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Executive Report

Political Steering Processes in Asia Aimed at the Photonics Industry

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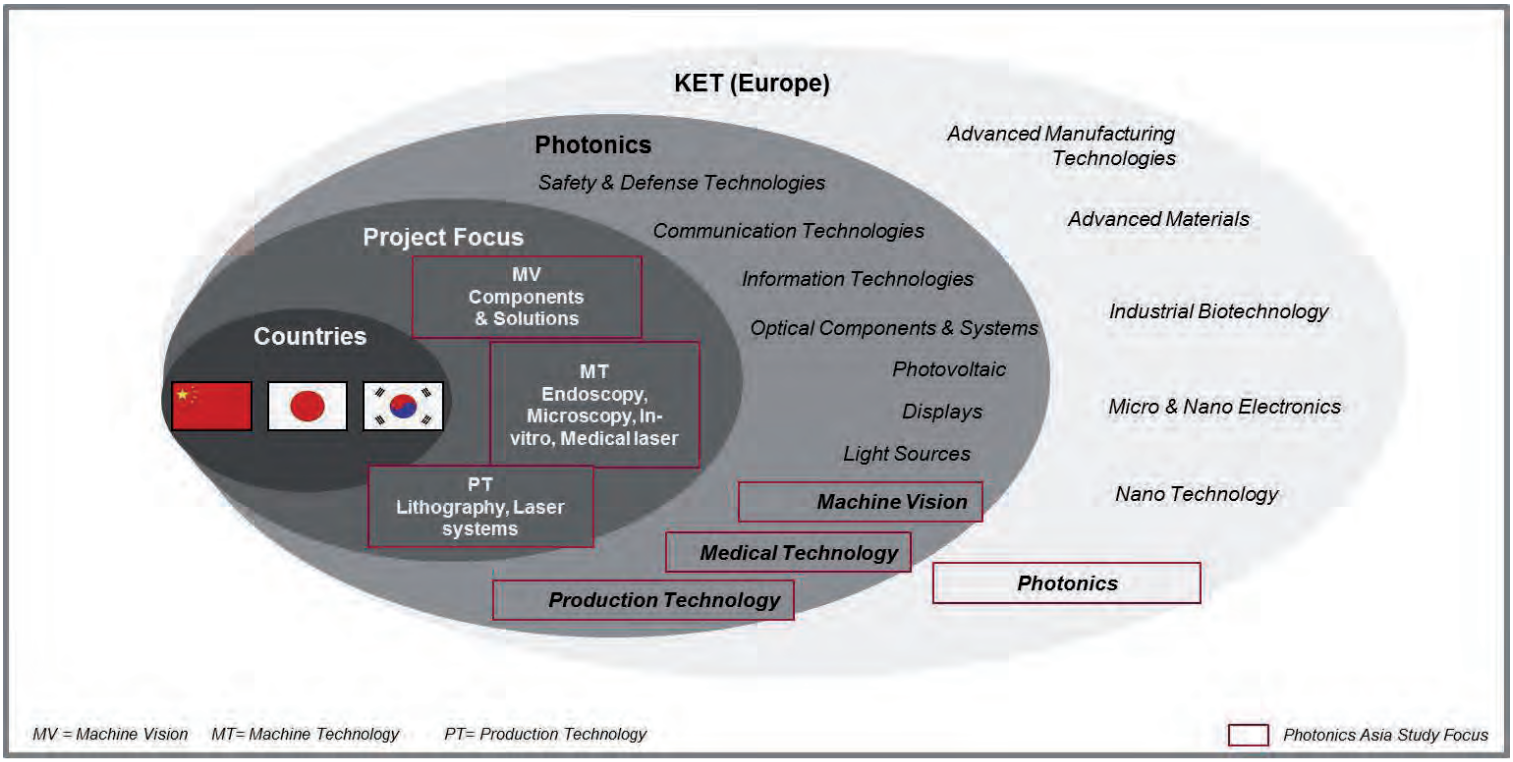
Index

1. Project Objectives and Methodological Approach

In Europe, Photonics has been selected by the European Commission as one of six Key Enabling Technologies (KETs). KETs are expected to be the main driving force behind the future development of the European industry and are therefore of great interest from both a political and economic perspective. In order to have a better understanding of how globally competitive Asian countries support their local Photonics industry, SPECTARIS, VDMA and an Industrial Steering Committee – supported by the German Federal Ministry of Education and Research – initiated a study to analyze political steering processes in Asia.

Figure 1: Project Scope



Source: EAC- Euro Asia Consulting PartG

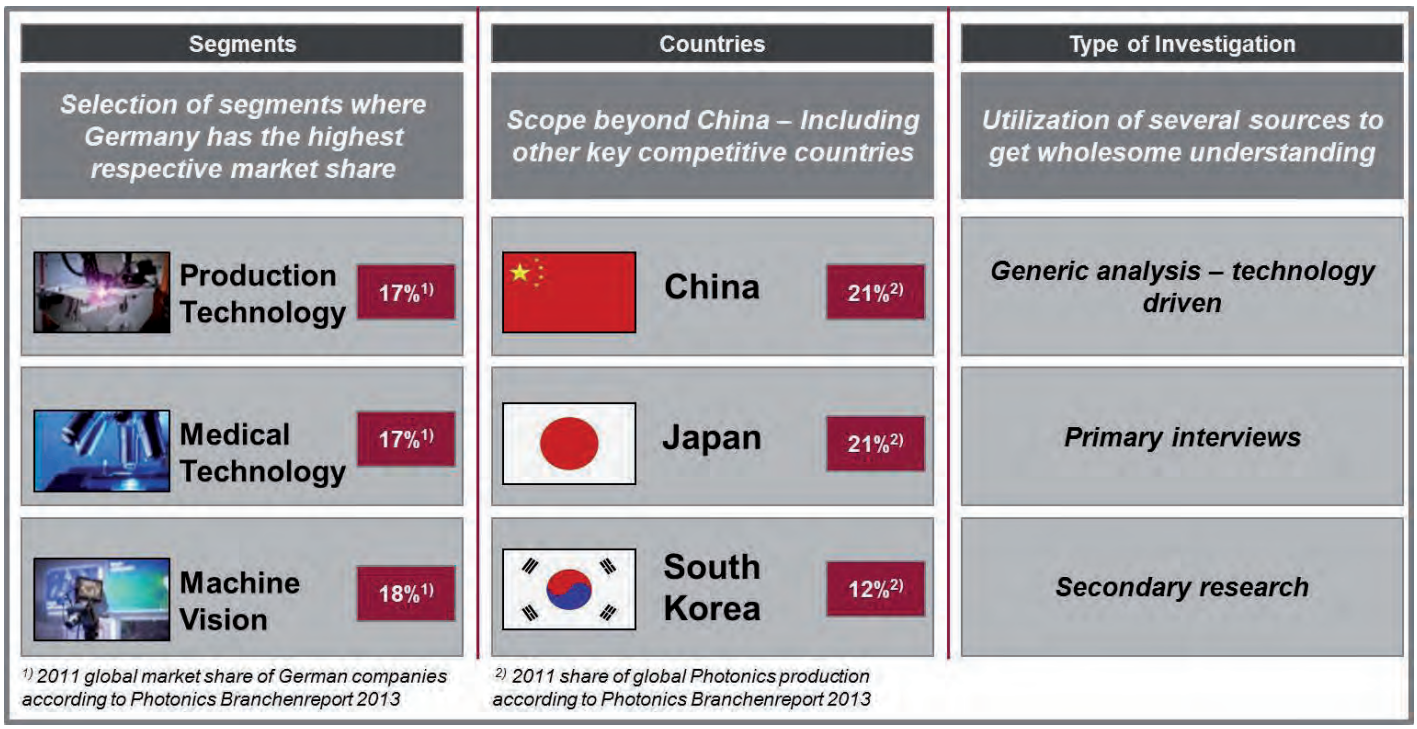
The key objectives and leading questions of the Photonics Asia Study are defined as follows:

- *How do Asian countries operate their political steering systems for research and innovation with regards to the Photonics industry?*

- *How do political steering processes in Asia impact the competitiveness of the selected core segments of the German Photonics industry?*
- *How "strategic" is the approach of Asian countries in the Photonics industry?*
- *How much are local Asian governments investing into research activities in the Photonics industry?*
- *What are current research topics and focus areas in the selected countries?*
- *Can and does the German Photonics industry benefit from governmental support measures in Asia?*

The Photonics Asia Study has been conducted by EAC- Euro Asia Consulting PartG. Data and information that this study is based on consists of both primary and secondary sources. Primary data was collected through interviews with local key decision makers, such as ministries, associations and research institutes, as well as local market experts. Secondary data was collected through analysis of a vast amount of written sources and assessment of more than 5.000 research programs carried out in the target countries.

Figure 2: Overview of Study Setup

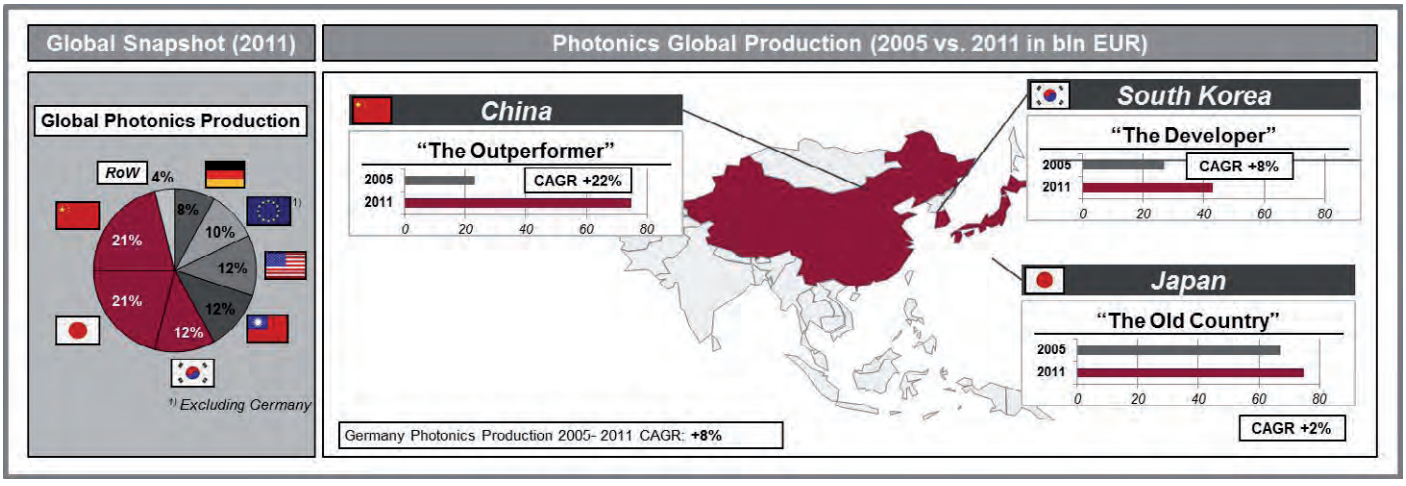


Source: EAC- Euro Asia Consulting PartG

The regional scope of the Photonics Asia Study includes China, Japan and South Korea. These three countries exhibit differing landscapes with regards to e.g. population, stage of development and Gross Domestic Product (GDP). China utilizes its vast territory and immense population of 1.3 bln as a basis for the world's biggest production base, but in terms of its level of industry development, China still lags behind Japan and South Korea. South Korea, which has a comparably small population of 50 mio inhabitants, has the smallest domestic markets within the three countries and consequently relies heavily on export. Japan, on the other hand, has a population of 127 mio that sufficiently supports domestic production and consumption.

As of today, these three countries together account for more than half of the global Photonics production and are expected to remain the center of Photonics in Asia, due to their continuously increasing levels of innovation.

