the sector it makes business and operational health and product cycles.

Equally, China is the number two spender in research and development in the world and relative investments in advanced manufacturing is presented in Table 1 on the next page. China is however ensuing more actively various ways to enhance the results (or economic profits) of these investments.

China's interest in collaboration and repositioning its economy is essential to their country's long-term development, especially when it comes to supply of advanced manufacturing across more crucial industry sectors such as clean energy, industrial manufacturing and advanced warehousing technology that better can secure future commodity suppliers.

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[28] China Unveils Blueprint to Upgrade Manufacturing Sector, WSJ.com 19 May 2015

[29] Swedish Industrial Corporations in China - 2015 Situation Report, Association of Swedish Engineering Industries, Jul 2015

[30] Ibid

Table 1: Relative investments in manufacturing research (2011–2014 data set)

Country	Program and Summary	Investment in U.S. dollars (billions)	Equivalent U.S. investment (billions)
Germany	**Fraunhofer Program.** World's most established and premier manufacturing research program; complements Max Plank Institutes (German analog to National Science Foundation).	1.0	3.0
	Spizencluster. Supports the best or 'leading-edge' German industrial clusters.	0.25	0.75
	Central Innovation Program. Provides grants to small and medium enterprises to finance research and innovation projects.	0.64	1.92
United Kingdom	**The Catapult Program.** Established seven centers in advanced manufacturing.	0.264	1.6
Australia	**Industry and Innovation Program.** Collaborations between academic, government and industry researchers to commercialize discoveries; $500 million over four years.	0.50	5.0
Japan	**New Energy and Industrial Technology Development Organization.** Promotes R&D for energy and industrial technologies.	1.64	4.89
	Other programs (Kohsetsushi Centers, Technology Advanced Metropolitan Area Association, Kawasaki Business Incubation Center).	0.51	1.45
Taiwan	**Industrial Technology Research Institute** (ITRI)	0.60	18.9
Finland	**Finland Science and Technology Council**	0.63	35.5
South Korea	**Ministry of Education Science and Technology.** Research programs in the 577 initiative target semiconductors, automobiles, machinery, health care and software.	12.8	175.0
Singapore	**Future of Manufacturing Program**	0.5	25.5
	Other programs (Satellite Industry Development, Collaborative Industry Projects).	0.19	9.7
France	**Competitiveness Clusters.** Similar to the German Fraunhofer program; 71 competitive clusters in "cutting edge and key technology sectors".	0.75	4.9
China	No government figures. Estimates are 1.7% of GDP, 82.7% of which supports manufacturing sector.	108	222

Source: Advanced Manufacturing Initiative: A National Imperative (2011)
Notes: Investments by federal government only, annualized investments and scaled by the size of GDP

As earlier depicted in Figure 3, there is significant room for productivity gains in China. Most countries plotted in the chart should see slower nominal wage growth than China in 2013–18. But among them only India can boast a labor force even approaching the size of China's, in an environment in which economies of scale are important. Even with increasing total costs in China, the analysis from EUI takes the view that low-cost manufacturers will not desert China en masse for other emerging markets in the coming years.

But this does not mean that the dynamics of supply chains will remain static between 2014–18. Even with fuel price fluctuations, the proximity to final markets will become an increasingly important factor because of shortening product life-cycles, a trend apparent across consumer goods segments, from clothing to technology.

Beyond domestic efforts, what is China internationally to promote various advanced manufacturing capabilities? One example of such collaboration is with the United States and the creation of the Advanced Manufacturing Partnership 2.0 Program which resulted from the original Advanced Manufacturing Program.

The AMP 2.0 program considers workforce development as an ecosystem that spans from high school into workers in industry with a special focus on training for veterans and discussions about workforce issues were focused on online training and educational information technology.[31] In the initial talks with China, the country has realized that money does not necessarily lead to innovation.