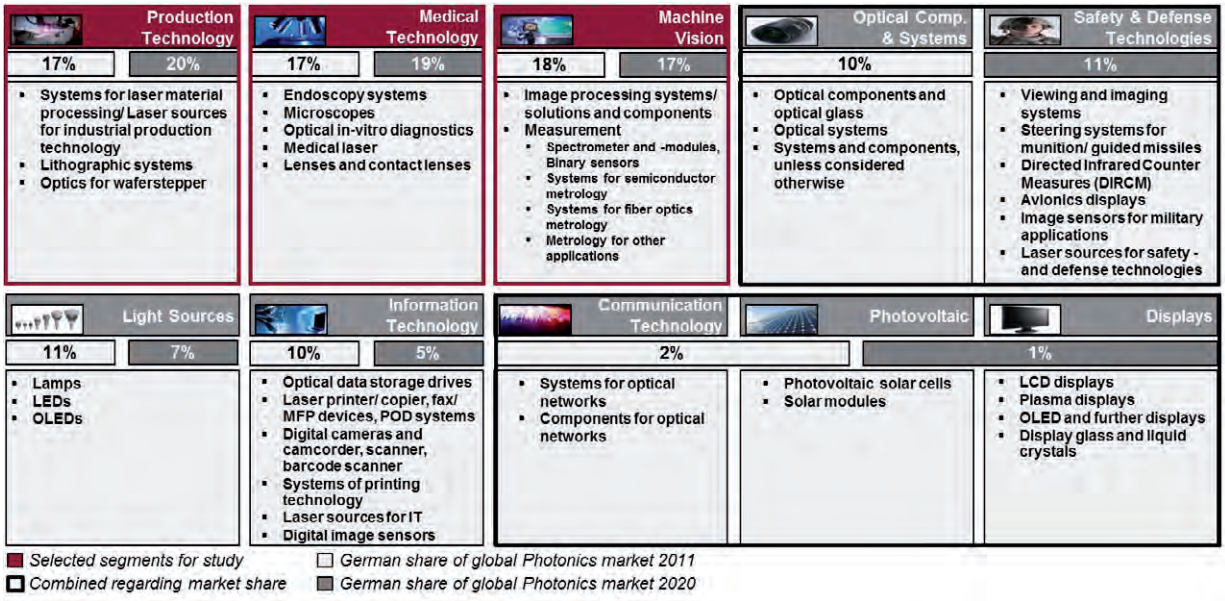
Figure 3: Photonics Production in Selected Asian Regions



Source: EAC Consulting PartG, Photonik Branchenreport 2013

Germany's Photonics industry has a strong position of ~8% of the Photonics world production – with significantly high global shares in specific core segments such as Production Technology, Medical Technology and Machine Vision. The study focuses on these strong segments, while other segments where Asian countries are dominating and Germany has limited presence, e.g. Information Technology, Displays or Photovoltaic, were not included.

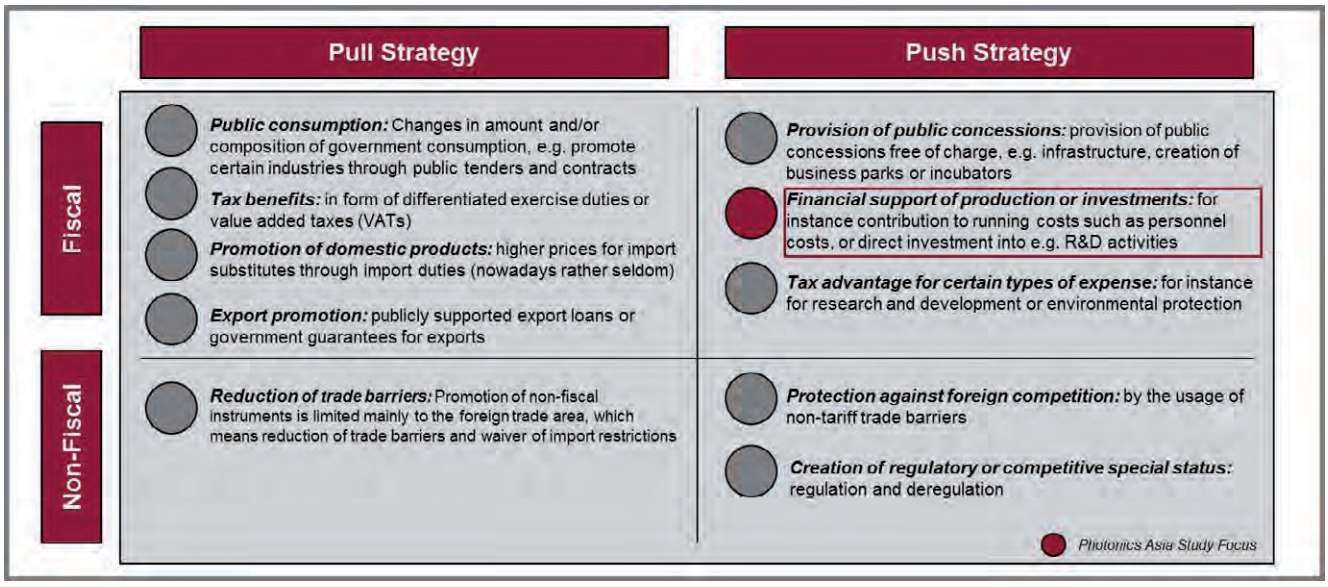
Figure 4: Photonics Asia Study Segment Focus



Source: EAC Consulting PartG, Photonik Branchenreport 2013

Political steering in this study is defined as measures of economic policies that selectively support economic elements and behaviors. Politically initiated economic steering thereby has to be distinguished from general macro-economic actions, such as overall economic recovery or growth-measures. The need for political steering derives from the fact that “normal” market operation does not realize targeted economic and societal outcome. The necessity of a correction of market mechanism is given.

Figure 5: Economic Steering Matrix



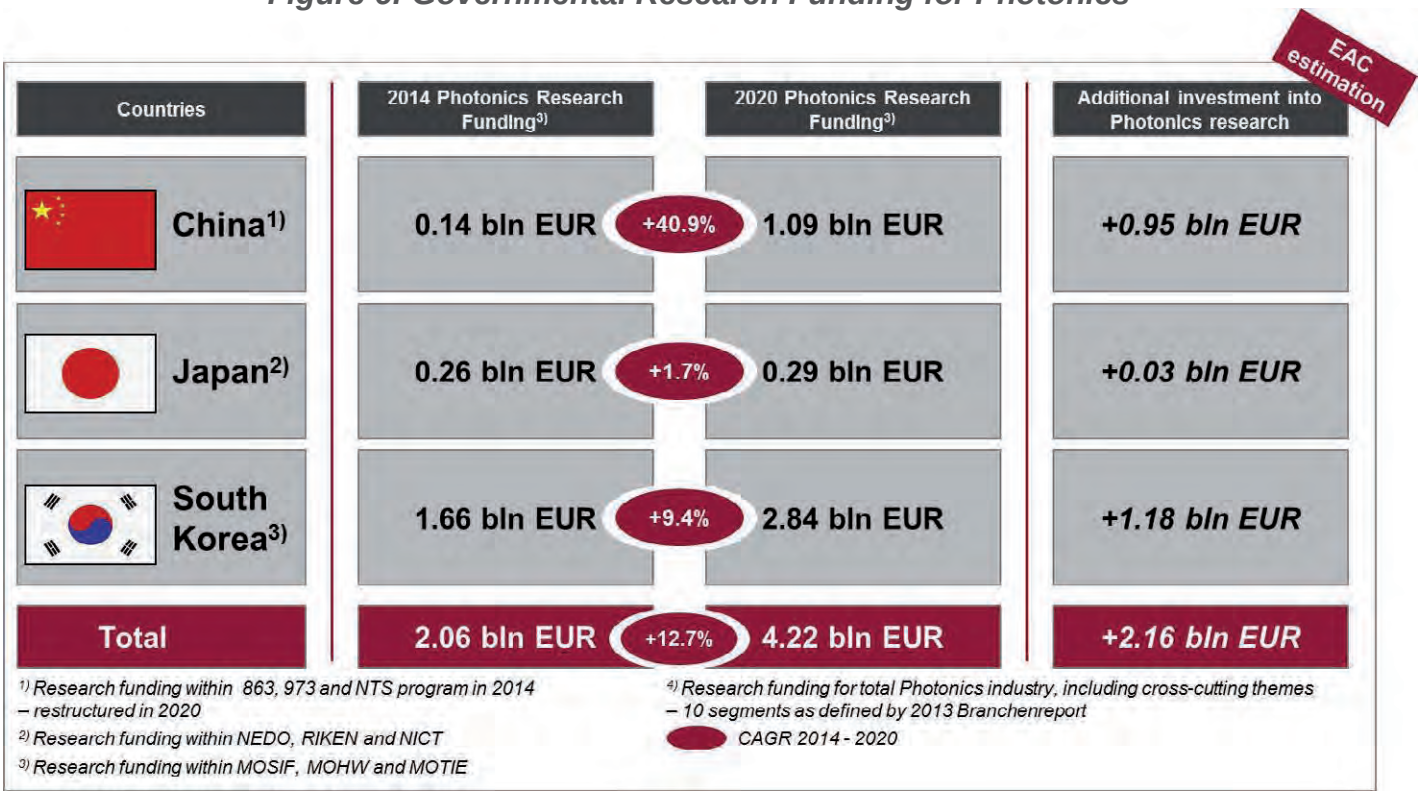
Source: EAC- Euro Asia Consulting PartG

To support a local industry from governmental side, a vast amount of direct and indirect measures with fiscal or non-fiscal effects can be applied. In order to increase both the competitiveness of the local payers and the sustainable industry development, governments may provide funding of research to upgrade the level of innovation created in the country. While the required research and development activities as well as its specific applications are primarily the responsibility of businesses, the government needs to put the right framework in place, so that the conditions and support instruments strengthen industrial capacities.

An evaluation and investigation of every single applied measure and instrument that may be used, and has the potential to impact the Photonics industry in Asia exceeds the scope of the Photonics Asia Study. Rather, the emphasis lies on the qualitative analysis of steering processes and structural approaches of dedicated research support in the selected Photonics segments. These direct support measures can give clear indications on the strategic importance Asian countries put on Photonics and the sustainable development of the industry.

In 2014, China, Japan and South Korea invested a total of approximately 2.06 bln EUR into their Photonics research. The estimated amount of annual funding is based on the respectively three biggest research funding structures in place in these countries.

Figure 6: Governmental Research Funding for Photonics



Source: EAC- Euro Asia Consulting PartG

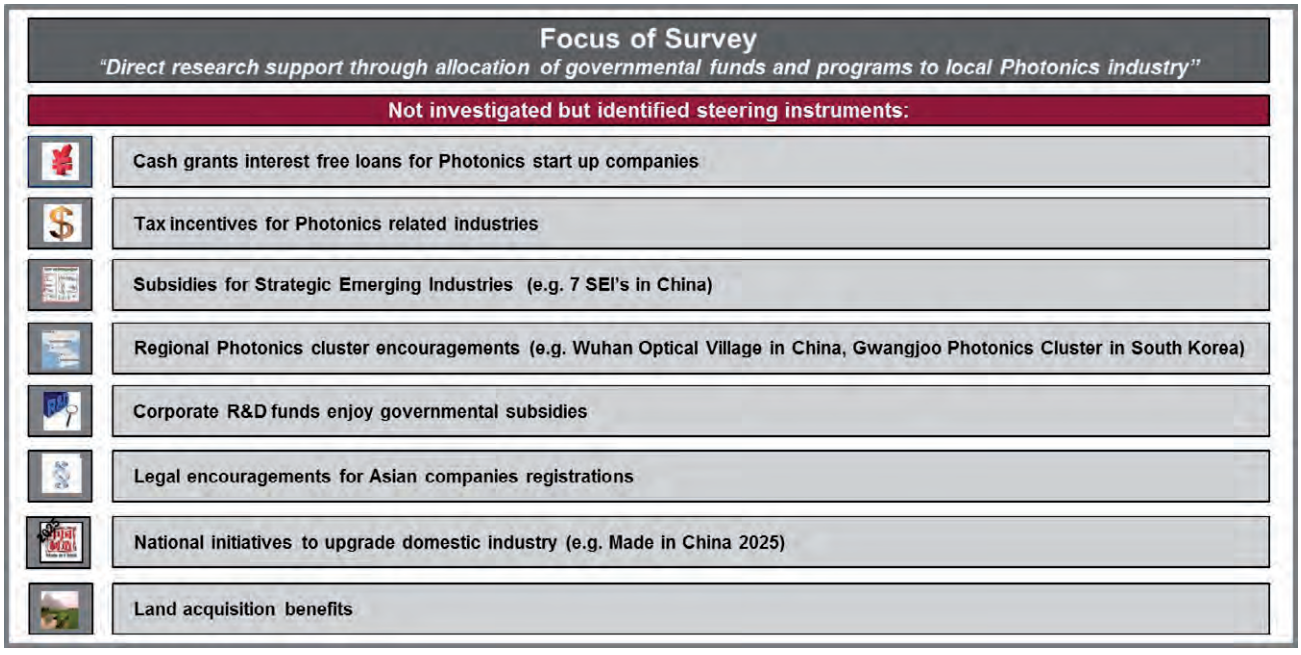
South Korea provides the largest share of investment, at an estimated level of 1.66 bln EUR. China's research funds are relatively low, compared to Korea, at 0.14 bln EUR. China has a lower level of funding, because of their nature of governmental research grants, which mainly cover only basic and application levels of research, rather than directly dealing with commercialization stages.

Government funds are expected to double to 4.22 bln EUR by 2020, growing at a CAGR of 12.7%. China's highest relative growth rate of 40.9% will give it an additional 0.95 bln EUR investment in Photonics research by 2020. South Korea's investment into research also shows high growth rates and is estimated to provide 2.84 bln EUR Photonics funding by 2020. Japan has the lowest increase in research funding. From 0.26 bln EUR in 2014, a growth of 1.7% CAGR will result in 0.29 bln EUR funding for research in their Photonics industry in 2020.

In comparison to Asia, the European organization Photonics21 PPP estimates the public funding amount in Europe, across the European Commission (through the Horizon 2020 program) and member states, to be in the range of 0.6-1.0 bln EUR per year. Thereby, around 600 mio EUR is going to Photonics research programs - additional funds are part of cross-cutting initiatives (e.g. Factory of the Future).

Additionally, several other steering instruments have been initiated by the local Asian governments to support their domestic industries, such as direct funding, regional funding, tax credits and other tax-related instruments, non-monetary funding, credits, grants, infrastructural support etc.

Figure 7: Additional Steering Instruments



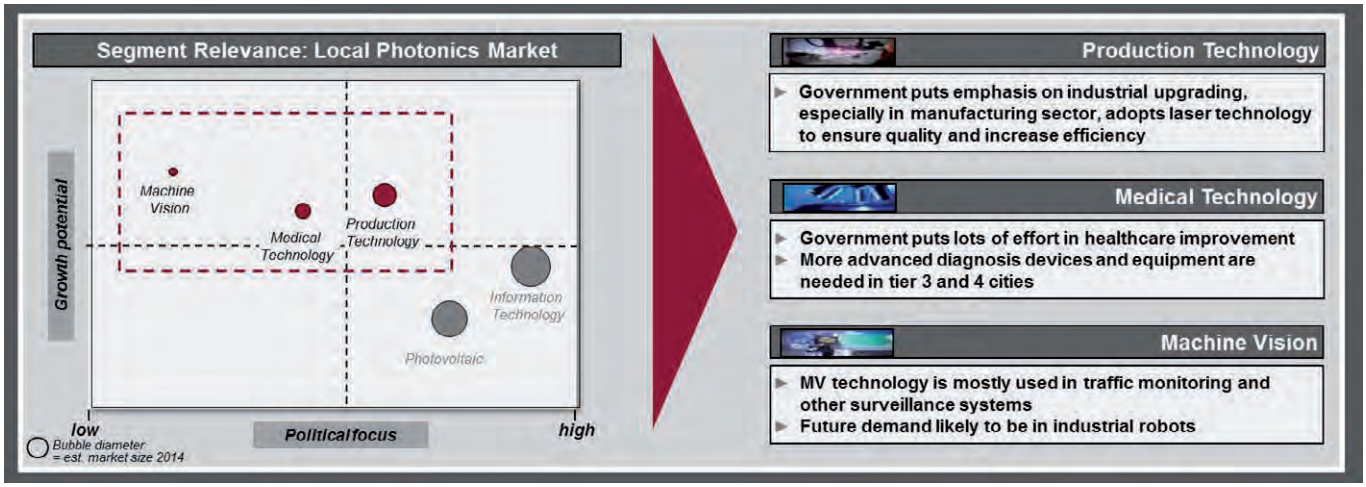
Source: EAC- Euro Asia Consulting PartG

2. Study Results – China

The Photonics industry in China is experiencing rapid and constant growth, mainly due to its huge domestic market, as well as China's strong position as a global production base. Among the ten segments of the Photonics industry, Information Technology and Photovoltaic currently serve as the main pillars of the Chinese local market, from which governmental support and company innovation efforts can be observed.

Among the focus segments, Production Technology receives the highest attention from the Chinese government, now and in the future. Medical Technology and Machine Vision are not explicitly targeted yet, but are expected to receive growing strategic consideration in the coming years.

Figure 8: Overview of Local Photonics Market in China



Source: EAC- Euro Asia Consulting PartG

Production Technology has the highest strategic importance for the Chinese government. China's goal to upgrade its economy from the world's "work-bench" to a more value-add driven center of high-technology, as well as its remarkable growth in key application industries, such as semiconductors, displays and photovoltaic, are the reason for strong political attention. Laser production receives the biggest support from the Chinese government within the Production Technology segment. Chinese players in this segment have yet to reach global industry standards, but are shortening the technological gap at a tremendous speed.

Medical Technology in China's domestic market is currently dominated by foreign players. Due to the high level of research and innovation required in this specific segment, Chinese players have yet to make a noticeable impact. The usage of Medical Technology in China remains at a growing stage. Thus, the industry has not been standardized and has a low penetration level of advanced equipment. However, as China thrives to develop future technologies, as well as address its demographic trends and issues, Medical Technology will gain more attention on the national level and gradually increase its market potential.

Machine Vision is a relatively new market segment in China. As of today, a limited strategic focus by the government and an underdeveloped local industry can be detected. But due to its overarching application potential, Machine Vision is being approached from numerous industries and technologies; covering a wide range of topics ranging from traffic surveillance, to robotics and factory automation, to 3D printing and to sphere panorama vision. A rapid market growth and increasing awareness of the strategic importance of the Machine Vision segment in China can be expected in the near future.

Societal Challenges and Megatrends

Gradually stepping away from its previous stage of aggressive growth and mass production, modern China faces several societal changes that directly impact the development of the local Photonics industry.

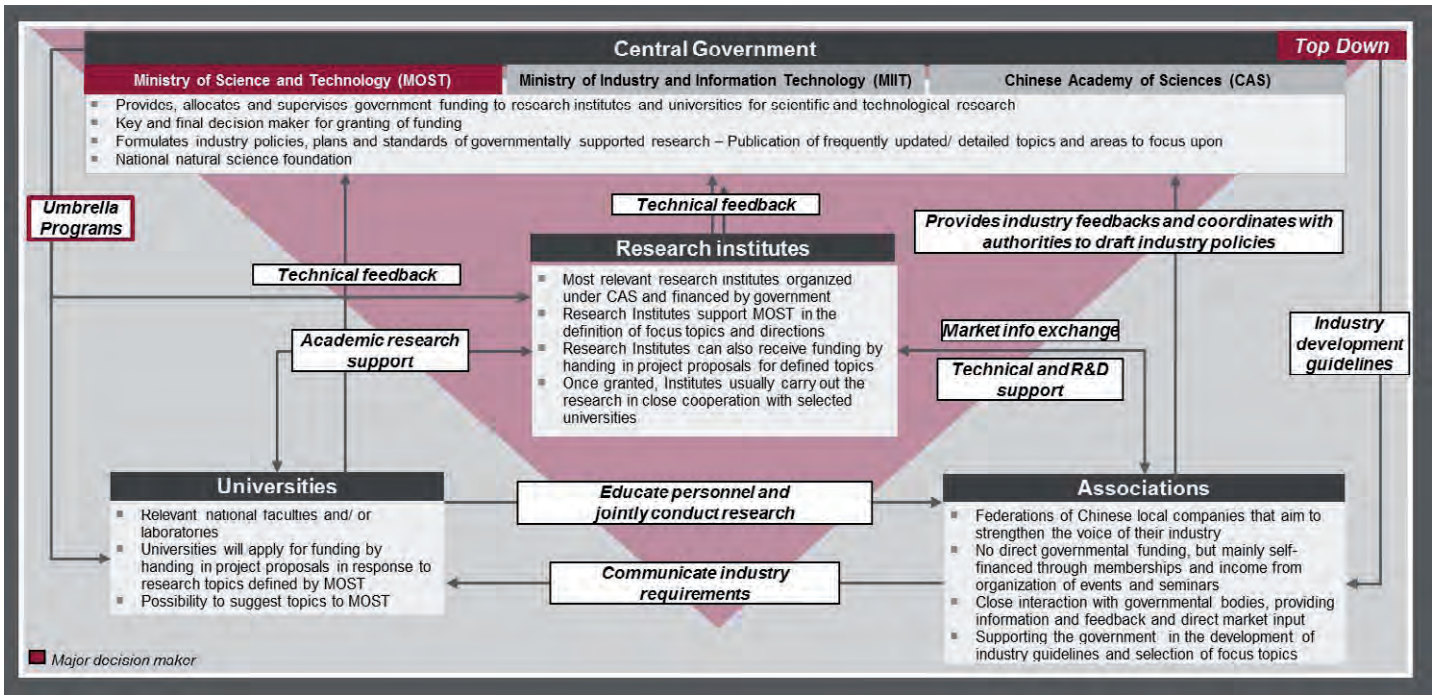
- *Industrial reformation and upgrades in quality and efficiency*
- *Aging society- senior population of age 65+ is growing at 3.28% annually*
- *Call for action on environmentally sustainable development*

The Chinese government, in response to these impending societal changes, is aiming to increase its annual R&D spending to 2.5% of GDP by 2020 in order to better meet the needs of enhancing local competitiveness as well as reducing reliance on foreign technology.

Government Research Programs and Political Steering

To foster research and innovation and to upgrade the competitiveness of the local industry, China has established three umbrella research programs, 863, 973 and NTS (National Technology Support). All three programs are initiated and supervised by the Chinese Ministry of Science and Technology (MOST) and can be characterized by strongly governmental-driven research structures, all of which are executed top-down.

Figure 9: The Governmental Research Steering System



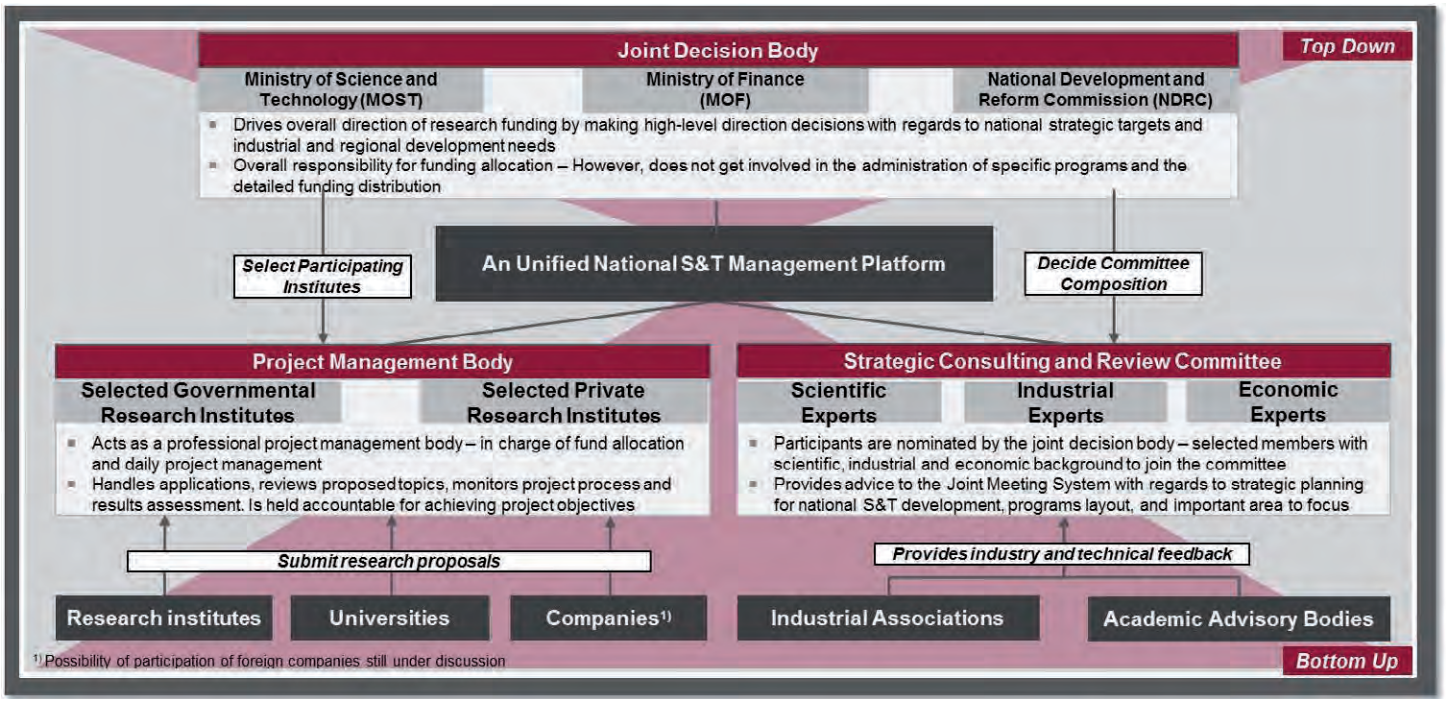
Source: EAC- Euro Asia Consulting PartG

MOST announces an annual list of newly covered topics, to which national institutes, university labs and non-profit organizations apply to. The private sector is not included as a main recipient of this governmental research framework, which naturally leads to a focus on disruptive and basic research.

However, the Chinese government has embarked upon a structural reform of governmental research programs. The current structure seemingly unfolds various aspects of inefficiency, such as a lack of market-driven research activities, fragmented allocation of resources and funding, as well as non-transparency of research management. This reform is set to be completed by 2017, and aims to create a brand new structure.

The new Science and Technology (S&T) plan of China will not only better reflect technological demand from the market; it will also actively include the private sector as a recipient for governmental research and innovation programs. As a result, the scope of activity will be set beyond the phase of research and development, and actively include the entire innovation process, in order to foster technology transfer up to the commercialization stage. The Chinese government clearly lays its emphasis on market realization of technologies, which is a major shift from the current focus on academic achievement.