Conclusively, China is proactively adopting to a new world order when it comes to growing and defending its installed manufacturing base. Government-led incentives to support and promote advanced manufacturing through funding various initiative, and ultimately enable movement of experts from industrial roles into institutional roles specifically endorsed to drive a better manufacturing setting in China currently seem finite. Chinese labor laws are relatively flexible, where economic security is not sought through remaining at one job for a entire length of a career but instead "jump ships" to maintain a steep learning curve while incrementing total compensation.

Culturally, China is spearheaded by the government and there is a strong impetus to build a stronger and united China when advanced manufacturing is discussed. What matters in any form of competitive collaboration is to pertain the extrovert energy where various components in the government, industry and academia as well as professional societies seek to connect and establish new collaborative partnerships. They share and transfer knowledge, draft and execute a vision ultimately to stay competitive. Even though, China can be considered as a cash rich consumption state, it is moving fast to reduce the technological gaps to best level, qualify and compete with its Western peers.

[31] PCAST Discusses Advanced Manufacturing Partnerships, Systems Engineering, and Innovation in China, American Institute of Physics, 16 May 2014

JAPAN AND ADVANCED MANUFACTURING

With recent two decades of gloomy economic development, Japan is still dueling with structural barriers that linger manufacturing productivity. Japans working-age population will decline from 79 million in 2012 to 71 million in 2025, and its dependency ratio is set to soar from 0.60 to 0.73 over the same period. Japan's labor productivity growth has stalled below 2 percent for much of the past two decades. Japan is on pace for sluggish annual GDP growth of just 1.3 percent through 2025 if these trends continue.

In 2012, the "three arrows" of Abenomics[32] were designed by the Japanese government to break the vicious economic cycle. In 2013, arrow one of Abenomics was established as a massive monetary stimulus which was redoubled last October. Arrow two was a fiscal stimulus, which turned into fiscal tightening last spring when the consumption tax went up. Arrow three is structural reforms aimed at boosting long-run growth.[33]

To boost advanced manufacturing in Japan, McKinsey Global Institute suggests in a 2015 report that Japan can add a "fourth arrow" to the Abenomics agenda by engaging the business community in a multifaceted, long-term national project that accelerate productivity growth and innovation in every sector of the economy. McKinsey's analysis finds that Japan can meet some 50 to 70 percent of its productivity challenge if the private sector adopts the best industry practices already in use by global companies in a variety of industries - outside of Japan.

It is estimated that Japan can successfully double its productivity growth rate, with a sharp focus on increasing the value added output as well as reducing costs, it could boost annual GDP growth to approximately 3 percent. Around one-third of the productivity potential can be captured within four sectors: advanced [industrial] manufacturing, commercial retail or "E-tail", financial services, and health care.[34] Japanese firms must become more globally integrated. Exporting to the fastest-growing overseas markets is one obvious route to overcoming sluggish demand growth at home. Today, Japan's exports to ASEAN are dominated by machinery and transport equipment.

These products, along with electronic equipment and other advanced manufacturing sectors, together account for nearly three quarters of all Japanese exports to ASEAN.[35] Japanese companies have formidable R&D operations, but most will need to reconfigure them to obtain better returns and impact. The process must start with an understanding of what the customer wants and a determination to deliver solutions accordingly. Closed and tightly managed R&D operations must be transformed into more fluid, open processes involving collaboration with customers and suppliers.[36]

Competition fuels productivity, as the most nimble and innovative companies win out over less efficient firms. But in Japan, highly indebted firms and even uncompetitive divisions of large conglomerates have often been kept alive in the interest of stability.[37] Japan has outsourced almost a third of its manufacturing today. For comparison, in the 1980s only a tenth of Japanese companies manufactured outside of Japan. This shift makes it hard for yen to boost exports overnight, and it reduces the overall impact

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[32] Abenomikusu or Abenomics refers to the economic policies advocated by Shinzō Abe since the December 2012 general election, which elected Abe to his second term as prime minister of Japan. Abenomics is based upon "three arrows" of fiscal stimulus, monetary easing and structural reforms.