Figure 10: Governmental Research Steering System after 2017 Reform



Source: EAC- Euro Asia Consulting PartG

Key Decision Makers

Under the current research structure in China, MOST is solely responsible for administrative management and budgeting of the three main governmental research programs, 863, 973, and NTS. The Ministry of Industry and Information Technology (MIIT) and the Chinese Academy of Sciences (CAS) play a supporting role by formulating research topic suggestions and industry policies. Main recipients of current research programs are university labs and national research institutes.

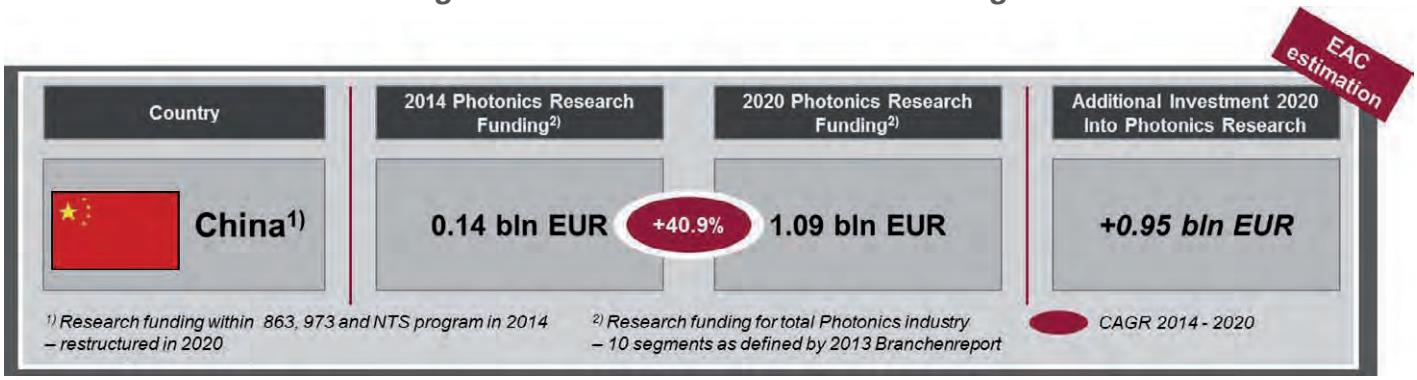
Key decision makers and executive bodies are bound to go through significant change by the time that the ongoing reform is completed in 2017. Three governmental bodies, including MOST, the Ministry of Finance (MOF) and the National Development and

Reform Commission (NDRC) will be entitled to make the budget preparation and execution. Administrative processes and overall management, however, will be assigned to selected research institutes, these will include universities, research institutes and most importantly business enterprises as main recipients of governmental research programs.

Governmental Research Funding

China is expected to substantially increase its funding of research activities in the coming years. Annual funding of Photonics within the three major research programs 863, 973 and NTS summed up to approximately 0.14 bln EUR in 2014.

Figure 11: Photonics Research Funding



Source: EAC- Euro Asia Consulting PartG

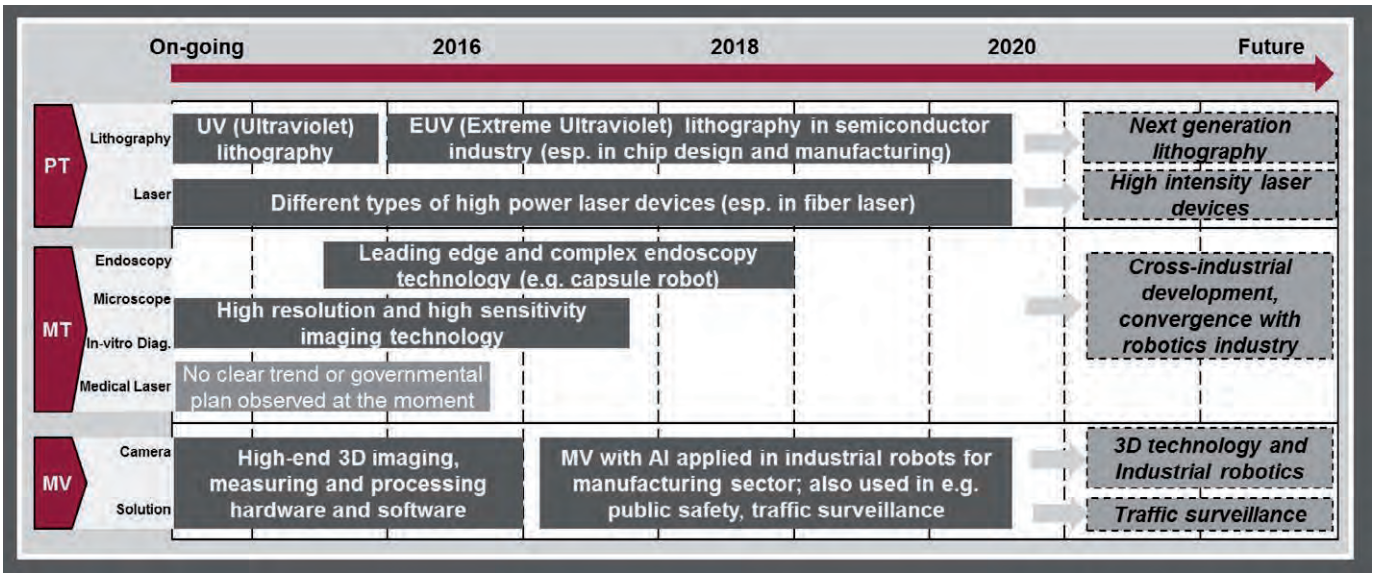
In 2020, research funds provided to the Photonics industry by the Chinese government are expected to reach 1.09 bln EUR. This tremendous increase of funding is directly linked to the reform of the research steering system in 2017. While funding in 2014 mostly focused on basic- and fundamental research activities, carried out by universities and research institutes, funding in 2020 will include more market-driven research activities and puts strong focus on the commercialization of innovation, which requires higher investments.

Future Technology Roadmap

Other than the structural reform, China has compiled a set of technology roadmaps in each respective segment of the Photonics industry, as a part of its strategic approach towards technology innovation and future market positioning.

Among the research topics, high power and intensity laser is one of the highest emphasis areas from the Chinese government, along with 3D imaging and industrial robots, all of which are in line with the long-term technological strategy of the Chinese government.

Figure 12: Future Technology Roadmap



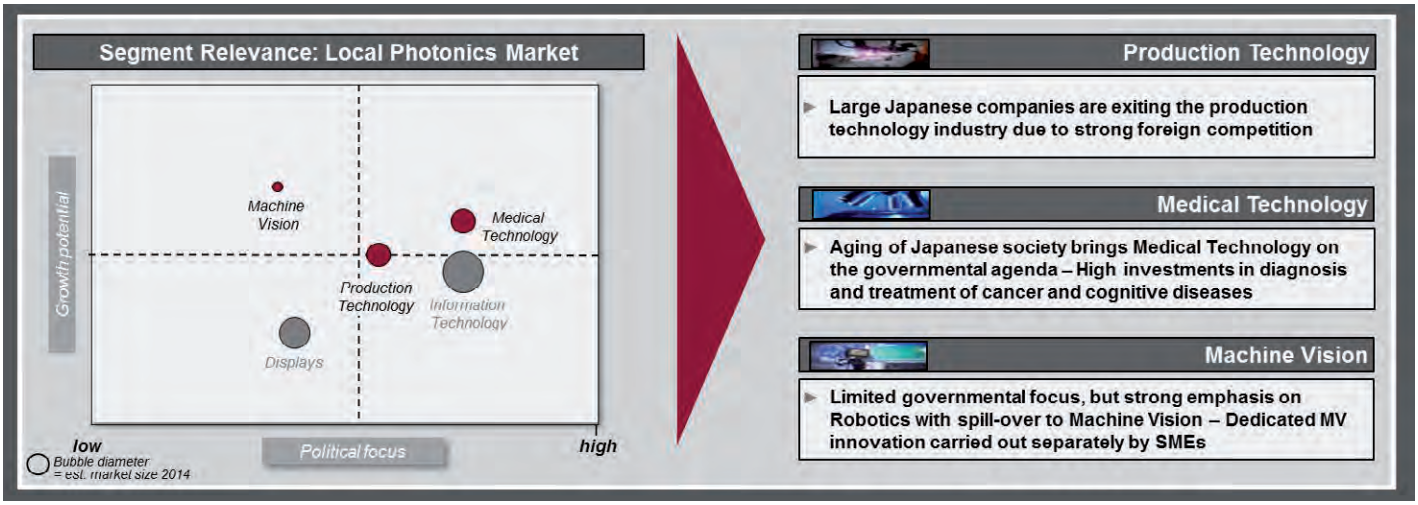
Source: EAC- Euro Asia Consulting PartG

3. Study Results – Japan

Japan has traditionally been outstanding in Asia as one of the strongest players in the global Photonics industry. Despite losing market share in recent years, Japan still accounts for approximately 21% of the global Photonics production. As a result of the global shift of production to more cost-competitive countries, Japanese players are being confronted with growing competition from emerging Asian countries, such as China and South Korea. Consequently, Japan is trying to look for new application industries. The domestic research landscape exhibits close cooperation between government and companies for commercialization of research results, as a response to increasing level of foreign competition.

Among the selected countries, Japan has achieved the highest technological sophistication in all three segments of the Photonics industry, including Japanese players showing strong performance in the global market. The government's future strategy and research focus lies in Medical Technology and Machine Vision, rather than Production Technology. Innovation in the latter segment is mainly driven from business enterprises, due to its high market maturity compared to the former two segments. This reflects that the rising industries in Japan, namely robotics and smart factory, as well as next generation medical devices are being noticed by the government.

Figure 13: Overview of Local Photonics Market in Japan



Source: EAC- Euro Asia Consulting PartG

Production Technology in Japan has shown steady growth in recent years. In spite of a high competitiveness of Japanese companies, a significant part of the market is

dominated by foreign players. Although the current market size of Production Technology exceeds that of Medical Technology and Machine Vision, increasing competition from foreign players has caused several local companies to exit the market. Accordingly, previous research programs in the Production Technology segment initiated by the government are not followed up by the private sector, despite the government's strategy to steer innovation in laser modules and processing. Overall economic recession has caused the local players to be more risk-averse towards being engaged in research and innovation.

Medical Technology in Japan will make the furthest progression among the three Asian countries, not only in terms of market size, but also in the perspective of technological level and innovation. Japan is the fastest aging society among the three Asian countries, and this societal challenge has created the need for a continuous development of next generation medical devices. Additionally, structure of research in the medical field has been optimized to better utilize budgets and reach the market efficiently. The Agency for Medical Research and Development (AMED), which was founded in April 2015, integrates the previously fragmented management of medical technology research along the whole innovation process into one solely responsible body.

Machine Vision is currently lacking an integrated approach from the government, but the strong emphasis on the robotics industry creates a certain spill-over effect, in which both the Japanese government and small businesses are respectively and collectively carrying out research and innovation. Especially imaging systems are developing quickly, because of strong local players with international presence. However, there isn't a focus on overarching initiatives. Machine Vision can be characterized as a closed market with an innovative landscape that has most research occurring in companies for internal usage.

Societal Challenges and Megatrends

Traditionally strong industries in Japan, such as automotive, semiconductor, and iron & steel industries have been the driving force for the development of the Photonics industry. However, new societal changes are expected to continuously impact the Japanese Photonics industry.