[33] Japan wages: Manufacturing consent, FT.com, 18 Feb 2015

[34] The future of Japan: Reigniting Productivity and Growth, McKinsey Global Institute, Mar 2015

[35] Japan-ASEAN Economic Partnership: Prospects for 2015 and Beyond, UN ESCAP, Feb 2015

[36] The Missing Arrow of Abenomics, The Project Syndcate, 15 May 2015

[37] The holy grail of macroeconomics: Lessons from Japan's Great Recession, Richard C. Koo, Wiley, 2009

it can have on the bottom line of corporations.[38] Manufacturers can augment or replace their assembly lines with technologies such as the IoT and 3D printing; two methods within the RDID activity space that is becoming more prevalent in the advanced manufacturing spaces in the developed and western economies.

Even such no so rosy view of how Japan has progressed, the three [or four] arrows of Abenomics seem to have obtained some advocacy to revitalize Japan's economy. First, Japanese Prime Minister Shinzo Abe made a landmark visit to the U.S. across east and west coasts for various sources of inspiration to revive the Japanese economy and to some extent contain a rising China.[39]

While the visit covered outdated policy reforms from the Second World Ear, to discussing the 12-country free trade agreement known as the Trans-Pacific Partnership, Abe also paid a visit to the West Coast of the U.S. to meet with the cutting edge tech frontier companies and expert groups to better understand the underlying methods that has enabled so much money and talent to pool up in Silicon Valley and recently enable focus new capital expenditures on reshoring of high tech manufacturing back to the United States.

Furthermore, The digital manufacturing (DM) market in Japan is set to grow at a CAGR of 7.70 percent over the period 2014–2019. DM software provides and supports process planning, factory modeling, visualization and simulation of operations, human factor analysis, and collaborative communication. It helps manufacturing companies to improve their production efficiency reducing production time and manufacturing expenses. The increasing need to validate product and plant design without physical prototypes is leading to the integration of DM with augmented reality.[40]

Japan is also deploying a new age of robotics that takes these machines away from the big manufacturing assembly lines, and into a wide variety of tasks. Using GPS technology, just like on smart phones, robots are beginning to be used in precision agriculture for weed control and harvesting.[41] Robots have been nursing roles: they help patients out of bed and support stroke victims in regaining control of their limbs. Smaller and more dexterous robots, such as Dexter Bot, Baxter and LBR iiwa, are designed to be easily programmable and to handle manufacturing tasks that are laborious or uncomfortable for human workers.

There are an estimated 2,000 European companies and European companies contribute 90 percent of foreign R&D expenditure. When it comes to various partnership initiatives, the Horizon 2020 program, the biggest EU Research and Innovation program with nearly €80bn of funding available over 7 years (2014 to 2020), is also a fully open to international participation. This targeted cooperation, usually emerges in the form of coordinated calls for project proposals, to ensure Horizon 2020 research answers universal questions. During a previous research funding program, around 70 Japanese-affiliated companies participated in Europe. Many of these companies are active in the field of ICT – in areas such as cognitive systems, robotics, the Internet of Things, digital libraries and more. Engineering, electronics and automobile conglomerates with legal status mainly in the United Kingdom, France and Germany.[42]

Another recent partnership inside Japan was struck between Toyota and Mazda.[43] The deal will let the two automakers collaborate on products funnels while sharing and transferring tech developments especially because each struggles to stay ahead in a competitive environment and because establishing future technologies are becoming severely more pricey whereby sharing costs and risks are becoming key strategic advantage.

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[38] Abenomics Succeeded in Weakening the Yen but 2015 Will Be Tough on Japan, marketpulse.com, 23 Dec 2014

[39] Japan's Abe Seeks Economic Inspiration During U.S. Visit, Forbes.com, 27 Apr 2015

[40] Japanese Digital Manufacturing Market 2015-2019 - Integration of DM with Augmented Reality, PRNewswire, 16 Jul 2015

[41] Top 10 emerging technologies of 2015, World Economic Forum - Agenda, 4 Mar 2015

[42] Paving the way for renewed industrial partnership with Japan, European Commission, 27 Apr 2015

[43] Toyota and Mazda strike long-term partnership to share tech, carmagazine.co.uk, 13 May 2015

Equally, the Embassy of Japan in the UK held a seminar on the new landscape of robotics research and future Japan-UK collaboration, which was co-sponsored by Japan External Trade Organization (JETRO). Going back to earlier description in this section , global competition to develop robots which are fused with ICT, including Big Data, is intensifying. It is under these circumstances that Prime Minister Shinzo Abe launched the "Robot Revolution Realization Council" last September.[44]

The council discussed specific measures, including the development of technology, regulatory reforms and the global standardization of Japan's robot technologies, and published a report entitled "Japan's New Robot Strategy" in January. Meanwhile, the UK Government, having prioritized "robotics and autonomous systems" as one of the "Eight Great Technologies", published its strategy for stimulating growth in July 2014.[45]

[44] Japan-UK Robotics Seminar, Accessed 29 Jul 2015

[45] Ibid & New Robot Strategy – Vision, Strategy, Action Plan, The Headquarters for Japan's Economic Revitalization, 10 Feb 2015

SINGAPORE AND ADVANCED MANUFACTURING

Since the nation's independence in 1965, Industry has been a vital part of the economy. Singapore consistently ranks as one of the world's most innovative nations. The World Bank calls Singapore the easiest place in the world to do business.[46] Manufacturing in particular has been the cornerstone of Singapore's economy. Although Singapore has specialized in digital and electronics manufacturing for the past forty years, the country has diversified into other forms of manufacturing. About 70 percent of the Singaporean economy is made of services production followed by 5 percent comes from ownership and dwellings[47]. The remaining 20 percent of the GDP output represent manufacturing led by electronics, chemicals and biotechnology industries.[48] The following chart presents the composition of the Singaporean manufacturing sector by share of GDP generation and absolute dollar terms in investments commitments:

Table 2: Singapore – Breakdown of the 25 percent annual output of GDP (2013)

MANUFACTURING	**Nominal Value Added (% Share)**	**Real Growth (%)**
Manufacturing	100.0	1.7
Electronics	30.3	3.5
Chemicals	6.9	0.7
Biomedical Manufacturing	20.5	0.0
Precision Engineering	13.0	-5.6
Transport Engineering	16.9	5.2
General Manufacturing Industries	12.4	2.8

Source: Singapore Ministry of Trade and Industry (2013)
Note: Real Growth reflects the year on year development

Table 3: Singapore 2013 investments commitment by manufacturing sub-sector

INVESTMENT COMMITMENTS	**$ Million**	**% Share**
Electronics	3.264	26.9
Chemicals	2.509	20.7
Biomedical Manufacturing	807	6.6
Precision Engineering	588	4.8
Transport Engineering	697	5.7
General Manufacturing Industries	94	0.8
Services Clusters	4.178	34.4
Foreign	8.991	74.1
Local	3.145	25.9
Total	12.135	100.0

Source: Singapore Ministry of Trade and Industry (2013)

[46] The secrets to Singapore's track record of innovation excellence, WP.com, 26 May 2015

[47] Structure of the Singapore Economy, 2013, Singapore Ministry of Trade and Industry (accessed 24 Jul 2015)

[48] Focus Economics, Singapore Economy (Accessed 4 Jul 2015)

In recent years, Singapore has made significant progress in promoting the growth of SMEs. Much of the impetus appears to have come from the government. For example, The 2012 budget provided a further boost to the Double Tax Deduction ("DTD") scheme for SMEs with overseas operations. It allows them to claim up to 200 percent tax deduction on four types of expenditure incurred in market expansion and investment-related activities.[49]

An academic study from 2008 comparing the interaction between investments in advanced manufacturing technologies and manufacturing infrastructure in Sweden and Singapore found positive effects for Sweden but not so much for Singapore. Although impact of such investments in these two areas could bring greater profits to a firm, the profits of such investments were positive for Sweden but not so for Singapore.

The study suggested deeper investigation to gather data on national culture and how heterogeneity and homogeneity of minds may affect collaboration between people to generate profits out of such set of investments. Equally, while Sweden has had very long legacy of building globally successful industrial corporations, they study addressed what staged of national development each country is in so that the vision and advocacy for the implementation of advanced manufacturing capabilities is accepted.