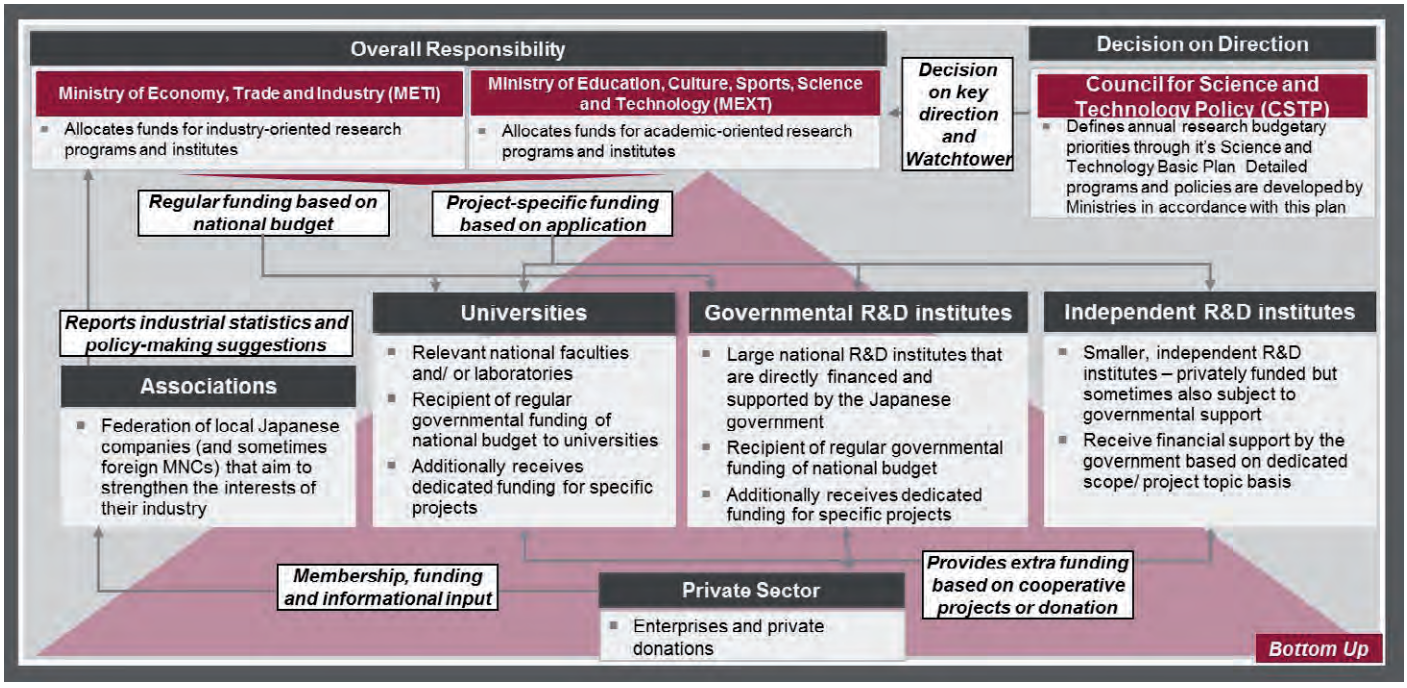
- *Long-term stagnation of Japanese economy - Japanese Yen has depreciated 30% since 2011*
- *Earthquake, Tsunami and Fukushima accidents raising public debate on Japan's energy strategy*
- *Quickly-aging population – 25% of population over 65 in 2013*

Japan is further aiming to strengthen its position in life science and green innovation by increasing its expenditure on R&D to 4% of GDP by 2020, as an approach to expand to foreign countries and revitalize its declining economy.

Government Research Programs and Political Steering

The mode of political steering can be characterized as bottom-up and market driven. Technological demand from the market side is collected and integrated that is then reflected in the Japanese government's research program structure and decision making process.

Figure 14: Governmental Research Steering System



Source: EAC- Euro Asia Consulting PartG

Recipients of government research and innovation programs are not limited to a single entity, rather it is granted to whomever the topic of research is initiated from, varying among public and independent research institutes, university labs and also business enterprises. A threefold approach, involving government, industry and academic relations can be observed, demonstrating the country's effort towards close cooperation and efficient transfer towards commercialization of technology.

Key Decision Makers

In Japan, two ministries are identified as the main executive bodies of governmental research programs; the Ministry of Economy, Trade and Industry (METI) and the Ministry

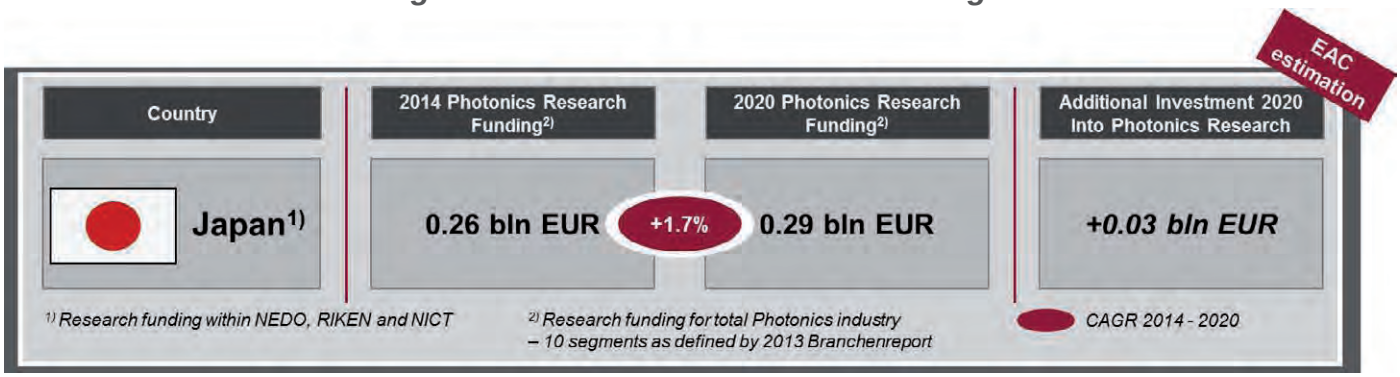
of Education, Culture, Sports, Science and Technology (MEXT) mainly play the role of preparing and allocating both regular and project-based research budget. While MEXT is more focused on academic research, METI is dedicated to the innovation and commercialization phases. The Council for Science and Technology Policy (CSTP) serves as a watchtower that aligns the governmental research programs in accordance with the national Science and Technology Basic Plan.

Recipients of governmental research programs are decided upon project-base, ranging from national and private research institutes, in which the “RIKEN” research center, The New Energy and Industrial Technology Development Organization (NEDO), both respectively affiliated to MEXT and METI, are included, as well as other university labs and business enterprises. However, executive entities are rather independent in carrying out research activities, and cooperation with government is a selective issue.

Governmental Research Funding

The Japanese government invested an estimated 0.26 bln EUR into research activities in the Photonics industry, in 2014.

Figure 15: Photonics Research Funding



Source: EAC- Euro Asia Consulting PartG

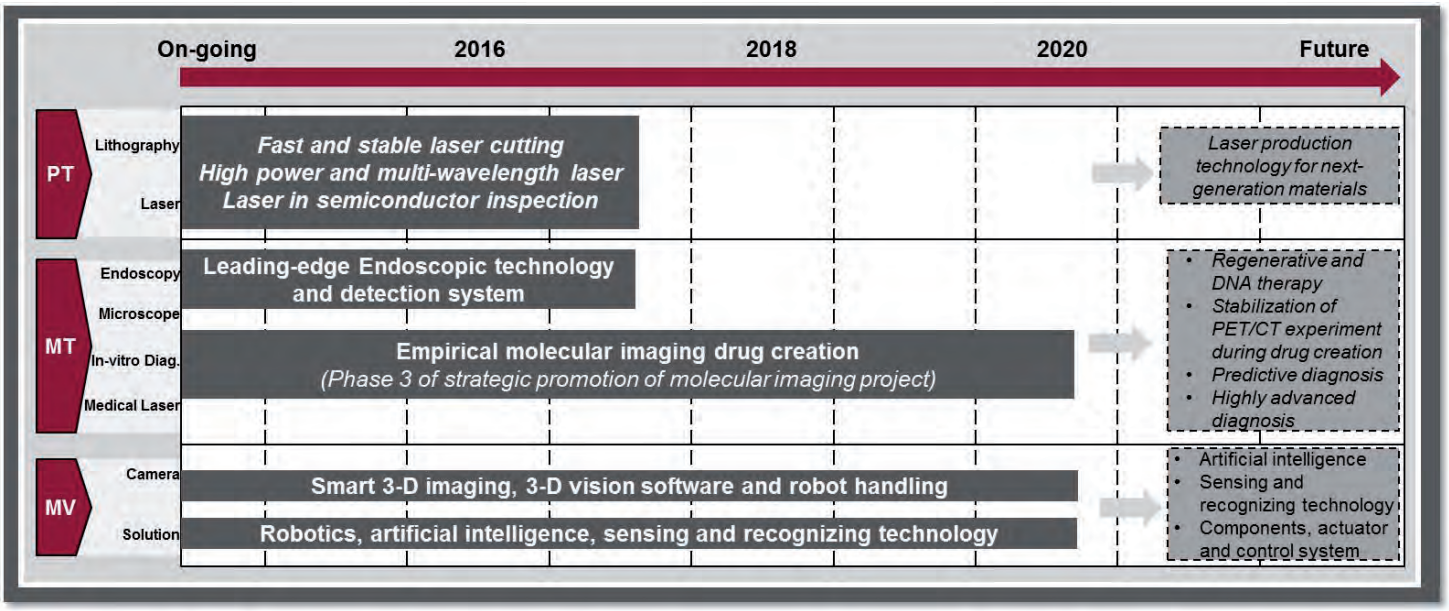
Recipients are scattered among national and independent research centers, university labs and business enterprises, among which NEDO, RIKEN and the National Institute of Information and Communications Technology (NICT) are collectively allocated with the highest proportion of the budget.Until 2020, no substantial increase in the annual Photonics research budget is expected. However, a shift in the distribution of funds within the Photonics industry is likely to happen that will lower funding for Production Technology, and at the same time increase funding provided to (besides other segments) Medical Technology and Machine Vision.

Future Technology Roadmap

Given that Japan's research is operated on a bottom-up basis, research topics are freely decided and announced annually by the executive bodies. This is mainly including research institutes, but also the Ministry of Education, Culture, Sports, Science and Technology (MEXT), from which future technological trends can be observed.

The Japanese government has been putting focus on the laser processing technology as an attempt to bring back the local players in the market and to effectively respond to the gradually increasing demand. Additionally, 3D imaging and robotics, as well as sensors and recognition systems, are emerging as future industries where governmental focus can be observed.

Figure 16: Future Technology Roadmap



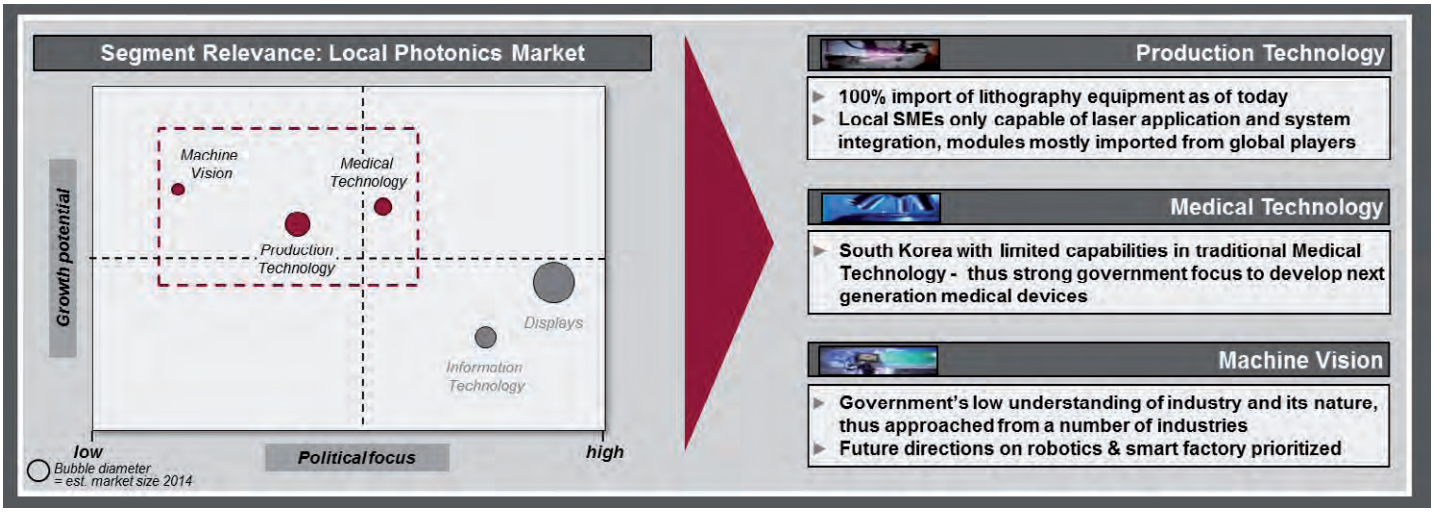
Source: EAC- Euro Asia Consulting PartG

4. Study Results - South Korea

South Korea traditionally has a strong market presence in the Photonics' core segments, such as Display and Information Technology, and a high degree of value chain integration within these segments. The government actively implements a structural support on small businesses, in order to enhance their research capabilities and facilitate expansion into other countries.

The government's strongest efforts are seen in the Medical Technology segment, aiming to respond to impending societal challenges of aging society and increasing importance of healthcare, as well as enhancing global competitiveness of local players. Research and innovation in Production Technology targets to achieve a higher degree of technological localization, while Machine Vision is addressed with regards to future industries, such as smart factory and robotics.

Figure 17: Overview of Local Photonics Market in South Korea



Source: EAC- Euro Asia Consulting PartG

Production Technology is developed relatively to its application industries, namely semiconductor, display, and photovoltaic. A close collaboration between leading players and the South Korean government is ongoing, trying to localize the lithography technology and reduce foreign (especially Japanese) market presence. A similar trend is observable in the laser production segment, which also aims to develop locally available technology for laser modules.