In addition, the Singapore government is expected to find it more challenging in the future to rely on foreign workers and new immigrants to extend the country's human capital stock and change its human capital profile. The liberal foreign worker and immigration policy has been seen by many as contributing to a number of social, political and economic woes such as widening income inequality, rising social tensions among the new and old residents, and the loss of social cohesion, which to an extend is similar in Sweden albeit less expressed.

Despite the government's efforts to convince national to be receptive to new arrivals and to integrate them, political pressure for tightening the foreign labor inflows is likely to persist. The government will face increasingly greater pressure to upgrade the local workforce and increase their productivity and hence wages. This will also entail encouraging companies to increase their investment in new technology and production structures.

A 2013 study from the OECD summarized that R&D spending by business enterprise in Singapore still lags behind levels in other R&D-intensive nations such as the OECD member countries, particularly Japan.[50] As innovation culture becomes more pervasive in Singapore and better accepted by the society, SMEs and large enterprises in Singapore might be expected to play an increasingly larger role in R&D and innovation activities. Over the next five years, the government intends to increase gross expenditure on R&D to 3.5 percent of GDP, a level similar to those in other R&D-intensive nations.

Earlier this year however, the country's manufacturing sector took a strides towards a more sustainable future in the advanced manufacturing capabilities by launching a facility which allows companies to breathe new life into old product components by reusing them in their manufacturing processes. The Advanced Remanufacturing and Technology Centre (ARTC)[51] is the first of its kind in the region dedicated to test-bedding and development of remanufacturing technologies through a public-private partnership approach, together with strategic partner Nanyang Technological University.

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[49] Double Tax Deduction for Internationalization, Singapore 2015 Budget (Accessed 16 Jul 2015)

[50] Structural Policy Notes – Singapore, South East Asian Economic Outlook 2013 – With Perspectives on China and India, OECD (2013)

[51] Singapore seizes future of manufacturing by catalyzing growth of sustainable production technologies, Agency for Sciences, Technology and Research, 28 Jan 2015

About five years ago, the entrepreneurial scene in Singapore was barren. Today the country claims to have over 42,000 start-ups registered, 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 and the entire ecosystem today employs 306,000 people.[52] While Singapore does not yet have any breakout start-up tech companies, incubators such as Block 71[53] 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.

With the government intervention to make Singapore a home for talent, one element has been to strategically respond to national trends. Singapore has benefited mightily from its geographic location close to the rising giant, China. As China is poised to be the world's No. 1 economy, Singapore has positioned itself as the go-to market for Western companies that want the Chinese exposure without, but not necessarily the costs and complexity at play required when setting up in Chinese mainland. Procter & Gamble has med Singapore a hub for consumer and beauty products or Nielsen making Singapore the location of an innovation hub. The U.S. incumbents such as DuPont, GM and ADM continue see Singapore an important part of their global strategy, attracted by Singapore's proximity to China and the ability to tap into Asia's future growth.

Clearly, Singapore offers a stable platform in which foreign companies are willing to expand. Inflow of investments, knowledge and experts support further curation of Singapore as healthy basis to develop sound foundation upon which RDID activities can expand and be implemented. What is required in Singapore by and large is continued developed, cultural development and experienced that can be overtime.

[52] Southeast Asia's innovative start-up boom, Future Ready Singapore, 12 May 2015

[53] Block 71 is a government experiment to bring the startup community under one roof, will double its capacity by the end of the year from its current 250 startups and 1,000 people to around 500 companies.

CONCLUSIONS

While some studies suggest no correlation between investments in advanced manufacturing and firm profits[54], many other studies suggest the very opposite[55]. Either way, it is important to investigate which industry sectors in an economy is least or most vulnerable to competition. Competitive advantage in a nation is built upon various metrics. From cost of labor and commodities or productivity per unit of labor or investment in any sort of manufacturing process to size of a domestic market, curation of an effective talent pool as well as government support toward legacy capabilities or strategic bets in new innovation areas. This paper took a broad look on how innovation, research & development and digitalization is being perceived and implemented in Japan, South Korea, Singapore and China.