Medical Technology is currently gaining attention and strategic relevance from the South Korean government, due to the fact that small businesses are dominating this industry, and have limited capabilities to carry out independent research activities independently. Application-wise, medical lasers are expanding their boundaries from conventional aesthetic & skin care to operational functions. Moreover, the South Korean government plans to achieve a first-mover advantage through convergence of medical devices and IT, latter of which is a traditional strength in Korea.

Machine Vision is represented by a range of industries and applications, from traditionally strong semiconductors, displays, and automotive, to future industries such as smart factories, robotics, and medical IT. This also suggests that the South Korean government doesn't fully grasp the nature of Machine Vision and therefore has a limited understanding on the overall industry development. Yet, conglomerates have recognized the potential deriving from applications such as smart factories and are in the beginning stage of establishing the basic infrastructure of the Machine Vision industry.

Societal Challenges and Megatrends

South Korea is trying to increase its R&D expenditures to 5% of GDP by 2017, as well as upgrade its governmental research programs to a more market-orientated approach in order to efficiently react to impending societal challenges.

- *Localization of core technologies to lower import ratio and expand export capacity*
- *Classified as aging society – 7% (2014) of population is 65+ senior citizens, which led to increased awareness of healthcare*
- *Internet of Things (IoT) and digital convergence, smart devices and robotics*
- *Eco-friendly manufacturing and environmentally sustainable economic development*

Due to its limited local market, both government and business enterprises in South Korea have put the utmost emphasis on market expansion into other countries. Localization of core technologies has become a prerequisite to achieve such a strategy. Inter-industry convergence and diversification of application industries can be identified as endeavors from South Korean government addressing this issue.

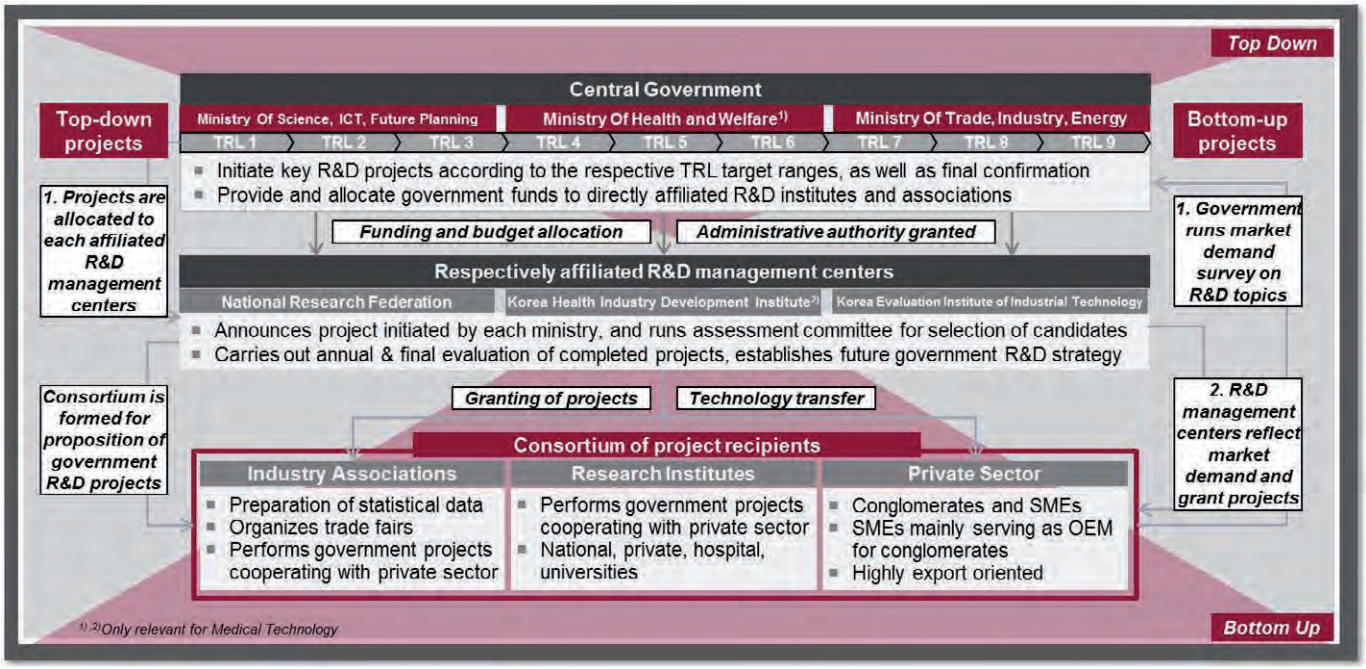
Government Research Programs and Political Steering

South Korea is identified to have the most efficient political steering structure within the selected Asian countries, operating on a dual mode of top-down and bottom-

up development. Such competitive funding approach enables more space for close interaction with private sector. Recipients of government research programs therefore show a split among research institutes, university labs, and most importantly the private sector.

South Korea's high level of involvement of private sector results in the most wholesome support throughout the innovation process among the three Asian countries. Technology transfer is actively supported through different ministries, who distribute duties of research and innovation and inter-ministry cooperation enables succession of research along the innovation process.

Figure 18: Governmental Research Steering System



Source: EAC- Euro Asia Consulting PartG

Key Decision Makers

In South Korea, there are three ministries and three management centers directly affiliated to each individual ministry, which are relevant to research and innovation activities in the Photonics industry. All three ministries have a dedicated scope of responsibilities along the Technological Readiness Level, the Ministry of Science, ICT, and Future Planning (MOSIF) is responsible for research and development stages, followed by the Ministry of Health and Welfare (MOHW), and the Ministry

of Trade, Industry, Energy (MOTIE) that respectively target certification and commercialization. The main role of these ministries is to prepare and execute the annual budget of governmental research programs.

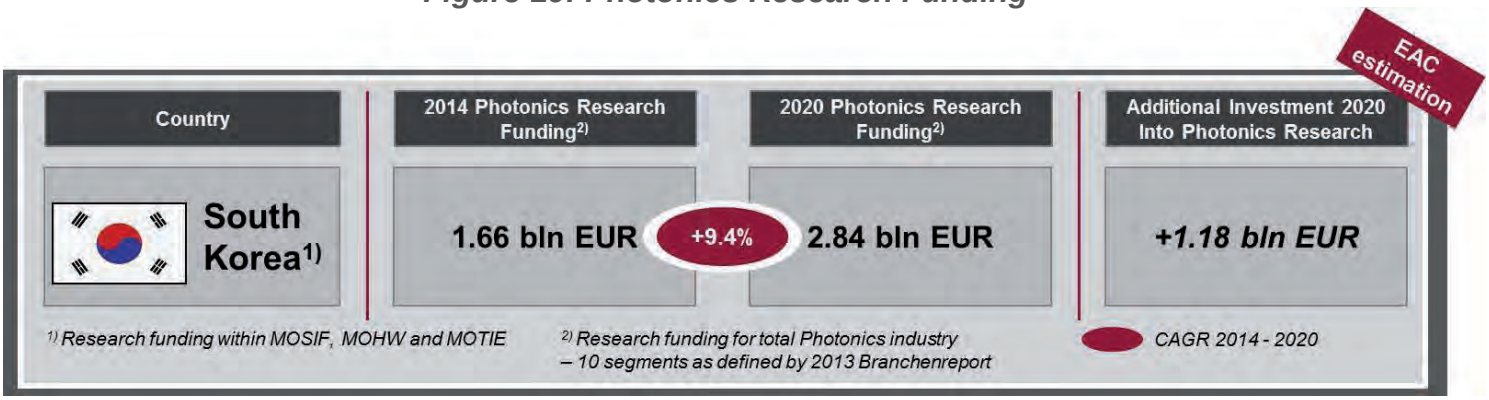
Research management centers are a distinct feature in South Korea. Respectively affiliated to each ministry, the three management centers are granted administrative authority regarding government research programs, from the initial announcement to candidate assessment and final selection. Other than these main features, the management centers are also entitled to the preparation of research topic suggestion and establishment of long-term technology development strategies on a national level.

Recipients of governmental research programs are encouraged to form a consortium of national research institutes, university labs and business enterprises, which facilitate close cooperation between the executive bodies from the commencement to the end of the project. The ratio of small to medium enterprises (SME) is expected to increase due to the government's recent prioritization of technology commercialization and export expansion.

Governmental Research Funding

South Korea is investing tremendously into the Photonics industry. In 2014, the funds provided to three relevant ministries, MOSIF, MOHW and MOTIE summed up to a total of 1.66 bln EUR. Moving forward, South Korea is expected to further increase research funding to reach 2.84 bln EUR by 2020. The high amount of funding provided directly is attributed to the close-to-market research approach of South Korea, and the successive support provided throughout the entire innovation process.

Figure 19: Photonics Research Funding



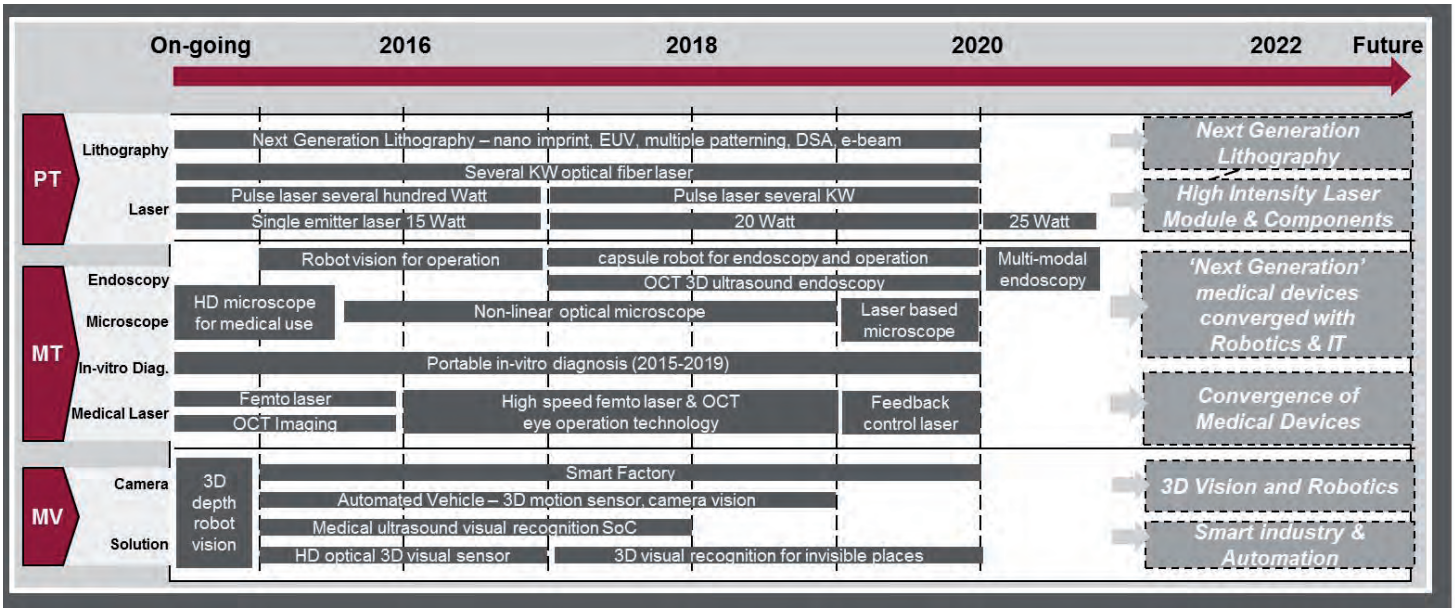
Source: EAC- Euro Asia Consulting PartG

Future Technology Roadmap

The South Korean government has established a number of dedicated institutes that publish long-term strategies of technology development and suggestions for the government. Governmental research and development programs therefore are structured within the technology roadmap published by these institutes.

South Korea shows a high penetration level on all selected Photonics segments in each of their research activities. Key tendencies are inter-industry convergence, localization of core technologies and expansion into future industries, such as robotics and smart factories. In the center of the research topics lies South Korea's core strength, IT and digitalization. This indicates that South Korea has a long-term future perspective and strategizes accordingly.

Figure 20: Future Technology Roadmap

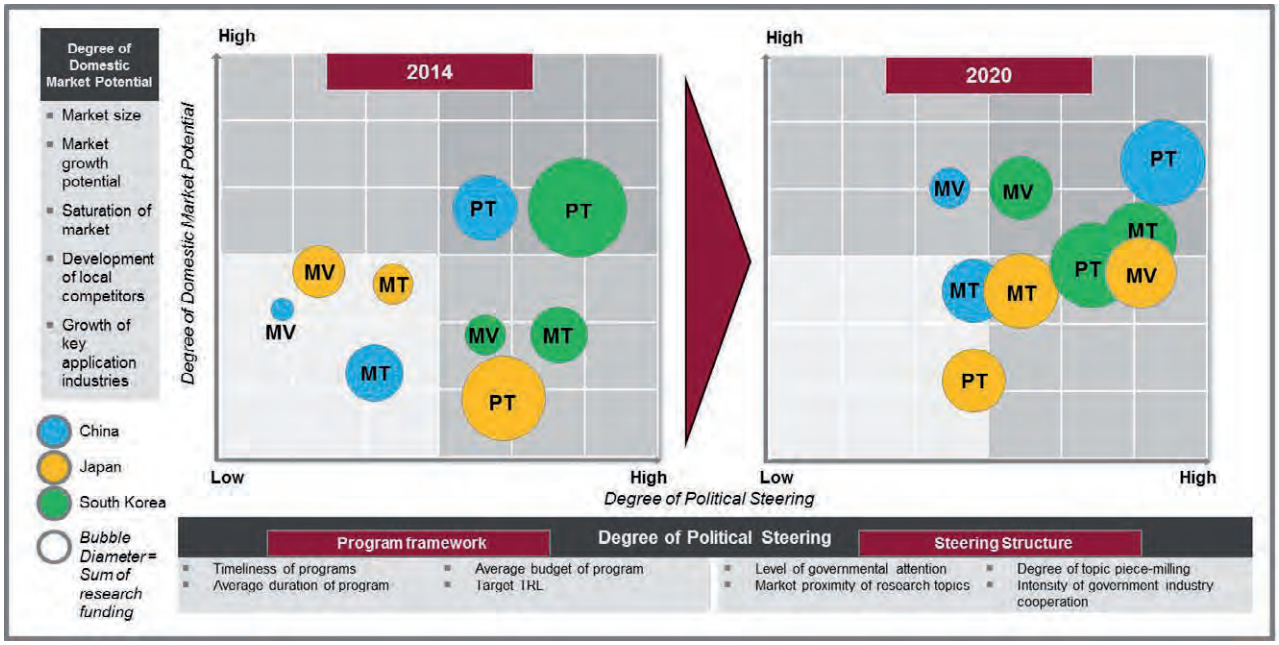


Source: EAC- Euro Asia Consulting PartG

5. Cross- Country Comparison

To create a holistic picture of the current and future steering structure of China, Japan and South Korea in the selected Photonics segments, study findings have been summarized in a result portfolio and put into relation to their domestic market potential.

Figure 21: Result Portfolio



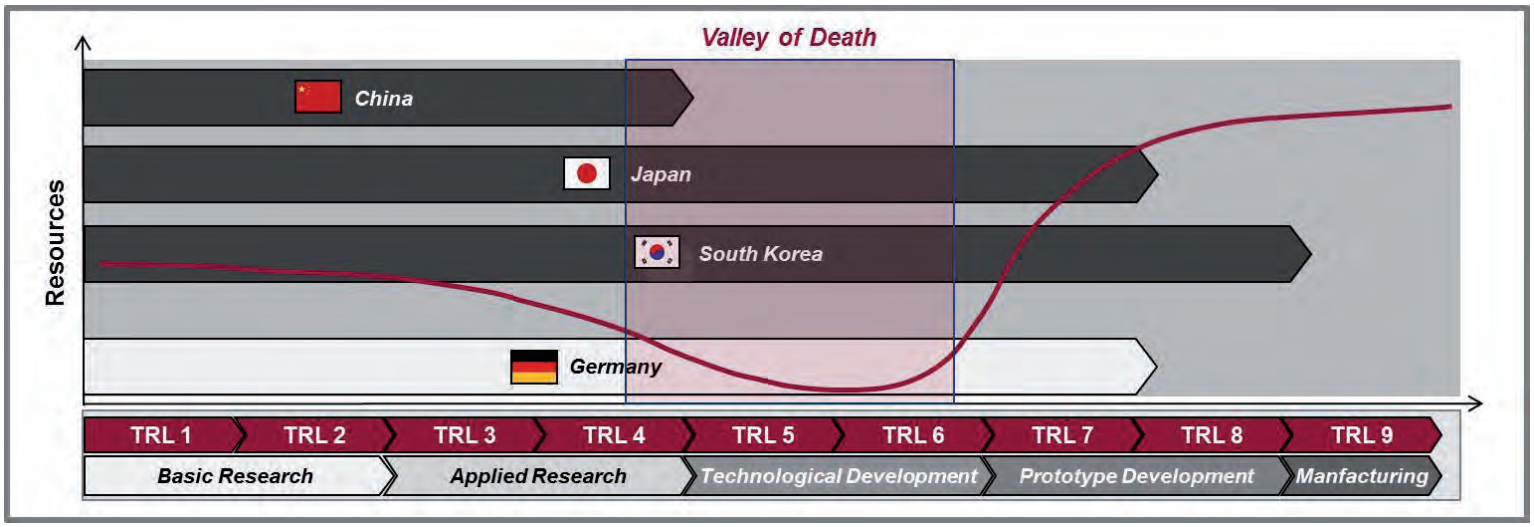
Source: EAC- Euro Asia Consulting PartG

Currently, the amount of research funding allocated to each Photonics segment differs substantially, with Production Technology receiving the largest portion and Medical Technology and Machine Vision lacking political awareness and dedicated and efficient research support in comparison. However, the landscape is expected to undergo significant changes, with both Medical Technology and Machine Vision are gradually shifting towards the center of the government's attention, most obviously in Japan and South Korea. Consequently, by 2020, the funding amount in the three segments will be similar to one another.

All three selected segments are expected to experience significant growth in terms of market potential and political awareness until 2020. Notably, Production Technology in China shows strong potential and is expected to take over the leading position from South Korea as of 2020, both in terms of domestic market potential and degree of political steering.

To analyze the innovation cycle as a whole from disruptive, basic research until reaching commercialization stage, the Technology Readiness Level (TRL) assessment can be applied. Hereby, the degree of technological development is broken down into 9 conclusive steps. While TRL 1 refers to the observation of basic principles, TRL 9 categorizes the production of developed products.

Figure 22: Technology Readiness Level (TRL)

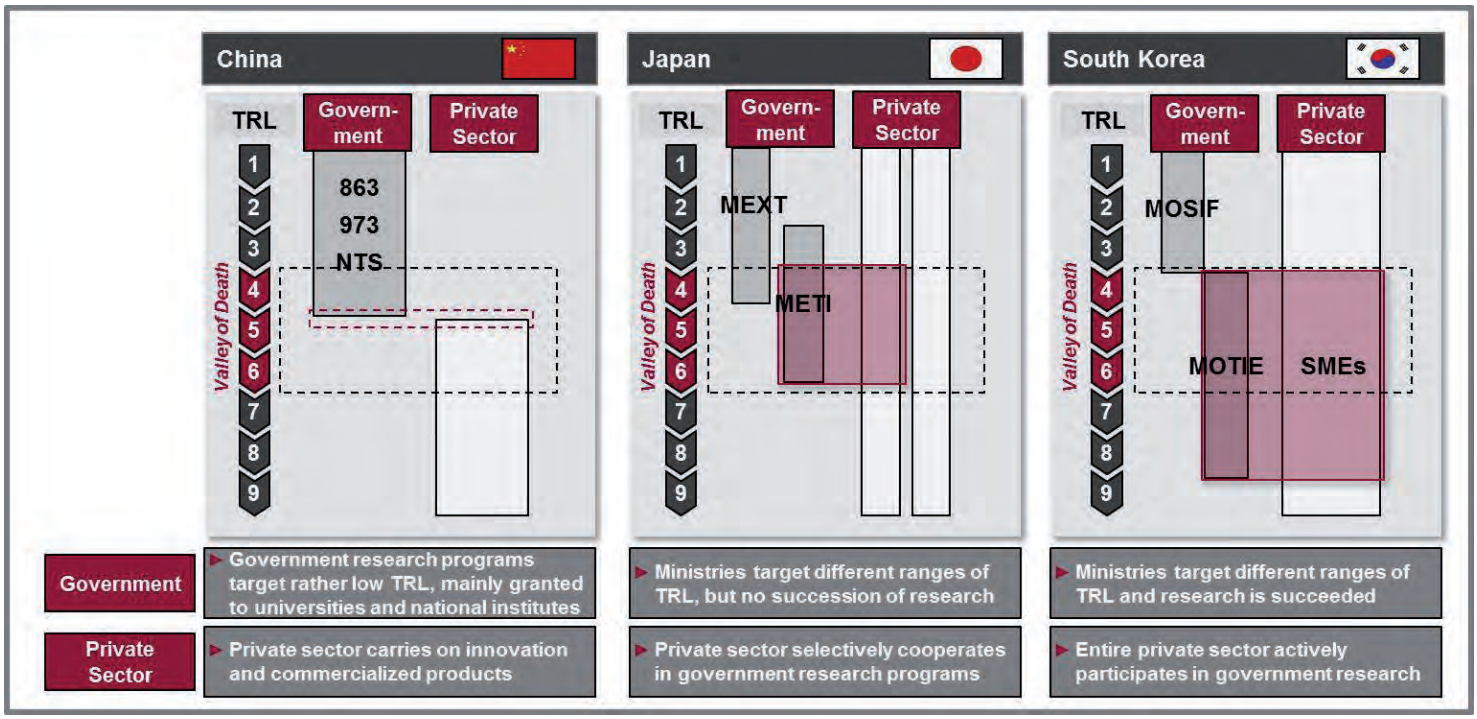


Source: EAC- Euro Asia Consulting PartG

Basic and applied research activities (TRL 1-4) are mostly carried out by universities and research institutes. Activities and investment of the private sector usually cover TRL 6-8, picking up ideas and innovations only after successful demonstration and proven usefulness. The existing gap between academia and practitioners is usually referred to as the “Valley of Death” – The place where “ideas go to die” and an active transfer towards the next stage is required in order to progress towards the commercialization of innovation. To bridge the “Valley of Death”, close alignment between stakeholders, subsequent responsibilities or dedicated technology transfer agents are required.

Taking a closer look at the national framework of research activities, it is evident that all three Asian countries are gradually aiming to bridge the “Valley of Death” by intensifying the government-industry interaction to actively enhance not only research and development, but also supporting the transfer of innovation into market stage.

Figure 23: Government - Industry Proximity Model



Source: EAC- Euro Asia Consulting PartG

The South Korean steering system achieves the highest stage, demonstrating a close interaction between all stakeholders. This is followed closely by Japan, where governmental research programs proven to have reached the innovation stage. Current research programs carried out in China have the lowest TRL achievement, lacking transfer of innovation into the market and solely focusing on academic results. However, this has also been realized by the Chinese government and the research steering system is currently undergoing a reformation process.

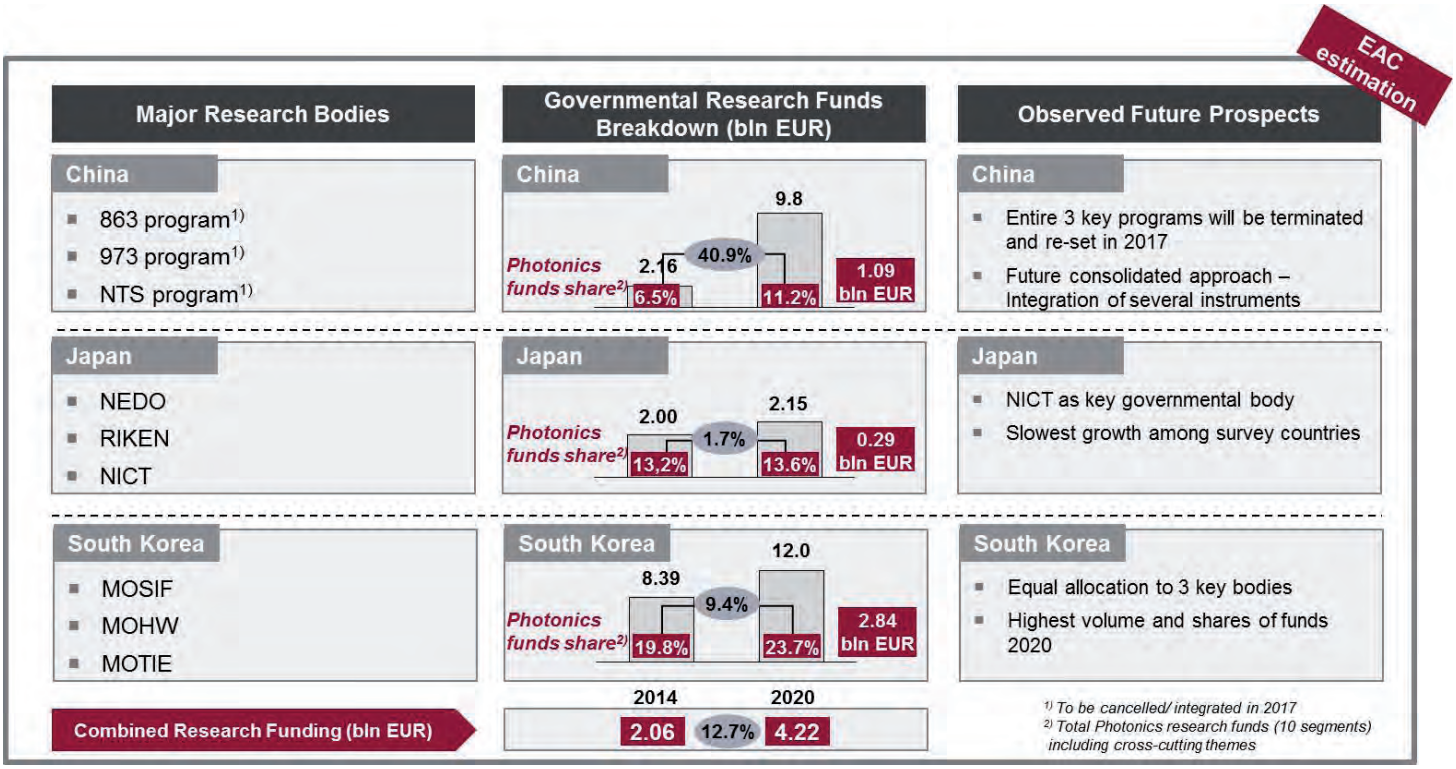
South Korea was identified as the best-in-class example with regards to the effectiveness of political steering and involvement of market side. While research and innovation activities along the TRL are allocated to different ministries, the technological development is succeeded from one ministry to another, latter of which actively involves private sector when carrying out commercialization.