Evidently, Japan and South Korea seem farther ahead than China and Singapore in their advanced manufacturing technology application. Japan and South Korea are both technology leaders which have resulted in global brands across the consumer and business customer sectors. Japan distinguishes itself as a capable technology inventor and a global leader in manufacturing electronics as well as automotives. South Korea has been able to design agile manufacturing platforms and processes compatible to take on Japanese technology through which it has assembled strong brands.

China and Singapore are however still learning. Singapore is relative to Japan and Singapore in its early stages of inventing its on national DNA in building a home grown genesis for potentially global innovative companies. However, Singapore hosts several international's incumbents relatively more advanced manufacturing facilities to either semi-assemble or end-assemble various products that is supplied regionally. Low lingual barriers, ease of establishing companies, and academically sounds education in Singapore together enables a strong foundation upon which Singapore can become an South Asian star of designing and inventing advanced manufacturing capabilities. What Singapore needs to more time to learn and grow as one nation in this particular field to not only cater take international investors manufacturing assets but also to invent its own foundation for advanced manufacturing assets across the RDID space.

China on the other hand has been the recipient of all kinds of labor intensive low cost manufacturing to its recent rise as rapid consumer of digitalization investment in its manufacturing sector. Where as Japan and South Korea both have been able to cultivate a home-grown innovation base, Singapore is still developing such a foundation. China however has a scale, it is vast and fast. It invests heavily in acquired technologies and has an active appetite in mimicking western brands. It is however walking backward in developing agile processes and system next in the RDID space. China produces about 700,000 engineers out of its universities. China's scale, bold and highly executive leadership in Beijing a national interest can together make China an ever stronger force to build RDID application across all facets of industrial manufacturing.

Each of the four countries have presented a government-led national agenda on how to prioritize advanced manufacturing efforts in the near future. Japan and China have globally broadcasted their national strategies through Made in China 2025 as well as Abenomics of Japan.

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[54] Strategy, advanced manufacturing and performance, Empirical evidence from U.S. manufacturing firms, Journal of Operations Management 18 (3) 257–277, Kotha, S., Swamidass, P., (2002)

[55] Explaining manufacturing technology use, firm size, and performance, using multidimensional use of technology, Journal of Operations Management 17 (1), 23–27, Swamidass, P, Kotha, S., (1998)

Equally, South Korea and Japan both seem to build strong collaborative sentiments with European and American governments and companies. China appears to progress more independently seeking an autonomous and domestic approach toward its advanced manufacturing planning. Singapore appears to focus more on nurturing existing manufacturing base, i.e. the external asset investments in the country, while building a larger startup base inside.

What however seems clear is that government intervention in terms of incentives and levies to various sectors are in place in order for companies to benefit from higher degree of partnerships while structural barriers hampering competitive advantage are identified and being addressed. In this theme, a persistent question to ask is why structural barriers arise?

One argument is that inflation, interest and exchange rates - which fundamentally is driven by human or man-made expectations - drive costs, new policies and thereby can hamper growth. Sweden for example has become an extraordinary high cost country, from cost of living to cost of employment in addition to relatively rigid labor laws that lowers employers-employee flexibility to actively rotate in the job market.