Similarities are spotted in Japan, where ministries target different ranges of TRL, one of which actively involving private sector in the governmental research. However, due to the fact that technological succession is not present between the ministries, and moreover, a significant part of private sector is not identified to be interacting with the government in research activities, efficiency of political steering in Japan needs to be improved in order to better support the innovation transfer.

Under the current political steering structure in China, succession from research and development to commercialization is not directly supported. The research programs operated by the Chinese government have a target TRL of 1 to 4. Therefore, commercialization is independently dealt with by the private sector, without direct management of the government - only through an indirect channel of monetary support.

The different level of technological readiness is reflected in the breakdown of the national research spending within each country. Close-to-market activities are often up to 10 times more expensive than fundamental research. China currently allocates only 6.5% (2014) of their total spending of 2.16 bln EUR within their three mayor research programs to Photonics. South Korea on the other hand is (within their three major ministries) investing nearly 1/5 of its total fund of approximately 8.39 bln EUR into high TRL activities close to the Photonics market.

Figure 24: Overview Steering Instruments



Source: EAC- Euro Asia Consulting PartG

The total identified research funds provided by the local Asian governments to the Photonics industry rounds up to approx. 2.1 bln EUR in 2014. Growing at a CAGR of 12.7%, dedicated research funding for the photonics industry is expected to double by 2020, reaching a total of around 4.2 bln EUR.

6. Key Findings and Summary

Japan and South Korea are operating (and China will soon implement) efficient political steering structures that aim to actively support local companies throughout the entire phase of research and innovation. A growing emphasis on all segments of the Photonics industry has been identified and further proven by the doubling of governmental funding of research programs regarding the Photonics industry by 2020.

Thereby, Photonics and its impact as a Key Enabling Technology (KET) still shows further development potential in the three Asian countries. As of today, the terminology 'Photonics' is either unutilized (in case of China), or refers to only a few segments in the industry (mainly light sources and information technology as in Japan and South Korea). The three selected segments, Production Technology, Medical Technology and Machine Vision, are used by a differing range of industries. Therefore, governmental research activities regarding the Photonics industry are rather fractured and lack a total understanding of the industry's nature. However, various political and fiscal instruments utilized by the Asian governments cover all of the segments of the Photonics industry, including the three selected ones.

Figure 25: Terminology "Photonics" in Survey Countries

	Production Technology		Medical Technology				Machine Vision	
	Lithographic Systems	Laser and Laser Systems for Material Processing	Endoscopy	Microscopy	In-Vitro Diagnostics	Medical Laser	Component	Solutions
China	▪ Production technology	▪ Material ▪ Display ▪ Information technology ▪ Production	▪ Bio-medical technology ▪ Population and public health				▪ Transportation ▪ New material technology ▪ Information technology ▪ Advanced production technology ▪ Smart robot and modern service ▪ Earth observation	
Japan	▪ Production technology	▪ Next generation material & processing ▪ Robot & new machinery	▪ Next generation medical devices ▪ Future medicine and medical devices ▪ Next generation medical ICT ▪ Next generation diagnosis and treatment technology				▪ Image processing ▪ Pattern recognition ▪ Volume computer aided design ▪ Robotics & smart robot ▪ Factory Automation	
South Korea	▪ Core industry technology ▪ Electronic information device	▪ Core industry technology ▪ Global professional technology	▪ Medical devices ▪ Bio-medical technology ▪ Electronic medical devices ▪ Cutting edge medical devices				▪ System semiconductor ▪ Robotics ▪ Electronic information device ▪ SW computing technology ▪ Smart car technology ▪ Ultra-wide 3D convergence	

Source: EAC- Euro Asia Consulting PartG

The three Asian countries manage their governmental research system with very different approaches. China still operates a top-down structure, which is a direct

contrast to Japan's bottom-up research programs. South Korea has a combined structure of both top-down and bottom up, depending on the level of government understanding and strategic emphasis. China's new research structure after the reform in 2017 will develop towards that of South Korea. A model with direct market interaction and close emphasis on technological transfer, to bridge the "Valley of Death", are key requirements in order to increase and foster innovation and sustainable economic development.

The total amount of governmental spending on Photonics industry research highlights the (future) importance of Asia in the industry. The doubling of the identified research funds provided by the local Asian governments to the Photonics industry from approx. 2.1 bln EUR in 2014 to 4.2 bln EUR in 2020 (CARG +12.7%) reveal strategic relevance as well as future emphasis on a more market-oriented innovation funding.

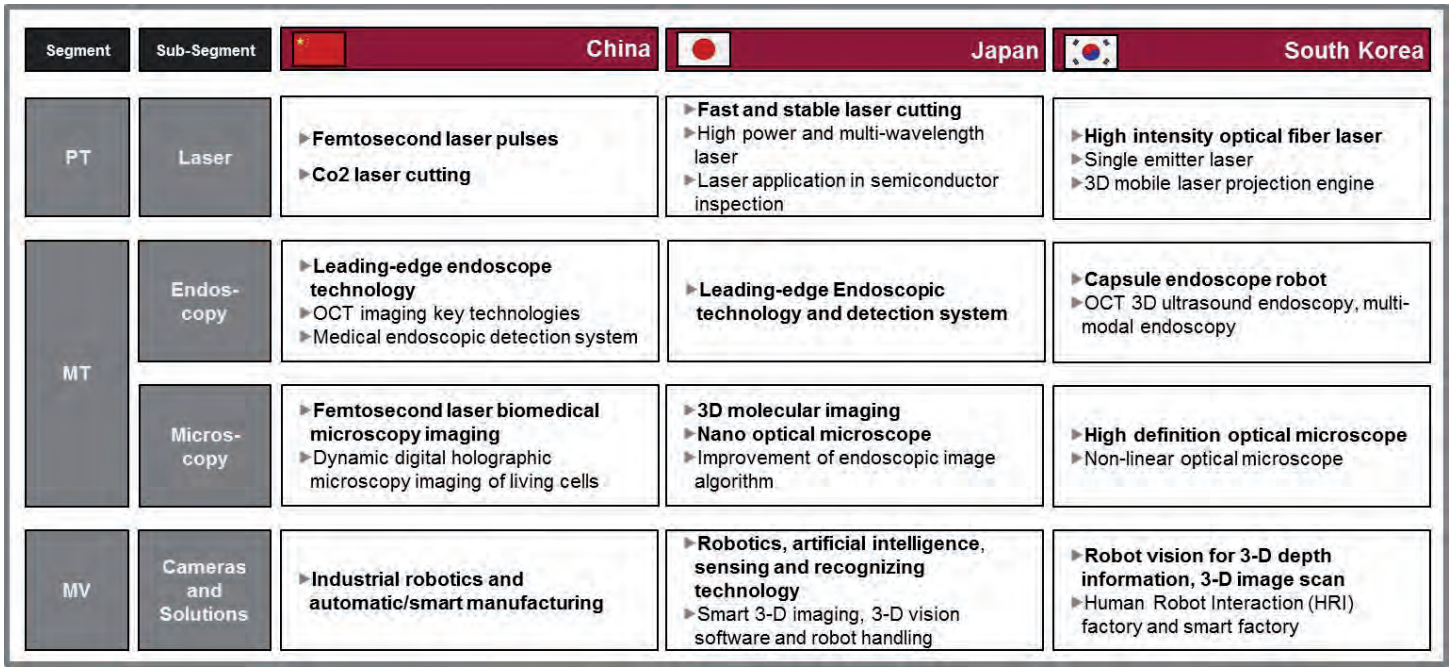
The funding provided by China, Japan and South Korea therefore exceeds the investment of the European Union in Photonics research, under the umbrella of the Horizon 2020 program and the individual funding provided by the EU member states combined. Total funding in the EU ranges between 0.6-1.0 bln EUR per year, herby including funding directly provided for Photonics projects as well as cross-cutting initiatives that partially target Photonics, such as projects concerning Factories of the Future or Smart Cities.

Apart from direct funding and operation of research programs, various fiscal and non-fiscal instruments are impacting the Asian Photonics industry. Especially China demonstrates a strong usage of additional monetary and non-monetary measures to reach strategic Photonics industry goals, e.g. through set up of industry cluster like the Optical Valley in Wuhan, direct cash grants, or measures such as tax incentives.

South Korea has utilized the concept of public purchasing to support the Photonics industry by establishing LUXKO, a co-brand for Photonics products manufactured by SMEs. LUXKO products are enlisted to the government purchase pool, and are granted with prioritized collective purchase contracts, thereby ensuring demand for locally manufactured products.

Cross-checking current and future research topics, China, Japan and South Korea show several commonalities. With regards to Machine Vision, future industries, namely Robotics, Smart Factory (Factory Automation) and 3D imaging and vision are focus-areas for all three Asian countries. The future technological roadmap takes up an important part of governmental strategic planning of the three Asian countries, which serves to prove the substantial achievement that these three countries have made in the Photonics industry.

Figure 26: Photonics Topics in Detail 2014 / 2015



Segment	Sub-Segment	China	Japan	South Korea
PT	Laser	▸**Femtosecond laser pulses** ▸**Co2 laser cutting**	▸**Fast and stable laser cutting** ▸High power and multi-wavelength laser ▸Laser application in semiconductor inspection	▸**High intensity optical fiber laser** ▸Single emitter laser ▸3D mobile laser projection engine
MT	Endos-copy	▸**Leading-edge endoscope technology** ▸OCT imaging key technologies ▸Medical endoscopic detection system	▸**Leading-edge Endoscopic technology and detection system**	▸**Capsule endoscope robot** ▸OCT 3D ultrasound endoscopy, multi-modal endoscopy
	Micros-copy	▸**Femtosecond laser biomedical microscopy imaging** ▸Dynamic digital holographic microscopy imaging of living cells	▸**3D molecular imaging** ▸**Nano optical microscope** ▸Improvement of endoscopic image algorithm	▸**High definition optical microscope** ▸Non-linear optical microscope
MV	Cameras and Solutions	▸**Industrial robotics and automatic/smart manufacturing**	▸**Robotics, artificial intelligence, sensing and recognizing technology** ▸Smart 3-D imaging, 3-D vision software and robot handling	▸**Robot vision for 3-D depth information, 3-D image scan** ▸Human Robot Interaction (HRI) factory and smart factory

Source: EAC- Euro Asia Consulting PartG

The possibility of participation of German companies in government funded research programs in the selected countries differs according to the target, nature and topic of the program. In China, the government direct funding is mostly provided to universities and research institutes. Foreign experts can be subject to government funding on the condition that they are directly affiliated to a university, (e.g. through a teaching assignment). However, respective IP rights will be attributed to the university. Likewise, Japan and South Korea also facilitates exchange of research between universities.

Participation of foreign companies is generally welcomed by the three selected countries, especially when they are deemed to have core competences in their technologies, from which the local industry can be expected to benefit. Prior to any kind of participation in the governmental research programs, it is required for all foreign companies to establish a local entity in the respective country.

For both direct and indirect funding of local research activities, foreign companies are required to commit to a certain degree of localization of production and research. Being located in one of the designated clusters, as well as obtaining the status of a high-tech enterprise are additional criteria that raises the possibility for foreign companies to be granted with government research funding.

Actual participation by German companies in the selected countries has been assessed to be very low. Key reasons for the lack of involvement are:

- *Generally little knowledge about local funding opportunities and ways of participation*
- *High bureaucratic effort and time consuming processes of administration required*
- *Low amount of funding compared to the strict participation criteria*
- *Danger of know-how drainage of German technology leadership*

Low levels of awareness by German companies towards the possibilities and chances of participation has yet hindered German players' active involvement in governmental research programs in China, Japan and South Korea. Therefore, the opportunity for German companies to further position themselves in the center of the global Photonics industry and at the same time benefiting from innovative research topics and growing direct funding provided are currently neglected.

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