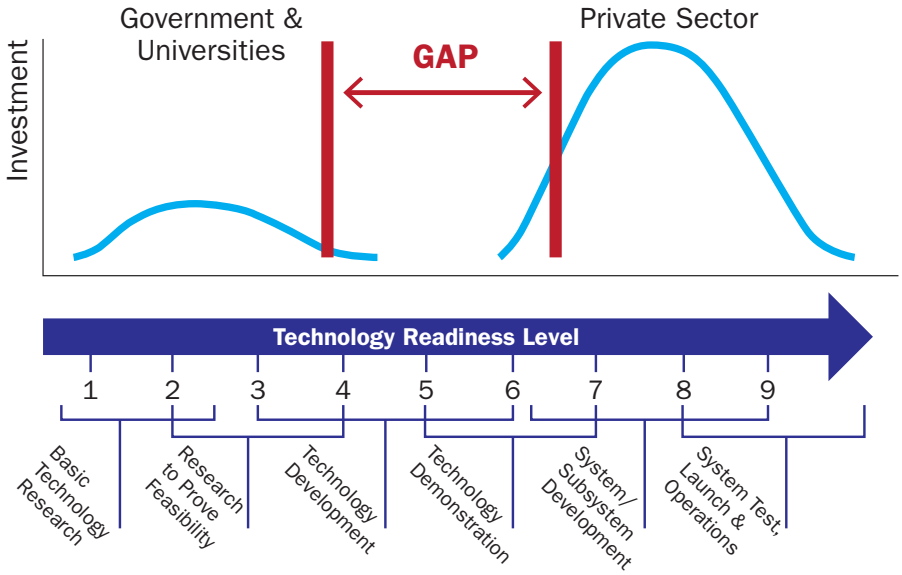
Such lack of movements hamper opportunity to transfer explicit knowledge and experiences. It also disables the ability to move an accumulated portfolio of knowledge from one industry to test and deploy into a new industry sector, i.e. to bring champions from one sector to another to incrementally or disruptively grow a competitive edge. With such structural barriers in place, some of which less controllable than others, a proactive and preventive approach is to establish bi -or multi lateral collaborations between various elements of the economy in order meet, build and implement strategic visions. Japan and South Korea present numerous examples of such cross-border partnership with the United States and EU and across academia, government and the private sectors.

Mutually agreed collaborations can enable an arena of thoughts where various groups of experts can confluence and establish a vision on how to capitalize on existing domestic abilities and capabilities specifically in the industry sector. Each participant brings a certain type of in-depth expertise to assess where it can fit in the overall strategic vision and support setting the various goals. Sweden already has a strong foundation to develop and deploy quality manufacturing processes capable of designing and producing quality goods for the industry sector.

But increasing productivity requires more than just technological innovation in advanced manufacturing; it also takes encouragement to address barriers while terminating inefficient practices throughout an economy. Decisions and actions must be taken.

Traditional ways of doing business may have to be abandoned. Business leaders need to combine big thinking with a focused attention to detail. Shareholders and senior executives could tie performance goals to incentives more so than classic remuneration set by boards. Boards themselves need to redraft their roles and responsibilities and at a faster pace collaborate with government officials. In addition, a proactive usage of research and development institutions in and utilization of alumni will be crucial to responsibly pass on a wealth of knowledge and its legacy to the next generation. Such engagement can also generate spillover effects. As shown in Figure 4, what needs to be overcome is the “chasm” the gap between government, academia and private sectors. It will be worth while to investigate how effective such tri-party relationships are managed in Japan, South Korea, Singapore and China, i.e. what policies are in place that can remove structural barriers so in order to achieve the utmost dialogue and executive abilities between the tree parties ultimately to shape the national agenda of being a highly competitive and globally robust economy.

Figure 4: Diffusing Research into Commercial Good: The Chasm amid Government, Universities and the Private Sector



Source: North American Manufacturing Research Institution of SME (2011)

Countries that have created a relatively important dependency on industrial manufacturing as a contributor to the GDP need to stay at par or ahead of the innovation curve. In order to compete, innovative solutions that converts more R&D dollars into commercially viable processes and system designs can bring better products to end customers. Today's customer base from consumers to businesses are savvy, agile and responsive. Brand equity is key but so is the content delivered in each product or service. Therefore, companies need to respond faster and better than competitors. This requires higher degree of implement technical innovation that can translate an idea into an end result desired by buyers.

In summary, the four countries investigated in this working paper are all active in areas of investing and implementing RDID strategies in the industrial manufacturing sectors. Lessons are many and with regards to above set of questions, one aim is to further analyze the four countries through a more delimited investigation of selected sector activities and investments in advanced manufacturing. Furthermore, it will be as important to extract cases that can capture how RDID investment activities convert to competitive advantage and how such advantage can be measured.

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I EN GLOBALISERAD VÄRLD ÄR KREATIVITETEN SVERIGES STYRKA

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